SDMS Document
111530

BROS PHASE 2 RI/FS
FIELD OPERATIONS PLAN
SAMPLING AND ANALYSIS PLAN

Bridgeport Rental and Oil Services Site
Logan Township, New Jersey

June 24, 1997
RESUBMITTED
June 25, 1999

Prepared for:

BROS Technical Committee

Prepared by:

ROUX ASSOCIATES, INC.
1222 Forest Parkway, Suite 190
West Deptford, New Jersey 08066

EPA Project Manager	Roux Associates, Inc. Project Manager
EPA Quality Assurance Manager	Roux Associates, Inc. Quality Assurance Manager

BROS PHASE 2 RI/FS
FIELD OPERATIONS PLAN
SAMPLING AND ANALYSIS PLAN

Bridgeport Rental and Oil Services Site
Logan Township, New Jersey

June 24, 1997
RESUBMITTED
June 25, 1999

Prepared for:

BROS Technical Committee

Prepared by:

ROUX ASSOCIATES, INC.
1222 Forest Parkway, Suite 190
West Deptford, New Jersey 08066

EPA Project Manager	Roux Associates, Inc. Project Manager
EPA Quality Assurance Manager	Roux Associates, Inc. Quality Assurance Manager

Document Submission Sheet

Phase 2 RI/FS Sampling and Analysis Plan

Roux Associates, Inc. has been contracted by the BROS Technical Committee, and thereby, as an authorized representative of the Settling Defendants, submits this document in compliance with the BROS Consent Decree.

Neil R. Rivers
Phase 2 RI/FS Project Manager
(Signed as per Paragraph 69 of the BROS Consent Decree)

c: Distribution List

Acronym And Unit Definitions

Acronyms	Description
ACL	Alternative Concentration Limit
ADQO	Alternate Data Quality Objective
AIC	Acceptable Intake - Chronic
AMSL	Above Mean Sea Level
AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate Requirements
ASP	Analytical Services Protocol
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	Area Use Factor
AWTS	Aqueous Wastewater Treatment System
BGS	Below Ground Surface
BOD	Biological Oxygen Demand
BROS	Bridgeport Rental and Oil Services
BTEX	Benzene, Toluene, Ethylbenzene and Total Xylenes
BTU	British Thermal Unit
CDM	Camp, Dresser and McKee
CEA	Classification Exception Area
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Register
CLP	Contract Laboratory Program
CLTL	Chemical Leaman Tank Lines
COD	Chemical Oxygen Demand
COPC	Constituent of Potential Concern
COPEC	Constituent of Potential Ecological Concern
CPF	Cancer Potency Factor
CRAVE	Carcinogen Risk Assessment Verification Endeavor
CRDL	Contract Required Detection Limit
CRPP	Community Relations Participation Proposal
CRQL	Contract Required Quantitation Limit
CRS	Cultural Resources Survey
DNAPL	Dense Non-Aqueous Phase Liquid
DO	Dissolved Oxygen
DQO	Data Quality Objective
DRBC	Delaware River Basin Commission
DRO	Diesel Range Organics
DUR	Data Usability Report

Acronym And Unit Definitions

Acronyms	Description
DVS	Data Validation Services
EDI	Estimated Daily Intake
ER-L	NOAA Effects Range - Low
ERA	Ecological Risk Assessment
FDA	Food And Drug Administration
FEMA	Federal Emergency Management Agency
FID	Flame Ionization Detector
FIT	Field Investigation Team
FOP	Field Operations Plan
FS	Feasibility Study
GIS	Geographical Information System
GPS	Global Positioning System
GRO	Gasoline Range Organics
GWQC	Ground Water Quality Criteria
HASCP	Health and Safety/Contingency Plan
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
ICLR	Incremental Lifetime Cancer Risk
IDL	Instrument Detection Limit
IRIS	Integrated Risk Information System
LC50	Lethal Concentration (for 50% of Population)
LD50	Lethal Dose (for 50% of Population)
LEL	Lowest Effect Level
LNAPL	Light Non-Aqueous Phase Liquid
MCL	Maximum Contaminant Limit
N.J.A.C.	New Jersey Administrative Code
NAAQS	National Ambient Air Quality Standards
NAPL	Non-Aqueous Phase Liquid
NCEA	National Center for Exposure Assessment
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NGVD	National Geodetic Vertical Datum
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level

Acronym And Unit Definitions

Acronyms	Description
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
O&M	Operation and Maintenance
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PAHs	Polynuclear Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PCE	Tetrachloroethylene
PEL	Permissible Exposure Level
PID	Photoionization Detector
PM_{10}	Particulate Matter Less Than 10 Micron in Aerodynamic Diameter
PPE	Personal Protective Equipment
PQL	Practical Limits of Quantitation
PRAO	Preliminary Remedial Action Objective
PRG	Preliminary Remedial Goal
PRM	Potomac-Raritan-Magothy
PRP	Potentially Responsible Party
PWSC	Pennsgrove Water Supply Company
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RA	Risk Assessment
RAGS	Risk Assessment Guidance for Superfund
RAO	Remedial Action Objectives
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RFD	Reference Dose
RI	Remedial Investigation
RMEI	Reasonable Maximum Exposed Individual
ROD	Record of Decision
ROST	Rapid Optical Screening Tool
SAB	Science Advisory Board
SAP	Sampling And Analysis Plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SCBA	Self Contained Breathing Apparatus
SCC	Soil Cleanup Criteria
SHSO	Site Health and Safety Officer

Acronym And Unit Definitions

Acronyms	Description
SMDP	Scientific/Management Decision Point
SOP	Standard Operating Procedure
SOW	Scope of Work
SPHEM	Superfund Public Health Evaluation Manual
SPLP	Synthetic Precipitation Leaching Procedure
SQB	Stream Quality Benchmarks
SQL	Sample Quantitation Limit
SQO	Stream Quality Objectives
SSL	Soil Screening Level
SVOC	Semivolatile Organic Compound
TBC	To-Be-Considered
TCE	Trichloroethylene
TCL	Target Compound List
TCLP	Toxic Characteristic Leaching Procedure
TDI	Total Daily Intake
TDS	Total Dissolved Solids
TI	Technical Impracticability
TIC	Tentatively Identified Compound
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TOX	Total Organic Halides
TPH	Total Petroleum Hydrocarbon
TSP	Total Suspended Particulate
TSS	Total Suspended Solids
UCL	Upper Confidence Limit
USACOE	United States Army Corps of Engineers
USDC	United States District Court
USEPA	United States Environmental Protection Agency
USGS	United Sates Geological Survey
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WET	Wetland Evaluation Technique

Acronym And Unit Definitions

Units	Description
μg/ℓ	Micrograms per Liter
μg/m^3	Micrograms per Cubic Meter
μg	Micrograms
μg/kg	Micrograms per Kilogram
μg/kg/day	Micrograms per Kilogram per Day
μℓ	Microliters
μ	Microns
cm^2	Square Centimeters
°C	Degrees Centigrade
°F	Degrees Fahrenheit
kg	Kilograms
K_p	Dermal Permeability Coefficient
ℓ/cm^3	Liters per Cubic Centimeter
ℓ/m^3	Liters per Cubic Meter
ℓ/day	Liters per Day
ℓ	Liters
m^3/day	Cubic Meters per Day
m^3/hour	Cubic Meters per Hour
mg/ℓ	Milligrams per Liter
mg	Milligrams
mg/m^3	Milligrams per Cubic Meter
mg/kg-day	Milligrams per Kilogram per Day (Daily Exposure)
mg/cm^2	Milligrams per Square Centimeter
mg/day	Milligrams per Day
mg/kg	Milligrams per Kilogram
mg/kg/day	Milligrams per Kilogram per Day (Average Daily Exposure)
mℓ	Milliliters
mm Hg	Millimeters of Mercury
ppb	Parts per Billion
ppm	Parts per Million

CONTENTS

1.0 INTRODUCTION 1

2.0 FIELD MANAGEMENT 3
2.1 BROS Technical Committee 3
2.2 Project Coordinator for the Settling Defendants 3
2.3 Project Manager 3
2.4 RI Manager 4
2.5 Field Team Leader 4
2.6 Site Health and Safety Officer 4
2.7 Laboratory Project Manager 4
2.8 Drilling Services Manager 5
2.9 Project Quality Assurance Coordinator 5
2.10 Field Technical Staff 5

3.0 SAMPLING OBJECTIVES AND DATA NEEDS 6
3.1 Phase 2 RI/FS Objectives 6
3.2 Scope of Work 19
3.3 Data Quality Objectives 20
3.3.1 DQOs for Monitoring, Field Screening, and Field Testing 22
3.3.2 Laboratory Analytical DQOs 26

4.0 SAMPLING TYPES, LOCATION AND FREQUENCY 29
4.1 Sample Matrix Types 29
4.1.1 Aqueous Matrix 29
4.1.2 Soil and Sediment Matrices 31
4.1.3 NAPL Matrix 33
4.2 Sample Location and Frequency 34
4.2.1 Task IIIA, Activity 2 - Soil Investigation 34
4.2.2 Task IIIA, Activity 3 - NAPL Investigations 38
4.2.3 Task IIIA, Activity 4a - Ground Water Investigation 39
4.2.4 Task IIIA, Activity 5 - Surface Water and Sediment Quality Evaluation 44
4.2.5 Task IIIA, Activity 7 - Ecological Evaluation 48

5.0 SAMPLE DESIGNATION 49

6.0 FIELD ACTIVITIES 52
6.1 Site Control 52
6.1.1 Field Work Zones 52
6.1.2 BROS Property Security and Access 53
6.1.3 Off-Property Access 53
6.2 Field Equipment 53
6.2.1 Equipment Calibration 54
6.2.2 Equipment Maintenance 54
6.3 Field Documentation 54
6.3.1 Field Logbooks 55

6.3.2 Field Documentation for Drilling, Well Installation, and Aquifer Testing 55
6.3.3 Sampling Documentation 55
6.4 Field Custody Procedures and Documentation 55
6.4.1 Field Custody 56
6.4.2 Laboratory Custody 56
6.5 Sample Handling and Analysis 57
6.5.1 Field Sample Handling and Shipment 58
6.5.2 Field Analyses 60
6.5.3 Laboratory Analyses 60
6.6 Decontamination Procedures 61
6.6.1 Drilling Equipment 61
6.6.2 Personnel Protection 62
6.6.3 Sampling Equipment 62
6.7 Waste Handling and Disposal 62
6.8 Boring/Well Abandonment 66

7.0 FIELD INVESTIGATION PROCEDURES 67
7.1 Task I, Activity 1 - Preparatory Activities 67
7.1.1 Activity 1a - Inspection and Repair of Existing Monitoring Wells 67
7.1.2 Activity 1b - Evaluation of Local Wells 69
7.1.3 Activity 1c - Stage 1B Cultural Resources Survey 71
7.1.4 Activity 1f - Analytical Method Development 72
7.2 Task IIIA, Activity 1 - Water Budget Investigation 75
7.2.1 Activity 1a - Meteorological Data Collection 76
7.2.2 Activity 1b - Stream Flow and Hydrograph Evaluation 77
7.2.3 Activity 1c - Water Level Measurements 80
7.3 Task IIIA, Activity 2 - Soil Investigation 83
7.3.1 Activity 2a - Background and Off-Property Soils 89
7.3.2 Activity 2b - On-Property Soils 91
7.4 Task IIIA, Activity 3 - NAPL Evaluation 97
7.4.1 Activity 3a - LNAPL Physical Characterization 99
7.4.2 Activity 3b - NAPL Chemical Characterization 100
7.4.3 Activity 3d - Recoverability Analysis 101
7.4.4 Activity 3e - DNAPL Investigations 101
7.5 Task IIIA, Activity 4 - Ground Water Investigation 103
7.5.1 Activity 4a - Ground Water Quality Evaluation 103
7.5.2 Activity 4b - Aquifer Testing 120
7.6 Task IIIA, Activity 5 - Surface Water and Sediment Quality Evaluation 124
7.6.1 Activity 5a - Gaventa and Swindell Ponds 124
7.6.2 Activity 5b - Little Timber Creek Swamp and Cedar Swamp 127
7.6.3 Activity 5c - Swale Along Route 130 135
7.6.4 Location Documentation of Surface Water and Sediment Sampling 135
7.7 Task IIIA, Activity 6 - Human Health Exposure Point Concentration Evaluation 136
7.8 Task IIIA, Activity 7 - Ecological Evaluation 137
7.8.1 Qualitative Flora and Fauna Survey 141
7.8.2 Dominant Vegetation Evaluation 143

7.8.3 *De Manifestis* Zone Mapping 144
7.8.4 Aquatic Macroinvertebrate Evaluation 144
7.8.5 Fish Survey/Sampling 145
7.8.6 Small Mammal Sampling 146

TABLES

1. Sample Types/Analyses in Task IIIA by Activity
2. Analytical Parameters for Task III, Activity 2 - Soil Samples
3. Sampling and Analytical Plan for Soil Samples
4. Analytical Parameters for Task IIIA, Activity 3 - LNAPL Samples
5. Analytical Parameters for Task IIIA, Activity 4 - Ground Water Investigation Samples
6. Analytical Parameters for Task IIIA, Activity 5 - Surface Water and Sediment Samples
7. Analytical Parameters for Task IIIA, Activity 7 - Ecological Risk Assessment Samples
8. Projected Number of Field Samples
9. Project Quality Control Summary
10. Field Quality Control Sample Frequency
11. Laboratory Quality Control Sample Frequency
12. Field Equipment Calibration Requirements and Maintenance Schedule
13. Preservation, Holding Times and Sample Containers
14. Summary of Existing Monitoring Well Construction Information
15. Justification and Screening Intervals for Proposed Monitoring Wells
16. Summary of Proposed Monitoring Well Construction Details

FIGURES

1. Site Location Map, Showing the Approximate BROS Property and BROS Site Boundaries
2. General Site Plan
3. Project Organization Chart
4. Soil Screening Flow Chart
5. Management of Investigation Derived Soil
6. Management of Investigation Derived Ground Water
7. Proposed Soil Boring and Monitoring Well Locations, Former Lagoon and Process & Tank Areas
8. Water Budget Analysis Data Points for Evaluation of Surface Water and Ground Water Exchange
9. Proposed and Existing Upper PRM Monitoring Well Locations
10. Proposed and Existing Upper Middle PRM Monitoring Well Locations
11. Locations of Wells Selected for Quarterly Monitoring
12. Sampling Locations for Gaventa and Swindell Ponds
13. Wetlands Sampling Locations
14. Wetland Reference Sampling Areas
15. Existing Monitoring Well Locations
16. Examples of Completed Sample Labels
17. Conceptual Illustration of Sampling Activities and Rationale in Former Lagoon
18. Typical Construction of Shallow and Deep Wetland Monitoring Wells

19. Typical Single- and Double-Cased Monitoring Well Construction
20. Conceptual Model and Characterization Strategy for the Upper PRM, Upper Middle PRM and Wetlands
21. Areas of Proposed Wetland Delineation

APPENDICES

A. Resumes of Field Management Team
B. Standard Operating Procedures
C. Target Compound and Analyte List Parameters
D. Field Forms
E. NJDEP Methodology for the Field Extraction/Preservation of Soil Samples With Methanol
F. Bail Down Test Protocol
G. Region II Low Stress (Low Flow) Ground Water Sampling Procedure
H. Surface Water Flow Meter Description
I. Bentonite and Dye Specifications
J. ASTM Method D 5613-94

PLATES

1. Phase 2 RI/FS Schedule

1.0 INTRODUCTION

The BROS Superfund Site is located in Logan Township, Gloucester County, New Jersey, approximately one mile east of the town of Bridgeport and west of the divergence of U.S. Route 130 and Interstate 295 (Figures 1 and 2). The BROS Phase 2 Remedial Investigation/Feasibility Study (RI/FS) Sampling and Analysis Plan (SAP) has been prepared to ensure that sample collection and analysis activities are conducted in accordance with technically acceptable protocols such that the resulting data meet Data Quality Objectives (DQOs), taking into account matrix complexities and limitations associated with the site (BROS Consent Decree, Appendix E - Statement of Work, 1997). The SAP, along with the Health and Safety Contingency Plan (HASCP) and the Quality Assurance Project Plan (QAPP), make up the Field Operations Plan. The HASCP and QAPP were developed as separate deliverables. The Work Plan outlines the Phase 2 RI/FS rationale and scope and was developed based upon a review of available data from prior investigations and remedial actions at the site. The SAP, HASCP, and QAPP build upon the Work Plan, providing detailed procedures and methodologies for implementing the Work Plan.

More specifically, the SAP consists of two parts: (1) a QAPP that describes the policy, organization, functional activities, and quality assurance and quality control protocols necessary to achieve DQOs based on the intended use of the data; and (2) the Field Sampling Plan (FSP) which provides guidance on all field work by defining in detail the sampling and data-gathering methods to be used on the project. Under the BROS Consent Decree Statement of Work, the FSP is identified as the SAP, and the QAPP is separate but related. The United States Environmental Protection Agency (USEPA) *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988) was used as the basis for the scoping and preparation of the Work Plan, SAP, HASCP and QAPP. The New Jersey Department of Environmental Protection (NJDEP) *Technical Requirements for Site Remediation* (N.J.A.C. 7:26E), the NJDEP *Field Sampling Procedures Manual* (1992), and the NJDEP *Field Analysis Manual* (1994) were also used as guidance.

The information generated during the Phase 2 RI/FS will be used to select remedial alternatives for ground water and wetlands which will be documented in the Phase 2 Record of Decision

(ROD). Sampling and data-gathering methods to carry out the tasks identified in the Work Plan are described in detail in this SAP. The Work Plan environmental setting and site history are provided in the Work Plan.

2.0 FIELD MANAGEMENT

A general discussion of the responsibilities of management and the field technical staff is provided below and arranged based on the overall management structure (Figure 3). Resumes of the individuals named in the following sections are provided (Appendix A).

2.1 BROS Technical Committee

The BROS Technical Committee is responsible for the implementation of the Phase 2 RI/FS. The BROS Technical Committee is responsible for making strategic decisions and monitoring the overall project progress.

2.2 Project Coordinator for the Settling Defendants

The Project Coordinator, Environmental Liability Management, Inc., (ELM) serves the BROS Technical Committee in an overall project direction and administrative capacity. The Project Coordinator serves as a liaison between the BROS Technical Committee, the USEPA and the RI/FS Contractors. The Project Coordinator manages the BROS Technical Committee review and approval of project deliverables through the distribution of draft reports, interpretation and reduction of comments, and the presentation of comments to the RI/FS Contractor. In addition, the Project Coordinator provides strategic and technical direction and comments based upon their review of project deliverables. Dr. Peter Brussock of Environmental Liability Management manages ELM's activities in their role as Project Coordinator.

2.3 Project Manager

The Project Manager works for the RI/FS Contractor, Roux Associates, Inc., and is responsible for defining project objectives. Mr. Neil Rivers of Roux Associates, Inc. is the Project Manager. In this capacity, he bears the responsibility for the successful completion of the work assignment within budget and schedule. This individual provides overall management for the execution of the Work Plan and directs the activities of the RI Manager, the Field Team Leaders and the technical staff. The Project Manager performs technical review of field activities, data review and interpretation and preparation of the reports. Activities of the Project Manager are supported by the Project Principal, the Project Quality Assurance Coordinator (PQAC), and the RI Manager.

2.4 RI Manager

The RI Manager, Mr. William Gilchrist, works for the RI/FS Contractor, Roux Associates, Inc., and provides overall management for the execution of the RI and directs the activities of the Field Team Leaders, Health and Safety Officers, Laboratory Manager, and Drilling Services Manager. Responsibilities include coordination of all field activities, data review and interpretation, and report preparation.

2.5 Field Team Leader

The Field Team Leader, Mr. John Lucey, works for the RI/FS Contractor, Roux Associates, Inc., and bears the responsibility for the successful execution of the field program. The Field Team Leader directs the activities of technical staff in the field and assists in the collection and interpretation of physical and chemical data, and report preparation. Responsibilities include the management of technical staff, and oversight of subcontractors such as the ecological sampling team, surveyors and drillers. The Field Team Leader reports to the RI Manager.

2.6 Site Health and Safety Officer

The Site Health and Safety Officer (SHSO), Ms. Brigid Tigani, works for the RI/FS Contractor, Roux Associates, Inc., and is responsible for health and safety activities throughout the Phase 2 RI/FS. The SHSO is responsible for implementation of the Health and Safety Contingency Plan. The SHSO works with the Field Team Leader, but reports directly to the Project Manager. The SHSO will also be responsible for calibration of sampling equipment as wells as health and safety equipment and maintaining a project-specific calibration field log book.

2.7 Laboratory Project Manager

Two off-site analytical laboratories and one on-site analytical laboratory will provide analytical services for the Phase 2 RI/FS. The laboratory Project Manager for the primary off-site analytical laboratory, Lancaster Laboratories, is Ms. Missy McDermott. The secondary off-site laboratory will be determined during the first six months of the RI activities, after the rate of sample production is more accurately established. The laboratory Project Manager for the on-site laboratory, On-site Environmental Laboratories, Inc. is Mr. Lonnie Fallin. The Laboratory Project Managers work for the laboratory subcontractors and are responsible for sample container

preparation, sample custody in the laboratory, and completion of the required analysis through oversight of the laboratory staff. The Laboratory Project Managers will ensure that quality assurance procedures are followed and that an acceptable laboratory report is prepared and submitted. The Laboratory Project Managers report to the RI Manager. To provide additional support to technical and methodology questions during on-site analytical services, the on-site laboratory will team with the primary laboratory throughout the project.

2.8 Drilling Services Manager

The Drilling Services Manager, Mr. Gerald Freck, works for the drilling subcontractor, Uni-Tech Drilling, Inc., and is responsible for providing the appropriate labor, equipment and materials to conduct soil borings and install monitoring wells in accordance with the SAP and the appropriate NJDEP requirements. The Drilling Services Manager also ensures that the appropriate drilling permits are secured and that boring/well logs are completed for the work done. The Drilling Services Manager reports to the RI Manager.

2.9 Project Quality Assurance Coordinator

The Project Quality Assurance Coordinator (PQAC), Ms. Joanne Yeary, works for the RI/FS contractor, Roux Associates, Inc., and is responsible for conducting reviews, inspections, and audits to assure the data collection is conducted in accordance with the SAP. These responsibilities range from ensuring effective field equipment decontamination procedures and proper sample collection, to the review of all laboratory analytical data (including tentatively identified compounds, if analyzed) for completeness and usefulness. The PQAC reports to the Project Manager.

2.10 Field Technical Staff

The tentative field technical staff individuals will include the following representatives from the RI/FS Contractor, Roux Associates, Inc.: Jonathan McLelland, Staff Geologist; Adam Karst, Staff Assistant Geologist; and Jerry Bjorkland, Technician. Anthony Esposito, Senior Biologist, from O'Brien and Gere Engineers, Inc., subcontracted to Roux Associates, Inc., will perform the wetlands delineation and coordinate the ecological sampling activities.

3.0 SAMPLING OBJECTIVES AND DATA NEEDS

The SAP describes in detail the sampling and data gathering methods to be used during implementation of the RI. Guidance for the SAP methodology was acquired from the USEPA *Compendium of Superfund Field Operations Methods* (USEPA, 1987), the NJDEP *Technical Requirements for Site Remediation* (N.J.A.C. 7:26E), the NJDEP *Field Sampling Procedures Manual* (1992), and the NJDEP *Field Analysis Manual* (1994). The SAP was prepared based upon a detailed review of available information developed during previous investigations and remedial activities performed at the site and is designed to obtain the data necessary to address the Phase 2 RI/FS data needs identified in the Work Plan.

3.1 Phase 2 RI/FS Objectives

A primary objective of the Phase 2 RI study is to collect the data necessary to adequately characterize the site for the purpose of developing and evaluating effective remedial alternatives, building from the previously conducted studies. In addition, the RI site characterization will provide the information for completion of a site-specific baseline risk assessment which will evaluate the current and potential threats to human health and the environment that may be posed by the contaminants being transported to ground water or surface water, releasing to the air, leaching through the soil, remaining in the soil, or bioaccumulating in the food chain. The risk assessment will be used to support the development, evaluation, and selection of appropriate response alternatives in the FS.

The primary objective of the FS will be to ensure that appropriate remedial alternatives are developed and evaluated such that relevant information concerning the remedial action options can be presented to a decision-maker and an appropriate remedy selected. Development of the alternatives will be fully integrated with the site characterization activities of the RI and the results of the risk assessment. Ultimately, the information compiled and generated during the Phase 2 RI/FS will be used to support the selection of a remedial action or actions for ground water and wetlands. The rationale for the decision, consistent with Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the National Oil and Hazardous Substances Contingency Plan (NCP), will be described in the Phase 2 Record of Decision (ROD).

The specific Phase 2 RI/FS objectives and data needs were identified and detailed as a result of the Work Plan scoping process and presented in Section 5.1 of the Work Plan. These objectives and data needs are summarized below.

Objective 1 - Establish a Water Budget for the Site

Data and Technical Evaluation Needs:

- Establish the direction and magnitude of water movement through various environmental compartments at the site, especially the discharge/recharge relationship between ground water and surface water.

- Understand the fluctuations in flow and discharge/recharge relationships caused by seasonal changes and precipitation events.

- Determine the relative potential for contaminant movement through aqueous pathways; soil leaching, incinerator ash/lime leaching, ground water movement, and surface water transport.

- Evaluate the effects of various potential remedial alternatives (i.e., capping, pumping and treatment, engineering containment) on the movement of water and associated contaminants as well as the hydrology of the adjacent wetlands.

The water budget analysis, linked with other sampling and evaluation activities, will satisfy the data needs identified above. Based on the water budget evaluation results, the conceptual site model will be refined and provide the template for the fate and transport assessment which will be used in human health risk assessment, ecological risk assessment, and the Phase 2 FS.

Objective 2 - Establish the Spatial Distribution, Volume and Mass of Contaminants Associated with Residual Source Areas

Data and Technical Evaluation Needs:

- Determine the vertical and horizontal distribution of free product; defined as the NAPL that would flow into a well or other recovery point.

- Evaluate the recoverability of the free product (LNAPL).

- Determine the vertical and horizontal distribution of residual product; defined as the LNAPL that remains in the soil pore space but will not flow into a well or other recovery point.

- Characterize the constituents of the LNAPL at various locations on the BROS property and in the adjacent wetlands.

- Understand the physical (e.g., viscosity, BTU value) and chemical characteristics of the LNAPL in the former Process and Tank Areas and lagoon residuals below and around the excavation limits of the incineration work.

- Determine the vertical and horizontal distribution of the peat layer encountered below the former Process and Tank Areas and at the base of the lagoon excavation.

- Understand the physical, hydrologic, and chemical characteristics of the peat layer beneath the former lagoon, especially its hydraulic conductivity and chlorinated solvent content.

- Estimate the mass of LNAPL above and below the current water table.

- Determine the relative mobility potential of the constituents of the LNAPL.

- Determine the vertical and horizontal distribution of the Constituents of Potential Concern (COPCs) in former source areas (Process Area, Tank Area, Lagoon). COPCs include chlorinated solvents (i.e., PCE, TCE) nonchlorinated solvents (BTEX), lead, and PCBs.

- Evaluate the Pepper Building for potential residual sources of contamination.

- Screen for DNAPL below the former Process and Tank Areas and the former lagoon.

Characterization of the secondary sources of contamination associated with the former primary sources of contamination is necessary to evaluate: the risks posed by the site currently and in the future; the reduction in toxicity, mobility, and volume resulting from the treatment of lagoon materials; the probable effectiveness and implementability of potential remedial alternatives; and reasonable restoration timeframes, considering the difficulty of remediating LNAPL and (if present) DNAPL which is at least in part trapped below the water table.

Objective 3 - Establish the Vertical Distribution and Characteristics of the Fill, Ash and Lime, and Cover Material Layers in the Former Lagoon

Data and Technical Evaluation Needs:

In order to complete the closure of the ash management unit and determine the hydrology in the former lagoon area, additional data are needed to augment the existing information.

- Detail the as built specifications including thickness and elevation of each layer placed in the former lagoon and how the thickness varies.

- Determine the physical, chemical, and hydrologic characteristics of the layers in the former lagoon.

Objective 4 - Determine the Distribution and Gradients of COPCs Along Potential Exposure Pathways Under Current Site Conditions

The substantial changes in the site conditions resulting from the lagoon incineration work and ground water pumping have altered the hydrology and influenced the distribution and concentration gradients of COPCs in the vicinity of the former lagoon. In addition, the data for the site are at least 5 to 8 years old and several data gaps are now apparent. The data needs for specific areas of the site are summarized below.

Off-Property Soils (Beyond BROS Property)

Data and Technical Evaluation Needs:

- Determine background soil quality by soil sampling at multiple locations (peach orchard and southeast of Route I-295).

- Survey the BROS property to determine the property boundaries.

- Delineate the vertical and horizontal distribution of site-related constituents which extend beyond the BROS property, especially near Cedar Swamp Road and U.S. Route 130.

Gaventa and Swindell Ponds

Data and Technical Evaluation Needs:

- Complete the evaluation of the distribution and gradients of Constituents of Potential Ecological Concern (COPEC) in surface water and sediments in the northwest corner of Gaventa Pond and confirm the previous results for Swindell Pond.

- Evaluate the hydrologic conditions and interactions between Gaventa and Swindell Ponds, ground water and the Little Timber Creek Swamp.

Little Timber Creek Swamp - Between Interstate Route 295 and U.S. Route 130 and Between U.S. Route 130 and Cedar Swamp Road

Data and Technical Evaluation Needs:

- Wetland delineation.

- Identify the vertical and horizontal distribution of COPECs in sediment.

- Understand the surface water flow patterns in the swamp.

- Identify the horizontal distribution of COPECs in surface water as related to sediment concentrations.

- Identify the key species and the assessment endpoints.

- Identify the distribution of key species in relation to surface water and sediment concentrations.

- Characterize of the areas dominated by *Phragmites* and containing residual LNAPL in sediment for evaluation of restoration alternatives as part of the Feasibility Study.

- Identification and characterization of reference areas.

Little Timber Creek Swamp - Between Cedar Swamp Road and the Tide Gate Along Route 44

Data and Technical Evaluation Needs:

- Wetland delineation.

- Identify the vertical and horizontal distribution of COPECs in sediment.

- Identify the key species and the assessment endpoints.

- Evaluate the concentration gradients of COPECs in the downstream direction of Little Timber Creek. Identify the horizontal distribution of COPECs in surface water as related to sediment concentrations.

- Identify the horizontal distribution of key species in relation to surface water and sediment concentrations.

Cedar Swamp - Downstream of the Tide Gate

Data and Technical Evaluation Needs:

- Wetland delineation.

- Evaluate the presence or absence of COPECs in depositional areas along the drainage channel downstream of the tide gate.

Ground Water - Upper PRM and Recent Alluvium

Data and Technical Evaluation Needs:

- Concentrations of COPCs representative of ground water quality after the conclusion of the lagoon work and determination of ground water flow near the former lagoon under existing hydrogeologic conditions.

- Vertical and horizontal distribution of COPC beneath Little Timber Creek Swamp.

- Horizontal distribution of COPCs beneath the former lagoon.

- Concentrations of COPCs possibly discharging to surface water in Little Timber Creek Swamp.

- Potential for sediment contamination to influence ground water quality during periods when surface water recharges ground water.

- Horizontal distribution of dissolved COPCs in the former Process and Tank Areas.

- Evaluate the potential occurrence of DNAPL below the former Process and Tank Areas and the former lagoon.

Ground Water - Upper Confining Layer

Data and Technical Evaluation Needs:

- Establish the vertical and horizontal extent of the strata beneath the former Process and Tank Areas, the former lagoon, the Little Timber Creek Swamp and to the north of Route 130.

- Determine concentrations and vertical distribution of COPCs in soils of this confining layer.

Ground Water - Upper Middle PRM

Data and Technical Evaluation Needs:

- Concentrations of COPCs representative of current ground water quality conditions.

- Vertical distribution of COPCs within the aquifer, especially below and near the former lagoon.

- Evaluate the potential occurrence of DNAPL below the former lagoon area.

- Horizontal distribution of COPCs beneath Little Timber Creek Swamp and between Interstate Route 295 and Swedesboro-Paulsboro Road.

Objective 5 - Establish the Degree of Hydraulic Connections Between the Aquifers and Surface Water

Data and Technical Evaluation Needs:

- Evaluate seasonally the flow direction and probable magnitude of flow between Swindell and Gaventa Ponds and the Upper PRM and Upper Middle PRM.

- Evaluate seasonally the flow direction and probable magnitude of flow between the Upper PRM and the Little Timber Creek Swamp.

- Determine the influence of pumping ground water in the Upper PRM on the Little Timber Creek Swamp, the adjacent ponds, and the Upper Middle PRM beneath the former lagoon.

- Determine the influence of pumping ground water in the Upper Middle PRM on the Little Timber Creek Swamp, the adjacent ponds, and the Upper PRM around the former lagoon. The degree of hydraulic interconnection between the Upper PRM and Upper Middle PRM will be specifically evaluated near the former lagoon.

These data will be used in the water budget analysis, fate and transport assessment of COPC, and feasibility study.

Objective 6 - Establish the Hydrogeologic and Chemical Relationship Between the Chemical Leaman Tank Lines Site and BROS site

Data and Technical Evaluation Needs:

- Evaluate the hydrogeology of the CLTL site to determine the interaction between the two sites and potential effects of the CLTL ground water remedial system on ground water flow and contaminant fate and transport at the BROS site.

- Determine the extent of the clay confining layer between the Upper PRM and Upper Middle PRM in the area between the CLTL property at the BROS property.

- Evaluate the chemical constituents of concern associated with the CLTL site versus those associated with the BROS site.

- Evaluate the vertical and horizontal extent of CLTL-related constituents to support the Feasibility Study evaluation of potential remedial technologies.

Objective 7 - Assess the Environmental Fate and Transport of COPCs Under Current Site Conditions and Assess Future Fate and Transport of COPCs

The Phase 2 RI/FS is a retrospective study, meaning the release of contaminants from the BROS waste oil operation occurred primarily in the past and the primary sources of contamination have been removed. Consequently, the mass loading of contaminants into potential exposure pathways has been decreased substantially and will continue to decline in the future. Under such conditions, the most direct way to predict the environmental fate and transport of COPC is to measure the concentration trends along exposure pathways and over time at various points along concentration gradients of contamination. However, assessment and modeling of various factors that affect the rate of natural attenuation to effectively reduce contaminant concentrations must also be evaluated separately, including: the biological and chemical degradability of the contaminants, the physical and chemical characteristics of the media, and physical characteristics

of the geological medium. The data needs identified below relate to completing the fate and transport assessment of COPCs under current and future conditions.

Data and Technical Evaluation Needs:

- Determine if the distribution of site-related constituents in the Upper PRM and Upper Middle PRM is expanding, stable or decreasing.

- Characterize the physical and chemical characteristics that relate to the evaluation of the natural attenuation mechanisms and processes in various environmental media.

- Estimate the rates of degradation of the organic COPC in various media and portions of the site.

- Determine the chemical and biological degradability of the contaminants under the various physical and chemical characteristics present at the site.

- Characterize the mechanisms of sequestration of COPC and establish the adsorptive and exchange capacities of the various media and across the site.

- Determine the physical characteristics of the geological media as necessary to assess and model the environmental fate and transport of the COPC.

- Based upon the results of additional chemical, hydrologic, and stratigraphic evaluations, evaluate the rate of chemical transport in different geologic media encountered below the site using column leaching studies.

Objective 8 - Determine Representative Exposure Point Concentrations and Characterize Potential Receptors

A large amount of data has been generated for the site over the past twenty years. However, to accurately estimate the exposure point concentrations and the risks, the exposure point concentrations must be specifically measured in a manner that can be related directly to current or

potential future receptors, human or ecological (USEPA, 1998). Exposure estimates must be conservative but within a realistic range of exposure, where unlikely exposure scenarios are eliminated from consideration consistent with USEPA policy and guidance. In considering land use and ground water use, Superfund exposure assessments most often classify land use into one of three categories (1) residential, (2) commercial/industrial, and (3) recreational; and ground water use is classified as potable or non-potable use.

In May 1997, the Settling Defendants reached an agreement with the owners of the BROS property that three perpetual deed restrictions in the form of Declaration Restrictive Covenants would be promptly established for the BROS property, which include the Pepper Building, the former Lagoon and former Process Areas. These deed restrictions are currently in place and properly recorded. The provisions of the restrictions include:

- Future use of the property excludes residential use and limits other uses to non-retail commercial and/or industrial use. These uses are consistent with the use at the time the release of hazardous substances began.

- All subsurface activities (e.g., digging) are prohibited without prior written approval of the USEPA and NJDEP.

- The installation and/or use of any ground water wells at the site is prohibited without prior written approval of the USEPA and the NJDEP.

Ground water use throughout the site is limited because most residents have connected to the municipal water supply which has also made available supplied to residents near the site. Consequently, the portion of the site beyond the BROS Property boundary area will be considered a potential future potable supply source but the current use risk assessment will be based on conditions established as part of this scope of work.

Data and Technical Evaluation Needs:

- Determine representative human health risk assessment exposure point concentration across various portions of the site in a manner consistent with current and future land use or water use.

- Identify ground water users and well configurations at the BROS site. Sample local private wells to evaluate the current extent and gradients of site-related COPCs in ground water and to assess representative COPC concentrations at potential receptor wells.

- Determine representative exposure point concentrations for key ecological receptors across various portions of the site.

- Annually evaluate the planned future of land, especially land development proposals in the vicinity of the site by contacting the Logan Township Planning Board throughout the duration of the Phase 2 RI/FS.

- Identify current and probable future ground water users have the potential to be receptors of site-related contaminants.

Objective 9 - Establish a Range of Remedial Alternatives that are Protective of Human Health and the Environment and Conduct Screening of Alternatives

In establishing the NCP-required range of remedial alternatives, several specific factors will be taken into account, including:

- there are various portions of the site where the distribution and composition of contamination varies as well as the potential receptors;

- guidance on the conventional methods, strategies, and technologies for ground water and volatile organic compounds in soils are available;

- the recognition that a variety of site-specific factors, such as LNAPL trapped below the water table and DNAPL (if present), may make remediation impracticable by conventional methods and technologies;

- there are potential adverse effects on sensitive ecological environments from some remedial alternatives;

- there are human health risks posed by various remedial alternatives;

- a limited number of site-related constituents pose the majority of the risks in various media and the evaluation will consider the costs and benefits of reducing the principal and secondary risk factors;

- the effect of the CLTL remedial activities on the aquifers beneath the BROS Site;

- in Little Timber Creek Swamp, the areas dominated by *Phragmites* and containing elevated concentrations of site-related constituents are recognized at the start as probably requiring remedial action;

- institutional controls that may already be in place, such as ground water Classification Exception Areas and the deed restrictions on the Borelli property;

- detailed evaluation of reasonable restoration times will be necessary as a result of the site-specific treatment limitations;

- a combination of remedial technologies and options as well as a phased remedial approach will be necessary to further reduce the toxicity, mobility, or volume of the remaining contamination, taking into account the treatment of wastes already completed.

In order to take these factors into account and develop an integrated remedial approach to the site, the data needs identified under the preceding objectives will be iteratively added into the feasibility study components.

Objective 10 - Conduct Relevant Treatability Studies

Based on data needs identified during the development and screening of remedial alternatives, treatability studies will be designed and conducted to reduce the uncertainty of whether some remedial technologies are feasible. Treatability studies will be described in a Technical Memorandum submitted to the USEPA after initiation of the field activities with the objective to complete the studies in time to be included in the FS Alternative Evaluation and in the Phase 2 RI/FS report.

Objective 11 - Complete the Cultural Resources Survey Requirements

Supplement the Stage 1A Cultural Resource Survey (CRS) to include the entire BROS site and conduct a Stage 1B CRS based on the previously completed Stage 1A CRS and the results of the supplemental Stage 1A CRS.

3.2 Scope of Work

The proposed Phase 2 RI/FS tasks detailed in the Work Plan are listed below.

- Task I - Scoping
- Task II - Community Relations
- Task III - Site Characterization
  - Task IIIA - Field Investigation
  - Task IIIB - Data Analysis
  - Task IIIC - Data Management Procedures
  - Task IIID - Site Characterization Deliverables
- Task IV - Identification of Candidate Technologies
- Task V - Treatability Studies
- Task VI - Baseline Risk Assessment
  - Task VIA - Human Health Risk Assessment
  - Task VIB - Ecological Risk Assessment
- Task VII - Remedial Investigation Report
- Task VIII - Development of Remedial Action Objectives and Screening of Remedial Alternatives
  - Task VIIIA - Development and Screening of Remedial Alternatives

Task VIIIB - Conduct and Document Screening Evaluation of Each Alternative

Task VIIIC - Presentation of Remedial Action Objectives and Development and Screening of Alternatives

Task IX - Feasibility Study Report

Task IXA - Detailed Analysis of Alternatives

Task IXB - Detailed Analysis Deliverables

The field activities to be completed to implement the Work Plan are discussed in Section 7.0, with relevant subtasks discussed in the succeeding subsections. Since various portions of the site (e.g. the former lagoon area, wetlands, the Upper PRM aquifer) have specific RI needs and goals, different combinations of the above tasks will be applied to each area in order to meet the area-specific goals.

In order to execute the RI in a cost-effective manner, the field tasks are designed to be implemented in a phased manner, but within one field mobilization to the maximum extent practicable. For example, the locations of shallow soil borings for LNAPL delineation will be established based upon the initial (deeper) delineation efforts and review of the USEPA Phase 3 RI data. Where season-dependent sampling must be conducted, such as for the sediment and biota investigations in support of the Ecological Risk Assessment, a second mobilization may be required depending upon the timing of Work Plan. The sampling and analysis program will be refined as information is developed for the site. Monthly Progress Reports and technical memoranda will be used to convey information to the USEPA and NJDEP, and to document changes in the technical approach for the RI/FS.

3.3 Data Quality Objectives

Data Quality Objectives have been developed for the Phase 2 RI/FS based upon the intended uses of the data and a recognition of the matrix complexities and limitations particular to the site. The DQOs were developed within the context of relevant guidance including the *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA QA/R-5) (USEPA, 1997a), the *USEPA Region II CERCLA Quality Assurance Manual*, and the seven step DQO process detailed in the *Guidance for the Data Quality Objectives Process* (EPA QA/G-4) (USEPA, 1994). The primary intended uses for RI data are for risk assessment and evaluation of

remedial alternatives. Specifically, the DQOs are the ability to use the data for comparison to risk-based remedial action criteria, including PRGs, ARARs and TBCs, and to support the estimation of COPC concentrations at the point of exposure. To achieve these data uses, two separate numeric DQOs have been established for different portions of the site. For the BROS property, the area between I-295 and Route 130 and the portions of Little Timber Creek Swamp west of Route 130 (where significant matrix interference effects are anticipated) the numeric DQOs are approximately 50% of the PRG. The selection of 50% of the PRG is intended to allow for anticipated difficulties in meeting the method detection limit due to matrix interference, while providing a low enough numeric DQO to protect against changes in regulatory standards and potential measurement errors. This approach is consistent with guidance provided in RAGS Part A (USEPA, 1989), RAGS Part D (USEPA, 1998a) and the *Ecological Risk Assessment Guidance For Superfund* (USEPA, 1997b). If the numeric DQOs for these areas are lower than the method detection limits, the method detection limit will be used as the DQO. For all areas where matrix interference effects are anticipated to be minimal or absent, the numeric DQOs will be the method detection limit. These numeric DQOs have been selected to provide for a high degree of usable data, given the prior concerns for matrix interference, while providing a low enough detection limit target to quantify compounds at levels that:

- can be used to assess the distribution of COPCs through gradients;
- may require consideration during the risk assessment;
- allows for revisions to the PRGs at a later time, if warranted.

Analytical method development activities are proposed (Section 7.1.4) in which the laboratories will evaluate different sample extract cleanup methods and different analytical methods for the types of media where matrix interference is of greatest concern.

DQOs for field screening data are established to ensure the safety of site workers and to provide meaningful data for the selection of site characterization samples and the assessment of the representativeness of sampling results.

DQOs for field screening, monitoring and field testing and laboratory analytical data are described below. A more detailed discussion of DQOs is provided in the QAPP.

3.3.1 DQOs for Monitoring, Field Screening, and Field Testing

Field measurements will be taken to assist in the selection of soil, ground water and surface water samples. Additionally, organic vapor monitoring will be conducted for health and safety purposes. DQOs for these measurements need to be stringent enough to accurately characterize site conditions to support sample collection activities and be protective of the health and safety of the field team based upon the action levels established in the HASCP.

A photoionization detector (PID) will be used for field screening and air monitoring. The DQO for the PID will be 1.0 part per million (ppm). To achieve this DQO, the PID will be operated and calibrated in accordance with the manufacturers' specifications.

A PID with an 11.8 electron microvolt (emv) detector will be used for field screening samples and air monitoring for health and safety purposes. The use of an 11.8 emv detector will ensure that xylenes, the most frequently detected COPC and the COPC detected at the highest concentration in soft bottom sediment and Phase 3 soil samples, will be detected by the PID. Additionally, other site-specific volatile COPCs (benzene, toluene, ethylbenzene, trichloroethene and vinyl chloride), which have ionization potential ranges from 8.82 to 9.99 emv will be detected.

Additionally, an evaluation of the Phase 3 USEPA data indicates that there was little correlation between FID results and sample results. As the FID is capable of detecting methane, which is believed to be present in the peat layer and surrounding soils and may also be the result of the biodegradation of the petroleum compounds present in the lagoon area, this poor correlation was likely related to methane detections. The detection of methane during field screening activities could result in a decision error for sample selection. Thus, for these reasons, the FID is not an appropriate field screening device for the BROS site.

To measure the ferrous iron content in ground water samples at the time of collection HACH™ field test kits will be used. The DQO for these test kits is 0.2 mg/l (ppm). To achieve this DQO

the procedures documented in the manufacturers' instructions will be followed (Appendix B). These iron concentration data will be used to evaluate treatment alternatives and environmental fate and transport of some constituents.

Other field parameters that will be measured for surface water and ground water include pH, Eh, dissolved oxygen (DO), temperature, and specific conductance. The data quality objectives for each parameter is described below:

pH - 0.1 standard unit,
Eh - 1.0 microvolt,
DO - 0.1 parts per million (ppm),
temperature - 0.1 degrees centigrade, and
specific conductance - 10 microsiemens.

To achieve these DQOs, the instruments will be calibrated and operated in accordance with the manufacturer's specifications. Calibration data will be documented in the project specific calibration logbook and will include: type and concentration of calibration standard used; instrument span setting; and the time, date and person doing the calibration.

On-Site Laboratory

An on-site laboratory will be used for the testing of soils, sediments, ground water and investigation-derived wastes (e.g. development water, drill cuttings). Soil samples will be analyzed for volatile organic compounds (by SW-846 method 8260B), lead (by x-ray fluorescence) and total petroleum hydrocarbons (TPH) (by SW-846 method 8015) using the on-site laboratory. Selected ground water and soil samples will be analyzed for NAPL using hydrophobic dye testing and ultraviolet (UV) fluorescence testing (Appendix B).

The on-site testing of soil samples will be used to select samples for off-site laboratory analysis and to screen for the presence of NAPL (Figure 4, Section 4.2.1). Analysis for VOCs, TPH and lead within the field screening plan will provide: an indicator of the relatively more mobile contaminants (i.e., VOCs); and a broader indicator of petroleum-related contaminants, consistent

with the chemicals processed at the site and the compounds detected in previous investigations. These data will provide a basis for establishing contaminant gradients that will be used to select samples for off-site analyses.

Analysis of soil samples for NAPL will be conducted using hydrophobic dye testing and UV fluorescence testing (Section 7.4, Appendix B) based upon the methods outlined in the USEPA OSWER guidance *Evaluation of the Likelihood of DNAPL Presence at NPL Sites* (USEPA, 1993a) and the USEPA Office of Research and Development Research Report *DNAPL Site Evaluation* (USEPA, 1993b). Sudan IV will be used as the hydrophobic dye.

Soil and sediment samples collected from the wetlands will be analyzed for TPH and lead using the on-site laboratory. For the wetlands samples, the on-site laboratory will be used to conduct an initial screening of TPH and lead as indicators for the distribution of constituents of potential ecological concern (COPECs) in sediments. The on-site screening data will be used to select locations for characterizing the distribution of site-related constituents and for characterization sampling in support of the ecological risk assessment. This sampling will also include confirmatory testing where the lead and TPH concentrations were below screening criteria to assess the potential for false negatives. At an off-site laboratory, samples from this second investigative phase will be analyzed for: TCL-VOC, TCL-SVOC, PCB, TAL-metals, Eh, pH, DO, TOC, TPH, grain size, volatile acid sulfide, CEC and SPLP VOCs and metals. The planned depths, locations and analyses for samples collected during this second investigative phase will be described in a Technical Memorandum along with the results of the initial screening investigation, the results of other relevant hydrologic (e.g. water budget) and ecological assessments and the rationale for selecting the specific analytes at each location and depth interval.

The selection of lead and TPH was based upon site-specific considerations (including waste characteristics, the conceptual model for the site, relevant transport mechanisms, and a correlation analysis between COPECs) that were detailed in the Work Plan. Petroleum hydrocarbons (oil) made up the majority of the mass of organic compounds in the release to the wetlands. Due to the nature of chemical processing at the BROS facility, all other organic compounds were almost completely dissolved in the hydrocarbon phase with only a small amount in the aqueous phase.

Lead was distributed in both the aqueous and oil phases, considering the processes that produced the wastes in the lagoon. Consequently, lead distribution would be a good indicator of the distribution of both organic and inorganic contaminants. Lead was also the inorganic chemical detected in highest concentrations in the wetlands. A statistical evaluation (Appendix E of the Work Plan) demonstrated a correlation between lead concentrations and the concentrations of other inorganic constituents .

The on-site testing of ground water will be performed to screen for the presence of DNAPL using hydrophobic dye (Sudan IV). This approach was selected based upon the methods outlined in the USEPA OSWER guidance *Evaluation of the Likelihood of DNAPL Presence at NPL Sites* (USEPA, 1993a) and the USEPA Office of Research and Development Research Report *DNAPL Site Evaluation* (USEPA, 1993b). In addition, ground water samples collected using the hollow-stem auger tool (Section 7.5.1) will be analyzed for VOCs using the on-site laboratory to establish the screened interval for five wells located southeast of I-295. VOCs were selected as the indicator parameters based upon the chemical properties of the source, historical ground water quality and the predicted fate and transport of site-related contaminants.

The on-site laboratory will be used to characterize investigation-derived wastes from areas off of the BROS property as a means of determining the disposition of these materials (Section 6.7).

The DQOs for the field laboratory are as follows:

- To rapidly screen for the presence of volatile COPCs in ground at concentrations at or below the Ground-Water Quality Standard to optimize the placement of monitoring well screen zones.

- To rapidly screen soil samples for the presence of VOCs, lead and TPH at concentrations at or below the New Jersey Soil Cleanup Criteria in order to establish COPC gradients to be used in optimizing the selection of samples for off-site laboratory analysis.

- To rapidly screen for the presence of elevated concentrations of VOCs in investigation-derived waste to determine waste handling procedures.

- To screen sediment samples for TPH and lead to define the limits of the *de manifestis* and intermediate zones, and assist in the selection of sediment sample locations for laboratory analysis.

Additional DQOs will be established for the on-site laboratory based upon the results of the analytical method development activities (Section 7.1.4). These DQOs will identified in the Technical Memorandum that will prepared at the conclusion of the method development evaluations.

3.3.2 Laboratory Analytical DQOs

Due to site complexities and matrix interference associated with the analysis of soil, sediment and lagoon residuals, it is likely that minimum detection limits for many analyses are not achievable. This condition has been recognized and the Consent Decree stipulates that, subject to approval by the USEPA, the potentially responsible parties (PRPs) may develop alternate data quality objectives (ADQOs), that are higher concentrations compared to DQOs. The development of ADQOs should not impact the usability of the data for risk assessment and remedial alternatives analysis purposes, provided the numeric DQO target of 50 percent of the PRG is met on the majority of samples.

The ADQOs selected for the site must allow the data to be used for the following purposes:

- site characterization;
- risk assessment;
- evaluating potential remedial alternatives; and
- conceptual engineering design during the FS.

Within the context of the risk assessment and the FS, laboratory data will be used for estimating the volumes and distributions of COPCs through the use of interpolation and extrapolation along

gradients. These results will then be used to calculate probable concentrations of exposure (with subsequent comparison to PRGs and other risk-based objectives) and to estimate restoration times for different alternatives.

The concerns for matrix interference are most acute for the wetland sediment samples. As the ecological risk assessment will integrate both quantitative and qualitative methodologies, the numeric DQOs will allow for the development and interpretation of risk-based remedial action strategies. In the more qualitative approach, the results of sediment analyses will be compared to risk-based screening values. In the quantitative approach, sediment analytical results will be used in conjunction with co-located ecological community data and/or appropriate toxicity tests and reference data to identify the boundaries of potential impact zones on the site. Measurement endpoints related to ecological community characteristics and toxicity test results are typically numerical expressions of observations that can be statistically compared to a control or reference site to detect adverse responses to site constituents.

To ensure that data quality needs are met and above objectives are achieved, the proposed numeric DQOs for laboratory analytical methods are typically 50 percent of the PRGs, with the exception of selected COPCs as outlined in Section 3.3 of the QAPP. Based upon risk assessment objectives and the importance of providing accurate data to property owners, the numeric DQOs for residential well samples will be the PQLs.

To achieve these numeric DQOs for soils, sediments, surface water and ground water; SW-846 (USEPA, 1997c) and USEPA methods will be used. The use of these methods provides the laboratory with the flexibility to use sample extract cleanup techniques and allows the use of spiking procedures that are not part of the Contract Laboratory Program (CLP) Scope of Work. The use of SW-846 Methods (USEPA, 1997c) is expected to provide the laboratories with the ability to achieve lower detection limits and a higher percentage of usable data. For non-conventional analyses, other published sources such as American Society Testing of Materials (ASTM) methodologies will be used.

As detailed in the QAPP, the quality control procedures that will be followed by the laboratory will ensure that the laboratory data package appears in a format similar to a CLP package, to the degree practical, and that the data can be validated using site-specific data validation criteria based upon the USEPA Region 2 data validation criteria.

4.0 SAMPLING TYPES, LOCATION AND FREQUENCY

Presented in Section 4.0 is a description of the sample matrix types, locations and frequency for each task. The samples will be collected from four matrices: soil, sediment, aqueous, and NAPL. The types of laboratory and field analyses are briefly discussed below. The sampling locations and frequency are introduced and presented in a series of figures and tables in this section. The specifics for the sampling activities are described in more detail in Section 7.0 by task and keyed into the tables and figure introduced in this section.

4.1 Sample Matrix Types

The four sample matrices to be collected during implementation of the Work Plan are soil, sediment(including muck), aqueous, and NAPL. Sample types and analytical parameters are summarized in Table 1 by the assigned RI task. The projected number of field samples for each task is presented in Tables 2 through 7.

Samples collected during the course of the field investigation at the site will be analyzed in accordance with the specified SW-846 (USEPA, 1997c) and USEPA methodologies for organic and inorganic parameters where applicable. The analytical suite for these samples may include VOCs, semivolatile organic compounds (SVOCs), pesticides and polychlorinated biphenyls (PCBs) listed on the Target Compound List (TCL); metals listed on the Target Analyte List (TAL), total petroleum hydrocarbons (TPH) and diesel range organics (DRO), gasoline range organics (GRO). The analytical parameters for the projected field samples are presented in Tables 2 through 7 and further described in the QAPP. The specific targeted analytes included in the TAL metals, TCL VOC, TCL SVOC and TCL pesticides lists are provided (Appendix C).

4.1.1 Aqueous Matrix

The aqueous matrix consists of ground water, surface water, purge/development water, aquifer testing water, and decontamination fluids.

Selected ground water and surface water samples will be analyzed by a NJDEP-certified laboratory for the following geochemical/conventional parameters:

- alkalinity;
- total suspended solids (TSS);
- total dissolved solids (TDS);
- sulfate;
- sulfide;
- chloride;
- nitrate;
- nitrite;
- orthophosphate;
- chemical oxygen demand (COD);
- total kjeldahl nitrogen (TKN);
- total organic carbon (TOC);
- hardness;
- organic acids;
- hardness;
- methane;
- ethane;
- ethene; and
- carbon dioxide.

In addition, several parameters will be measured in the field (e.g. Eh, pH, ferrous ion) as outlined in Section 7.0. The methods for the analysis of the geochemical/conventional parameters are presented in the QAPP.

The purpose of the ground water and surface water samples is to establish the distribution and gradients of COPCs in ground water and surface water with respect to likely receptors and their environmental fate and transport, in order to evaluate exposure routes and potential risks.

Ground water generated during the monitoring wells development and sampling processes and aquifer testing; and decontamination fluids generated during site activities will be containerized in

bulk storage on site. Composite samples will be collected for waste characterization purposes to ensure the waste streams are disposed in accordance with Federal, State and local laws. The waste classification samples will be analyzed for:

- VOCs;
- SVOCs;
- TAL metals;
- PCBs;
- Pesticides;
- Resource Conservation and Recovery Act (RCRA) Characteristics:
  - ignitability,
  - corrosivity (based upon pH),
  - reactivity; and
- parameters required by the disposal facility.

4.1.2 Soil and Sediment Matrices

The soil and sediment matrices consist of: saturated and unsaturated soils collected from surface and subsurface intervals; sediment collected from wetland areas and surface water bodies (including ponds and streams); and drill cuttings from the monitoring well/soil boring installation processes.

Selected soil/sediment samples will be analyzed by a NJDEP-certified laboratory for pH, Eh, TOC, volatile acid sulfide, and cation exchange capacity. The methods for the soil/sediment analyses described above are presented in the QAPP.

The purpose of the soil and sediment samples is to establish the distribution and gradients of COPCs is soil and sediment, with respect to likely receptors, and evaluate their ability to partition to ground water and/or surface water in order to evaluate exposure routes and potential risk.

Selected soil samples collected during the course of the RI will be analyzed by a geotechnical laboratory. The methods to be used by the geotechnical laboratory are presented in the QAPP. The geotechnical parameters are:

- specific gravity;
- grain-size analysis (sieve with hydrometer, if applicable);
- plastic limits;
- water content (percent moisture);
- horizontal and vertical permeability;
- porosity; and
- dry bulk density of soils.

Drill cuttings generated during the monitoring well/soil boring installation processes will be stored in drums or in a lined and covered roll-off container prior to disposal. Composite waste characterization samples will be collected to ensure that the soils are disposed in accordance with Federal, State and local laws. The waste characterization samples will be analyzed for:

- Toxicity Characteristic Leaching Procedure (TCLP)VOCs;
- TCLP SVOCs;
- TCLP metals;
- PCBs;
- Pesticides;
- RCRA Characteristics:
  - ignitability,
  - corrosivity (based upon pH),
  - reactivity; and
- parameters required by the disposal facility.

4.1.3 NAPL Matrix

NAPL samples will be collected from soil borings where NAPL is detected based upon field screening (Figure 4) and where a considerable thickness of NAPL exists. NAPL samples will also be collected from separate-phase layers in monitoring wells, where NAPL is present in sufficient volume. NAPL samples will be collected to evaluate LNAPL recoverability and LNAPL and DNAPL disposal requirements for the assessment of remedial technologies and to evaluate the impact of NAPL on ground water for risk assessment purposes. NAPL samples will be analyzed for the following parameters:

- specific gravity;
- American Petroleum Institute (API) gravity;
- viscosity;
- DRO;
- GRO;
- TCL VOCs;
- British Thermal Unit (BTU) content;
- TCLP VOC;
- TCLP SVOC;
- TCLP metals;
- PCBs;
- RCRA Characteristics;
  - ignitability,
  - corrosivity,
  - reactivity.

An assessment of the results of the DRO/GRO analysis, in conjunction with the VOC and SVOC results, will be used to characterize the relative proportions of different hydrocarbon types (the distribution of molecular weight fractions) in the NAPL. As the original source was a mixture of waste oils and petroleum distillates that would include a variety of hydrocarbons that are not quantified in the VOC and SVOC analyses, the DRO/GRO data will provide additional

information for characterizing NAPLs by hydrocarbon type. The specific hydrocarbon types will have differing solubilities, environmental fates, and migration rates in the aquifer; which will be considered in the risk assessment and the FS.

Field instrumentation will be used to measure physical parameters [e.g., pH, Eh, conductivity, dissolved oxygen (DO), ferrous iron, and temperature] in ground water. Sections 3.0 and 7.0 of the QAPP discuss the field, mobile laboratory and laboratory analytical method choice rationale.

4.2 Sample Location and Frequency

Sample locations, number of samples collected and analyzed, and the analytical parameters vary by task, as is summarized below and in Figures 7 through 13 and Tables 2 through 7. The projected number of quality control samples to be collected during field activities is presented in Table 8. The project quality control summary is included in Table 9. Specifics regarding the collection of samples at each location and for each task are provided in Section 7.0 of this SAP. Quality control samples for the field and laboratory are summarized in Tables 10 and 11, respectively. A project schedule has been developed (Plate 1).

The following sampling activities will be completed as part of the field investigation (Task IIIA). Additional field activities which do not include laboratory or field analysis (e.g., water level measurements) will be performed during the Phase 2 RI and are described in Section 7.0.

4.2.1 Task IIIA, Activity 2 - Soil Investigation

Soil borings will be completed in the former Lagoon Area and former Process Areas and will be sampled to characterize the spatial distribution of COPCs and to determine hydrogeologic conditions. Fifty-six soil borings will be drilled at these areas; 26 in the former Lagoon Area (including two borings that will be used for the installation of monitoring wells), and 30 in the former Process Areas (Figure 7). Other monitoring wells will be constructed in additional borings in these areas (Section 4.2.3). With the exception of six of the borings (L-3, L-4, L-5 ad L-6; MW-26D and MW-27D) to be constructed through the former lagoon and five soil borings around the Pepper Building, the depths of the borings will extend to a minimum of the top of the clay confining layer between the Upper PRM and Upper Middle PRM, or to the depth of

unimpacted soil based on visual observation and field screening. The five soil borings around the Pepper Building will terminate at two feet below the water table and six of the borings through the lagoon (L-3 through L-6, MW-26D, MW-27D) will be extended to the base of the Upper Middle PRM.

Continuous split-spoon sampling will be performed in each of the borings and soil samples will be field screened. The field screening and sample collection process is summarized in a flow chart (Figure 4) and outlined for specific borings (Table 3). Field screening of soil borings will include measurement of head-space organic vapors using a photoionization detector calibrated to detect chlorinated VOCs, visual observation for staining and sheens, tactile assessment for slipperiness, and classification of soils according to the Burmister method. Field screening will also include the use of an on-site laboratory for NAPL and chemical analyses (VOCs, lead and TPH). As presented in the soil screening flow chart (Figure 4), the results of visual/tactile observations, soil classification and PID screening will be the basis for selecting samples for on-site laboratory screening. In some instances, such as at confining layers and where NAPL is observed, samples will routinely be collected for laboratory analysis, as summarized below and described in more detail in Section 7.0.

The on-site laboratory will be used to infer gradients of soil contamination, based upon the results of other screening methods and a comparison to existing data, as a tool in selecting samples for off-site laboratory analyses. As such, chemical analyses using the on-site laboratory will be conducted more frequently for off-property soils and for those distant from expected sources than for those in source areas. The on-site laboratory will not be used for chemical analyses of highly contaminated soils as this extra volume will limit the daily throughput of the lab, especially where multiple dilutions are required or when gas chromatograph columns must be replaced. Moreover, the on-site laboratory results will provide duplicative data when compared to results from the off-site laboratory. NAPL detection screening will include UV fluorescence and hydrophobic dye testing as described in Activity 3.

At least three soil samples from each former Process Area boring (P-20 through P-44) will be collected for off-site laboratory analyses:

- one will be biased to the zone exhibiting the most evidence of contamination based on field screening and visual observation;

- the second will be collected from a depth below the first where field screening indicates substantially less contamination; and

- the third sample will be collected at the base of the boring or at an alternate, shallower, location where field screening indicates lower concentrations of COPCs in order to establish the vertical distribution of COPCs through the use of gradients.

Additional samples may be collected for off-site chemical analyses based upon field conditions and on-site laboratory results. For example, additional samples may be collected where NAPL is indicated (see Activity 3 - NAPL Investigations) or to evaluate the vertical distribution of COPCs in the confining layer in order to support the evaluation of remediation timeframes. The sample selection for on-site and off-site laboratory analyses will be flexible to meet the objectives of determining the concentration gradients of the COPCs and additional samples will be collected if warranted.

For the lagoon borings (L-1 through L-8 and L-9A through L-16B), up to four samples from each boring will be collected for off-site laboratory analyses. One sample will be collected from the lagoon residuals, the second sample will be collected from the peat layer, the third sample will be collected from the top of the clay layer or silty strata, and the fourth from approximately three feet into the clay/silt layer. For the deeper soil borings (L-3, L-4, L-5 and L-6, and the borings for MW-26D and MW-27) an additional four soil samples will be collected for off-site chemical analyses. One sample will be collected from the top of the Upper Middle PRM just below the clay/silt layer, the second will be collected from the intermediate depth interval exhibiting the greatest evidence of contamination based upon field screening, the third will be collected from the top of the clay layer at the base of the Upper Middle PRM and the fourth will be collected from approximately three feet into the clay layer. Selected samples will be screened for the presence of LNAPL or DNAPL using the methodology as described in Activity 3. In addition, five soil samples each will be collected from the ash and sand fill placed in the former Lagoon Area.

For the Pepper Building borings (PB-1 through PB-5) three soil samples will be collected for off-site analysis based upon field screening (Figure 4). One sample will be collected from the zone of greatest contamination within the unsaturated zone, the second will be collected from the sample interval immediately above the water table and the third will be collected from the base of the boring. All soil borings will be abandoned as described in Section 6.8.

Although all the previous soil sampling for VOCs at the site did not use chemical preservation of the soil samples, methanol preservation will be used for samples collected at all VOC sample locations during the Phase 2 RI (Appendix E), unless a change is approved by the USEPA following the Methods Development Study. Methanol preservation is intended to prevent the potential large loss of VOCs from the soil sample and will reportedly produce more representative sample results than unpreserved samples. Furthermore, the NJDEP now requires soil samples collected for the analysis of VOCs to be preserved using methanol.

Because previous soil samples collected for VOCs were not preserved using methanol, a percentage of collocated split samples will be collected without methanol preservation (i.e. preserved with ice) to assess the comparability of data for site-specific constituents and soil conditions. The percentage of soil samples collected without methanol preservation in the source areas (Former Process Area and Former Lagoon) will be 20% of the samples collected for VOC analysis up to a maximum of 20 samples. In areas outside of the source areas, where COPC concentrations are expected to be lower, 40% of the samples collected for VOC analysis will be preserved by both methods, up to a maximum of 50 samples. The specific comparability samples will be determined in the field based upon field screening and sample recovery, with the objective of collecting samples with a range of contaminant types and concentrations to allow for a comparison of sample preservation methods across a range of site conditions.

A summary of soil samples to be collected during Activity 2 and associated analytical parameters is provided in Table 2. Additional detail on specific sampling and analytical plans for soils are provided in Table 3. Task IIIA, Activity 2 activities are further detailed in Section 7.3.

4.2.2 Task IIIA, Activity 3 - NAPL Investigations

LNAPL has been identified on top of the water table near the Pepper Building, along the drainage swale, east of the former lagoon and in the wetland area containing the common reed (*Phragmites*). Residual LNAPL has been identified below the water table along the northern edge of the lagoon and near the office trailers. LNAPL is also suspected to be a result of the lagoon dewatering. LNAPL present on top of the lagoon water was trapped in the soils and sludges along the sides and at the base of the lagoon; and consequently, LNAPL on the water table was drawn down into the saturated zone. No DNAPL is presumed at the BROS site, based upon:

- a consideration of the historical waste management processes used at the site;
- the results of previous investigations;
- and the physical/chemical properties of DNAPL as it behaves in the environment (See Work Plan Section 2.5.1.2).

Although DNAPL is not probable, investigative methods to detect DNAPL will be employed. DNAPL investigations are focused on the places where DNAPL would pool and accumulate, where it would wick into low-permeability units and where it would leave residual DNAPL in soil pore spaces.

During the Activity 3 investigation of the former Lagoon Area and former Process Area, field screening for NAPL will be conducted (Figure 4). This will include headspace monitoring for VOCs, visual and tactile evaluation of samples, UV fluorescence testing and hydrophobic dye testing based upon the methods outlined in the USEPA OSWER guidance *Evaluation of the Likelihood of DNAPL Presence at NPL Sites* (USEPA, 1993a) and the USEPA Office of Research and Development Research Report *DNAPL Site Evaluation* (USEPA, 1993b). Sudan IV will be used as the hydrophobic dye. The dye testing methods are described in the SOP (Appendix B).

If NAPL is present, samples will be collected. The number of NAPL-containing samples that will be collected is based on the frequency and characteristics of the NAPL encountered in the soil borings and monitoring wells.

If present in sufficient volume, one LNAPL sample will be collected for characterization from each of three existing monitoring wells: MW-1A, MW-13A, and S-11A. If LNAPL occurs in additional monitoring wells or if DNAPL is detected in any well, one NAPL sample from each affected well will be collected. If more than one type of NAPL is identified, each type will be collected for characterization. A summary of NAPL samples to be collected and associated analytical parameters for Task IIIA, Activity 3 is provided in Table 4 and further discussed in Section 7.4.

4.2.3 Task IIIA, Activity 4a - Ground Water Investigation

Forty-five monitoring wells will be installed to characterize hydrogeologic and ground water quality conditions in the Little Timber Creek Swamp, Upper PRM aquifer and deeper Upper Middle PRM aquifer. The 12 wetland monitoring wells installed in pairs will have the shallow well designated with an "A" and the deeper well designated with a "B" (Figure 8). Locations of the proposed Upper PRM and Upper Middle PRM wells are shown in Figures 9 and 10, respectively.

Sixteen Upper PRM monitoring wells will be installed. Twelve of these wells (which are designated with an "S") will be screened across the water table, with the exception of two wells (MW-26S and MW-27S) which will be screened below the water table within the backfill in the lagoon (i.e. below the ash layer). Two monitoring wells, MW-21L and MW-22L, will be installed to the base of the Upper PRM (screened above the clay confining unit) and are designated with an "L". Two monitoring wells (PZ-1 and PZ-2) will be installed through the base of the ponds to the south and southwest of the former BROS Lagoon. Monitoring well PZ-1 will be installed in the northeast corner of Gaventa Pond and monitoring well PZ-2 will be installed in the northern portion of Swindell Pond. Both monitoring wells will have a ten-foot screen, and the top of the screen will be set five feet below the bottom of the pond.

In the Upper Middle PRM, five intermediate wells (which are designated with an "I") will be screened at the top of the Upper Middle PRM; and twelve deep wells (which are designated with a "D") will monitor ground water conditions in the bottom of the Upper Middle PRM. The screened interval for five of the Upper Middle PRM wells (MW-17D, MW-18D, MW-19D, MW-33D and MW-34D) will be established based upon the collection and on-site laboratory screening of ground water samples using slotted augers. The zone indicating the highest concentration of VOCs based upon screening will be selected as the screened interval. In the event that VOCs are not detected by the on-site laboratory, which is probable at the eastern- and western-most locations (MW-17D and MW-19D), the well will be screened at the base of the Upper Middle PRM.

For those wells where the slotted auger will not be employed, soil samples will be collected continuously from the deepest well in any cluster and from all of the shallow individual monitoring well pilot boreholes (i.e., those not in monitoring well clusters) to evaluate soil quality. A summary of soil samples to be collected from monitoring well borings is provided in Table 5 and discussed in more detail in Section 7.5.

Ground water samples will be collected from selected monitoring wells on a quarterly basis throughout the RI/FS. The sampling activities are intended to characterize the distribution and gradients of COPCs under current site conditions, to assess temporal changes in ground water quality and to provide data to support an evaluation of natural attenuation processes at the site. An assessment of fate and transport will be completed through the integration of ground water quality data and geochemical data with hydrologic data (e.g. ground water elevations, permeabilities, the juxtaposition of stratigraphic units and ground water). Based upon the anticipated schedule of Phase 2 RI/FS activities, four quarterly rounds of ground water samples will have been collected prior to submission of the Draft RI Report. The locations of the monitoring wells proposed for quarterly sampling are depicted in Figure 11. A summary of ground water samples to be collected as part of Task IIIA, Activity 4b and corresponding analytes is provided in Table 5. If LNAPL is encountered in a monitoring well the thickness will be measured but the well will not be sampled.

Prior to the first, third and fourth ground water sampling events, water levels in all site monitoring wells and select CLTL monitoring wells within 1,500 feet of the BROS site will be gauged. This data will be used to construct ground water flow maps, evaluate hydrogeologic relationships between the BROS site and CLTL site, and to support ground water modeling efforts documented in Activity 4b, which is described below.

Prior to the second sampling event, the water level elevations in all site monitoring wells and an expanded suite of CLTL monitoring wells will be gauged. The CLTL wells to be included in this gauging round will be selected based on the following:

- well construction;
- the condition of the monitoring wells;
- CLTL treatment system design; and
- access issues.

The CLTL wells to be included in this second round of gauging and the rational for selecting these wells will be provided in a Technical Memorandum to the USEPA.

The initial round of ground water sampling will be performed prior to the installation of new monitoring wells to evaluate the current ground water quality. During the initial round of ground water sampling, the following 43 monitoring wells will be sampled: all 30 of the "MW" series wells, S-1A, S-1B, S-1C, S-2A, S-2C, S-3A, S-3C, S-4, S-6, S-11A, S-11C, EPA-107 and EPA-108.

The second round of ground water sampling will take place after the new wells have been installed. During the second round of ground water sampling all of the new wells will be sampled plus the following existing monitoring wells: MW-1A, S-2C, S-3C, MW-5B, MW-7A, MW-8A, MW-8B, MW-10B, MW-11B, S-11A, S-11C, MW-13A and MW-14B.

During the third and subsequent rounds of quarterly ground water sampling the previously existing wells sampled in the second round plus the following recently installed monitoring wells will be included in the quarterly monitoring program: MW-18D, MW-20D, MW-21D, MW-22D, MW-23D, MW-24S, MW-25S, MW-33 and MW-34D. The intermediate zone wells (L-series and I-series) which will be included in the quarterly monitoring program will be determined after the initial sampling of these wells. Ground water samples collected during subsequent rounds will be analyzed for the second quarterly round parameters once a year and for VOCs during the remaining rounds. Proposed changes to the quarterly monitoring program will be identified in a Technical Memorandum for USEPA approval.

All of the monitoring wells sampled will be purged and sampled using the March 20, 1998 Region II Low Flow/Low Stress Sampling Protocol (USEPA, 1998b), which has been appended (Appendix G). However, all previous ground water sampling was performed using traditional purge and sampling methods. For this reason, a comparability analysis of data obtained using both methods will be performed. The objective of the comparability analysis is to establish the trends between historical and new ground water quality data; this will facilitate the evaluation of the influence of the lagoon work and the COPC concentration changes associated with natural attenuation, which will provide the data necessary for the prediction of spatial and temporal changes in ground water quality. The collection of a minimum of three rounds is proposed to establish a mean and standard deviation for assessment of comparability.

For the comparability analysis, the following monitoring wells will be purged and sampled using traditional methods in addition to being purged and sampled using low flow/low stress techniques:

- For the first sampling event: S-11C, MW-5B, MW-7A, MW-8A, MW-8B, MW-10B, MW-11B and MW-14B.

- For the second and third round sampling events: the monitoring wells listed above for the first round plus the following new monitoring wells: MW-18D, MW-20D, MW-21D, MW-22D, MW-23D, MW-24S, MW-25S, MW-29S, MW-33D and MW-34D.

- For subsequent rounds: a maximum of 30% of the wells or ten of the wells listed for the second and third rounds, whichever is less, if needed based upon the results of the prior rounds.

Low flow purge methods will be used first, then traditional purge sampling will be conducted as described in the Appendix B.

As discussed in the Phase 2 RI/FS Work Plan private water supply wells in the vicinity of the BROS site may be sampled if those wells are deemed within the horizontal extent of site-related COPCs or in the immediate downgradient vicinity. The results of a ground water use survey being completed as part of the Preparatory Activities will be presented to the USEPA in a Technical Memorandum. The Technical Memorandum will identify any wells proposed for sampling and the sampling parameters. Currently, it is anticipated that the sampling parameters will be limited to TCL VOCs; using the current drinking water analytical method (EPA 500 series) will be used to assure that the method detection limits are below the applicable federal and state MCLs. In addition, ground water from supply wells within 0.5 miles of the BROS property will also be analyzed for TCL-SVOCs and TAL metals if these constituents are likely to be present based upon the well location and ground water quality data available at the time.

After the installation of the new monitoring wells has been completed, the wells will be sampled for COPCs as well as geochemical parameters. Ground water from all of the monitoring wells will be analyzed for the following chemical parameters TCL VOCs, TCL SVOCs (base neutral/extractables only) and TAL metals as specified in USEPA's May 8, 1998 letter transmitting comments to the June 24, 1997 Phase 2 RI/FS Work Plan. The following general chemistry parameters will be analyzed: TDS, TSS, alkalinity, TOC, sulfate, chloride, nitrate, ammonia, silica, orthophosphate, sulfide, nitrite, COD, TKN, hardness, volatile fatty acids, methane, ethene and ethane. The following field chemistry parameters will be analyzed: pH, specific conductivity, Eh, dissolved oxygen (DO), ferrous iron, temperature, carbon dioxide and hydrogen sulfide. For the first round of sampling, the wells will be analyzed for the full TCL SVOC scan as the acid extractable portion of the SVOC analysis may identify compounds that include degradation products of the source material COPCs. In addition, during the first round all

monitoring wells will be sampled for dissolved iron (samples for iron will be filtered in the field using a 0.45 micron filter) to evaluate total versus ferric/ferrous iron concentrations detected using the Hach™ field test kit. Subsequent rounds of ground-water sampling will use the Hach™ field test method for field analysis of ferrous iron. New monitoring wells MW-4D, MW-26S, MW-26I, MW-26D, MW-27S, MW-27I, MW-27D and MW-29S, and existing wells MW-1A and S-11A are located close to the former lagoon and ground water samples from these wells collected for metals analysis will be filtered to remove fine particulates associated with the ash/lime layer in the former lagoon. The results of TAL metal analyses of these filtered samples will be compared with the results of unfiltered samples to assess the fate and transport of metals in ground water near the former lagoon. Additionally, pre-purge samples of stagnant water will be collected from the bottom of wells S-3C, S-11C, MW-4D, MW-5B, MW-21L, MW-21D, MW-22L, MW-22D, MW-23D, MW-26D and MW-27D using clear plastic, bottom-loading bailers to screen for the presence of DNAPL using a hydrophobic dye test.

A more detailed discussion of the ground water investigation activities is provided in Section 7.5.

4.2.4 Task IIIA, Activity 5 - Surface Water and Sediment Quality Evaluation

The surface water and sediment investigation includes the collection of samples from Gaventa and Swindell Ponds (Activity 5a), Little Timber Creek Swamp and Cedar Swamp (Activity 5b) and the swale along U.S. Route 130 (Activity 5c).

Gaventa and Swindell Ponds

Eight sediment samples will be collected from Gaventa Pond (Figure 12). Surface water samples will be collected concurrently with sediment samples at 3 locations (Figure 12). Three surface water and three sediment samples will be collected from Swindell Pond. A summary of sediment and surface water samples to be collected from Gaventa and Swindell Ponds, along with a listing of the planned analytical parameters, is provided (Table 6). A more detailed discussion of the Gaventa and Swindell Pond sampling activities is presented in Section 7.6.

Little Timber Creek Swamp and Cedar Swamp

Seventy-six sediment sampling locations and 27 surface water locations are planned for the assessment of Little Timber Creek Swamp, Cedar Swamp and associated reference areas (Figures 13 and 14). A summary of sediment and surface water samples to be collected from the Little Timber Creek Swamp and Cedar Swamp during Task III, Activity 5b and corresponding analytes is provided (Table 6).

The 76 sediment locations include 7 points within the approximate area of the *de manifestis* zones, three points in each of the five reference areas, and a total of 54 points within the approximate area of the intermediate and de minimis zones (Figures 13 and 14). Samples will be collected for an initial screening of sediment indicator compound concentrations using in-field analyses. The screening samples will preliminarily define the horizontal extent of sediment contaminant and assist in selecting specific sediment sample locations for full laboratory characterization which will confirm the horizontal extent of COPEC. The screening samples will be analyzed for TPH and lead using the on-site laboratory. While the second round of sediment investigation samples will be collected for a more comprehensive analytical suite. Twenty-two surface water samples will be collected as grab samples moving from downstream (north) to upstream (south) through Little Timber Creek Swamp and Cedar Swamp. An additional five surface water samples will be collected at the reference areas. The specific locations of surface water samples will be defined based upon the results of qualitative dye studies. Samples will be collected from preferential flow paths to directly characterize transport conditions.

As described previously, background samples will be collected from five different reference areas (Figure 14). Three sediment sample locations (with two sediment samples collected from specific depth intervals) and one surface water sample will be collected from each reference area. The sediment/soil samples will be collected from the same depths intervals as the samples proposed for the intermediate and de minimis zones. The sediment/soil and surface water samples from the reference areas will serve as background concentrations of COPECs and be used in the ecological risk assessment.

The soil/sediment samples collected from the Little Timber Creek and Cedar Swamp areas will be analyzed for chemical, geochemical and waste classification parameters (Table 6). All of the

soil/sediment samples from the reference areas and those collected during the second, delineation, round of sampling will be analyzed for the following chemical and geochemical parameters: VOCs, SVOCs, PCBs, TPH, metals, DO, Eh, pH, TOC, and grain size. Encore™ samplers will be used for sediment samples collected for VOC analyses as described in Appendix B. The use of methanol preservation for sediment samples was evaluated during the Method Development activities (Section 7.1.4) and subsequently not selected because the dilution of the sample that occurs during the preservation will likely increase the detection limit achievable by the lab above the limits required to achieve the numeric DQOs for the project. The Technical Memorandum No. 2 Analytical Method Development study will be consulted for potential changes to sediment preservation procedures. Approximately 30% of the samples will be analyzed for volatile acid sulfide and cation exchange capacity. In addition, up to four samples will be collected for the following waste disposal parameters: TCLP VOCs, TCLP SVOCs, and TCLP metals; total PCBs; ignitability; corrosivity; reactivity; TOX and BTU content. The samples collected for waste disposal parameters will be biased to the *de manifestis* zone (i.e., former overflow area) to evaluate the remedial treatment or disposal options for the LNAPL residuals in this area.

Sediment sampling will be performed for screening, confirmation, determining the distribution (vertical/horizontal) of site-related chemicals, and exposure point evaluation. For screening purposes to determine the approximate horizontal distribution of site-related chemicals, sediment samples will be collected from the zero to six inch depth interval of the sediment/substrate and from the zero to six inch interval of the first inorganic layer beneath the surface to assess the mobility of COPECs. The screening samples will be analyzed in an on-site laboratory for TPH and lead.

Based on the results of the screening samples, sediment sample locations will be selected that will be analyzed for a broad suite of parameters at an off-site laboratory. These data will also be used for comparison to sediment screening values and to develop biota sediment accumulation factors (BSAFs) for burrowing receptors. Samples will be collected from the zero to six inch interval of the sediment/substrate surface and the zero to six inch interval of the first inorganic layer beneath the surface to assess the vertical mobility of COPECs. The horizontal distribution confirmatory sampling locations will be established based upon the results of the sediment screening

investigations and the biota surveys described in Section 7.8, and will be detailed in a Technical Memorandum.

Zero to one inch interval samples will be used at selected locations (approximately 50% of the confirmatory sampling locations) to evaluate exposure point concentrations for non-burrowing benthic and terrestrial (swamp is dry at the surface approximately 6 months/year) receptors, as well as to develop biota sediment accumulation factors (BSAFs) for non-burrowing receptors. The areas selected for sampling of the zero to one inch interval will be predominately those drier areas where the sediment is not inundated by surface water during much of the year. In defined stream channels (near culverts and downstream of the tide gate) where greater mixing and turbulence commonly occur, only the zero to six inch interval will be sampled. Any suggested changes to the confirmatory sampling strategy will be identified in the Technical Memorandum for USEPA review and approval.

For purposes of determining the vertical extent of contamination in areas with residual LNAPL, sediment/soil samples in the *de manifestis* zones will be collected from six-inch intervals to a depth of five feet BGS, or one foot below the LNAPL, based upon field screening (Figure 4). All soil/sediment borings will be abandoned as described in Section 6.8.

Further, six sediment/soil samples collected from the intermediate zone and three samples from the *de manifestis* zone, as estimated based on visual inspection, will be analyzed for SPLP VOCs and metals to assess the leachability, mobility and bioavailability of COPECs in the sediment/soils.

All of the surface water samples collected for chemical analysis will be analyzed for the following parameters: VOCs, SVOCs, PCBs, TPH and metals. The surface water samples collected for SVOCs, PCBs, and metals will be analyzed for total and filtered (dissolved) constituents as significant suspended solids may be encountered during sample collection. A comparison of total and filtered (dissolved) concentrations will provide information for assessing the mobility and bioavailability of COPCs. Approximately 50% of the surface water samples will be analyzed for the following geochemical parameters: TSS, TDS, sulfate, sulfide, chloride, nitrate, nitrite, TKN, hardness, and ferrous iron. All of the surface water samples collected will be analyzed for the

following geochemical parameters: TOC, Eh, pH, DO, and alkalinity. In addition, the filtered surface water samples will also be analyzed for TOC.

US Route 130 Swale

Two surface water composite samples will be collected from the swale along U.S. Route 130 (Table 6). The samples will be collected during a storm water run-off event as standing water is not typically present in the swale. The sampling locations will be selected following the LNAPL investigations in this area and will target points upstream of the LNAPL, within the LNAPL area, and downstream of the LNAPL. The specific sampling locations will be established in the field following the LNAPL investigations. Surface water sampling in the swale is discussed in Section 7.6 and the sampling of soils is described in Section 7.3.1.

Additional Investigations

Should site-related contaminants be detected above applicable sediment screening criteria or surface water standards beyond the limits of the sampling points, an additional sampling proposal will be presented to the USEPA, NOAA and NJDEP in a Technical Memorandum for discussion and approval. Sediment and surface water results will be compared to current, peer-reviewed and relevant guidance available at the time of data evaluation.

4.2.5 Task IIIA, Activity 7 - Ecological Evaluation

The ecological evaluation is segregated into three discrete assessments: Gaventa Pond, Swindell Pond, and Little Timber Creek/Cedar Swamp. Each will be evaluated separately due to their spatial separation and the minimal interconnection (no connection approximately 6 months/year and limited flow between the two areas) between the ponds and the swamps, but possible interactions resulting from mobile ecological receptors will be considered in Activity 6 (i.e., step 6 of the ecological risk assessment process) and during the risk management assessment (USEPA, 1997b). Much of the ecological evaluation will utilize the sediment/surface water quality data. In addition, the results of qualitative habitat and wildlife utilization information and analytical data will be used to select locations for biological effects evaluations using toxicity tests, macroinvertebrate community analyses, and tissue sampling. A more detailed description of the ecological evaluation samples is presented in Section 7.8.

5.0 SAMPLE DESIGNATION

Sample bottles (including those containing preservatives, where necessary), labels, shipping containers, trip blanks, and field blank water will be provided by the laboratory. During collection of soil and sediment samples, containers will be labeled with the following information:

- site identifier (BROS);
- Roux Associates, Inc.'s project number;
- sample location identifier and field quality control (QC) identifier (if applicable);
- sample type (media) and identification code;
- sample depth and analysis identifier;
- date and time of collection;
- type of preservative added (if applicable);
- sample collector's initials.

During collection of ground water samples, containers will be labeled with the following information:

- site identifier (BROS);
- Roux Associates, Inc.'s project number;
- sample location identifier and field QC identifier (if applicable);
- sample type (media) identification code;
- date and time of collection;
- field handling (e.g., filtration);
- type of preservative added (if applicable); and
- sample collector's initials.

The sample identification code provided on each sample label will include the sample location/sample type/depth interval (soil and sediment samples only)/QC qualifiers using the abbreviations presented below.

1. Sample location abbreviations will be as presented below.

- former lagoon area soil boring = L followed by the designated boring number.
- former process area soil boring = P followed by the designated boring number.
- Pepper Building boring = PB followed by the designated boring number.
- monitoring well = the designated well number, including all prefixes and suffixes. For example, MW-10B, MW-21L, EPA-108, etc.
- wetland monitoring well = WMW followed by the designated well number.
- Gaventa Pond sediment/surface water samples = GVT followed by the designated sample location number.
- Swindell Pond sediment/surface water samples = SWD followed by the designated sample location number.
- Swale surface water sample = SWL followed by the designated sample location number.
- Little Timber Creek and Cedar Swamp sediment/surface water samples = LTC followed by the designated sample location number.
- Wetland Reference Area sediment/surface water sample = R followed by the designated sample location number.

2. Sample type (media) abbreviations will be as presented below.

- surface water sample = SW
- ground water sample = GW
- soil sample = SO
- sediment sample = SED
- non aqueous phase liquid = NAPL

3. Depth intervals will be designated in feet or tenths of a foot (e.g., 0.1, 1.0, etc.).

4. QC identifiers will be as follows:

- Trip blank = TB
- Field blank = FB
- Matrix Spike and Matrix Spike Duplicate = MS/MSD
- Filtered water samples = F

For example, the designation "L-8/SO/12-14" would indicate that the sample was collected at former lagoon area soil boring L-8, that it was a soil sample, and that it was collected at a depth interval of 12 feet (ft) to 14 ft below land surface (Figure 16). A sample designation "MW-10/GW/F" would indicate a filtered ground water sample collected from Monitoring Well MW-10 (Figure 16).

Field replicates are to provided with discrete sample numbers and not designated with an "R". Field replicates should be designated sequentially starting with A-1. It is necessary to record the replicate pairs in the field logbook. An example designation for a replicate sample would be "A-23/SED/0-1", which would indicate a replicate sediment sample collected from the 0 to 1 inch depth interval.

6.0 FIELD ACTIVITIES

The following sections describe the standard protocols to be used by field personnel during the course of the RI sampling activities. Standard Operating Procedures (SOPs) to be used by the sampling team are included in Appendix B and will be referenced where applicable. Additional information regarding quality assurance/quality control (QA/QC) protocols and methods may be found in the QAPP. The HASCP details procedures and action levels for the implementation of monitoring and engineering controls based upon organic vapor concentrations detected during the Phase 2 investigation.

6.1 Site Control

Site control procedures have been developed to minimize both the risk of exposure to contamination and the spread of contamination during field activities at the site. In order to accomplish this objective, the following precautionary measures will be performed:

- the establishment of discrete work zones in the investigation area in accordance with the HASCP;
- the implementation of security and access procedures for the site; and
- the decontamination of field equipment (see Section 6.6).

All personnel who come onto the site, including site employees, contractors, and observers, will be required to adhere strictly to the conditions imposed herein, and within the provision of the HASCP.

6.1.1 Field Work Zones

Field work zones will be established in accordance with the HASCP where intrusive activities, including soil sampling, ground water sampling, and drilling are conducted. Access to the work zone will be limited in accordance with the HASCP. Control of work zone access will be the responsibility of the Field Team Leader and SHSO.

6.1.2 BROS Property Security and Access

The BROS property is currently enclosed by a fence to limit access. Access to the property will be through the main gate, which is located adjacent to Cedar Swamp Road. At the completion of each working day, all equipment (e.g., sampling equipment, water level measuring devices, coolers, etc.) will be secured in trailers or removed from the site. Heavy equipment, such as the drill rig, will remain within the current work zone until properly decontaminated or if decontaminated parked within the fenced parking area. The Pepper Building, which is on the BROS property, will require access during the soil investigation (Task IIIA, Activity 2). Permission will be obtained from the property owner prior to initiation of the activities being performed in the Pepper Building.

6.1.3 Off-Property Access

Many of the sampling locations are located off of the BROS property. Access agreements will be obtained with the property owners prior to commencement of field activities. Prior to initiating work activities at a property, the specific access agreement will be reviewed for notification and coordination provisions. Copies of access agreements will be maintained at the command trailer on the BROS property. At the completion of each working day, all sampling equipment will be taken to and secured in the trailers located on the BROS property. Heavy equipment, such as the drill rig, may remain at the sampling location, if necessary and approved by the property owner, or will be removed from the site after each working day. If the heavy equipment remains off-site overnight, a security fence or caution tape will be placed around it. At the conclusion of each day and at the conclusion of a task at a property, cleanup and property restoration will be completed in accordance with the property-specific access agreement.

6.2 Field Equipment

All field equipment will be operated in accordance with the manufacturer's instructions and the applicable SOPs in Appendix B. Methods of calibrating and maintaining the equipment are provided below.

6.2.1 Equipment Calibration

All measurement equipment will be calibrated according to the manufacturer's recommendations, where applicable. The SHSO will be responsible for performing the equipment calibration on both sampling and health and safety equipment. Frequency of instrument calibration will be dictated by the type of measurement device. Table 12 lists the field equipment to be used and the calibration frequency for the instrument. Records of all calibrations (both frequency and results) will be kept in the project-specific calibration field logbook. The information contained within the calibration fieldlog book will include the type and concentration of calibration standard used, the instrument span settings, and the time, date and name of the person performing the calibration. Copies of these records will be included with the RI Report.

6.2.2 Equipment Maintenance

All field equipment will be stored in a clean, controlled environment to prevent damage due to heat, cold, moisture, and dust prior to use. Reusable equipment will be decontaminated as soon as reasonably possible after use and stored as described above. Decontamination procedures are provided in Section 6.6 and in the SOPs (Appendix B). Maintenance for measurement equipment and health and safety monitoring instruments will be in accordance with the schedule included in Table 12.

Equipment failing to meet manufacturer's minimum specifications will be removed from service immediately and kept out of service until the problem is identified and/or resolved. Records of all routine maintenance and repair will be kept in the instrument or field logbook. Copies will be available upon the request of USEPA.

6.3 Field Documentation

The following sections provide guidance to field personnel in the areas of documentation and record keeping. The goal of field documentation is to provide a clear and complete record which can be referenced and/or retrieved at a later date. All field documentation will be recorded in bound logbooks or pregenerated, activities-specific forms using indelible ink. Copies will be available upon the request of USEPA. Details of record keeping requirements are described in Appendix B and in the QAPP. Samples of field forms are provided in Appendix D.

6.3.1 Field Logbooks

Field logbooks will be used for all record keeping to provide a permanent, bound record of all field-related activities. Additional records may be kept on pregenerated forms for sample tracking and other purposes. The types of information and level of detail required for logbook recording are described in the Field Record Keeping and Quality Assurance/Quality Control SOP provided in Appendix B and in the QAPP.

6.3.2 Field Documentation for Drilling, Well Installation, and Aquifer Testing

Daily field activities will be summarized in a field notebook to ensure that an accurate record of all field investigations tasks are maintained. Specific documentation requirements for aquifer tests are discussed in detail in the SOP provided in Appendix B. Documentation of the aquifer testing will be performed using the field notebook and data loggers. Geologic logs and well construction details will be recorded in the field notebook during the drilling of soil borings and the installation of the monitoring wells. The lithology encountered will be described in accordance with the Burmister Method (Appendix B) . For each soil boring completed and monitoring well constructed during the RI, a typed geologic log and well construction detail, respectively, will be prepared (Appendix D) for inclusion in the RI Report.

6.3.3 Sampling Documentation

A complete record of how each sample was selected, aliquotted, packaged, and preserved for analysis will be maintained in field logbooks. Specific procedures regarding the level and type of sampling documentation can be found in the activity-specific SOPs that are provided in Appendix B. Sample designation and labeling are discussed in Section 5.0 of this SAP. Questions regarding sampling methods and QA will be addressed by the Project Manager, RI Manager or the Roux Associates, Inc. PQAC.

6.4 Field Custody Procedures and Documentation

The following sections describe the procedures necessary to document sample custody. The purpose of documenting sample custody is to ensure that the integrity and handling of the samples is not subject to question. Sample custody will be maintained from the point of sampling through the analysis. Specific procedures regarding sample tracking from the field to the laboratory are

described in the SOP provided in Appendix B and in the QAPP. Examples of a chain of custody form and a custody seal can be found in Appendix D.

6.4.1 Field Custody

Each individual collecting samples is personally responsible for the care and custody of the samples. The sample collection data will be entered on a chain-of-custody form immediately after the sample is collected and the samples will be placed in a cooler with ice and cooled to 4°C. After daily sampling activities are completed, the technical staff will review all field activities with the Field Team Leader to determine whether proper custody procedures were followed during the field work and to decide if additional samples are required.

Samples must be accompanied by a properly completed chain of custody form (Appendix D). The sample numbers will be listed on the chain of custody form. When transferring the possession of samples, individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents transfer of custody of samples from the sampler to another person, to/from a secure storage area, to the sample container courier and to the laboratory.

Samples will be packaged for shipment with custody seals on the cooler and dispatched to the appropriate laboratory for analysis with a separate signed custody record enclosed in each sample box or cooler. Shipping containers will be locked and/or secured with strapping tape in at least two locations for shipment to the laboratory.

If split samples are requested, a separate chain of custody form is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the facility or agency will request the representative's signature on the chain of custody form, acknowledging sample receipt. If the representative is unavailable or refuses, this will be noted in the "Received By" space.

6.4.2 Laboratory Custody

The sample custodian at each laboratory will ensure that chain of custody records are completed upon receipt of the samples and will note questions or observations concerning sample integrity.

The laboratory's QA officer will also ensure that sample-tracking records are maintained. These records will follow each sample through all stages of laboratory processing. The sample tracking records must show the date of sample extraction or preparation and the date of instrument analysis. These records will be used, in part, to determine compliance with holding time requirements. Section 5.0 of the QAPP describes the specific laboratory custody and sample handling procedures required for this project.

6.5 Sample Handling and Analysis

To assure quality data acquisition, and collection of representative samples, there are specific procedures to minimize sample degradation or contamination. These include procedures for preservation of the samples as well as sample packaging and shipping procedures. These items are summarized below and discussed in detail in Section 5.0 of the QAPP.

Previous investigations conducted at the site indicated the presence of acetone, methylene chloride and carbon disulfide in numerous samples, especially those collected near Monitoring Well S-11C. It is uncertain to what extent the presence of these compounds in the laboratory results can be attributed to cross-contamination in the field or laboratory, although the results between sampling rounds were variable. Field and laboratory personnel will be reminded to take care during equipment decontamination and sample handling in order to reduce the possibility of cross-contamination of samples. For samples collected near S-11C, a notice will be entered on the chain of custody forms to alert the laboratory to take additional precautions with these samples.

Insect/tick repellent will be used for health and safety purposes by field personnel during all data gathering activities. Care will be taken by the field personnel to avoid cross-contamination of samples with insect/tick repellent through the judicious application of the repellent and care in avoiding contact between the repellent and sampling equipment. Field personnel are reminded to use repellent according to the manufacturer's directions and to replace gloves or equipment if they come in contact with repellents or clothing that has been treated with repellents. The use of repellents will be noted in the field log.

6.5.1 Field Sample Handling and Shipment

All samples will be collected and handled according to the appropriate protocols for each matrix as described in the SOPs provided in Appendix B. The types of containers, volumes needed and preservation techniques for the testing parameters described in Section 4.0 are presented in Table 13.

Sample packaging and shipping procedures are based upon USEPA specifications, as well as US Department of Transportation (DOT) regulations. The procedures vary according to potential sample analytes, concentration, and matrix, and are designed to provide optimum protection for the samples and the public. Sample packaging and shipment must be performed using the general outline described below. Additional information regarding sample handling is provided in the SOPs (Appendix B) and in Section 5.0 of the QAPP.

All samples will be shipped within 48 hours of collection and will be preserved appropriately from the time of sample collection. A description of the sample packing and shipping procedures is presented below.

1. Prepare cooler(s) for shipment.

    - Tape drain(s) of cooler shut;
    - Affix "This Side Up" arrow labels and "Fragile" labels on each cooler; and
    - Place mailing label with laboratory address on top of cooler(s).

2. Arrange sample containers in groups by sample number and cross check the sample labels against the chain of custody completed for the respective sample group while minimizing out of cooler time for ice preserved samples.

3. Ensure that all bottle labels are completed correctly. Place clear tape over bottle labels to prevent moisture accumulation from causing the label to peel off.

4. Arrange containers in front of assigned coolers.

5. Seal sample containers within plastic zip-lock bags to prevent leakage.

6. Place approximately 2 inches of vermiculite or other packaging material at the bottom of the cooler to act as a cushion for the sample containers.

7. Arrange containers upright in the cooler so that they are not in contact with the cooler or other samples.

8. Fill remaining spaces with vermiculite or other packaging material.

9. Ensure all containers are firmly packed in vermiculite or other packaging material.

10. If ice is required to preserve the samples, ice cubes should be repackaged in double zip-lock bags, and placed on top of the vermiculite or other packaging material. Enough ice or ice packs must be included with the cooler to maintain the samples at 4°C for at least 24 hours, taking into account the ambient weather conditions and whether the courier system will provide air-conditioned storage during transit.

11. Sign chain of custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or other carrier, as appropriate.

12. Separate copies of chain of custody forms. Seal proper copies within a large zip-lock bag and tape to inside of cooler lid. Retain copies of all forms.

13. Close lid and latch.

14. Secure each cooler using custody seals.

15. Tape cooler shut on both ends.

16. Relinquish to Federal Express or other courier service as appropriate. Retain airbill receipt for project records. (Note: All samples will be shipped for "NEXT DAY" delivery and samples collected on Friday will be shipped for delivery on Saturday).

17. Telephone laboratory contact and provide him/her with the following shipment information:

    - sampler's name;
    - project name;
    - number of samples sent according to matrix and concentration; and
    - airbill number.

18. Telephone laboratory contact to confirm receipt of samples and sample integrity the following day.

6.5.2 Field Analyses

Field analyses for specific conductivity, dissolved oxygen, temperature, Eh and pH in aqueous media will be conducted in accordance with the SOPs included in Appendix B.

6.5.3 Laboratory Analyses

Analytical methods for the constituents of concern have been chosen based upon DQOs to provide the highest level of data quality for purposes of the evaluation of remedial alternatives. Laboratory analyses will be conducted using standard methodologies as summarized in Table 9. Additionally, sample extract cleanup methods or method modifications may be utilized to help meet the required DQOs based upon the results the analytical method development activities discussed in Section 7.1.4. Applicable field and laboratory QA/QC are described in Table 10 and Table 11, respectively. Rationale for the choice of specific analytical methods is provided in Section 7.5 of the QAPP.

6.6 Decontamination Procedures

The procedures for the decontamination of field equipment, personnel and sampling equipment are outlined in the following sections. Decontamination will be conducted in accordance with the HASCP. Detailed procedures for the decontamination of field and sampling equipment are included in the SOPs provided in Appendix B.

In an attempt to avoid the spread of contamination, all equipment (i.e., drilling tools, sampling equipment, etc.) must be decontaminated at a reasonable frequency discussed below. All vehicles, driller's equipment, construction equipment and associated tools will be decontaminated at a portable decontamination station or in the Decon Pad located along the northern edge of the site, as shown, on Figure 7. A portable decontamination station will be used where the movement of materials and equipment is likely to track mud, dirt and contaminated materials onto roadways and private properties. The portable decontamination station will be used to remove gross levels of contaminants and dirt/mud, with additional decontamination being completed at the BROS property. All solids and wash water generated during cleaning will be managed in accordance with the procedures outlined in Section 6.7 and summarized in Figures 4 and 5. Where practical, monitoring equipment and sampling tools (e.g. water level indicators, pH meters) will be decontaminated in the field, for example to avoid having to return to the on-Property Decon Pad between each well of a gauging round.

6.6.1 Drilling Equipment

The drill rig, construction equipment, site vehicles and all associated equipment will be cleaned by the contractor before arriving at and exiting the site. The augers, drilling casings, rods, samplers, tools, and any piece of equipment that may come in contact (directly or indirectly) with the soil, or ground water will be steam cleaned prior to use to ensure proper decontamination. The same steam cleaning procedures will be followed for augers and sampling tools used for each borehole. Additional decontamination procedures will be used for split spoon samplers (Appendix B).

All steam cleaning (decontamination) activities will be monitored and documented by Roux Associates, Inc. Specific procedures for decontaminating drilling equipment are provided in the SOP in Appendix B.

6.6.2 Personnel Protection

Any decontamination of personnel required will be performed at a designated area of the site or within the work zone as described in the HASCP and appropriate decontamination materials (e.g., boot wash) will be maintained for use in this area. The level of protection that will be used during decontamination and field sampling activities will be task-specific as detailed in the HASCP. The guidelines for upgrading the level of protection (and specific personnel protective equipment required for each level of protection) are also provided in the HASCP.

6.6.3 Sampling Equipment

All soil and water sampling equipment will be decontaminated prior to sampling and between sampling locations according to the procedures outlined in the SOPs included in Appendix B. To reduce the chances of cross-contamination, new tubing will be used to sample each monitoring well so that only decontamination of the submersible pump is required. If feasible and practical within the procedures outlined in the SOPs, dedicated or disposable samplers will be used to sample surface water and ground water so that decontamination between uses will not be required. Disposable bailers will be used to collect LNAPL samples and to screen for the presence of DNAPL in wells (Section 7.5.1) in order to prevent the cross-contamination of wells through bailers.

6.7 Waste Handling and Disposal

Wastes generated during the performance of the field investigation will be managed in a manner to mitigate further contribution to environmental degradation or pose a threat to public health or safety. The procedures for handling field derived wastes (Figures 4 and 5) are consistent with those specified in the NJDEP *Field Sampling Procedures Manual* (1992).

Wastes generated during the implementation of the RI will be stored, handled, and disposed in accordance with applicable local, state and federal regulations and the requirements of the Consent Decree. All wastes generated, discussed below, will be staged in a secure area on the BROS property pending proper disposal.

Drill Cuttings or Other Waste Soil/Sediment

Excess soil or sediment generated on the BROS site, which is not in an area where contamination is known to exist and exhibits no visual or field screening evidence of contamination, will be placed on the ground adjacent to the area in which it was generated (Figure 5). Excess soil or sediment generated from off property locations, where no significant contamination is expected, will be managed in accordance with the request of the property owner (e.g., placed on the surface near the location generated or removed from the property).

In areas where the material is expected to be contaminated, or determined to be contaminated based on visual inspection or field screening (including analysis in the on-site laboratory), the material will be placed in a lined roll-off container located on the BROS property. After all activities have been completed which generate waste soil/sediment, a composite sample will be collected from the roll off for waste classification purposes. After the results of the waste characterization sample are received, the materials will be disposed at an appropriate facility, based upon the waste classification. The selection of disposal facilities will be completed based upon waste characteristics, applicable laws and regulations at the time of disposal, the requirements of the BROS Consent Decree and the permit requirements of the disposal facility.

Ground Water and Decontamination Water

Similar to waste soil/sediment, waste ground water will be handled based on whether it may be contaminated or not and where it was generated (Figure 5) If the waste ground water is generated from an area that was previously sampled and determined not to contain VOCs in excess of the New Jersey Ground Water Quality Criteria or more stringent PRGs defined in the Work Plan, the water will be placed on the ground surface and permitted to percolate back into the ground water system. Where the water may contain limited site-related constituents, the water generated will be applied to the ground surface if the following conditions are met:

- the water is not permitted to flow off the property;

- there is no potential for contaminating a previously unimpacted aquifer (e.g., if the water was generated from the Upper Middle PRM and the overlying Upper PRM is known to be less impacted); and

- the discharge will not cause an increase to ground surface contamination (e.g., water from below former lagoon will not be placed on the ground surface as there is a clean fill cap at the surface).

Where new wells are being installed off of the BROS property and the quality of the ground water is uncertain, the water (including drilling mud) will be contained in a temporary storage tank or drums and analyzed using the on-site laboratory. If the waste water is determined not to contain VOCs in excess of the New Jersey Ground Water Quality Criteria or more stringent PRGs defined in the Work Plan, the water will be placed on the ground surface and permitted to percolate back into the ground water system, subject to property-owner approval. All waters generated at the BROS property, and those subsequently characterized as containing VOCs in excess of the New Jersey Ground Water Quality Criteria or more stringent PRGs defined in the Work Plan, will be transferred to a temporary storage tank located on BROS property. All decontamination water will also be managed in a similar manner, with any decontamination water generated on the BROS property being placed in the temporary storage tank. Well development and decontamination water will be disposed with purge water generated during the second ground water sampling event.

Water generated during the step drawdown test and long-term pumping tests will be pumped into aboveground holding tanks and transferred to tank trucks on an as-needed basis and for transport to the off-site disposal facility. On-site treatment and discharge to surface water was rejected due to technical impracticability considerations. The number of tanker trucks and the capacity of on-site storage will be established based upon the projected pumping rates and the estimated time for travel to and from the disposal facility, including off-loading and waste approval time. Specific procedures will be detailed in the Aquifer Testing Technical Memorandum (Section 7.5.2). The likely disposal location for aquifer test waters is the DuPont facility, located in Deepwater, New Jersey. The RCRA-permitted DuPont facility specializes in the management of aqueous waste

streams and is located within 15 miles of the BROS site. Assuming a 200-gallon per minute pumping rate and a projected turnaround of two hours (which will allow a safety factor for delays in off-loading and acceptance) the volume of water generated in two hours will be 24,000 gallons. Based upon this volume, six 5,000-gallon capacity tankers are needed on a continuous basis throughout the aquifer tests to transport water to the DuPont facility. Temporary high capacity storage tanks (e.g. 20,000-gallon baker tanks) may also be used to provide additional storage capacity and a safety margin in the event of delays at the disposal facility. The tanks will be used to ensure adequate capacity during loading of trucks, and in the event loading delays occur, so that the pumping tests will not have to be suspended due to lack of capacity. Given the anticipated pumping rate, a total capacity of 600,000 gallons will be needed for each pumping test. The tanks of the Aqueous Wastewater Treatment System will be evaluated for their suitability for temporary water storage as will various temporary storage alternatives such as mobile frac tanks, baker tanks and temporary build-in-place tanks.

After the results of waste characterization sampling are received, the materials staged at the BROS property will be disposed at an appropriate facility, based upon the waste classification. The selection of disposal facilities will be completed based upon waste characteristics, applicable laws and regulations at the time of disposal, the requirements of the BROS Consent Decree and the permit requirements of the disposal facility.

Personal Protective Equipment

Used personal protective equipment (PPE) and associated materials, such as Tyvek coveralls, gloves, respirator cartridges, plastic sheeting, and paper towels, will be placed in plastic bags in a roll off container located on the BROS property. The roll off will be covered and will be staged in a central storage area until the investigation is completed. After the investigation is complete the PPE will be sent off site for the disposal. The selection of disposal facilities will be completed based upon waste characteristics, applicable laws and regulations at the time of disposal, the requirements of the BROS Consent Decree and the permit requirements of the disposal facility.

The handling of all wastes will conform to all health and safety requirements outlined in the HASCP. Sample types, analytical parameters, and number of samples analyzed will be dependent

upon state and federal transportation, landfill and/or site disposal requirements, and the requirements of the contracted waste hauler and waste-processing facility for hazardous wastes.

6.8 Boring/Well Abandonment

Any soil boring, monitoring well or piezometer abandonment will be performed by a New Jersey licensed well driller and completed in accordance with the specifications detailed in N.J.A.C. 7:9-9.1 et seq. When Geoprobe® direct push equipment or hand auger sampling techniques are used, the abandonment procedures specified in Appendix II of the July 1994, NJDEP *Alternative Ground Water Sampling Techniques Guide* (NJDEP, 1994a) will be employed.

At the completion of soil sampling in a borehole completed using hollow-stem auger, mud-rotary drilling, Geoprobe® direct push equipment or hand auger any foreign material (e.g., sampling equipment, temporary casing, etc.) must be removed from the borehole prior to abandonment. As specified in Appendix II of the July 1994, NJDEP *Alternative Ground Water Sampling Techniques Guide* (NJDEP 1994a), boreholes will be filled using either a Portland neat cement, Portland cement/high-grade bentonite, or high-grade bentonite grout, mixed using potable water. The grout will be pumped through a tremie pipe from the bottom to the top of the borehole.

7.0 FIELD INVESTIGATION PROCEDURES

The methods to be utilized during implementation of each of the field activities are described below (Section 6.0 of the Work Plan). The seven activities identified in the Work Plan which require field investigation procedures are:

- Task I, Activity 1 - Preparatory Activities;
- Task IIIA, Activity 1 - Water Budget Investigation;
- Task IIIA, Activity 2 - Soil Investigation;
- Task IIIA, Activity 3 - LNAPL Evaluation;
- Task IIIA, Activity 4 - Ground Water Investigation;
- Task IIIA, Activity 5 - Surface Water and Sediment Quality Evaluation; and
- Task IIIA, Activity 6 - Ecological Evaluation.

The balance of this section is organized by task and provides descriptions of the methods to be utilized in the performance of each task.

7.1 Task I, Activity 1 - Preparatory Activities

Preparatory activities which include field activities are the inspection and repair of existing monitoring wells (Activity 1a), local well identification (Activity 1b), the Stage 1B Cultural Resources Survey (Activity 1c), and Analytical Method Development (Activity 1f). These activities can be performed independent of the other field investigations and as they warrant early completion in the event that supplemental investigations are necessary. A description of these activities is provided below.

7.1.1 Activity 1a - Inspection and Repair of Existing Monitoring Wells

To date 57 monitoring wells have been installed on the BROS site (Figure 15). Existing monitoring wells at the site will be inspected by a Roux Associates, Inc. hydrogeologist to identify locations where well repairs, redevelopment, abandonment, or replacement is necessary to ensure the collection of representative data. Any necessary work (i.e., abandonment of existing wells,

installation of replacement wells, repair of the cement collar to ensure that it is sloped to permit runoff away from the well annulus, well development) with regards to the existing wells will be performed by a New Jersey-licensed well driller in accordance with applicable SOPs (Appendix B, Section 10) and will be completed prior to the planned ground water quality evaluation activities (Task IIIA, Activity 4a). It is uncertain at this time whether the well repairs will be conducted under the direction of USEPA or the BROS Technical Committee. If the repairs are performed by the BROS Technical Committee all work performed with regard to the existing wells will be supervised by a Roux Associates, Inc. hydrogeologist and will be documented in accordance with the QAPP. If the USEPA performs the well repairs, a Roux Associates, Inc. hydrogeologist will observe the work. The locations of the existing monitoring wells are indicated on Figure 15 and well construction details are provided in Table 14.

The locations of the wells will be identified in the field and the integrity and slope of the concrete collars and the protective steel casings or curb boxes will be inspected. The depth to the bottom of the monitoring wells will be determined and compared with as-built information to evaluate the silting of the wells. A standard disposable bailer will be placed in the well to confirm that the casing is not bent and that sampling of ground water can be completed. Repairs will be made on concrete collars and the protective steel casings or curb boxes, as needed. If a well exhibits significant silting, greater than 20 percent of the screen length, or if the casing is damaged or bent so that a representative ground water sample cannot be collected; the need to redevelop, abandon and/or replace the well will be evaluated. The existing monitoring wells have not been sampled since March 1993. All of the existing monitoring wells which will be sampled during the ground water investigation (Task IIIA, Activity 4) will be redeveloped so that subsequent sampling efforts will obtain ground water samples representative of the formation water. The procedure for development of the monitoring wells is included in Appendix B, Section 10. Data from the well inspection will be recorded in the field book and/or a well inspection checklist (Appendix D).

The measuring point for subsequent depth-to-water measurements will be chosen and clearly marked on the inside casing for future reference to insure consistency between measurement events. Each monitoring well will be clearly labeled with its monitoring well designation to facilitate quick identification during gauging and sampling events.

All existing monitoring wells that are judged to be usable during the existing well evaluation will be surveyed by a surveyor licensed in the State of New Jersey. Surveying activities will be conducted in accordance with the standard of care set forth in Chapter 40 of the State Board of Professional Engineers and Land Surveyors Administrative Rules and Regulations. A global positioning system (Appendix B) will be used for surveying unless overhead obstructions (tree canopy, buildings) prevent the use of this technology or where greater accuracy is required, in which case traditional methods will be employed. The surveyor will maintain field notes in a bound logbook and copies of the notes will be provided in the RI Report. Vertical control of land surface and measuring point elevations will be measured to the nearest 0.01 foot, relative to mean sea level. The surveyor will also determine horizontal control of the existing monitoring wells to the nearest 0.10 foot. The measuring points will be located according to the New Jersey State Plane coordinates and surveyed for elevation in reference to the National Geodetic Vertical Datum (NGVD). The results of the survey will be used to update the existing base map early in the project. The updated base map and current ground water potentiometric surface map will be used to refine the siting of new monitoring wells.

7.1.2 Activity 1b - Evaluation of Local Wells

In order to determine if any existing water supply wells on or in the vicinity of the BROS site are currently operational, a mailing will be sent to all of the property owners on or in the vicinity of the BROS site requesting information on whether they have a water supply well and the current status of their water supply well. The list of residences will be based upon property owner information from the Logan Township tax office, records of the Pennsgrove Water Supply Company and a review of NJDEP Bureau of Water Allocation permits. The search area will include all properties within a 0.5 mile radius of the BROS Property and will also extend approximately one mile to Swedesboro-Paulsboro Road between Repaupo Road and Hendrickson Mill Road. This search distance was selected based upon the known limits of ground water contamination with the objective of collecting information from residential and agricultural properties. The search distance extends beyond the well search radius required in the *Technical Requirements for Site Remediation* (N.J.A.C. 7:26E-4.4). A follow up telephone call or visit to each of the properties will be conducted to confirm and/or supplement the results of the response to the mailing. If existing private wells are identified, the Township Health Officer will be

contacted to determine if additional information is available. The local water purveyors will then be contacted to determine if the property is supplied with a municipal water source. If the homeowner does have a serviceable well the following information will be requested from the property owner:

- supply a copy of the well log, if available;
- the depth of the well and what is the screened interval;
- what is the well currently used for;
- the size of the holding tank;
- how often the well is used; and
- is there a water treatment system, and if so what type.

If wells are identified that are operational, samples may be collected depending on the well location and construction. The specific sampling and analytical plan will be detailed in a Technical Memorandum for USEPA approval. If wells are sampled, the samples will be collected in accordance with the SOP provided in Appendix B and analyzed for TCL VOCs by EPA Method 524.2. Samples from wells within 0.5 miles of the BROS property, if any, will also be analyzed for TCL SVOCs and TAL metals if these constituents are likely to be present based upon the well location and ground water quality data available at the time. Sampling data will be recorded in the field book and on a well sampling data form (Appendix D).

The private water system will be inspected to locate the well, pump, storage tanks and any treatment systems. Samples will be taken as close to the pumping well as possible and prior to any storage tanks or treatment systems. If a sample must be taken following a treatment unit, the type, size and purpose of the unit will be noted in the field notebook.

The water system will be sampled in accordance to the procedures specified in the SOP (Appendix B). The water sample will be collected directly into the appropriate sampling container as outlined in Section 6.5.1.

7.1.3 Activity 1c - Stage 1B Cultural Resources Survey

A Stage 1A Cultural Resource Survey (CRS) was completed by the USEPA in April 1992. Based on the findings of the Stage 1A CRS, the USEPA recommended that a Stage 1B CRS be completed. The area of the 1992 study was limited to the area between Routes 295 and 130 with a small area investigated between Routes 130 and 44. Because some of the proposed field activities to be performed as part of the Phase 2 RI/FS will occur outside of the area of the 1992 CRS study, and the FS may consider remedial actions in a broader area, the Stage 1A CRS will be expanded to include the entire footprint of the BROS Site.

Upon completion of the Supplemental Stage IA CRS activities, the Stage IB CRS will be initiated in the areas determined to having high potential for significant archaeological or historical features. Roux Associates, Inc., with the assistance of Hunter Research, Inc. submitted a scope of work for the CRS activities (Hunter, 1998) which was subsequently approved (USEPA, 1998c). The Stage 1B Cultural Resource Survey (CRS) will be performed in accordance with the New Jersey Historic Preservation Office *Guidelines for Phase I Archaeological Surveys* (NJDEP, 1996) and the USEPA-approved plan (Hunter, 1998) and field procedures are detailed in this plan. The Stage 1B CRS will include site inspections and field tests in specific areas which have been defined as sensitive to cultural resources, based on the Stage 1A CRS, or where cultural resources are expected. The field test will be completed to evaluate if evidence of pre-historic human-related activities exists at the site.

The Stage 1B CRS will be conducted by a certified archaeologist who has the required health and safety training. Fieldwork will consist of a combination of systematic surface collection and the excavation of a series of hand-dug 1.5-foot diameter shovel test pits to inspect for ash layers, artifacts, or bones which may serve as evidence of cultural activities at the site. The depth of the shovel test pits will be determined by the archaeologist based on the results of site inspections and background investigation. Soil from all shovel test pits will be screened through one quarter inch hardware cloth. Shovel test pits will be recorded using munsell designations, and will include soil texture, wetness, composition, and other pertinent information. All shovel test pits will be backfilled and restored to their original contours. The field work activities will be required to follow the health and safety and decontamination procedures identified in the HASCP.

7.1.4 Activity 1f - Analytical Method Development

The laboratory service firms that have participated in the development of the Work Plan, and who will likely perform the chemical analyses of samples from the BROS site, evaluated potential matrix interference concerns based on the review of past site data. The laboratories were tasked with identifying potential laboratory methods which can reliably achieve detection limits consistent with the numeric DQOs, given the likely matrix interference concerns. Based upon this evaluation, the laboratories proposed that SW-846 methodologies, as opposed to CLP methods, be used and that method development activities be conducted prior to the receipt of site characterization samples. The use of SW-846 methods (USEPA, 1997c) will provide the laboratory with greater flexibility in methodology and cleanup procedures which, in the experience of the laboratories, will allow the laboratories to achieve lower detection limits and a higher percentage usable data that are more consistent with the project DQOs. As provided in more detail in the QAPP, the laboratories will follow SW-846 methods while maintaining consistency with CLP protocols, to the extent practical.

The laboratories will use media from the BROS site to evaluate potential method modifications and cleanup methods for VOC, SVOC and PCB analyses as a means of addressing matrix interferences before site characterization samples are received. The completion of method development activities ahead of the site characterization will provide the laboratories with the ability to perform various trial modifications without exceeding the holding times for characterization samples. Moreover, the early development and approval of revised methods will reduce the likelihood of having to repeat sampling and field activities due to critical RI data being qualified or rejected.

The Analytical Method Development activity involves the collection of samples of the following complex matrices from the BROS site:

- LNAPL from existing site monitoring wells MW-1A and S-11A (Figure 9);
- peat from proposed boring locations PB-4 and P-24 (Figure 7);

- lagoon residuals/mud wave soils from boring locations L-9A and L-10A (Figure 7);
- sediments from the *de manifestis* and intermediate zones at LTC-8, LTC-10, LTC-25 and LTC-28 (Figure 13);
- ground water from monitoring wells S-2A and MW-13A located in the vicinity of the lagoon (Figure 9); and
- two surface water samples from Little Timber Creek at locations FM-1 and FM-2.

Sample locations will be based on a review of historical site data and field observations at the time of sample collection. Sample collection will be in accordance the procedures set forth in the relevant sections of this Sampling and Analysis Plan, with the exception of the sediment samples as described below, and will require the use of a drill rig to facilitate the collection of subsurface soil and peat samples.

The Analytical Method Development will also include an assessment of different preservation methods for sediments. In earlier drafts of the Work Plan, sediment samples were not going to be preserved using either the methanol or sodium bisulfate methods. The use of methanol will dilute the sample, resulting in higher method detection limits (MDLs). These MDLs will exceed the screening criteria used for the evaluation of sampling results (i.e. 50% of the PRGs as defined in Section 5.2). Due to the predicted density of the sediment and the fixed volume of the sodium bisulfate sampling kits, increased MDLs are also predicted with this preservation technique. Moreover, in the experience of the laboratories who will analyze the samples, sediment samples frequently effervesce when preserved with sodium bisulfate; rendering the sample unusable. The benefits of attaining an MDL that meets the project-specific sediment screening criteria and provides data that can be used in decision making are more consistent with the project DQOs than employing field preservation to reduce potential VOC losses during sediment sampling. USEPA has required that sediment samples be preserved, either with methanol or sodium bisulfate. In order to evaluate the potential impacts of these preservation methods, replicate sediment samples will be preserved by three different methods: (1) methanol, (2) sodium bisulfate using the

EnCore® sampler and (3) ice. The samples will be analyzed and the results compared to assess the attainable MDLs and potential for effervescence using the three preservation techniques.

After the samples are collected, they will be submitted to the laboratory for analysis for VOCs, SVOCs, and PCBs. The laboratory will then evaluate the analytical data quality and determine if sample extract cleanup for SVOCs and PCBs (or other method modifications) will improve data usability or more effectively achieve DQOs. If the initial analysis of the SVOC and PCB samples indicates that the quantitation limits do not meet the required DQOs, sample extract cleanups will be conducted on each matrix to be analyzed for SVOCs and PCBs to evaluate the effectiveness of the cleanup procedures. The analysis of cleaner extracts requires less dilutions and results in lower quantitation limits. Cleanup methods are not available for VOCs using SW-846 (USEPA, 1997c) or CLP methodologies. Potential sample extract cleanup methods may include:

- gel permeation chromatography for SVOCs,
- sulfur cleanup for PCBs, and
- sulfuric acid cleanup for PCBs.

If, after cleanup of the SVOC and PCB extracts, the detection limits still do not meet the required DQOs, the laboratory will employ the use of selected ion monitoring (SIM) mass spectrometry. SIM may also be used for VOC analysis if the numeric DQOs can not be achieved for the initial samples. The use of SIM mass spectrometry generally results in a lowering of the detection limits by a factor of ten.

The laboratory will evaluate the effectiveness of using sample extract cleanup methods and SIM analysis and recommend method changes for inclusion in the QAPP. A Technical Memorandum detailing proposed sample extract cleanup methods and method modifications will then be prepared and submitted to the USEPA for review and approval.

The surface water samples collected from Little Timber Creek at locations FM-1 and FM-2 (Figure 8) as part of the analytical method development activities will be collected for PCB

analysis. The PCB analyses of surface water samples are proposed to evaluate to what degree the laboratory can achieve the numerical DQO of 0.007 µg/l which is below the laboratory's standard reporting limit of 0.1 µg/l.

Additional method development activities that will be conducted include an evaluation of the amount of preservative (hydrochloric acid) required to reduce the pH of ground water samples to be analyzed for VOCs to less than two standard units (i.e. pH < 2.0). This task will be accomplished by collecting ground water samples at S-2A and MW-13A and testing the pH of the samples in the field using a pH test strip. If the pH is less than two standard units, the laboratory will be notified that the amount of preservation provided is adequate. If the pH of the sample is greater than two standard units, additional preservative will be added a drop at a time until the pH is reduced to less than two standard units. The laboratory will then be notified of the amount of additional preservative required to achieve the desired pH and this volume will be used for all subsequent ground water sampling events.

7.2 Task IIIA, Activity 1 - Water Budget Investigation

Analysis of the water budget in vicinity of the former BROS Lagoon is essential to understanding the fate and transport of COPCs and selecting remedial options for ground water and wetlands. This information will be used to model surface water/ground water interaction; assess transport of COPCs; evaluate potential receptors, exposure routes and potential risks and evaluate remedial alternatives. The water budget study area will be focused between Routes I-295 and 130 and several monitoring points north and east of Route 130.

The scope of work for evaluating the water budget was developed based upon the methods included in *Planning Hydrology for Constructed Wetlands* (Pierce, 1993). The regional framework of the water budget will be evaluated through the use of reference data available through the USGS, FEMA, NJDOT, and DRBC; and information developed on the neighboring CLTL site. The water budget investigation includes the following activities:

- measurement, over a course of twelve months, of surface water and ground water elevations for each season of the year;

- measurement of precipitation and the effect of precipitation on surface water and ground water elevations and flow rates based on hydrographs constructed from data collected at surface water flow gauging stations;

- determination of the interaction between surface water and ground water through the use of staff gauges and clustered wells installed in different strata beneath the site, as well as aquifer pumping tests; and

- analytical evaluation based on site-specific empirical data (modeling).

For each measurement effort, data collection activities will extend over one month to ensure several precipitation events are evaluated during relatively wet and dry times of the year. Meteorological data will be collected throughout the 12 month course of the study. The RI/FS field tasks performed as part of the water budget analysis are:

- Activity 1a - Meteorological Data Collection;
- Activity 1b - Stream Flow and Hydrograph Evaluation; and
- Activity 1c - Water Level Measurements.

7.2.1 Activity 1a - Meteorological Data Collection

Precipitation and evaporation will be measured to evaluate their influence on surface water and ground water flow. Evapotranspiration rates will either be obtained from a local weather reporting station, if available, or estimated using the Thornwaite method as described in Pierce (1993). Precipitation will be measured at two locations using a tipping bucket variety of precipitation gauge. The gauges will contain heating elements to melt and measure the water content of snow and frozen rain, but will be designed to avoid evaporative loss.

Evaporation will be measured using an evaporation gauge that uses a balanced sensor assembly coupled with a standard Class A evaporation pan. The sensor assembly includes a float which rises and falls with the water level in the pan and measures the movement using a potentiometer. The precipitation gauges and evaporation pans will be placed at two locations; one in the Little

Timber Creek Swamp and the other in an open, unshaded area nearby. Both gauges will be situated in an accessible location within 100 feet of the AWTS (a source of electric power). These locations will have vegetative cover and protection from the wind that are similar to the conditions in the broader study area (i.e. separate gauges for both the swampy area between Routes I-295 and 130 and the ponds). As the evaporation pans will be placed outdoors in areas that are representative of the site, evaporation rates will be actual and will not require correction to wind, temperature and humidity.

The meteorological data will be collected using hourly averages and stored electronically on a data logger. The information stored on the data logger will be downloaded to a portable computer in the field or obtained via modem over a phone line installed at the site. The data will be stored on an electronic database and included as an appendix in the RI Report. Seasonal averages will be calculated for each parameter. Meterologic data will be collected for the duration of the Water Budget Investigation.

7.2.2 Activity 1b - Stream Flow and Hydrograph Evaluation

Surface water elevation data and ground water elevation data from the Upper PRM will be evaluated to determine the relationships between surface water and ground water in Little Timber Creek Swamp and to determine if there is net flow in or out of the system. Measuring points will include all surface water gauging stations, staff gauges, and wetlands monitoring wells indicated on Figure 8 and all Upper PRM monitoring wells indicated on Figure 9. A detailed discussion of water level measurements is provided in Section 7.2.3. These data will be used to support the fate and transport models for COPCs.

All of the measuring points will be surveyed to establish vertical and horizontal control by a surveyor licensed in the State of New Jersey. Surveying activities will be conducted in accordance with the standard of care set forth in Chapter 40 of the State Board of Professional Engineers and Land Surveyors Administrative Rules and Regulations. A global positioning system will be used for surveying unless overhead obstructions (tree canopy, buildings) prevent the use of this technology, in which case traditional methods will be employed. The surveyor will maintain field notes in a bound logbook and copies of the notes will be provided in the RI Report.

Vertical control of land surface and measuring point elevations will be measured to the nearest 0.01 foot, relative to mean sea level. The surveyor will determine horizontal control of the staff gauges and surface water flow measuring stations within 10 feet and all wetlands monitoring wells within 0.01 feet. The measuring points will be located according to the New Jersey State Plane coordinates and surveyed for elevation in reference to the National Geodetic Vertical Datum (NGVD).

Surface water flow gauging stations will be located where Little Timber Creek passes through culverts at a location upstream at Route I-295 and downstream at U.S. Route 130, and at stormwater drainage pipes leading from I-295 to Little Timber Creek Swamp. A portable flow meter similar to the type described in Appendix H and capable of monitoring extremely low flow rates (less than 5 centimeters per second) will be used at the storm water culverts to allow for the measurement of surface water flow into and out of the study area based upon water height and velocity. The portable flow meter will be used to collect instantaneous flow measurements at the storm water culverts (similar to grab sampling). For the seasonal water level measurements (i.e. measurements on a daily basis for one month each season) the portable flow meter will be used to obtain three measurements on a daily basis for one month each season.

During the significant precipitation event measurements (greater than 1-inch, and preferably greater than 2 inches in 24 hours) the portable flow meter will be used to obtain measurements on an hourly basis during day light hours at each of the monitoring points depicted on Figure 8, subject to accessibility. Monitoring of the precipitation event will commence 24 hours prior to the predicted precipitation event and continue until the start of precipitation and 72 hours after precipitation stops or base flow on Little Timber Creek returns to within +/- 10% of the prestorm rate for at least four consecutive hours.

The gauging stations, designated FM-1 through FM-4 will utilize existing culvert structures for flow control to the degree practical in order to minimize disturbance to upgradient areas and to better monitor low flow events. The dimensions of the culverts at these gauging stations will be established, including a depth profile so that elevation measurements from staff gauges can be used to calculate the cross-sectional area of flow. Coupled with flow velocity data collected at

the station, a flow rate will be calculated. Velocities will be measured at two foot intervals across the width of the culvert to account for variations due to frictional drag and obstructions. The design of the flow gauging stations will be refined based on input from the New Jersey Department of Transportation, the Delaware River Basin Commission (DRBC) and the Federal Emergency Management Agency.

Hydrographs, consisting of water level evaluations versus time plots, will be prepared for each monitoring point. Where staff gauges are nested with wetland monitoring wells, the hydrographs will be superimposed upon each other. The hydrographs will be used to compute ground water elevation data to surface water elevation data. Evaluation of the hydrographs will then be conducted to determine: if surface water discharges to ground water or ground water discharges to surface water; and if there are seasonal variations between the relationships. Net flow data will be evaluated by comparing flow readings from the surface water gauging stations (FM-1 through FM-4) and data from staff gauges SG-9 (located at the interconnection between Swindell Pond and Little Timber Creek Swamp) and SG-13 (located in Little Timber Creek upstream of Route I-295). The volumetric flow into and out of the Little Timber Creek Swamp will be calculated based upon a comparison of the sum of the upstream points (FM-1, FM-3 and FM-4) with the flow at the discharge point (FM-2). Staff gauge readings from SG-9 and SG-13 will be compared to the surface water elevations at other, nearby, points to qualitatively evaluate the potential for other sources of surface water inflow to the study area. Hydrographs will also be compared to assess the storage dynamics of the Little Timber Creek Swamp under differing seasonal and hydrologic conditions.

Tidal and barometric pressure influences on surface water and ground water elevations will be evaluated through a comparison of meteorological and tidal data (from direct measurements and regional sources such as NOAA and the DRBC) with water levels measured using pressure transducers connected to data loggers. Although maximum tidal fluctuations of five feet have been measured in Little Timber Creek near its confluence with the Delaware River, a tide gate eliminates tidal fluctuations upstream of U.S. Route 130 (CH_2M Hill, 1996) except during extreme high flows or unusually high storm tides. Moreover, tidal influences were not observed in the Upper PRM during studies completed by CH_2M Hill (1996).

Additional investigations that will be conducted as part of this activity include dye studies to confirm streamflow data and establish preferential flow patterns. Dye testing will be conducted in accordance with ASTM Method D 5613-94 (Appendix J). Intracid Rhodamine WT, an environmentally safe, non-toxic dye (Appendix I) will be introduced into surface water at various locations and allowed dissipate. The specific locations will be established in the field but will include points near inlets to the Little Timber Creek Swamp along I-295, at the connection between Swindell Pond and Little Timber Creek Swamp, and locations within the swamp where flow patterns appear braided. Dye testing will be conducted during both high flow and low flow periods to assess differences in flow patterns related to water level. Intracid Rhodamine WT is a dark red solution that can be traced visually and at low concentrations using a fluorometer. As such, dye dispersion patterns will be tracked visually and by collecting water samples that will be analyzed at the field laboratory. The dispersion patterns will be observed and mapped over the course of the day. The flow patterns will be mapped. The surface water flow patterns will be used to refine surface water and sediment sampling locations as described in Section 7.6.

7.2.3 Activity 1c - Water Level Measurements

Surface water and ground water elevation data will be collected throughout a twelve month period to assess variations in ground water/surface water interactions due to seasonal influences. Although the primary focus of this investigation is the Little Timber Creek wetlands, measurement points throughout the site have been established to support RI data evaluation. Water level measurements will be conducted to evaluate seasonal variations in elevations and flow directions; to assess the rate of change following precipitation events; and approximate the flow of surface water into and out of the Study Area (Figure 8). The collection of elevation and flow measurements is outlined below.

As noted in the scoping meetings, it is essential that the full range of hydraulic conditions be measured in order to evaluate the response of the wetlands and upper aquifer to ground water pumping remedial alternatives. In addition, to be able to put the year of water budget measurements in the context of average variability (wet year, dry year), monthly precipitation records for a location near the site will be acquired and summarized. This analysis will be

valuable in predicting the influence of pumping shallow ground water for a several year period which is likely to encounter relatively wet and dry years.

The water level measurements will be collected from wetland monitoring wells, staff gauges, well points and surface water flow gauging stations (Figure 8) as well as the Upper PRM monitoring wells (Figure 9). Prior to measuring water levels, the field team will inspect the tide gate to ensure that it is operating properly. Water levels will be measured only during daylight hours each weekday at two to four hour intervals (longer intervals will be used during times where there is ample daylight), for a minimum of three complete rounds per day. Data from monitoring points outfitted with data loggers, as identified below, will be down-loaded during the first daily round. The water level measurements will be collected daily for a one-month period during each season, over a course of 12 months, to ensure the range of hydraulic conditions are measured.

Two significant precipitation events (greater than 1-inch, and preferably more than 2" in 24 hours) will be monitored more aggressively to develop stream hydrographs and evaluate the response of the various environmental compartments in the water budget. One event will be completed during a drier period (late summer) and the other during a wetter period (early spring) to provide information over a range of hydrologic conditions. Monitoring of the precipitation event will commence 24 hours prior to the predicted precipitation event and continue until the start of precipitation and 72 hours after precipitation stops or base flow on Little Timber Creek returns to within +/-10% of the prestorm rate for at least four consecutive hours. Water levels and flow rates at the surface water flow gauging stations will be measured on an hourly basis during day light hours at each of the monitoring points depicted on Figure 8, subject to accessibility. Data from the data loggers will be down-loaded during the first daily round.

The more intensive measurement periods will be for a short time before, during, and for several days after the significant precipitation event for a total time of at least five days. Selected monitoring points will have pressure transducers installed to monitor the water levels while other points will be measured manually on an hourly basis during daylight hours. The preliminary monitoring points selected to have pressure transducers MW-22S, MW-23S, WMW-2, SG-2 (collocated with WMW-2), WMW-3, SG-3 (collocated with WMW-3), and FM-1 through FM-4.

The pressure transducer locations may be adjusted based on the number and type of equipment used and the results of preliminary water level measurements. If pressure transducers will not be used at one of the aforementioned locations, USEPA will be notified and the manual measurement procedures will be employed.

Ground water elevations in monitoring wells will be measured to evaluate seasonal variability in elevations and flow direction, for comparison to surface water elevations, and to assess the rate of change following precipitation events. All existing and proposed wells will be used for quarterly elevation measurements (Section 7.5.1). Some CLTL wells will also be included, subject to receipt of access. The RI Manager will identify those wells that will gauged for each event. Wells WMW-2, WMW-3, MW-22S and MW-23S will be fitted with water level recorders (pressure transducers integrated with data loggers) to assess the rate of change during and after significant precipitation events.

Surface water elevations in Gaventa Pond, Swindell Pond and Little Timber Creek will be recorded through direct measurement using staff gauges. As listed previously, selected staff gauges will be fitted with stilling wells to allow the use of water level recorders when more frequent monitoring is necessary. The staff gauges will be installed on wooden or steel stakes placed through the bottom of the ponds or stream (Figure 8). The gauges will be scaled at an interval of hundredths of a foot. The gauges will be situated so they can be easily read from the bank of the stream or pond and will be located in accessible positions, where possible. Six of the staff gauges will be collocated with wetland monitoring wells described below.

Wetland monitoring wells constructed by alternative techniques suitable for the field conditions (Section 7.5.1) will be installed in the Little Timber Creek wetlands to measure ground water elevations in the alluvium below the standing water in the wetlands/creek. These data will be used to assess head differences and discharge/recharge relationships between ground water and surface water. Sampling of these wells will be performed to characterize ground water quality and estimate the flux of COPCs between surface water and ground water. The wetland monitoring wells will be constructed at two screened intervals. The shallow points will monitor the surface water zone and the deeper point will monitor the top of the Upper PRM aquifer. The monitoring

well points are designated WMW-1A through WMW-6A and WMW-1B through WMW-6B (Figure 8). The construction and sampling of the wetland monitoring wells is discussed in Section 7.5.

Surface water flow gauging stations will be established where Little Timber Creek passes through culverts at a location upstream at Route I-295 and downstream at Route 130 to evaluate stream flow and at the two stormwater discharge pipes adjacent to Route I-295. Manual flow meters and staff gauges will be used at the surface water flow gauging stations to allow for the measurement of surface water flow into and out of the study area.

7.3 Task IIIA, Activity 2 - Soil Investigation

Soil investigations will be completed as part of the Phase 2 RI in a phased approach to: identify any remaining sources of contamination; characterize the residual contamination in terms of location and vertical and horizontal gradients of COPCs; and obtain data to support the HHRA, ERA, FS and treatability studies. The areas targeted for the soils investigation are the background and off-property soils (Activity 2a) and the on-property soils (Activity 2b), which include the former Process and Storage Tank Area and former Lagoon Area. Additional soil sampling will be conducted during the installation of monitoring wells as discussed in Section 7.5. Soil boring, drilling, and sampling procedures to be used are provided in Appendix B. A general discussion concerning soil boring installation at the site is provided below.

Soil borings will be drilled using either hollow stem auger drilling methods or mud rotary drilling methods (Appendix B), depending on the geologic conditions encountered. Soil samples that will be collected to depths of 15 to 20 feet BGS can be completed using hollow stem auger drilling methods. However, below 15 to 20 feet, running sands may be encountered which rush into the annulus of the hollow stem auger preventing the collection of an undisturbed soil sample. Therefore, mud rotary drilling may be required in order to prevent the influx of running sands. The use of mud, which has a higher specific gravity than water, prevents water, and sand in suspension in the water, from entering the borehole. Appendix I contains technical specifications for the bentonite material used in mud rotary drilling. Split-spoon soil samples can be used to collect undisturbed soil samples below the bottom of the borehole through the drilling mud. All

soil borings which penetrate the former lagoon area or the confining layer between the Upper PRM and Upper Middle PRM will be drilled using the mud rotary technique to reduce the potential for carry down of COPCs from shallow soil or NAPL. Soil borings that will penetrate the confining layer between the Upper PRM and Upper Middle PRM will be double cased.

At each boring location, split-spoon soil samples will be collected continuously, in 2-foot intervals, from land surface into the horizon or geologic unit targeted by that boring. The depths of the borings will extend to a minimum of the top of the clay confining layer between the Upper PRM and Upper Middle PRM, or to the depth of unimpacted soil based on visual observation and field screening. Upon completion of each soil boring it will be abandoned as described in Section 6.8.

The field screening and sample collection process is summarized in a flow chart (Figure 4) and outlined for specific borings (Table 3). Field screening of soil borings will include measurement of head-space organic vapors using a photoionization detector calibrated to detect chlorinated VOCs, visual observation for staining and sheens, tactile assessment for slipperiness, and classification of soils according to the Burmister method. Field screening will also include the use of an on-site laboratory for NAPL and chemical analyses (VOCs, lead and TPH). As presented in the soil screening flow chart (Figure 4), the results of visual/tactile observations, soil classification and PID screening will be the basis for selecting samples for on-site laboratory screening. In some instances, such as at confining layers and where NAPL is observed, samples will routinely be collected for laboratory analysis, as summarized below and described in more detail in Section 7.4.

The on-site laboratory will be used to infer gradients of soil contamination, based upon the results of other screening methods and a comparison to existing data. It will also be used as a tool in selecting samples for off-site laboratory analyses. As such, chemical analyses using the on-site laboratory will be conducted more frequently for off-property soils and for those distant from known or suspected sources than for those in documented source areas. The on-site laboratory will not be used for chemical analyses of highly contaminated soils as the extra volume will limit the daily throughput of the lab especially where multiple dilutions are required or when gas

chromatograph columns must be replaced. NAPL detection screening will include UV fluorescence and hydrophobic dye testing as described in Activity 3.

Process Area Borings

At least three soil samples from each former Process Area boring (P-20 through P-44) will be collected for off-site laboratory analyses:

- one will be biased to the zone exhibiting the most evidence of contamination based on field screening and visual observation;
- the second will be collected from a depth below the first where field screening indicates substantially less contamination; and
- the third sample will be collected at the base of the boring or at an alternate, shallower, location where field screening indicates lower concentrations of COPCs in order to establish the vertical distribution of COPCs through the use of gradients.

Additional samples may be collected for off-site chemical analyses based upon field conditions and on-site laboratory results. For example, additional samples may be collected where NAPL is indicated (see Activity 3 - NAPL Investigations) or to evaluate the vertical distribution of COPCs in the confining layer in order to support the evaluation of remediation timeframes. The sample selection for on-site and off-site laboratory analyses will be flexible to meet the objectives of determining the concentration gradients of the COPCs and additional samples will be collected if warranted. USEPA will be advised of any additional sample collection needed to meet the sampling objectives.

Lagoon Area Borings

For the lagoon borings (L-1 through L-8 and L-9A through L-16B), up to four samples from each boring will be collected for off-site laboratory analyses. One sample will be collected from the lagoon residuals; the second sample will be collected from the peat layer; the third sample will be collected from the top of the clay layer or silty strata; and the fourth from approximately three feet

into the clay/silt layer. For the deeper soil borings (L-3, L-4, L-5 and L-6, and the borings for MW-26D and MW-27) an additional four soil samples will be collected for off-site chemical analyses:

- one sample will be collected from the top of the Upper Middle PRM just below the clay/silt layer;
- the second sample will be collected from the intermediate depth interval exhibiting the greatest evidence of contamination based upon field screening;
- the third sample will be collected from the top of the clay layer at the base of the Upper Middle PRM; and
- the fourth sample will be collected from approximately three feet into the clay layer.

Selected samples will be screened for the presence of LNAPL or DNAPL using the methodology as described in Activity 3. In addition, five soil samples each will be collected from the ash and sand fill placed in the former Lagoon Area.

Pepper Building Area

Because the Pepper Building was used to store hazardous substances and LNAPL has been identified off the southern end of the building, a soil investigation consisting of five soil borings (PB-1 through PB-5) will be completed around the perimeter of the building to determine if LNAPL may originate from beneath the Pepper Building (Figure 7). The investigation is described later in this section. The five soil borings proposed for the Pepper Building will be biased to locations of suspected areas of concern based upon the inspection. Additional borings may be completed along the perimeter of the building if a measurable thickness of free product is encountered in any boring. All five borings will be completed to a depth of two feet below the water table. After completion of the borings around the perimeter and visual reconnaissance inside the building, the need for any additional borings through the building floor will be evaluated, in consultation with the USEPA.

For the Pepper Building borings (PB-1 through PB-5), three soil samples will be collected for off-site analysis based upon field screening (Figure 4): one sample will be collected from the zone of greatest contamination within the unsaturated zone; the second will be collected from the sample interval immediately above the water table; and the third will be collected from the base of the boring.

Methanol Preservation Comparability Testing

Although the previous soil sampling for VOCs at the site did not use chemical preservation of the soil samples, methanol preservation (Appendix E) will be used for all VOC samples during the Phase 2 RI except the samples collected as part of the methanol preservation comparability testing program described below. Methanol preservation is intended to prevent the potential large loss of VOCs from the soil sample and will reportedly produce more representative sample results than unpreserved samples. Furthermore, the NJDEP now requires soil samples collected for the analysis of VOCs to be preserved using methanol.

Because previous soil samples collected for VOCs were not preserved using methanol, a percentage of split samples will be collected without methanol preservation to assess the comparability of data for site-specific constituents and soil conditions. In the source areas (former process area and former lagoon), 20% of the VOC samples (up to a maximum of 20 samples) will be collected without methanol preservation. In areas outside of the Source areas (where COPC concentrations are expected to be lower) 40% of the VOC samples (up to a maximum of 50 samples) will be preserved by both methods. The specific split samples collected for VOC analysis with no methanol preservation will be determined in the field based upon field screening and sample recovery. The objective of collecting samples with a range of contaminant types and concentrations is to allow for a comparison of sample preservation methods across a range of site conditions.

Sampling Procedures

The sampler will wear new disposable, phthalate-free sampling gloves for each split spoon-sample collected. Each soil sample will be geologically logged, in accordance with the Burmister method (Appendix B), to characterize the soil and to identify the vertical extent of any visually-

contaminated soil. All soil samples will be screened with a PID (Section 3.3.1) to measure volatile organic vapors in the soil (Appendix B).

Soil samples will be collected for chemical analysis using the protocol presented in Appendix B. The soil quality data will be integrated with the existing data to evaluate the risks posed by the residual chemicals in soils at the site. Soil sampling intervals will be selected based on soil screening results and/or lithology and are designed to allow the interpretation of vertical gradients of soil quality conditions upon receipt of the laboratory data. Split-spoon samples and undisturbed samples collected with Shelby tubes from below the water table will also be used to characterize hydrogeologic conditions (Appendix B). Where Shelby tubes cannot be collected due to tube deformation during sample collection (potentially in zones of coarser grained materials) or loss of sample through the bottom of the tube, soil core samples will be collected using the ring-line barrel sampling method (modified ASTM Method D 3550), to the extent practicable. This method uses a series of four six-inch brass rings stacked within a three-inch split-spoon sampler with a sample retention basket which is pressed into the formation by the drill rig (Appendix B). If necessary, hydraulic properties will be estimated based on textural analyses and technical literature.

Soil samples will be collected for chemical, geochemical/conventional and geotechnical analyses as well as waste classification parameters. The sampled intervals will be determined by a Roux Associates, Inc. hydrogeologist and will be based on screening results (i.e., staining, elevated PID readings, on-site laboratory analysis) and stratigraphy (i.e., clay, peat). The analytical parameters for the different borings are summarized in Table 2 of this SAP. Excess soil cuttings will be managed as discussed in Section 6.7.

With the exception of soil borings completed for the purpose of installing monitoring wells, all borings will be abandoned in accordance with the procedures detailed in Section 6.8. Following completion of soil boring and sampling, a surveyor licensed in the State of New Jersey will survey each boring for both horizontal and vertical control. Surveying activities will be conducted in accordance with the standard of care set forth in Chapter 40 of the State Board of Professional Engineers and Land Surveyors Administrative Rules and Regulations. A global positioning

system will be used for surveying unless overhead obstructions (tree canopy, buildings) prevent the use of this technology, in which case traditional methods will be employed. The surveyor will maintain field notes in a bound logbook and copies of the notes will be provided in the RI Report. Vertical control of land surface and measuring point elevations will be measured to the nearest 0.01 foot, relative to mean sea level. The surveyor will determine horizontal control of the soil borings within 10 feet. The measuring points will be located according to the New Jersey State Plane coordinates and surveyed for elevation in reference to the National Geodetic Vertical Datum (NGVD).

7.3.1 Activity 2a - Background and Off-Property Soils

Background

Two soil samples will be collected at each of six off-property locations during the installation of the following monitoring wells: MW-20D, located to the west of the BROS property; and MW-17D, MW-18D, MW-19D, MW-33D and MW-34D located to the southeast of Route I-295. Consistent with RAGS (USEPA, 1989a) the background soil data gathering efforts of the Phase 2 RI are intended to collect data that are relevant to the risk assessment to the degree practical. The soil samples will be collected from the 0 to 6 inch depth interval and the 18 to 24 inch depth interval and analyzed for the following parameters; TCL VOCs, TCL SVOCs, PCBs, and TAL metals. These locations are far enough away from the BROS property that activities on the property would not have contributed COPCs to the surface soil at these background locations. The sampling frequencies and depths are based upon the procedures outlined in N.J.A.C. 7:26E-3.10(a)3.

Swale

LNAPL has been identified in monitoring well MW-13A which is located in the drainage swale along Route 130. This area will be investigated during the Former Process Area investigation (Task IIIA, Activity 2b) and the LNAPL investigation (Task IIIA, Activity 3) and four soil borings (P-30, P-31, P33 and P-35) will be collected and screened for the presence of LNAPL and geotechnical parameters as described in Sections 7.3.2 and 7.4.1. The depths of the borings will extend to the top of the clay confining layer between the Upper PRM and Upper Middle PRM (up to a maximum of 40 feet BGS), or to the depth where, based on visual observation,

field screening and gradients, the vertical distribution of COPCs can be established. In the northern portions of the BROS property, the confining layer will likely be encountered at a depth of 20 to 25 feet BGS. Three soil samples from each boring will be collected for analyses as described in Section 7.3. Soil samples will be collected for analysis for TCL VOCs, TCL SVOCs, PCBs, TAL metals, TOC, moisture and pH to evaluate the distribution of COPCs in the swale and the potential for transport to Little Timber Creek.

Peach Orchard

One soil boring will be completed in the peach orchard located to the west of the BROS property (MW-20D). Soil samples will be collected during the installation of MW-20D as described in the background discussion above and during the monitoring well installation (Section 7.5.1). The soil samples from MW-20D will be collected from the surface (0 to 6 and 18 to 24 inch depth intervals) and from different lithologic units encountered during completion of the boring (e.g., base of Upper PRM and underlying confining layer). The soil samples will be analyzed for TCL VOCs, TCL SVOCs, PCBs and TAL metals.

In addition, an estimated six soil borings will be completed near the Peach Orchard during the Former Process Area and Former Lagoon Area Investigations (Activity 2b). Borings PB-1 and PB-2 will be completed to the west of the Pepper Building to a depth of two feet below the water table. Borings P-20, P-21, L-15B and L-16B will be completed to the west of the former lagoon and will be completed to a depth of 40 feet BGS to the top of the confining clay layer between the Upper PRM and Upper Middle PRM, or to the depth where, based on visual observation, field screening and the use of vertical gradients, the vertical distribution of COPCs can be established. The soil sampling rationale will be the same as outlined in Section 7.3. The samples will be analyzed for chemical and geochemical parameters. The chemical parameters include TCL VOCs, TCL SVOCs, PCBs, TPH and TAL metals. The geochemical parameters are TOC, Eh and pH.

7.3.2 Activity 2b - On-Property Soils

Former Process and Storage Tank Area

Thirty soil borings (P-20 through P-44 and PB-1 through PB-5) will be completed in the former Process Area, the area around and between the Pepper Building and the corner of Gaventa Pond, and the aqueous wastewater treatment system (AWTS) area including the wetlands immediately to the east (Figure 7).

Four zones will be evaluated during the soil investigation in the Former Process Area: surface, vadose, capillary fringe and saturated.

Surface Soil

Consistent with RAGS Part A (USEPA, 1989) the soil data gathering efforts of the Phase 2 RI will provide information that is relevant to the risk assessment, to the degree practical. As such, surface soil samples will be collected from the upper two inches of the soil column to characterize the concentrations associated with the potential exposure point. Surface soil samples from two depth intervals (0 to 2 inches BGS and 2 to 12 inches BGS) will be collected from three locations in the Former Process Area in order to evaluate the concentration of COPCs for use in the human health risk assessment (Task VIA). The surface soil samples will also be used to assess the potential for COPCs in the fill which was placed at the BROS property during regrading. As such, surface soil samples will not be collected in areas that are currently covered by asphalt, gravel or similar impervious surfaces. One set of surface soil samples will be collected from boring P-26, near the current location of the office trailers, the second set of samples will be from boring P-34, in the middle of the former tank farm, and the location of the third set will be selected in the field.

Vadose Zone

Vadose zone soil samples (i.e. those from the unsaturated zone below the surface soil interval) will be collected from the 30 planned borings to determine the stratigraphy and concentration gradients of the COPCs. The sampling and analytical rationale is described below.

Capillary Fringe Zone

During the completion of the 30 planned soil borings in the Former Process Area, soil samples will be collected from the capillary fringe zone, with a primary objective being the identification of LNAPL. If it is determined that residual product is present, samples will be collected as described in the LNAPL investigation (Section 7.4).

Saturated Zone

Saturated zone soil samples will be completed from the 25 P-series borings to determine stratigraphy and to establish the distribution and gradients of COPCs. Many of the 30 borings to be completed in the former Process Areas have been located based on visual observation of the USEPA Phase 3 borings and draft results of the Phase 3 investigation. Some of the borings have been targeted to be installed in areas where LNAPLs are suspected and will serve as a prescreening of the areas for subsequent monitoring well installation to delineate the extent of LNAPL. As with the boring locations proposed within and around the former lagoon, the actual locations may be modified based on conditions encountered in the field. For example, borings proposed in the decommissioned AWTS area may be moved, in consultation with the RI Manager or the Project Manager, to the closest accessible location if the AWTS equipment will preclude sampling activities. The depths of borings P-20 through P-44 will extend to the top of the confining layer between the Upper PRM and Upper Middle PRM or a minimum of 40 feet BGS, whichever is encountered first. In the northern portions of the BROS property, the confining layer will likely be encountered at a depth of 20 to 25 feet BGS. The protocol for selecting samples for off-site characterization was outlined previously. In addition, a minimum of two soil samples each will also be collected from the confining layer between the Upper PRM and Upper Middle PRM and the peat layer located on top of the confining layer, if encountered.

Because the Pepper Building was used to store hazardous substances and LNAPL has been identified off the southern end of the building, a soil investigation consisting of five soil borings (PB-1 through PB-5) will be completed around the perimeter of the building to determine if LNAPL may originate from beneath the Pepper Building (Figure 7). The investigation will also entail a visual reconnaissance of the building interior and exterior to establish boring locations. The visual reconnaissance will identify potential areas of discharges to ground water consistent

with the *Technical Requirements for Site Remediation* (N.J.A.C. 7:26E-1.8). These include floor drains, discolored, deteriorated or dirt flooring, evidence of spills, and stressed vegetation. The five soil borings will be biased to locations of suspected areas of concern and the proposed locations of the five borings (Figure 7) will be adjusted accordingly. All five borings will be completed to a depth of two feet below the water table. Additional borings may be completed along the building perimeter if a measurable thickness of free product is encountered in any boring. After completion of the borings around the perimeter and visual reconnaissance inside the building, the need for any additional borings through the building floor will be evaluated, in consultation with the USEPA.

Analytical Parameters for the Former Process and Storage Tank Area

The following sampling parameters will be evaluated (Tables 2 and 3).

- Chemical parameters will include: TCL, VOCs, TCL SVOCs, PCBs, TPH, and TAL metals.

- Geochemical parameters (TOC, Eh and pH) will be analyzed in all of the samples to support the evaluation of mobility and partitioning to ground water.

- Shelby tube samples or ring-line barrel soil cores will be collected at eight locations and analyzed for geotechnical parameters (permeability, porosity, water content, specific gravity, plastic limits and grain size). The planned Shelby tube sample locations are borings P-20, P-23, P-26, P-28, P-31, P-36, P-41 and P-43 (Figure 7). The depth at which the soil core samples are collected will be determined in the field as the depths will correspond to the intervals with the most evidence of contamination based on field screening. A minimum of two soil core samples will also be collected from the clay confining layer between the Upper PRM and Upper Middle PRM and the peat layer located above the confining layer.

- In addition, up to four soil samples from the Former Process Area will be analyzed for waste classification parameters to evaluate potential remedial action alternatives. The

waste classification samples will be collected at locations that are biased to the most evidence of soil impact. The waste classification parameters include: TCLP VOCs, TCLP SVOCs, TCLP metals, total PCBs; ignitability; corrosivity; reactivity; and BTU content.

Former Lagoon Area

Soil borings will be completed in the former Lagoon Area to evaluate the distribution and characteristics of the chemical residuals remaining from the lagoon remediation (Figures 7 and 14). One set of surface soil samples (0 to 2 and 2 to 12 inch depth intervals) will be collected from the lagoon cover (from the location of boring L-4) to assess the concentrations of COPCs in support of the human health risk assessment. Ten soil borings (L-1 through L-8 plus MW-26 and MW-27) will be completed through the former lagoon to: assess the lagoon configuration; determine the water table location; identify any perched water tables: characterize the ash and sand layers; and evaluate the characteristics of the residuals which underlie the former lagoon. In addition, eight transects (L-9 through L-16) containing two borings each for a total of 16 borings, will be completed radially around the former edge of the lagoon. The transects will be installed to assess the horizontal extent and characteristics of the lagoon residuals (including the mud wave) along the edge of the former lagoon. The borings will also be completed to evaluate if the clay confining layer above the Upper Middle PRM aquifer is present below the base of the lagoon and to support the analysis for potential DNAPL in both the Upper PRM and the Upper Middle PRM.

All soil borings in the lagoon area will be installed using mud rotary techniques. Split spoon soil samples will be collected continuously in borings from within the former lagoon and around the perimeter of the former lagoon. The soil screening (Figure 4) and sample collection procedures are as described previously. The actual boring locations and sample collection depths may be modified based on the results of the soil sampling performed during the installation of the deep wells (MW-26D and MW-27D) or modified in the field based on the findings of the initial borings. With the exception of borings L-3 through L-6; the total depth of the borings will extend through the peat/mud wave and six feet into the underlying clay layer or silty layer, or to 60 feet BGS - whichever comes first. Based on the available data, the clay layer will occur at approximately 40 feet BGS. The soil borings L-3, L-4, L-5 and L-6, and the borings for monitoring wells MW-26D and MW-27D, will be extended to the base of the Upper Middle PRM (estimated to be 120 feet

BGS) to provide additional stratigraphic and chemical characterization data, and to evaluate the potential for NAPL (Activity 3) from beneath the former lagoon.

Ash

The ash that was stabilized with lime was placed into the excavation of the former lagoon during the lagoon incineration remedial action. Although the ash was reportedly placed above the water table, precipitation infiltration percolating through, or across the top of the ash layer may affect the underlying and downgradient ground water geochemistry. Further, the ash fill line may extend below the water table in some areas. The lagoon soil borings will be sampled continuously to identify the contact between the ash and backfill and to assess the presence of perched water on top of the ash. Soil samples collected from the ash layer encountered in borings L-1, L-2, L-4, L-6 and L-8 will be analyzed for the following geochemical parameters; TOC, Eh, pH, and cation exchange capacity.

Backfill

In addition to the ash, sand from the site (former berms) and off site sources were used as backfill in the lagoon. In order to evaluate the potential affect of the sand backfill on the ground water geochemistry, five samples will be collected of the sand backfill below the ash layer, from borings L-1, L-2, L-4, L-6 and L-8. The samples will be analyzed for geotechnical parameters (TOC, Eh, pH, and cation exchange capacity). One soil core sample will also be collected from the sand backfill below the ash layer to determine the geotechnical properties of the backfill relative to ground water movement through the former lagoon.

Lagoon Residuals

Up to four samples from each boring will be collected for off-site laboratory analyses. One sample will be collected from the lagoon residuals, the second sample will be collected from the peat layer, the third sample will be collected from the top of the clay layer or silty strata and the fourth from approximately three feet into the clay/silt layer. For the deeper soil borings (L-3, L-4, L-5 and L-6, and the borings for MW-26D and MW-27) an additional four soil samples will be collected for off-site chemical analyses (Figure 14).

- One sample will be collected from the top of the Upper Middle PRM just below the clay/silt layer.

- The second sample will be collected from the intermediate depth interval exhibiting the greatest evidence of contamination based upon field screening.

- The third sample will be collected from the top of the clay layer at the base of the Upper Middle PRM.

- The fourth sample will be collected from approximately three feet into the clay layer.

Selected samples will be screened for the presence of NAPL as described in Section 7.4. Additional samples may be collected based on field screening and visual observation. Soil samples will also be collected for geochemical, hydrologic and geotechnical analyses as discussed below (Tables 2 and 3).

The lagoon residuals and surrounding fill material in borings L-1 through L-8, MW-26D and MW-27D (below the former lagoon) and in borings L-9 through L-16 will be analyzed for the following chemical groups which include the compounds of potential concern: TCL VOCs, SVOCs, and PCBs; TPH and TAL metals. All of the samples collected from the former lagoon perimeter borings (L-9A through L-16B) and the peat layer beneath the lagoon will also be analyzed for diesel range organics (DRO) and gasoline range organics (GRO). Up to twelve samples from the lagoon residuals, peat and clay will be analyzed for synthetic precipitation leaching procedure (SPLP) VOCs and metals to assess partitioning, aid in designing column leaching studies, and assess restoration timeframes. The lagoon residuals and underlying peat and clay samples will also be analyzed for geochemical parameters (TOC, Eh and pH). Six samples will be analyzed for geotechnical parameters (permeability, porosity, water content, specific gravity, plastic limits and grain size) to support the analysis of fate and transport and to evaluate potential restoration timeframes. The Shelby tubes for the geotechnical samples will tentatively be collected from borings L-1, L-2, L-4, L-8, L-10A and L-12A. At least three Shelby tubes will be collected from each of the following: the lagoon residuals; the peat layer; and the top of the clay

or silty layer; and the middle of the clay or silty layer. In the event that Shelby tube samples can not be collected (i.e. due to compression of the Shelby tube or poor recovery), samples will be collected using the ring-line barrel sample method (ASTM Method D 3550) as described in Appendix B. Where no wells are screened in a specific strata, split spoon samples will be analyzed for density, water content, plastic limits and grain size. These geochemical and geotechnical parameters will be evaluated along with the candidate technologies and preliminary remedial alternatives to decide if additional sampling is warranted.

7.4 Task IIIA, Activity 3 - NAPL Evaluation

Light nonaqueous phase liquid (LNAPL) is a hydrocarbon, with a density less than water, that exists as a separate, immiscible phase when in contact with water and/or air (USEPA, 1995). At the BROS site, LNAPL is a complex mixture of petroleum hydrocarbons, primarily the oil range compounds. LNAPL has been identified in several areas on and surrounding the BROS property:

- along the southwest and east sides of the Pepper Building;
- along the drainage swale along Route 130 (MW-13A);
- east of the former lagoon (MW-1A, S-11A);
- south and southeast of the former lagoon (Phase 3 soil borings S9W-2, S11AA-2 and S11AA-4);
- along the northern edge of the former lagoon (Phase 3 soil borings B-21, B-36 and B49W-1);
- near the office trailers (Phase 3 soil borings B-9 and R39I-1); and
- in the area of Common Reed (*Phragmites*) in the wetlands adjacent to the BROS property.

The objectives of the LNAPL investigation are to evaluate the quantity, spatial distribution (including LNAPL trapped below the water table), characteristics and recoverability of the

LNAPL on and adjacent to the BROS property. The field activities which will be performed to meet the objectives are:

- LNAPL physical characterization (Activity 3a);
- NAPL chemical characterization (Activity 3b); and
- LNAPL recoverability analysis (Activity 3d).

No DNAPL is likely present at the BROS site, based upon a consideration of: the historical waste management processes used at the site; the results of previous investigations; and the physical/chemical properties of DNAPL as they behave in the environment (Section 2.5.1.2). Based upon the concentrations of TCE detected in well S-11C, CH_2M Hill monitored for the presence of DNAPL in monitoring wells proximate to S-11C (MW-5B, S-11C, and MW-11B). The assessment involved the collection of ground water samples with a clear plastic bailer and visual observations for DNAPL. Further, DNAPLs were not reported during the 1990 and 1993 ground water sampling events conducted by CH_2M Hill. Concentrations of VOCs reported in CH_2M Hill (1996a) suggest that DNAPL is not present at the BROS site. Based upon these findings and conclusions, no additional investigations were proposed by CH_2M Hill for DNAPL evaluation.

Although DNAPL is not probable, additional investigative methods to detect DNAPL have been incorporated into the field activities at the USEPA's request. These investigations are focused on the places where DNAPL would pool and accumulate, where it would wick into low-permeability units and where it would remain after the passage of free product. The investigation has been developed based upon the USEPA OSWER guidance *Evaluation of the Likelihood of DNAPL Presence at NPL Sites* (USEPA, 1993a) and the USEPA Office of Research and Development Research Report *DNAPL Site Evaluation* (USEPA 1993b). The DNAPL investigation includes field tests for the presence of DNAPL (Activity 3e) and the analysis of laboratory data for conditions that suggest the presence of DNAPL (Section 7.4.4). In the event that free DNAPL is detected, chemical characterization of DNAPL will be completed as described in Activity 3b. Based upon all of these studies, a weight of evidence approach will be applied to determine whether DNAPL exists at the BROS site In the event that DNAPL is detected, the scope of any

further evaluation of the distribution and volume of DNAPL will be provided in a Technical Memorandum. The approach outlined in Activity 3c and the previously cited guidance would serve as the basis for these additional investigations, if needed.

During the Activity 3 investigation of the former Lagoon Area and former Process Area, field screening for NAPL will be conducted (Figure 4). This will include headspace monitoring for VOCs, visual and tactile evaluation of samples, UV fluorescence testing and hydrophobic dye testing based upon the methods outlined in the USEPA OSWER guidance *Evaluation of the Likelihood of DNAPL Presence at NPL Sites* (USEPA, 1993a) and the USEPA Office of Research and Development Research Report *DNAPL Site Evaluation* (USEPA, 1993b). Sudan IV will be used as the hydrophobic dye. The dye testing methods are described in the SOP (Appendix B, Section 22).

7.4.1 Activity 3a - LNAPL Physical Characterization

Soil borings performed as part of the Soils Investigation (Task IIIA, Activity 2) will be used to evaluate the spatial distribution of LNAPL. Soil samples in which LNAPL is suspected (significantly discolored, elevated PID/FID screening reading or visual evidence of LNAPL) will be field screened using UV fluorescence and hydrophobic dye testing as described in the SOP (Appendix B) which was developed based upon the methods described in the NJDEP *Field Analysis Manual* (NJDEP, 1994). The hydrophobic dye test is specified in NJDEP's *Technical Requirements for Site Remediation* (NJDEP, 1997) for the identification of LNAPL. Soil samples for geologic logging will be collected continuously in all of the borings from the former Process Area. Soil samples will be inspected and field screened for evidence of VOCs with selected samples screened for the presence of LNAPL (Figure 4). Soil samples which will be collected for off-site laboratory analysis based upon the field screening (Figure 4).

In addition, supplemental soil borings will be completed using a Geoprobe® to better define the extent of LNAPL. The Geoprobe® was selected because of the shallow depths planned for LNAPL studies and due the smaller diameter hole installed (as compared to hollow stem and mud rotary drilling) which will minimize the potential for smearing of LNAPL into deeper zones. The Geoprobe® boring locations will be targeted to establish the distribution of LNAPL identified in

the soils investigation; as such, the locations of these borings will be selected after the soils investigation. All Geoprobe® borings will be abandoned as described in Section 6.8.

The soil samples collected from suspected LNAPL areas will be analyzed for TOC, bulk density and porosity to support the calculation of site-specific soil/water distribution coefficients (K_d), which will be used in the evaluation of LNAPL mobility. Where appropriate, soil borings will be converted into monitoring wells to evaluate the presence of LNAPL and to assess actual LNAPL thickness and recoverability (Activity 3d). If LNAPL is observed, samples of the material will be collected for chemical characterization (Activity 3b).

7.4.2 Activity 3b - NAPL Chemical Characterization

Samples of the NAPL will be collected for analysis to determine constituent concentrations, define fate and transport-related characteristics, and provide information on potential remedial action alternatives. As LNAPL may exist below the water table, LNAPL and DNAPL will be distinguished based upon the relative abundance of constituents (e.g. chlorinated versus nonchlorinated hydrocarbons, DRO/GRO components) and the specific gravity of the separate-phase NAPL. Samples will be collected from each different type of NAPL encountered based on color (e.g., black, clear), apparent viscosity (e.g., thick, thin) and depth interval encountered. A primary characterization objective is to assess the relative hydrocarbon fractions (e.g. aromatics, PAHs, isoparrafins, chlorinated VOCs) that make up the NAPL as these characteristics are directly related to solubility, adsorption, mobility and recoverability and will be used in the risk assessment and to evaluate remediation timeframes and remedial alternatives effectiveness. These hydrocarbon fractions will be determined through analysis of NAPL for: TCL-VOCs, specific gravity; API gravity; viscosity; DRO; GRO; PCBs and lead (Table 4). Soil samples containing suspected NAPL will also be analyzed for VOCs and soil samples saturated with NAPL will be analyzed using the synthetic precipitation leaching procedure (SPLP) for VOCs and metals to evaluate the concentration and constituents which can leach into ground water.

SPLP will provide a basis for the selection of samples for subsequent column leaching tests and for the assessment of contaminant fate and transport. In particular, chemical testing, SPLP, and

permeability results will be used to select a range of stratigraphic units, contaminant types and contaminant concentrations for column leaching tests. Also, the SPLP results for samples from various stratigraphic units will be used to assess the relative contributions of residual NAPL to the dissolved phase constituents. The SPLP results will assist with a determination of the degree to which LNAPL will serve as a long term source for ground water COPCs. As such, SPLP samples will be collected from a range of NAPL types and stratigraphic units.

7.4.3 Activity 3d - Recoverability Analysis

Monitoring wells in which LNAPL is detected, historically MW-1A, MW-13A, S-11A and in the "USGS" monitoring well near the Pepper Building, will be evaluated to determine the thickness of the product in the well using a bail down test (USEPA, 1996; Hughes et al, 1988). The bail down test methodology used to calculate the actual thickness of free product is provided (Appendix F).

Product baildown tests will be conducted monthly for up to six months, in order to evaluate the variability in bail down results and to assess at what rate LNAPL will continue to move into the well. After at least three rounds of data have been collected, the potential for total fluids recoverability testing and/or pilot testing of LNAPL recovery will be assessed.

The LNAPL that is recovered during the bail down tests will be placed into 55-gallon drums. Each type of LNAPL, based on color (e.g., black, clear) and apparent viscosity (e.g., thick, thin) will be placed in separate 55-gallon drums. The drums will be placed in a secure place on the BROS property and will be labeled as to which well or wells were the source of the LNAPL and the beginning of the accumulation period. At the end of the LNAPL recoverability analysis samples will be collected from each type of LNAPL and analyzed for waste classification parameters (TCLP, VOCs, SVOCs, PCBs, and metals; ignitability; corrosivity; and reactivity) plus any waste disposal facility parameters.

7.4.4 Activity 3e - DNAPL Investigations

DNAPL investigations are focused on the places where DNAPL would pool and accumulate, where it would wick into low-permeability units and where it would leave residual DNAPL. The investigation has been developed based upon the USEPA OSWER guidance *Evaluation of the*

Likelihood of DNAPL Presence at NPL Sites (USEPA, 1993a and the USEPA Office of Research and Development Research Report *DNAPL Site Evaluation* (USEPA 1993b). An assessment of historical data coupled with the conceptual model describing DNAPL fate and transport was used to develop the scope of DNAPL investigations. These investigations include a variety of site characterization methodologies, as listed below.

- Installation of soil borings (Activity 2) and monitoring well pilot holes (Activity 4), with the collection of continuous split-spoon soil samples from the Upper PRM and Upper Middle PRM in the former Process and Tank area and the former Lagoon area. Soil samples will be collected from immediately above and within low permeability units to assess the potential for accumulation and wicking of DNAPL. Based upon screening in the field (Figure 4), soil samples will be evaluated for DNAPL using UV fluorescent and hydrophobic dye screening and laboratory analysis.

- Installation and sampling of monitoring wells screened at the base of the Upper PRM aquifer to assess vertical gradients of VOC concentrations.

- Installation and sampling of monitoring wells screened at the base of the Upper Middle PRM aquifer to screen for free-DNAPL and assess vertical gradients of VOC concentrations.

- Collection of pre-purge samples of stagnant water from the bottom of wells S-3C, S-11C, MW-4D, MW-5B, MW-21D, MW-22D, MW-23D, MW-26D and MW-27D using clear plastic, bottom-loading bailers to screen for the presence of DNAPL using a hydrophobic dye test (Activity 4).

- Should DNAPL be encountered and sampled, a waiting period of at least 24 hours will occur before collecting ground-water samples to allow time for the aquifer to stabilize.

- Collection of ground water samples using the USEPA Region 2 Low Stress (Low Flow) sampling procedure and analysis of ground water samples for VOCs (Activity 4).

7.5 Task IIIA, Activity 4 - Ground Water Investigation

The ground water investigation is designed to supplement the existing data and to:

- determine the nature and extent of LNAPL;
- screen for the presence of DNAPL;
- delineate the extent of COPCs in the Upper PRM;
- delineate the extent of COPCs in the Upper Middle PRM;
- obtain treatability and geochemical data to support the FS;
- evaluate the temporal and spatial changes in the site hydrology and ground water quality;
- evaluate the fate and transport of compounds of concern; and
- assess the processes of natural attenuation.

There are currently approximately 55 monitoring wells and five piezometers installed on and around the BROS site. The Phase 2 RI activities will install approximately 45 additional wells; 12 of which are the wetland monitoring wells. The wetland monitoring wells only have two feet of screen and are either two or five feet below the ground surface (Figure 18). The final locations of the 33 new conventional monitoring wells, excluding the wetland monitoring wells, are illustrated in Figures 9 and 10 and their justification is summarized in Table 15. The actual locations of the monitoring wells will be determined based on field screening activities, results of preceding activities and property access. A summary of the proposed monitoring well construction details is presented in Table 16. The monitoring well construction will be consistent with the New Jersey monitoring well specifications (N.J.S.A. 58: 4A-4.1 et seq.) (Figure 19).

7.5.1 Activity 4a - Ground Water Quality Evaluation

Monitoring Well Installation

To assess hydrogeologic and ground water quality conditions, 45 monitoring wells (33 with MW- or PZ-designations and 12 with WMW-designations) will be installed during the RI. The WMW-

designated monitoring wells are shallow monitoring wells located in the Little Timber Creek Swamp. The MW-designated wells includes five monitoring well clusters and 11 individual wells. The overall objective of this task is to characterize hydrogeologic and ground water quality conditions in the Little Timber Creek Swamp, Upper PRM and Upper Middle PRM aquifers underlying the site. The shallow wetland monitoring wells, screened between 0 and 2 feet BGS, will be designated with an "A" and the deeper wetland monitoring wells, screened between 3 and 5 feet BGS, will be designated with a "B". These wells are represented in Figure 17, which presents the rationale for water level investigations in the wetlands areas.

Monitoring wells screened in the shallow water-table aquifer (i.e., Upper PRM) will be designated by "S"; deeper wells, screened at the base of the Upper PRM will be designated by "L"; intermediate wells screened within the top of the Upper Middle PRM will be designated by "I"; and deep wells screened within the bottom of the Upper Middle PRM will be designated by "D".

Wetland Monitoring Wells

The wetland monitoring wells will be installed by a New Jersey-licensed driller using hand auger techniques. The shallow wetland monitoring wells (WMW-1A through WMW-6A) will consist of a two foot section of stainless steel riser, used for stability, attached to the bottom of a 2-inch diameter, 0.010 inch slot, stainless steel well screen (Figure 18). The screen size was selected due to the presence of silt and small organic particles present in the wetlands. A three foot length of 2-inch diameter stainless steel riser with locking well cap will be placed above the screen. When installing a shallow wetlands monitoring well, the driller will advance a hand auger inside temporary casing to three feet below the ground surface. The assembled well components will be lowered through the surface casing and driven until the top of the screen zone is one foot below the ground surface and the riser extends two feet above the surface. Sand pack (No. 0 Morie) will be placed in the annular space and the surface casing will be removed. This size sand is appropriate for filtering fines from the formation water while minimizing the volume of sand passing into the well through the screen.

The deep wetlands monitoring wells (WMW-1B through WMW-6B) will be constructed of a two-foot length of 2-inch diameter, 0.010 inch slot, stainless steel screen with a six-foot length of

2-inch diameter stainless steel casing above the screen, the casing extends two feet above the ground surface (Figure 18). When installing this type of well, the driller will hand auger to six feet BGS inside a temporary surface casing. The assembled well components will then be placed through the surface casing and sand pack (No. 0 Morie) will be placed in the annular space to approximately 6-inches above the top of the screen. The temporary casing will then be removed and the remaining annular space will be filled with a cement/bentonite slurry.

A protective surface casing with a locking cap will be installed over the top of the monitoring well casing, where possible. Where a locking cap is used on the casing the well will be vented on the side. A concrete well "apron" will be applied at the surface and graded away from the well unless this configuration is restricted by the presence of surface water or by very shallow ground water that would result in the apron bridging the water table.

Upper PRM and Upper Middle PRM Monitoring Wells

Shallow monitoring wells (less than 30 feet deep) installed in the Upper PRM aquifer/fill material will be installed through hollow-stem augers with the exception of the shallow wells installed within the former lagoon which will use mud rotary drilling equipment. Deeper monitoring wells (greater than 30 feet) installed into the Upper PRM, and all monitoring wells installed in the Upper Middle PRM will be completed using mud rotary drilling equipment. All of the proposed monitoring wells installed in the Upper PRM will be constructed as single-cased wells (Figure 19). All monitoring wells installed in the Upper Middle PRM (all intermediate and deep wells), will be constructed as a double-cased well with the outer casing seated into the confining layer between the Upper PRM and Upper Middle PRM (Figure 19).

All Upper PRM and Upper Middle PRM monitoring wells will be constructed of two-inch stainless steel screens and risers. A 10-foot, 20-slot continuously-wrapped well screen will be installed in the zones to be monitored. The screen size is consistent with the 35 monitoring wells installed in the MW-series by CH_2M Hill during the last investigation phase. A filter pack of washed Morie #1 sand will be placed in the annulus between the borehole and the screen from the base of the screen to approximately two feet above the top of the screen. This size sand is appropriate for filtering fines from the formation water while minimizing the volume of sand

passing into the well through the screen. A bentonite-cement grout will be installed in the annulus above the sand pack to the ground surface using a tremie pipe. Each monitoring well will be completed with a flush-mounted, bolt down curb box or a stick-up, steel protective casing. A concrete "apron" will be completed at the surface and graded away from the well to prevent pooling of water around the well. Access to the monitoring well will be prevented by a locked cap or casing. A more detailed description of the monitoring well installation protocol is presented in Appendix B.

Roux Associates, Inc. will provide oversight of all well drilling, installation, and development activities in accordance with the SOPs which are presented in Appendix B. Monitoring well pilot boreholes will be drilled according to the procedures described under Task IIIA, Activity 2, with the following exceptions:

- At locations where monitoring well clusters are proposed, the deep pilot borehole will be installed first, with split spoon soil samples being collected continuously to determine hydrogeology. Split-spoon samples will not be collected from the shallower wells in each cluster.

- Two soil samples will be collected from the wells for laboratory analyses, with the exception of the clustered wells. For well clusters, five soil samples will be collected from the deepest pilot borehole within the cluster; soil samples will not be collected from the shallower pilot boreholes within the cluster unless they are necessary to supplement other samples (e.g. in cases of poor recovery).

- Natural gamma borehole geophysical logs will be completed in all twelve of the deep monitoring wells (MW-4D, MW-17D, MW-18D, MW-19D, MW-20D, MW-21D, MW-22D, MW-23D, MW-26D, MW-27D, MW-33D and MW-34D). Pilot borings will be logged in monitoring wells MW-18D, MW-20D, MW-21D and MW-22D so that the clay confining unit between the Upper PRM and Upper Middle PRM can be identified and the screens of the shallower wells can be accurately installed. Natural gamma logs will be completed within the slotted augers at MW-17D, MW-19D, MW-33D and MW-34D to

aid in the selection of the screen zone. The remainder of the wells will be logged after completion of the deep wells. The natural gamma logs will detect clay and silt zones based on their increased natural radioactivity compared to the clean sands which dominate the PRM aquifers. The fine grained units can be correlated between monitoring wells based on the profile of the logs. Numerous previously installed monitoring wells were logged for natural gamma (CH_2M Hill, 1996) which will be used for correlation of stratigraphic units in cross-sections across the site in various directions.

All monitoring well boreholes will be logged based on visual inspection of the soils collected from split spoon samplers. The well logging will be done in accordance with the Burmister Method (Appendix B). Monitoring well logs will be prepared using the Well Monitoring Log (Appendix D). A monitoring well construction form will be completed for each well (Appendix D) to document the construction details of each well.

Except where slotted auger screening will be used, up to five soil samples from each of the deep monitoring well borings will be collected for analyses:

- a sample will be collected from the base of the Upper PRM;
- a second sample will be collected from the top of the Upper Middle PRM just below the clay/silt layer;
- a third sample will be collected from the intermediate depth interval exhibiting the most evidence of contamination based on field screening and visual observation;
- a fourth soil sample will be collected from top of the clay layer at the base of the Upper Middle PRM; and
- a fifth sample will be collected approximately three feet into the clay layer at the base of the Upper Middle PRM.

Additional samples may be collected, based upon field conditions and soil screening (Figure 4), to evaluate the vertical distribution of COPCs in the confining layer as this data will be important in evaluating remediation timeframes. Sample strategies will be consistent with those outlined for deep soil borings (Activity 2). Soil samples collected for analysis will be sent to a laboratory and analyzed for TCL VOCs and SVOCs, PCBs and TAL metals.

Soil samples from the shallow monitoring wells (MW-24S, MW-25S and MW-28S through MW-32S) will be collected continuously from the surface to the bottom of the borehole. Two soil samples will be collected for off-site laboratory analysis during each well installation; a sample from the six-inch interval above the water table and one from a greater depth to evaluate vertical contamination gradients. The location of this deeper sample will be based upon field screening as described in Activity 2.

The investigation-derived wastes generated during monitoring well installation and development will be collected, containerized, sampled for waste disposal parameters, and transported and disposed in accordance with the Consent Decree and applicable Federal and State regulations as described in Section 6.7.

The newly installed monitoring wells will be developed after completion to remove fine sediment from the well and enhance the hydraulic connection between the well and the surrounding formation. Monitoring wells and wetlands monitoring wells will be developed using one or more of the following methods based upon the location of the well, the materials encountered during installation and the degree of development necessary:

- pumping;
- surging (with a surge block) with or without jetting with air;
- jetting with compressed air; and
- pumping with compressed air.

Well development will be conducted in accordance with NJDEP protocols as presented in the SOP (Appendix B). Development will continue until each monitoring well produces sediment-clear water to the extent possible, a good hydraulic connection is established between the well screen and the aquifer and the following geochemical parameters have stabilized (i.e., measurements collected at five minute intervals do not vary by more than 10%): pH, specific conductivity, and temperature. In the event that the geochemical parameters do not stabilize after the development water has cleared, development may be suspended and resumed at a later date. All development water will be managed as described in Section 6.7. The well development will be conducted in accordance with SOPs provided in Appendix B.

Following installation of all monitoring wells, each well will be surveyed for horizontal and vertical coordinates by a New Jersey-licensed surveyor in accordance with the procedures outlined in Section 7.1.1. Both surface elevations and measuring point elevations will be measured at each well. Horizontal control will be measured to an accuracy of 0.10 foot, and vertical control will be measured to an accuracy of 0.01 foot.

Proposed Upper PRM Monitoring Wells

Sixteen monitoring wells will be installed into the Upper PRM or fill material (Figure 9). The monitoring wells in the Upper PRM will supplement the existing network of Upper PRM wells to define the extent of LNAPL and COPCs in the Upper PRM. The data obtained from the monitoring wells will also be used to calibrate the ground water flow model, and for the fate and transport assessment, the risk assessment and the feasibility study.

Monitoring wells MW-24S, MW-25S, MW-28S, MW-29S, MW-30S, MW-31S, MW-32S will be screened across the water table and will evaluate the presence of LNAPL and concentrations of COPCs in the former source areas. These monitoring wells will be completed to a depth of approximately seven feet below the water table with a screen extending three feet above the water table, allowing free product to enter into the well, if present. Depending upon the time of year that the wells are installed, the screened interval may need to modified to ensure that the screen bridges the water table and that any free LNAPL can enter the well. The specific screened

interval should be selected based upon evidence of staining, the presence of ground water or mottled soils and water level data from prior investigations.

Monitoring wells MW-26S and MW-27S will be installed in the sand backfill in the lagoon (i.e., below the ash layer) to evaluate the ground water quality and hydrology within the lagoon. Nearby monitoring wells will be gauged to evaluate the equilibrated depth to water level prior to setting the screen and casing in the borehole. Monitoring wells MW-21S and MW-22S will be installed across the water table in the Little Timber Creek wetlands to the southeast of the former lagoon. Monitoring well MW-23S will be installed across the water table to the south of the former lagoon, immediately adjacent to Swindell Pond.

Two monitoring wells, MW-21L and MW-22L, will be installed to the base of the Upper PRM (screened above the clay confining unit) and are designated with an "L". In conjunction with the results of soil investigations (Activity 2), these wells will provide data to evaluate the vertical and horizontal distribution of COPCs in the Upper PRM downgradient of the BROS property. Other wells screened near the base of the Upper PRM aquifer (MW-11A(D), MW-14A, MW15A, MW-16A) will also be sampled during the Phase 2 RI. Additional L-series wells will be installed near the former lagoon and former Process Area if warranted based upon the results of the soils investigation. The locations and rationale for any additional wells will be provided in a Technical Memorandum for USEPA review and approval.

Two monitoring wells will be installed through the base of the ponds to the south and southwest of the former BROS Lagoon. The monitoring wells will be used to characterize the surface water/ground water relationship between the ponds and the underlying Upper PRM aquifer and will also be used to calibrate the ground water modeling efforts. Monitoring well PZ-1 will be installed in the northeast corner of Gaventa Pond and monitoring well PZ-2 will be installed in the northern portion of Swindell Pond. Both monitoring wells will be completed with ten feet of screen, with the top of the screen set five feet below the bottom of the pond. Stainless steel casing and riser will stick up a minimum of three feet above the surface of the pond. The objective of the screened interval is to monitor the Upper PRM immediately below the ponds. If the Upper PRM is either too thin to monitor or not present, the screen will be set into the clay or

silt layer below the pond or into the top of the Upper Middle PRM below the anticipated clay confining layer. The wells will be installed using a hollow-stem auger drill rig mounted on a barge or pontoon-type boat. In order to stabilize the casing which sticks up above the bottom of the pond several guide wires will be attached to the casing and installed into the sides of the pond or anchored at the bottom of the pond. Shelby tube samples will be collected from near the top of these well borings (i.e. near the base of the pond) for geotechnical analysis. The purpose of the geotechnical analysis is to evaluate the flow between the pond and ground water. The Shelby tube sample will be collected from the first encountered firm material (as opposed to loose sediment near the base of the pond) which is expected to be fine-grained residuals from the sand mining operations. Geotechnical data from this depth interval should provide a basis for the evaluation of conductivity from the zone of lowest transmissivity.

Sampling of soils in the monitoring well clusters (MW-21, MW-22, MW-23, MW-26, and MW-27) will completed in the deepest well, which will be installed first, to evaluate the subsurface conditions at each location. Based on the soil sampling performed in the deep well, the screened interval for each shallower monitoring well in the cluster will be determined and the wells will be installed without soil sampling. Additional sampling could be conducted if recovery volumes or site conditions warrant.

Soil samples from the shallow monitoring wells not in clusters (MW-24S, MW-25S and MW-28S through MW-32S) will be collected continuously from the surface to the bottom of the borehole. Given that most of these wells are being installed to delineate the suspected LNAPL areas, soil samples will be field screened (Figure 4) and screened for the presence of LNAPL as discussed in Section 7.4 (Task IIIA, Activity 3). A maximum of two soil samples for laboratory analysis will be collected during each well installation; a sample from the six-inch interval above the water table and a sample which exhibits the most evidence of contamination visually or through field screening. The soil samples will also be analyzed for VOCs, SVOCs, metals and PCBs (Table 5). In addition, Shelby tube or ring-line barrel samples will be collected from the screen zones of selected wells based upon the results of the soils investigation. Preliminarily, these wells are identified as MW-24S, MW-25S, and MW-31S. The undisturbed soil core samples will be analyzed for porosity, grain size, permeability, water content, specific gravity and plastic limits.

Proposed Upper-Middle PRM Monitoring Wells

Seventeen monitoring wells will be installed into the Upper Middle PRM, (Figure 10). Monitoring wells will be screened at the top and bottom of the aquifer to assess the vertical distribution of COPCs. Five of the proposed monitoring wells will be installed in the upper portion of the Upper Middle PRM aquifer and are designated with an "I" for intermediate depth. Twelve of the proposed monitoring wells will be installed at the base of the Upper Middle PRM aquifer and are designated with a "D" for deep. The proposed monitoring wells in the Upper Middle PRM will supplement the existing network of Upper Middle PRM wells to evaluate horizontal and vertical distribution of COPCs downgradient of the source areas, and to evaluate the vertical hydraulic gradients. The data obtained from the monitoring wells will also be used to calibrate the ground water flow model (Task IIIB, Activity 4b).

Monitoring wells MW-21I, MW-21D, MW-22I and MW-22D will be installed in Little Timber Creek wetlands to the southeast of the former lagoon to monitor the Upper Middle PRM aquifer. Shallower S- and L-series wells will also be installed at these locations. Monitoring wells MW-23I and MW-23D will be located adjacent to the northern end of Swindell Pond in a cluster with shallow well MW-23S to monitor the top and base of the Upper Middle PRM aquifer, respectively.

Monitoring well MW-4D will be installed to screen for the presence of DNAPL at the base of the Upper Middle PRM and to assess the vertical and lateral distribution of COPCs immediately to the south of the former lagoon. One monitoring well proposed to monitor the base of the Upper Middle PRM, MW-20D, will be installed to the west of the former BROS Lagoon in the orchard north of Gaventa Pond.

Monitoring wells MW-26I, MW-26D, MW-27I and MW-27D will be installed through the former lagoon and will monitor the Upper Middle PRM aquifer (Figure 14). During installation of monitoring wells MW-26D and MW-27D, soil samples will be collected for geotechnical parameters to confirm the presence of a low permeability silt and clay layer below the base of the former lagoon. In addition to the samples selected for dye testing based upon field screening, soil samples collected near the base of the former lagoon, approximately 25 to 35 feet BGS, will be

tested for the presence of NAPL (see Section 7.4). Monitoring wells MW-26D and MW-27D will monitor the base of the Upper Middle PRM. Monitoring wells MW-26I and MW-27I will be installed in the Upper Middle PRM just below the lagoon. The monitoring wells in the Upper Middle PRM aquifer installed below the former BROS Lagoon will be used to screen for the potential presence of DNAPL; to evaluate vertical and horizontal ground water quality trends; and to evaluate the hydraulic relationships between the ground water in the former lagoon, Gaventa Pond and the Upper Middle PRM aquifer.

Well Installation Based Upon Ground Water Screening Using Slotted Augers

Monitoring wells MW-17D, MW-18D, MW-19D, MW-33D and MW-34D will be installed to the south of Route I-295 to determine the horizontal distribution and gradients of COPCs south of Route I-295. Through the use of slotted auger screening of ground water, information will also be collected on the vertical distribution of COPCs in this area. The screen interval for these wells will also be defined using the slotted auger data. Access agreements will be required for these off-property wells prior to installation. Therefore, the actual locations of these wells will be adjusted to accommodate the local property owners and allow for easy access for drilling equipment and future sampling events. Due to the importance of these locations in achieving the Phase 2 RI/FS objectives, the field schedule has been structured so that these wells will be installed early in the project to allow for rapid sampling and installation of additional wells if warranted. These monitoring wells will be sampled two weeks after development with analysis for VOCs on a rapid turnaround basis. If the ground water quality from these monitoring wells suggests that additional locations are necessary, additional locations will be proposed in a Technical Memorandum.

Slotted augers will be used to field screen the vertical extent of COPCs in ground water at monitoring well locations MW-17D, MW-18D, MW-19D, MW-33D and MW-34D. The first step of the process will be to install a pilot boring at one location (MW-18D) to the top of the confining unit between the Upper Middle and Lower Middle PRM in order to evaluate stratigraphy southeast of I-295. The stratigraphy will be evaluated by collecting continuous split spoon samples from the surface to the confining layer between the Upper Middle and Lower Middle PRM, a natural gamma log on the boring will be conducted to verify visual observations.

The pilot boring will then be abandoned using procedures described in Section 6.8. Information from the pilot boring will be compared to existing site data to develop stratigraphic interpretations of the Upper PRM and Upper Middle PRM southeast of I-295. Because the monitoring wells south of Route I-295 (MW-17D, MW-18D, MW-19D, MW-33D and MW-34D) are parallel to strike and the stratigraphy in this area is anticipated to be similar between wells (as was seen in MW-14B through MW-16B), the depth of the confining layers can accurately be extrapolated laterally when combined with existing site stratigraphic information and the results of gamma logging. Therefore, only one pilot boring is proposed in this series of wells.

For the other slotted auger locations (MW-17D, MW-19D, MW-33D and MW-34D), the screened interval will be established based upon the ground water screening results from the slotted augers and a natural gamma log performed through the slotted auger system. These field results will be compared to the stratigraphic information from the pilot boring at MW-18D (i.e. classification of split spoon samples, natural gamma logging, ground water quality data) and the existing stratigraphic data from other wells throughout the study area to determine the optimum location for the screened interval at MW-17D, MW-19D, MW-33D and MW-34D. The USEPA will be verbally apprised of the results of the analysis before the well screen intervals are set.

For the Upper PRM, the slotted augers will be advanced to a point five feet below the water table; a sample will be collected for VOCs and analyzed by a field laboratory using SW-846 methodology (USEPA, 1997c). Additional samples will be collected for field laboratory testing in the Upper PRM at 20 foot intervals, until the confining layer at the base of the Upper PRM is reached. One additional sample will be collected from the interval just above the confining layer between the Upper PRM and Upper Middle PRM,; this sample will be analyzed for VOCs by the field laboratory. The auger string will then be removed. The bore hole will be reamed with a larger diameter auger. A surface casing will be installed into the confining layer and grouted in place to facilitate sampling in the Upper Middle PRM and the eventual installation of a deep monitoring well.

The well casing will be allowed to set for two days prior to the collection of ground water field screening samples from the Upper Middle PRM. The slotted auger will be advanced five feet

below the confining unit; a ground water sample will be collected and analyzed for VOCs by the field laboratory. Subsequent ground-water samples will be collected from the Upper Middle PRM at 20 feet intervals and analyzed for VOCs by the field laboratory. One additional ground-water sample will be collected from the five foot interval above the confining layer between the Upper Middle and Lower Middle PRM and analyzed for VOCs by the field laboratory.

A natural gamma log will be performed on the boring through the slotted auger to aid with the evaluation of the stratigraphy. After the field laboratory results are received they will be evaluated and, along with a comparison of the natural gamma log to stratigraphic information from other wells around the site, the screen zone for the well will be selected. The deep monitoring well will be completed through the surface casing in accordance with the procedures outlined in the Appendix B, the drill rig will be mobilized to the next location and the procedure will be repeated.

Physical and Chemical Analysis

If possible, Shelby tube samples will be collected during monitoring well installation to provide geotechnical information about the aquifer matrix. The geotechnical parameters include porosity, water content, specific gravity, plastic limits, grain size and permeability. As numerous Shelby tube samples will be collected during the soils investigation (Task IIIA, Activity 2), collection of monitoring well-specific Shelby tubes in the Upper PRM will be limited to samples near the screened zones for three monitoring wells, preliminarily identified as MW-24S, MW-25S and MW-31S. For the Upper Middle PRM wells, Shelby tube samples will be collected near the screened interval for each well. Additional Shelby tubes may be collected based upon the observations of stratigraphic units in the field. Shelby tube samples will be collected in accordance with the procedures set forth in ASTM D 1587 *Thin-Walled Tube Sampling of Soils* (Appendix B). In the event that Shelby tube samples can not be collected (i.e. due to compression of the Shelby tube or poor recovery), samples will be collected in a series of four six-inch brass rings stacked within a three inch split-spoon sampler with a sample retention basket using the procedures presented in ASTM Standard Method D 3550 Ring-Line Barrel Sampling of Soils (Appendix B). If neither of these methods are successful in collecting undisturbed samples slug

testing of monitoring wells situated in these units will be performed as described in Appendix B to estimate aquifer parameters.

Ground water sampling will be performed quarterly at the site (Table 5). SOPs for measuring water levels; sounding monitoring wells; decontamination of nondisposable measuring, sampling, and field analytical equipment; and implementing QA/QC procedures are provided in Appendix B. Purging, sampling, and pump decontamination will be performed in accordance with the procedures outlined in Appendix B. The pump used for ground-water sampling will be an adjustable rate stainless-steel positive displacement bladder pump. The bladder will be Teflon® and the pump tubing will be Teflon®-lined polyethylene. The pump will be held in place with Teflon®-coated stainless steel wire. Well sampling will begin in background and relatively clean areas and progress towards the wells with higher concentrations of COPCs to reduce cross-contamination possibilities. In addition, the well with the lowest concentrations of COPCs in a cluster will be sampled prior to the wells with higher concentrations, if any of the same equipment will be used for both wells. All disposable sampling equipment (e.g., disposable bailers) will be discarded in an appropriate manner. A synopsis of these procedures is provided below. The locations of the monitoring wells proposed for quarterly sampling are depicted in Figure 11. A summary of ground water samples to be collected as part of Task IIIA, Activity 4b and corresponding analytes is provided in Table 5.

Prior to the first, third and fourth ground water sampling events, water levels will be gauged in all BROS site monitoring wells and select CLTL monitoring wells within 1,500 feet of the BROS site. The RI Manager should be consulted to identify the CLTL wells to be gauged. Prior to the second sampling event, the water level elevations in all site monitoring wells and an expanded suite of CLTL monitoring wells will be gauged. The CLTL wells to be included in this gauging round will be selected based on the following:

- well construction;
- condition of the monitoring wells;

- CLTL treatment system design; and
- access issues.

The CLTL wells to be included in this second round of gauging and the rational for selecting these wells will be provided in a Technical Memorandum to the USEPA.

The initial round of ground water sampling will be performed prior to the installation of new monitoring wells to evaluate the current ground water quality. During the initial round of ground water sampling, the following 43 monitoring wells will be sampled: all 30 of the "MW" series wells, S-1A, S-1B, S-1C, S-2A, S-2C, S-3A, S-3C, S-4, S-6, S-11A, S-11C, EPA-107 and EPA-108.

The second round of ground water sampling will take place after the new wells have been installed. During the second round of ground water sampling all of the new wells will be sampled plus the following existing monitoring wells: MW-1A, S-2C, S-3C, MW-5B, MW-7A, MW-8A, MW-8B, MW-10B, MW-11B, S-11A, S-11C, MW-13A, and MW-14B.

During the third and subsequent rounds of quarterly ground water sampling, the previously existing wells sampled in the second round plus the following new monitoring wells will be included in the quarterly monitoring program: MW-18D, MW-20D, MW-21D, MW-22D, MW-23D, MW-24S, MW-25S, MW-33 and MW-34D. The intermediate zone wells (L-series and I-series) which will be included in the quarterly monitoring program will be determined after the initial sampling of these wells. During the subsequent rounds, only the wells that were sampled during the third quarterly round will be resampled; samples collected during subsequent rounds will be analyzed for the second quarterly round parameters once a year and for VOCs during the remaining rounds. Proposed changes for the quarterly monitoring program will be identified in a Technical Memorandum for USEPA approval.

All of the monitoring wells sampled will be purged and sampled using the March 20, 1998 Region II Low Flow/Low Stress Sampling Protocol (USEPA, 1998b), which has been appended

(Appendix G), unless modifications have been approved by USEPA due to excessive turbidity or difficulty in reaching the stabilization criteria. However, all previous ground water sampling was performed using traditional purge and sampling methods. For this reason, a methods comparability analysis of data obtained using both methods will be performed. The objective of the comparability analysis is to establish the trends between historical and new ground water quality data; this will facilitate the evaluation of the influence of the lagoon work and the COPC concentration changes associated with natural attenuation, which will provide the data necessary for the prediction of spatial and temporal changes in ground water quality. The collection of a minimum of three rounds is proposed to establish a mean and standard deviation for assessment of comparability. All samples will be analyzed for TCL-VOCs.

For the comparability analysis, certain monitoring wells will be purged and sampled using traditional methods in addition to being purged and sampled using low flow/low stress techniques:

- For the first sampling event, the following monitoring wells will be included in the comparability analysis: S-11C, MW-5B, MW-7A, MW-8A, MW-8B, MW-10B, MW-11B and MW-14B.

- For the second and third round sampling events, the monitoring wells listed above for the first round plus the following new monitoring wells: MW-18D, MW-20D, MW-21D, MW-22D, MW-23D, MW-24S, MW-25S, MW-29S, MW-33D and MW-34D.

- For subsequent rounds, a maximum of 30% of the wells or ten of the wells listed for the second and third rounds, whichever is less, if needed based upon the results of the prior rounds.

Low flow purge methods will be used first, then traditional purge sampling will be conducted as described in Appendix B. Prior to sampling each well, a water level and LNAPL thickness measurements will be recorded. Ground water samples will not be collected from wells containing measurable LNAPL. Ground water sampling will not be performed less than two

weeks after completion of the aquifer tests (Section 7.5.2) to avoid collection of a ground-water sample that is from a stressed aquifer.

The wells will be sampled for COPCs, as well as geochemical parameters. Ground water from all of the monitoring wells will be analyzed for the following chemical parameters TCL VOCs, TCL SVOCs (base neutral/extractables only) and TAL metals. Because the analytical suite and sampling locations for the ground water investigation may be modified based upon data collected throughout the RI (subject to USEPA approval), the RI Manager should be consulted to verify the sampling and analysis plan. The following general chemistry parameters will be analyzed: TDS, TSS, alkalinity, TOC, sulfate, chloride, nitrate, ammonia, silica, orthophosphate, sulfide, nitrite, COD, TKN, hardness, volatile fatty acids, methane, ethene and ethane. The following field chemistry parameters will be analyzed: pH, specific conductivity, Eh, dissolved oxygen (DO), ferrous iron, temperature, carbon dioxide and hydrogen sulfide. For the first round of sampling, the wells will be analyzed for the full TCL SVOC scan, as the acid extractable portion of the SVOC analysis may identify compounds that include degradation products of the source material COPCs. In addition, during the first round, all monitoring wells will be sampled for both total dissolved iron as a measurement of the ferrous iron in ground water. Samples for dissolved iron will be filtered in the field using a 0.45 micron filter. The results will be compared to iron results from unfiltered ground water samples that have been analyzed using the Hach™ field test kit. The results from the two analytical methods will be used to develop a correlation between the methods so that subsequent rounds of ground water sampling will use the Hach™ field test method for analysis of ferrous iron. New monitoring wells (MW-4D, MW-26S, MW-26I, MW-26D, MW-27S, MW-27I, MW-27D and MW-29S) and existing wells (MW-1A and S-11A) are located close to the former lagoon and ground water samples from these wells will be filtered to remove fine particulates associated with the ash/lime layer in the former lagoon. The results of TAL metal analyses of these filtered samples will be compared with the results of unfiltered samples to assess the fate and transport of metals in ground water near the former lagoon. Additionally, pre-purge samples of stagnant water will be collected from the bottom of wells (S-3C, S-11C, MW-4D MW-5B, MW-21L, MW-21D, MW-22L, MW-22D, MW-23D, MW-26D and MW-27D) using clear plastic, bottom-loading bailers to screen for the presence of DNAPL using a hydrophobic dye test.

The sampling team will wear new disposable, phthalate-free sampling gloves at each well. The ground water samples will be placed directly into appropriate laboratory-supplied containers (Table 13) and covered with Teflon™ septa and caps. The sample for VOCs will be decanted with minimum agitation and the vials will be filled to exclude headspace. The samples collected for filtered (dissolved) TAL metals will be field-filtered using a 0.45-micron membrane to remove particulates prior to submitting the sample to the laboratory. The SOPs for field-filtering water samples and for obtaining field measurements are included in Appendix B.

7.5.2 Activity 4b - Aquifer Testing

Both pumping tests (Upper PRM and Upper Middle PRM) will be performed on wells located in the vicinity of the former lagoon. The preliminary pumping well locations are midway between MW-1A and S-2C along the edge of the former lagoon for the Upper PRM test and near S-11C for the Upper Middle PRM test. The planned locations are near the greatest VOC concentrations in ground water, proximate to the potential areas of where ground water restoration is likely to be most difficult and near the wetlands. As such, the aquifer tests will provide valuable information on the effects of extraction on the source area and on potential impacts to neighboring wetlands and ponds. The timing of the pumping tests will be during the driest period of (lowest water table elevations) the year (September) to evaluate the extent and likelihood of any impact to the wetlands during the most stressful time of the year for the wetland plants.

The final locations of extraction and monitoring points will be defined following review of ground water results from the second quarterly sampling round and any recently available data from the neighboring CLTL site. This information will be used to redefine the optimum design of pumping and monitoring wells, pumping rates, and to assess the potential effects on the neighboring wetlands.. The specific pumping well locations, water level measurement locations, additional water management procedures and the chemical sampling approach will be detailed in a Technical Memorandum for USEPA approval. This Technical Memorandum and will serve as the basis for conducting the pumping tests. USEPA's *Suggested Operating Procedure for Aquifer Pumping Tests* (USEPA, 1993c) will be referred to during development and performance of the tests. An SOP for aquifer testing is provided in Appendix B which will be modified and provided to USEPA as part of the Technical Memorandum. The waste management procedures described in

Section 6.7 will be updated based upon current ground water quality data and expanded in the Technical Memorandum to reflect the specific procedures for the pumping tests.

Existing monitoring points will be utilized during the pumping tests where appropriate. The pumping wells will be ten inches in diameter and will be screened across the entire aquifer, approximately 25 to 30 feet for the Upper PRM pumping well and 40 to 50 feet for the Upper Middle PRM well. The pumping wells will be constructed with carbon steel casing and stainless steel continuous wire-wound screen. The screen slot size will be selected based upon a review of the results of a sieve analyses of sediments in the aquifers collected during the monitoring well installation.

To the degree practical, the monitoring points for obtaining drawdown data in response to pumping of the wells will include existing and proposed monitoring wells in both the Upper PRM and Upper Middle PRM in the immediate vicinity of the pumping wells. In accordance with the New Jersey Geological Survey recommendations for aquifer test monitoring points (NJGS, 1992), the monitoring points will include the following:

- a stilling tube inside the pumping well casing to monitor drawdown in the pumping well;
- a 1-inch diameter PVC stilling tube in the gravel pack outside of the pumping well casing to measure well loss across the screen and well efficiency;
- a 2-inch diameter PVC piezometer installed approximately 10 feet from the pumping well;
- two 2-inch diameter PVC piezometers installed 90 degrees apart with respect to the pumping well at distances from the pumping well equal to approximately 1.5 times the saturated thickness; and
- an existing or proposed monitoring well located at a distance of approximately five times the saturated thickness from the pumping well.

All piezometers will have ten-foot screens located approximately mid-point with respect to the pumping well screen, unless otherwise noted.

For the pumping test of the Upper PRM aquifer, an additional 2-inch diameter PVC piezometer will be installed approximately ten feet from the pumping well. The screened interval for this piezometer will be top of the Upper Middle PRM aquifer in order to measure vertical gradients across the confining clay unit and estimate vertical leakage under pumping conditions. This piezometer will be installed in a double cased borehole. This piezometer will be installed in a cluster with the 2-inch piezometer screened in the Upper PRM aquifer, and situated ten feet from the pumping well, that was listed above. If an existing well can be used, this piezometer will not be required.

For the pumping test of the Upper Middle PRM aquifer, two additional 2-inch diameter PVC piezometers will be installed approximately ten feet from the pumping well. The screened interval for one piezometer will be the base of the Upper PRM aquifer and for the second will be the top of the Lower Middle PRM aquifer. These piezometers will be used to measure vertical gradients across the confining clay units and estimate vertical leakage under pumping conditions. The deeper piezometer will be installed in a triple cased borehole. These piezometers will be installed in a cluster with the 2-inch piezometer screened in the Upper Middle PRM aquifer, and located ten feet from the pumping well, that was listed above. If existing wells can be used, these piezometers will not be required.

Well points and staff gauges in the Little Timber Creek wetlands and piezometers and staff gauges in Gaventa and Swindell Ponds will also be monitored during the aquifer tests. In conjunction with ground water elevation data, the water level data from the well points, piezometers and staff gauges in the wetlands and ponds will be used to establish the relationship between surface water and ground water in the Upper PRM aquifer. In addition, depending on the location on the Upper PRM pumping well with respect to Swindell Pond, additional monitoring points may be located between the pond and the Upper PRM pumping well. These points will be monitored to measure horizontal gradients across the pond side banks under pumping conditions as a means of assessing the potential for leakage.

Each aquifer test will consist of three phases: a background test to evaluate ambient hydrologic conditions, a step-drawdown test to determine the specific capacity of the well and approximate pumping capacity; and a 48-hour constant rate pumping test to evaluate the radius of influence and calculate the aquifer properties.

The background test will be performed prior to the performance of the step-drawdown test. Water levels in selected monitoring wells and the pumping wells, barometric pressure and precipitation will be measured over a 72-hour period to evaluate background conditions. A synoptic round of water levels will be collected from selected nearby monitoring points and automatic water level measuring data loggers will be installed into the pumping well, both 2-inch PVC piezometers and two additional monitoring points (e.g. wells, piezometers, temporary well points in Little Timber Creek wetlands) closest to the pumping well and within the anticipated zone of influence of the pump test. In addition, a data logger will be installed in the background well. The water levels in these points will be monitored continuously for 72 hours to evaluate the effects of barometric pressure changes, tidal fluctuations and precipitation. The location of the background well, which will be situated in the same aquifer as the pumping well at a distance beyond the predicted radius of influence for the pumping well, will be selected based upon the location of the pumping well and will be identified in the Technical Memorandum detailing the aquifer test protocols. Although an attempt will be made to identify a well within 0.5 miles of the BROS site, one possible location for background water-level monitoring is a USGS well cluster located at the intersection of Swedesboro and Tomlin Station Roads approximately two miles east of the BROS property. The well cluster consists of Upper, Middle and Lower PRM monitoring wells. This well was used as the background well for the aquifer tests at the CLTL site. The data loggers will start recording pre-test data approximately 72 hours prior to and during the step-drawdown test and prior to and during the constant rate pump test until the water levels have recovered to 90 percent of their pre-test values. The discharge rate of the pumping well during the test will be measured using an in-line flowmeter with a direct read gauge and checked manually throughout the test. Proof of calibration for the flow meter will be presented to the USEPA prior to conducting the aquifer tests.

The pumping rate for the 48-hour constant rate pumping test will be selected based on the results of the step drawdown tests. Based upon a review of the pumping test data from the CLTL site, pumping rates of between 150 and 200 gallons per minute will likely be employed for both aquifers. Additionally, data obtained from the nearby monitoring points and a background well will be evaluated to ensure the selected monitoring points are adequate for the constant rate pumping test. A round of water levels will be collected prior to starting the pump test and data loggers will be installed in select monitoring wells. The pumping test will commence for 48 hours at which time the pumping well will be turned off and recovery data will be collected until water levels have recovered to 90 percent of their pre-test values. The flow rate from the pumping well will be monitored as described above, and barometric pressure and precipitation will be recorded on a continuous basis throughout the course of the pumping tests.

7.6 Task IIIA, Activity 5 - Surface Water and Sediment Quality Evaluation

Surface water and soil/sediment samples will be collected from Gaventa Pond, Swindell Pond, Little Timber Creek and associated wetlands, the swale along U.S. Route 130 and north of Route 44 to major depositional areas down stream of the tide gate. The primary objectives of the sampling are to determine the spatial distribution of COPCs in relation to potential receptors and to evaluate the transport potential of COPCs via surface water from various locations within the swamp. The specific suite of analytes for samples collected from the various surface water bodies at the site are selected based upon the results of prior sampling and the understanding of historical and current site conditions as outlined in the Work Plan (see Sections 2.5 and 6.6.2 of the Work Plan), including the minimal surface water connections between the ponds and the swamp. As detailed in the Ecological Risk Assessment portions of the Work Plan (Section 6.6.2), the potential effects to receptors of the COPECs detected in the separate areas will be evaluated both individually by area and as groups where receptors are likely to use more than one area.

7.6.1 Activity 5a - Gaventa and Swindell Ponds

Surface water and sediment samples will be collected from the northeast corner of Gaventa Pond and the northern portion of Swindell Pond.

Gaventa Pond

The northeast corner of Gaventa Pond is closest to the former BROS lagoon and was previously identified to have a sheen. Three surface water samples and eight sediment samples will be collected from Gaventa Pond for laboratory analysis (Figure 12).The surface water samples will be collected from the mid-depths of the pond from a boat using a weighted-bottle sampler (Appendix B). Prior to sampling, a temperature and dissolved oxygen profile will be established to evaluate the presence of a thermocline. The profile will be established by measuring temperature and dissolved oxygen at two foot intervals from the water surface to the pond bottom. A rapid drop in temperature with depth will indicate the presence of a thermocline. If the dissolved oxygen is substantially reduced (less than 4 mg/L) below the thermocline, all surface water samples will be collected from above the thermocline where the fish are more likely to occur. The surface water samples will be collected from locations designated GVT-1 through GVT-3. The pond water samples will be analyzed for chemical and geochemical parameters to support the risk assessment and to provide data on COPC fate and bioavailability (Table 6). The chemical parameters include SVOCs and total metals. The surface water samples will also be analyzed for alkalinity, TDS, TSS, TOC, hardness, DO, pH, Eh, and ferrous iron.

The sediment samples will be collected using an Eckman sampler from a boat (Appendix B). The eight sediment samples will be designated GVT-1 through GVT-8. The sediment sample GVT-1 will be from the deeper portion of the northeastern corner of the pond. Samples GVT-2 and GVT-6 will be collected near the northern bank and samples GVT-3, GVT-4, GVT-5, and GVT-7 will be collected along the eastern bank of the pond from locations where water depth are at least 3.5 feet. If a thermocline is found to be present at these shallow sediment sample locations, the locations will be moved to locations where the sediment is above the thermocline. GVT-7 will be collected at a deep spot identified by CH_2M Hill (1996) during their bathymetric study, in an area where the pond depth is expected to be more than 20 feet.

GVT-8 will be collected from along the bank in the area of the former seep. In addition, the lateral extent of the former seep will be measured (based upon observations of staining) during the sampling effort. This information will be used in conjunction with the soils investigation (Borings L-15A and L-15B; Figure 7) to estimate the volume of contaminants remaining in soils between

the former lagoon and the northeast corner of Gaventa Pond. The sediment samples will be analyzed for chemical parameters and several geochemical parameters (Table 6). The chemical parameters include: VOCs, SVOCs, PCBs, and metals. Sediment sample GVT-1 will also be analyzed for pesticides. The geochemical parameters to be analyzed are pH, Eh, acid volatile sulfide, grain size, TOC, and cation exchange capacity.

Swindell Pond

Three surface water samples and three sediment samples will be collected from Swindell Pond for laboratory analysis (Figure 12). The surface water samples will be collected from the mid-depths of the pond from a boat using a weighted-bottle sampler (Appendix B). The surface water samples will be collected from locations designated SWD-1 through SWD-3. The samples will be collected in a few feet of water toward the former lagoon near proposed monitoring well cluster MW-23 (SWD-1), in the deep hole identified by CH_2M Hill during their bathymetric study (SWD-2), and near where Gaventa and Swindell Ponds have been connected (SWD-3).

Prior to sampling, a temperature and dissolved oxygen profile will be established to evaluate the presence of a thermocline. If a decrease in oxygen to less than 4 mg/L is associated with the thermocline the depth of water sample will be adjusted to above the thermocline. The pond water samples will be analyzed for chemical and geochemical parameters to support the risk assessment and to provide data on COPC fate and bioavailability (Table 6). The chemical parameters include SVOCs and total metals. The surface water samples will also be analyzed for alkalinity, TDS, TSS, TOC, hardness, DO, pH, Eh, and ferrous iron.

The Swindell Pond sediment samples will be collected using an Eckman sampler from a boat (Appendix B). The three sediment samples will be designated SWD-1 through SWD-3. The sediment samples will be analyzed for chemical parameters and several geochemical parameters (Table 6). The chemical parameters include the following metals: arsenic, chromium, copper, lead and zinc. Sediment sample SWD-2 will also be analyzed for pesticides. The geochemical parameters to be analyzed are pH, Eh, acid volatile sulfide, grain size, TOC, and cation exchange capacity.

7.6.2 Activity 5b - Little Timber Creek Swamp and Cedar Swamp

Twenty-two surface water, 61 soil/sediment and 12 shallow ground water sampling locations are planned for the Little Timber Creek and the swamp area to the east of the former BROS Lagoon between Routes I-295 and 130 and to the north of Route 130 (Figure 13). In addition, a total of five surface water and 15 soil/sediment sampling locations are planned for the five reference areas (Figure 14). The sampling locations are depicted on recent aerial photographs in response to a request of USEPA during the initial scoping process. This figure conveys the relationship between sampling locations and wetland features (i.e. vegetation and surface water patterns). Specific sampling locations will be established in the field as described below.

Soil/sediment samples will be collected to characterize the concentration gradients of COPECs extending out from areas with residual LNAPL (Figures 13 and 19). Sediment sample locations will target biologically active areas of the wetland that may have received site releases, as identified through the macroinvertebrate evaluation component of the wildlife survey (Section 7.8.4) and the dye tracer study (Section 7.2.2), respectively. Within Little Timber Creek Swamp, sample locations within the exposure pathway of site related COPECs, will target the microhabitats that contain the greatest number and diversity of macroinvertebrates, such as hummock sides, the vicinity of tree roots, or centers of depressions. Sediment samples will not be collected at bridges, culverts, or areas potentially scoured during high flows as these are not depositional areas where COPECs associated with fine texture particulates would accumulate. Within Cedar Swamp, depositional areas within the drainage channel downstream of the tide gate will be sampled. Where the project schedule permits, sediment samples for macroinvertebrate community analyses and/or sediment toxicity tests will be collected from the same locations as the sediment quality characterization samples to correlate biological observations with chemical concentrations. Surface water samples will be used to determine the mobility of the residual contaminants based on sediment contaminant distribution and surface water flow analysis. These sampling results will also serve as inputs to the human health and ecological risk assessment.

The sampling plan has been developed to complement the water budget analysis and to:

- characterize the horizontal and vertical distribution of LNAPL in the *de manifestis* zone to support an estimate of the volume of contamination;
- establish gradients of COPECs to define the intermediate zone boundaries;
- determine the distribution of residual contaminants as related to exposure point concentrations;
- characterize the physical and chemical properties of surface water and sediment in the wetlands in support of the fate and transport analysis used for the risk assessment and FS;
- characterize the de minimis zone; and
- update the contaminant transport model.

The previous wetland investigation focused on the areal extent of contamination in Little Timber Creek Swamp adjacent to the former lagoon and identified the presence of site-related constituents at the downstream end of the swamp at Route 130. Delineation of the wetlands contamination is proposed as a phased approach. The sampling plan is designed to be completed in phases, using an on-site laboratory to screen sediment samples for TPH and lead. The on-site screening results will be mapped to establish gradients of contamination and develop a preliminary assessment of the boundaries between the *de manifestis*, intermediate and *de minimis* zones. Additional sampling and laboratory analysis of sediment samples, targeting a broader suite of analytes, will be completed to confirm the results of the initial screen and to provide data for the ERA. The project will allow ample time for the collection and analysis of surface water and sediment samples in two phases, based upon the anticipated timing of Work Plan approval (late-January) and the data collection requirements for the aquifer tests and the ecological sampling (i.e. field activities during April through early October).

The sampling detailed in this SAP will occur from upstream locations south of Interstate 295 along Little Timber Creek and Swamp, north of Route 44 to the tide gate where Little Timber Creek is a drainage channel. Based on retentive nature of the Little Timber Creek Swamp, the

evaluation of site-related COPECs upstream of the tide gate is focused on the residual LNAPL (*de manifestis*) area and gradients of residuals extending from the LNAPL (Figure 13). In addition, several sampling locations are situated north of Cedar Swamp Road; adjacent to Route 44, and downstream of the tide gate.

Surface Water Sampling and Analysis

Twenty-two surface water samples will be collected as grab samples moving from downstream (north) to upstream (south) (Figure 13). An additional five surface water samples will be collected at the reference areas (Figure 14). The specific locations of surface water samples will be defined based upon qualitative dye studies (Section 7.2.2). Samples will be collected from preferential flow paths to directly characterize transport potential. All of the surface water samples collected for chemical analysis will be analyzed for the following parameters: VOCs, SVOCs, PCBs, TPH and TAL metals (Table 6). The surface water samples collected for SVOCs, PCBs, and metals will be analyzed for total and filtered (dissolved) constituents as significant suspended solids may be encountered during sample collection. A comparison of total and filtered (dissolved) concentrations will provide information for assessing the mobility and bioavailability of COPECs. Approximately 50% of the surface water samples will be analyzed for the following geochemical parameters: TSS, TDS, sulfate, sulfide, chloride, nitrate, nitrite, TKN, hardness, and ferrous iron. All of the surface water samples collected will be analyzed for the following geochemical parameters: TOC, Eh, pH, DO, and alkalinity. In addition, the filtered surface water samples will also be analyzed for TOC. The filtered ground-water samples are being collected for fate and transport evaluation, to assess the source of COPECs in surface water in order to evaluate potential remedial alternatives during the feasibility study. In addition, ground water samples will be collected from the six wetlands monitoring wells pairs (WMW-1A through WMW-6A and WMW-1B through WMW-6B) installed in the Little Timber Creek Swamp between Routes 130 and I-295, as discussed in Activity 4a (Section 7.5.1).

The sediment samples will be collected from 76 locations using either a sediment core or a stainless steel hand auger through temporary casing to minimize cave-in. The sediment samples collected in and adjacent to Little Timber Creek between Routes 130 and I-295 are designated LTC-1 through LTC-39. The sediment samples collected in and adjacent to Little Timber Creek

Swamp and Cedar Swamp north of U.S. Route 130, designated LTC-40 through LTC-61, will be collected in depositonal areas.

Sediment Sampling and Analysis

An initial screening of the distribution of sediment indicator compound concentrations using in-field analyses will be performed to preliminarily determine the horizontal distribution of site-related chemicals and to assist in selecting specific sediment sample locations for full laboratory characterization. TPH was selected as an indicator of organic constituents because petroleum hydrocarbons made up the majority of the mass of organic compounds released to the swamp. Other nonpolar or low polarity organic compounds are dissolved in the petroleum or, to a lesser degree, in the aqueous phase. Lead was identified as an indicator constituent for inorganic constituents since lead was the COPEC detected at the highest concentration in the swamp and in both the aqueous and oil phases of the source material. Samples for more comprehensive laboratory characterization will be collected to determine COPEC concentrations horizontally and vertically throughout the sediment across the site, as well as to define the perimeter of the site. These samples will be collected in the second field phase, following an evaluation of the gradients of contaminants within the context of the probable contaminant pathways and receptor locations.

De Manifestis Zone

From the areas preliminarily identified as *de manifestis* zones, samples will be collected at one location north of U.S. Route 130 (LTC-50) and at six locations (LTC-5, LTC-7 through LTC-11) from between Routes 130 and I-295 (Figure 13). The sediment samples collected from the *de manifestis* zone will be collected at six-inch intervals to determine the vertical concentration gradients of the COPCs. The borings will terminate at a depth of five feet BGS or one foot below the visual or PID screening evidence of residual product, whichever is first. The samples will be analyzed for TPH and lead in using the on-site laboratory. Analysis will be on a fast turnaround basis using the on-site laboratory and additional samples will be analyzed if the results of the deepest sample exceed 10,000 mg/kg TPH or 500 mg/kg lead.

Intermediate and De Minimis Zones

Sediment samples will be collected from the areas preliminarily described as intermediate and *de minimis* zones, a total of 108 samples two depth intervals at each of the 54 locations: LTC-1 through LTC-4, LTC-6, LTC-12 through LTC-49 and LTC-51 through LTC-61, will be collected to determine the distribution, approximate boundaries of the sediment contamination and concentration gradients of TPH and lead. The distribution from screening analyses will be used to determine the sampling locations for the second phase of sediment sampling that will determine the distribution of COPECs andd the boundary of the site in the wetlands areas.

Sampling Intervals

Sediment sampling will be performed for screening, confirmation, and exposure point evaluation (Figure 13). For screening purposes, sediment samples will be collected from the zero to six inch depth interval of the sediment/substrate and from the zero to six inch interval of the first inorganic layer beneath the surface to assess the mobility of COPECs. The screening samples will be analyzed in an on-site laboratory for TPH and lead. These data will be used to preliminarily determine the horizontal extent of site-related chemicals-of-concern.

The confirmatory sediment samples, which will be analyzed for a broader suite of parameters at an off-site laboratory, will be collected from the zero to six inch interval of the sediment/substrate for chemical characterization and comparison to screening values and to develop biota sediment accumulation factors (BSAFs) for burrowing receptors. In addition, samples will be collected from the zero to six inch interval of the first inorganic layer beneath the surface to assess the vertical mobility of COPECs. The confirmatory sampling locations will be established based upon the results of the screening investigations and the biota surveys described later in this SAP, and will be detailed in a Technical Memorandum.

Zero to one inch interval samples will be collected at selected locations (approximately 50% of the confirmatory sampling locations) to evaluate exposure point concentrations for non-burrowing benthic receptors and receptors that utilize the surface of the swamp where it is not flooded (approximately 6 months/year); to establish the boundaries between the *de manifestis*, intermediate and *de minimis* zones; and to develop biota sediment accumulation factors (BSAFs)

for non-burrowing receptors. The areas selected for sampling of the zero to one inch interval will be predominately those drier areas where the sediment is not inundated by surface water during much of the year. In defined stream channels where greater mixing and turbulence commonly occur, only the zero to six inch interval will be sampled. Any changes to the confirmatory sampling strategy will be identified in the Technical Memorandum for USEPA review and approval.

Our current understanding of the sediment food chains emphasizes the major role that epifauna plays. This understanding is supported by Kozlowski (1984), who demonstrated profound ecological and electrochemical changes and chemical transformations that occur between the aerobic and anaerobic sediment zones.

The zero to one inch sampling interval was selected for the purposes of characterizing the epifauna zone consistent with regulatory guidance and current scientific literature. USEPA (1987b) guidance for sampling for organic contaminants in sediments indicates that a 2-cm depth is generally recommended to evaluate surface sediment chemistry for recently deposited sediments and that this depth holds the majority of benthic organisms and constitutes the "bioactive layer". ASTM has published several standard methods for the collection of sediment samples. The ASTM method for sediment sampling for toxicological testing indicates that that the top 1 or 2 cm is the most common depth to evaluate the depositional layer of concern (ASTM 1994). The ASTM method for evaluating the bioaccumulation of sediment-associated contaminants by benthic invertebrates recommends sampling the upper 2 to 3 cm layer because it is the most recently deposited, it is in contact with the overlying water, and represents the most biologically active zone (ASTM 1995). Thomas *et al.* (1995) found that the "feeding and reworking activities of benthic organisms are almost entirely confined to the top few centimeters of sediment" and that population densities of aquatic organisms typically decrease rapidly with depth, with up to 85% of the organisms found in the top 2 cm. USEPA (1998) defines exposure as "the co-occurrence of contact of the stressor with the ecological components, both in time and space" and DiBello (1975) describes the animal component of benthic systems as generally divided into infauna (animals that live within the sediments) and epifauna (animals that live on the sediment surface or just above it). Based on these considerations, different sediment sample intervals are necessary to

characterize exposure points for different receptors. The proposed sampling intervals will be reevaluated after the biota survey, initial sediment sampling and reevaluation of the assessment and measurement endpoints.

Should the results of proposed sampling detect site-related contaminants above applicable sediment screening criteria or surface water standards beyond the limits of the sampling points outlined in this Work Plan, a scope of work for additional sampling RI activities will be developed and presented to the USEPA, NOAA and NJDEP in a Technical Memorandum for approval. The initial sampling results will be evaluated statistically, using correlation coefficients, to refine the analytical suite of COPECs where possible. Various COPECs will be compared against each other (e.g., lead versus total metals, TPH versus lead) to identify indicator parameters for subsequent sampling efforts. The results of the statistical analysis will be reviewed within the context of the ecological risk assessment prior to recommending changes in analytical parameters. If the analytical suite is refined, a representative percentage of the samples will be analyzed for a broader suite of analytes. The Technical Memorandum will include a summary of the results of the initial surface water and sediment sampling efforts and the recommended analytical strategy for subsequent data collection efforts.

Reference Areas

In addition to the wetland sediment and surface water samples identified above, background samples will be collected from five different proposed reference areas (Figure 14), to depth intervals at three sampling locations. Six sediment samples (two depth intervals at three sampling locations) and one surface water sample will be collected from each reference area. The sediment samples collected from the reference areas are designated R-1 through R-15. The sediment/soil samples will be collected from the same depth intervals as the second phase of samples proposed for the intermediate and de minimis zones (see above). The sediment/soil and surface water samples from the reference areas will be evaluated individually for each proposed reference area and collectively among proposed reference area to determine the background COPEC concentrations that will be used in the ecological risk assessment consistent with USEPA guidance (USEPA, 1998). The suitability of the reference areas for use in establishing a reference condition for the site will be reevaluated based on the sampling data from the reference areas, the

results of the biota surveys and inspections of wetland study areas that will be conducted as part of the Phase 2 RI, and reexamination of the assessment and measurement endpoints. This reevaluation will be summarized in a Technical Memorandum for USEPA review and approval.

Laboratory Analytes

Reference area sediment samples and confirmatory soil/sediment samples collected from the Little Timber Creek and Cedar Swamp areas will be analyzed for chemical, geochemical and waste classification parameters (Table 6). All of these soil/sediment samples will be analyzed for the following chemical and geochemical parameters: VOCs, SVOCs, PCBs, TPH, metals, Eh, pH, TOC, and grain size. One sediment sample from each reference area (R-2, R-5, R-8, R-11 and R-14) will also be analyzed for pesticides. Pesticide analyses will also be performed on 10% of the confirmatory sediment samples collected from Little Timber Creek Swamp and Cedar Swamp. The locations of these samples will be detailed in the Technical Memorandum prepared following the screening phase investigation. Encore™ samplers will be used to collect the sediment samples for VOC analysis (Appendix B). Technical Memorandum No. 2 Analytical Method Development should be consulted for potential changes to sediment preservation procedures.

Approximately 30% of the samples will be analyzed for acid volatile sulfide and cation exchange capacity. In addition, up to four samples will be analyzed for the following waste disposal parameters: TCLP VOCs, TCLP SVOCs, and TCLP metals; total PCBs; ignitability; corrosivity; reactivity; TOX and BTU content. The samples collected for waste disposal parameters will be biased to the areas preliminarily identified as the *de manifestis* zones (i.e., former overflow area) to evaluate the remedial treatment or disposal options for the area. Further, six sediment/soil samples collected from the areas preliminarily identified as the intermediate zones and three samples collected from the predicted *de manifestis* zone will be analyzed for SPLP VOCs and metals to asses the leachability, mobility and bioavailability of COPECs in the sediment/soil. The location of these samples will be determined in the field based upon visual inspection and

screening but the preliminary locations are LTC-7, LTC-8, LTC-14, LTC-16, LTC-25, LTC-37, LTC-44, LTC-45, LTC-50. Analysis of the *de manifestis* zone has been limited as this area will likely undergo active restoration and will not factor into an analysis of future risk.

7.6.3 Activity 5c - Swale Along Route 130

Surface water samples will be collected from the swale which parallels U.S. Route 130 North. The objective of the surface water sampling is to evaluate the fate and transport of COPCs; especially relative to potential background sources (e.g., the highway) and the LNAPL identified in MW-13A in the swale.

Time-weighted storm water samples will be collected during a significant rainfall event (greater than 1-inch, and preferably 2 inches in 24 hours) at two locations. The locations are (1) adjacent to Route 130 along the Cedar Swamp Road access to Route 130 and (2) just prior to the point that the swale discharges to Little Timber Creek. The water samples will be collected using a an ISCO model 6700, or equivalent, automatic surface water composite sampling device or, if necessary, an in-ground storm water collection system and transferred directly into the appropriate sample containers, if possible. If collection directly into the sample bottle is not possible, a laboratory-cleaned sample bottle will be used to collect the sample and the sample will be transferred to the appropriate sample container. The storm water sample will be analyzed for VOCs, SVOCs, PCBs, metals and TPH (Table 6). Portions of each sample will be filtered in the field and analyzed for dissolved SVOCs, PCBs and metals.

7.6.4 Location Documentation of Surface Water and Sediment Sampling

Surface water, sediment, soil, and biological samples will be collected from the Little Timber Creek and associated wetlands and Cedar Swamp as part of the Tasks IIIA, Activity 5 (Sediment and Surface Water Quality Evaluation) and Task VIB Ecological Risk Assessment. The majority of the sampling locations will be accessible only by hiking and/or wading through dense vegetative growth and swamp areas. To facilitate plotting the sampling locations accurately on a map, and relocating the sampling points in the field for subsequent tasks of the Phase 2 RI, each location will be marked with a metal rod.

Surface water and sediment sampling locations will be surveyed to establish vertical and horizontal control. Surveying activities will be conducted in accordance with the standard of care set forth in Chapter 40 of the State Board of Professional Engineers and Land Surveyors Administrative Rules and Regulations. A global positioning system will be used for surveying unless overhead obstructions (tree canopy, buildings) prevent the use of this technology, in which case traditional methods will be employed. The surveyor will maintain field notes in a bound logbook and copies of the notes will be provided in the RI Report. Vertical control of land surface and measuring point elevations will be measured to the nearest 0.01 foot, relative to mean sea level. The surveyor will determine horizontal control of the sample location to within 10 feet. The measuring points will be located according to the New Jersey State Plane coordinates and surveyed for elevation in reference to the National Geodetic Vertical Datum (NGVD).

7.7 Task IIIA, Activity 6 - Human Health Exposure Point Concentration Evaluation

Within the baseline risk assessment exposure point concentrations (EPCs) may be estimated using monitoring data alone, or a combination of monitoring data and environmental fate and transport models. In addition to chemical characterization data, site-specific data that will be collected in support of estimating EPCs include:

- the location, depth and uses of supply wells in the area, based upon the well survey;
- the types of fish species present in Swindell and Gaventa Ponds, based upon biological surveys (see Section 7.8.5);
- areas where development will be precluded due Land Use restrictions, based upon the wetlands delineation;
- the potential for land development and the likelihood that new developments will utilize public water supplies, based upon information obtained from the Logan Township Planning Office; and

- the frequency, locations and types of uses of the ponds and wetlands by hikers, campers, fisherman and swimmers based upon observations by Roux personnel on the site during the RI.

The collection and analysis of soil, sediment, ground water, surface water and NAPL samples will be used to support the estimation of EPCs. Methods and procedures associated with the collection of monitoring data for use in estimating EPCs include the various media characterization activities outlined throughout this SAP. In addition, the potable supply well survey and wetland delineation activities will provide empirical data that will be used for estimating EPCs. At least annually throughout the RI/FS, the Logan Township Planning Office will be contacted to identify the potential for land development and the likelihood that new developments will utilize public water supplies.

Throughout the RI field activities, Roux Associates, Inc. personnel will document relevant observations of human use of the site. For example, direct observations or evidence of trespassers (e.g. damaged fences, litter), hikers, campers and swimmers will be noted in the field logbook and reported to the RI Manager. Direct observations or evidence of fishermen using the ponds, streams and wetlands will also be recorded.

7.8 Task IIIA, Activity 7 - Ecological Evaluation

The ecological evaluation is divided into three discrete assessments: Gaventa Pond, Swindell Pond, and Little Timber Creek Swamp. Each will be evaluated separately due to their spatial separation but possible interactions resulting from mobile ecological receptors will be considered in Activity 7 (i.e., step 6 of the ecological risk assessment process) and during the risk management assessment (USEPA, 1997b). As detailed in the Work Plan, each of the first several steps in the ecological risk assessment process will be completed following the first phase of sediment investigations and biota surveys. The scope and specific procedures for the subsequent evaluations will be outlined in a Technical Memorandum for review by the USEPA.

The initial phase of the ERA consists of the performance of a biological survey to identify the receptors and their respective habitats in the vicinity of the site, and sampling and analysis of

surface water and sediments from the ponds and wetlands of the site. As specified in the BROS Consent Decree, these biological surveys could not be completed prior to approval of the Phase 2 RI/FS Work Plan. Therefore, the existing ecological evaluation scope of work was developed based upon limited site visits and existing information on the potential species at the site. The results of these efforts will be discussed with USEPA as a Scientific/Management Decision Point (SMDP). The discussion will focus on determining the receptors or exposure pathways of concern.

Subsequent phases of the Ecological Evaluation will include the sampling and analysis of animal tissue, the evaluation of macroinvertebrate community characteristics, and the performance of sediment toxicity tests. The specific animal tissue types, analytical procedures, target analytes, and test methods will be determined based upon the results of the initial phase of sediment and surface water sampling (Section 7.6) and the completion of the biological surveys described below. Samples will be collected from appropriate trophic levels to assess exposures through the food chain. Sediment toxicity testing and macroinvertebrate community analyses, along sediment contamination gradients of the swamp, will provide an effects measure for assessment endpoints related to direct contact exposures. Based on the results of the sediment field screening sediment sample locations for toxicity testing and collocated sediment chemical characterization samples will be selected to represent the contamination gradient across the site. The scope of work, proposed sample locations, sampling and analytical methodologies, and DQOs for tissue studies and sediment toxicity testing will be included in the Technical Memorandum describing the initial phase of sediment and surface water investigations (Section 7.6.2).

Gaventa Pond

Existing data indicates a concentration of site-related constituents in the northeast corner of Gaventa Pond, closest to the former BROS lagoon location. The primary objectives of surface water and sediment sampling in Gaventa Pond are to: (1) evaluate the current site-related constituent concentrations in these media since the remediation of the BROS lagoon; (2) evaluate COPECs based on comparison of detections to ecological screening criteria; (3) evaluate the need for additional ERA activities; and (4) evaluate the need/feasibility of focused remedial activities in the corner of the pond. Surface water and sediment sampling and analyses, discussed in Section

7.6.1, focus on chemical and geochemical parameters to support chemical fate and transport evaluations and bioavailability. Sediment samples collected to support the screening assessment in the ERA will be collected from the zero to six inch sediment depth interval for comparison to screening values. Elevated COPEC concentrations in pond media will trigger discussion with USEPA leading to a scientific management/decision point (SMDP) to evaluate whether additional ecological risk characterization is required or if a remedial alternative evaluation is warranted. If COPECs are not identified above relevant criteria, no additional ERA activities or remedial activities will be required.

Swindell Pond

Site-related constituents have been detected in Swindell Pond (CH_2M Hill, 1996). The primary objectives of surface water and sediment sampling in Swindell Pond are to: (1) evaluate the current site-related constituent concentrations in these media since the remediation of the BROS lagoon; (2) evaluate COPECs based on comparison of detections to ecological screening criteria; (3) evaluate the need for additional ERA activities; and (4) evaluate the need/feasibility of focused remedial activities. Surface water and sediment sampling and analyses, discussed in Section 7.6.2, focus on chemical and geochemical parameters to support chemical fate and transport evaluations and bioavailability. Sediment samples collected to support the bioavailability assessment in the ERA will be collected from the zero to six inch sediment depth interval for comparison to screening values. Elevated COPEC concentrations in pond media will be a scientific management/decision point (SMDP) to evaluate whether additional ecological risk characterization is required or if a remedial alternative evaluation is warranted. If COPECs are not identified above relevant criteria, no additional ERA activities or remedial activities will be required.

Little Timber Creek Swamp

An overall objective of the Little Timber Creek Swamp ecological evaluation field work is to collect data to determine if there is a correlation between biological effects and the gradient of site-related constituent concentrations, independent of the natural gradient of physical factors found in the swamp (e.g., water depth and thickness of organic muck layer). The end result of this field evaluation will be used to define the boundaries of three zones (*de manifestis*,

intermediate, and de minimis) as defined in the Work Plan. To achieve this objective, the field assessment components have been arranged into a series of logical steps:

1. A qualitative faunal survey of representative habitats conducted concurrently with the flora mapping (Section 7.8.1).

2. Surveying and mapping of the dominant vegetation patterns (overstory and understory) and hydrology (depth., flow rates, and flow patterns) utilizing sampling locations along transects set perpendicular to the dominant stream flow conditions. Flow patterns will be determined by dye testing (Sections 7.2.2 and 7.6.2).

3. Mapping of the *de manifestis* zone based on aerial photographs and on-site field observations, such as visually determining the extent of LNAPL residuals in the sediment and in relation to plant transitions (Section 7.8.3).

4. In the *de manifestis* zone (Figure 13), the sampling will be limited to defining the vertical extent of contamination and characterizing the sediment for evaluation of remedial alternatives (Section 7.6.2).

5. Outside the *de manifestis* zone (Figure 13), surface water, ground water, and sediment sampling will be conducted to determine: the vertical and horizontal distribution of contaminants; the potential movement of contaminants (from various portions of the site) in surface water; the relationship between sediment contamination and ground water contamination (Figure 20); the environmental fate of the residual constituents; and the identification of which receptors contact the residual lagoon constituents. The sediment sampling locations extend out radially from the *de manifestis* zone (Figure 13) and are designed to establish concentration gradients, as well as vertical distribution. Surface water sample locations were placed: (a) to measure concentrations and sources of runoff related to differing sediment concentrations, (b) in downstream locations to determine potential transport, and (c) collocated with ground water monitoring wells to evaluate the discharge/recharge dynamics of surface water and ground water (Section 7.6.2).

6. Sampling of the biota, some concurrently with the sampling in (5) above (Sections 7.8.4, 7.8.5, and 7.8.6).

Prior to initiating the steps outlined above and detailed on the following pages for biota evaluation, field verification of the sampling plan will be completed.

7.8.1 Qualitative Flora and Fauna Survey

The evaluation of potential biotic receptors associated with the site and immediate surroundings will be performed through site reconnaissance and literature review. Resident and transient wildlife species within a 0.5 mile radius of the site will be identified during a site reconnaissance performed by trained field ecologists. The 0.5 mile radius represents a reasonable area from which transient wildlife could visit the site and this search radius will be supplemented by a review of published literature and information available through the NJDEP's Office of Natural Lands Management - Natural Heritage Program to identify other potential species that visit the area surrounding the site. The qualitative wildlife survey will be based on visual and auditory indicators, consisting of actual sightings, tracks, burrows, scat, browse or song recorded along five transects walked across the area of investigation. The transects will be oriented in a southeast to northwest direction and will cover the area beginning at the intersection of Interstate 295 and the exit ramp from Route 130 and ending at the eastern edge of Gaventa Pond. The transects will be spaced at 500 foot intervals and will begin at Interstate 295 and terminate at the channel north of Route 44. Surveys will be performed between one half hour before sunrise and 10:00 AM and between 17:00 (i.e. 5:00 PM) and sunset to coincide with peak wildlife activity. Surveys will be performed during wet (Spring) and dry (Summer) conditions of the wetland to evaluate changing receptors and exposure pathways during different hydrologic conditions. Plant communities of the site vicinity will also be characterized and delineated for the development of a cover type map of the environs within 0.5 miles of the site. The cover type delineations will be based on aerial photograph interpretation and dominant plant communities observed during the site reconnaissance. Information presented in the literature related to typical wildlife inhabitants of the plant communities will also be used to develop the list of potential biotic inhabitants of the site habitats.

Surveys of aquatic receptors of the site ponds and wetland areas will be performed to identify potential ecological receptors of each habitat. Three sediment grabs will be collected from each of the two ponds on the site and up to 10 sediment grabs will be collected from wetland areas to evaluate the benthic invertebrate community at these locations. In addition, the fish community will be evaluated by electroshocking, seining, gill-netting, or trapping, as discussed in Section 7.8.5.

These field determinations of the species present and their distributions will be used in the refinement of assessment and measurement endpoints, including the scope of the toxicity and tissue testing.

On-Site Wetland Delineation Activities

The NJDEP has federal jurisdiction for freshwater wetlands in New Jersey except for those wetlands that are within 1,000 feet of tidal areas. This jurisdiction may apply to some of the wetlands in the project area (Figure 21). Wetland boundaries will be identified in accordance with the methodologies identified below. The wetland boundaries and their respective transition areas will be depicted on the site plan when completed.

In 1991, CH2M HILL delineated wetland boundaries in Little Timber Creek Swamp south of Rt. 130, an area totaling approximately 170 acres (CH2M HILL, 1992). However, the delineation did not cover properties north and south of the site and no record of the established boundaries is available. Therefore, under this RI effort, the boundaries of wetlands in the areas north and south of the site (Figure 21) will be delineated.

Surface water and sediment sampling under the RI will extend into Cedar Swamp. Cedar Swamp is a large wetland of relatively homogeneous vegetation that extends from Interstate 295 north almost to the Delaware River. A wetland boundary determination is required in this area for future evaluations of areal impacts. Therefore, the wetland boundaries of these portions of Little Timber Creek Swamp and Cedar Swamp will be delineated using procedures presented in the 1989 *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (Federal Interagency Committee, 1989). Due to the large size of the wetland, delineation efforts will focus

on identifying the perimeter wetland boundaries north of Interstate 295, west and south of Repaupo Road and its intersection with an overhead power line, and north and east of the eastern banks of the former channel to the overhead power line. The northern wetland boundary will not be identified or delineated. The identified wetland boundaries will be flagged in the field for subsequent surveying. The wetland boundaries will be included on the cover type map of the site. Vegetative and hydrologic characteristics of the delineated wetland will be recorded to classify the wetland types.

A potential reference area has been identified for the project along little Timber Creek south of the site where surface water and sediment samples will be collected (Figure 14). Although characterization of this area is critical to supporting its selection as a reference area, delineation of the precise boundaries of wetlands in the area is not necessary because areal impact evaluation does not apply. However, the relative size of the area in relation to wetlands potentially impacted by site releases is important. Therefore the wetland boundaries of this area will be qualitatively identified in this approximately 90 acre parcel based on limited field evaluations and data collection. Characterization of the wetland will be performed under separate efforts associated with the selection of reference sites.

The identified wetland boundaries will be flagged in the field for subsequent instrument surveying. The wetland and transition area boundaries will be included on the cover type map of the site. Vegetative and hydrologic characteristics of the delineated wetland will be recorded to classify the wetland type.

7.8.2 Dominant Vegetation Evaluation

Vegetation evaluation will be performed to evaluate the assessment endpoint related to the effects of chemical exposure on species dominance and diversity in Little Timber Creek Swamp. The measurement endpoint used for this assessment is the identification of plant species and the calculation of dominance and diversity in representative plots in the wetland and reference sites. Vegetation surveys will be conducted in 30 feet by 30 feet quadrats established at 100 foot intervals along the transects, utilized for the wildlife survey, with the transect interval beginning at the midpoint of the quadrat. The data collection methodology is based on the vegetation analysis

methodology for wetland delineation (Federal Interagency Committee, 1989). The Standard Operating Procedure for quantitative vegetation surveying is presented in Appendix B. The quadrat will be subdivided into four quadrants within which the four layers of a forested wetlands are evaluated; these include: overstory trees; understory trees; shrubs/saplings; ground cover (herbaceous). Seedlings of dominant tree species will be identified and enumerated. Also, ground cover (herbaceous) vegetation evaluation quadrats will be established within each quadrant. Two vegetation transects will also be established in each of five reference sites to provide baseline vegetation data for red maple forested wetland habitats in the vicinity of the site. Transect length in the reference areas will correspond to the respective size of the reference area.

Vegetative dominance within each strata will be identified as those species or commonly occurring associations of species comprising 50% or more of the sum of all plants in a quadrat. In addition, those species whose total numbers exceed 20% of the midpoint of the sum will be identified as dominant. These data will be compared to data from the de minimis zone and the reference areas to evaluate if a correlation exists between changes in tree dominance and chemical concentration in the soil or sediment of the zones taking into account changes in hydrology and other relevant factors.

7.8.3 *De Manifestis* Zone Mapping

Mapping of the *de manifestis* zone will be performed based on aerial photograph interpretation and on-site field observations. Preliminary zone boundaries will be identified based on vegetation changes observed on aerial photographs prior to and following the release from the BROS lagoon. Preliminary boundaries will be refined based on in-field evaluations of visible indicators of LNAPL residuals in the sediment (based upon soil core or hand auger assessment), observed plant community transitions, and chemical characterization data evaluation.

7.8.4 Aquatic Macroinvertebrate Evaluation

Aquatic macroinvertebrate abundance and diversity in the sediments along the gradients of contamination is a measurement endpoint of the ecological risk assessment. The Standard Operating Procedure for the collection of macroinvertebrates in sediments is presented in Appendix B.

Sampling locations will be selected following a review of sediment characterization data collected under this RI. Up to 15 locations in site wetlands and one location in each reference area will be selected to represent the range of COPEC concentrations and biological habitats. Sampling will be performed in triplicate at each sample location for statistical community evaluations. Sampling will occur in similar hydrologic conditions at each location. Sampling will not be performed near roads or culverts because of localized influences and the poor representation of wetland habitats. Similar habitats will be sampled in the site and in reference sites for accurate community comparisons. Field data sheets will be utilized to document the habitat type at each sampling location.

Results of the macroinvertebrate community analyses will be evaluated in relation to the measured concentrations of COPECs, the reference locations, and the relevant assessment endpoints. Based on this analysis, sediment toxicity testing will be proposed that is representative of the BROS site conditions. The specific test type and organisms to be tested will be identified, along with the rationale for the proposal. Sediment toxicity tests commonly used by USEPA are methods 100.1 and 100.2, which evaluate chronic exposure effects on *Hyalella azteca* and *Chironomus tentans*, respectively. The potential intermediate zone boundary can then be refined based on the weight of evidence provided by the evaluations identified above.

7.8.5 Fish Survey/Sampling

A fish survey will be conducted in Gaventa Pond, Swindell Pond, and Little Timber Creek from above Route I-295 to the tidal gate north of Route 44. The surveys will be conducted to evaluate whether fish are present, what species are present, and their relative abundance at each location. The fish sampling will be conducted by electroshocking, dip netting, trapping and/or seining. The Standard Operating Procedures are presented in Appendix B. The most appropriate sampling method will be selected in the field based on the specific conditions of the sampled water body. Electroshocking would be used in shallow (<3 ft) water with emergent vegetation and would be performed for up to 4 hours at each location. Seining would be incorporated in unobstructed shallow water areas and would be performed for up to 4 hours at each location. Gillnets with varying mesh size panels and minnow traps baited with bread will be set for up to 2 days and nights at each location. It is currently estimated that two locations will be sampled in each pond

and up to 10 locations in site wetlands will be sampled to evaluate the fish communities. Required permits for sampling activities will be obtained prior to initiation of the aquatic receptor survey. Sampling will be conducted by searching for the locations of representative habitats in each area. Potential sampling locations in Little Timber Creek Swamp will be identified during the performance of the vegetation transect survey, discussed in Section 7.8.2. All fish will be identified to species; length and weight will be measured prior to their return to the place of collection. The need for fish toxicity testing or tissue analyses will be evaluated based on the abundance of the fish population, the concentration of COPECs present, and the potential for those COPECs to affect fish or bioaccumulate in fish

7.8.6 Small Mammal Sampling

Based upon the initial sediment and surface water sampling (Section 7.6) and the biota surveys described earlier in this section, the potential for predatory birds of Little Timber Creek Swamp and terrestrial portions of the Site to be exposed to COPECs will be evaluated through the collection and analysis of small mammals, a primary dietary component of some predatory birds. Small mammal trapping will be performed in areas of the Site with contaminant concentrations typical of the intermediate and de minimis zones, as defined by the first phase of investigations. Based on the species present and their distribution in relation to COPECs, specific whole body tissue analyses will be proposed to determine exposure point concentrations for use in a food chain model for a predatory bird selected as an assessment endpoint. Small mammal sampling will be conducted in accordance with the SOP presented in Appendix B. The specific sampling locations, numbers of samples and analytical protocols will provided in a Technical Memorandum for USEPA review and approval.

REFERENCES

ASTM, 1994. *Standard Guide for Determination of the Bioaccumulation of Sediment-Associated Contaminants by Benthic Invertebrates.*

CH_2M Hill, 1992. *Technical Memorandum No. 11, Wetlands Assessment at the Bridgeport Rental and Oil Services Site.*

CH_2M Hill, 1996. *Summary of the Phase Two Remedial Investigation (RI) Work Performed to Date*, Prepared for USEPA.

DiBello, D.A. 1975. *Tidal Flats in Estuarine Water Quality Analysis.* EPA-660/3-75-025.

Federal Interagency Committee, 1989. Federal Manual For Identifying and Delineating Jurisdictional Wetlands.

Hughes, J.P.; C.R. Sullivan, R.E. Zinner, 1988. *Two Techniques for Determining the True Hydrocarbon Thickness in an Unconfined Sandy Aquifer.*

Hunter Research, Inc., 1998. *Amendment to the Workplan Scope of Work for the Stage IB and Supplementary State IA Cultural Resources Surveys at the BROS Superfund Site.* February 13, 1998.

New Jersey Department of Environmental Protection (NJDEP). 1992, May. *Field Sampling Procedures Manual.*

NJDEP 1994, July. *Field Analysis Manual.*

NJDEP 1994a, July. *Alternative Ground-Water Sampling Techniques Guide.*

NJDEP 1996. *New Jersey Historic Preservation Office Guidelines for Phase I Archaeological Surveys.*

NJDEP, 1997. *Technical Requirements for Site Remediation.* N.J.A.C. 7:26E.

NJGS, 1992. *Guidelines for Preparing Hydrogeologic Reports for Water Permit Allocations (GSR 29).*

Pierce, G.J., 1993. *Planning Hydrology for Constructed Wetlands.* Wetland Training Institute, Inc.

Thomas et al. 1995. *Models for Alteration of Sediments for Benthic Organisms.* Water Environment Research Foundation.

USEPA, 1987, December. A *Compendium of Superfund Field Operations Methods.* Office of Emergency and Remedial Response, EPA/540/P-87/001.

USEPA, 1987a. *Data Quality Objectives for Remedial Response Activities.* Office of Emergency and Remedial Response, EPA/540/G-87/004.

USEPA, 1987b. *Guidance for Sampling of and Analyzing for Organic Contaminants in Sediments.* Office of Water Regulations and Standards, Criteria and Standards Division, SCD #8.

USEPA, 1989. *Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part A).* Interim Final. Office of Emergency and Remedial Response. USEPA/540/1-89/002.

USEPA, 1993a. *Evaluation of the Likelihood of DNAPL Presence at NPL Sites National Results*, EPA 540-R-93-073, September 1993.

USEPA, 1993b. *DNAPL Site Evaluation*, EPA 600-R-93-022, February 1993.

USEPA, 1993c. *Suggested Operating Procedures for Aquifer Pump Tests.* EPA/540/5-93/503.

USEPA, 1994. EPA QAG-4: *Guidance for the Data Quality Objectives Process.* EPA/600/R-96/055.

USEPA, 1995c. *Ground Water Issue - Light Nonaqueous Phase Liquids.* EPA/540/S-95/500

USEPA, 1996, February. *How to Effectively Recover Free Product at Leaking Underground Storage Tank Sites - A Guide for State Regulators.* EPA 510-R-96-001.

USEPA, 1997a. QA/R-5: *EPA Requirements for Quality Assurance Project Plans*, QAM-005/80.

USEPA, 1997b. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments.* Interim Final. U. S. Environmental Protection Agency, Environmental Response Team, Edison, NJ.

USEPA, 1997c. *Test Methods for Evaluating Solid Waste Physical/Chemical (SW-846) Third Edition.* May 1997.

USEPA, 1998. *Environmental Protection Agency Guidelines for Ecological Risk Assessment.* USEPA, Risk Assessment Forum, Washington, D.C. EPA-630-R-95-002.

USEPA, 1998a. *Risk Assessment Guidance for Superfund: Volume I: Human Health Evaluation Manual. Part D. Standardized Planning, Reporting and Review of Superfund Risk Assessments.* Interim. Publication 9285.701D. January 1998.

USEPA, 1998b. USEPA Region II Ground Water Sampling Procedure Low Stress (Low Flow) Purging and Sampling.

USEPA, 1998c. Letter from Ronald Naman to Peter Brussock, Ph.D. of Environmental Liability Management, Inc. April 16, 1998.

TABLES

Table 1. Sample Types/Analyses in Task IIIA by Activity. BROS Phase 2 RI/FS; Bridgeport, New Jersey.

Activity	Matrix	Field Analyses	Laboratory Analyses
2: Soils Investigation	Soil	Photoionization Detector (PID) Screening, Non-Aqueous Phase Liquid (NAPL) Screening	TCL VOCs, TCL SVOCs, GRO/DRO, TPH, PCBs, TAL Metals, TOC, pH, Eh, Cation Exchange Capacity, Geotechnical Parameters, Waste Classification Parameters
3: Non Aqueous Phase Liquid (NAPL) Evaluation	LNAPL	PID Screening, NAPL Screening	TCL VOCs, PCBs, Lead, DRO/GRO, Specific Gravity, API Gravity, TOX, Viscosity, Waste Classification Parameters
4: Monitoring Well Installation	Soil	PID Screening, NAPL Screening, VOCs	TCL VOCs, TCL SVOCs, PCBs, TAL Metals, Geotechnical Parameters, Waste Classification Parameters
4: Ground Water Quality Evaluation	Water	pH, Conductivity, Eh, DO, Temperature, Ferrous Iron, Turbidity, VOCs	TCL VOCs, TCL SVOCs, TAL Metals (total and dissolved), TOC, Alkalinity, Hardness, Sulfate, Sulfide, Nitrate, Nitrite, Ammonia, TSS, TDS, Chloride, COD, CO_2, H_2S, TKN, Orthophosphate, Silica , Methane, Ethane, Ethene, Organic Acids, Waste Classification Parameters
5: Surface Water Sampling	Surface water	pH, Conductivity, Eh, DO, Temperature, Ferrous Iron	TCL VOCs, TCL SVOCs, TPH, PCBs, TAL Metals, Hardness, Alkalinity, TSS, TDS, TOC, Chloride, TKN, Sulfate, Sulfide, Nitrate, Nitrite, Ammonia
5: Sediment Sampling	Soil/Sediment	PID Screening, NAPL Screening, TPH, Lead	TCL VOCs, TCL SVOCs, TPH, DRO, GRO, PCBs, TCL Pesticides, TAL Metals, SPLP VOCs and Metals, Volatile Acid Sulfide, Cation Exchange Capacity, TOC, pH, Eh, Grain Size, Geotechnical Parameters
7: Ecological Sampling	Sediment	Temperature, Fish Identification	Macroinvertibrate Identification

TCL = Target Compound List
VOC = Volatile Organic Compound
SVOC = Semivolatile Organic Compound
TPH = Total Petroleum Hydrocarbons
GRO/DRO = Gasoline Range Organics/Diesel Range Organics
PCBs = Polychlorinated Biphenyls
TOC = Total Organic Carbon

TSS = Total Suspended Solids
TDS = Total Dissolved Solids
COD = Chemical Oxygen Demand
TKN = Total Kjeldahl Nitrogen
DO = Dissolved Oxygen
TAL = Target Analyte List
API = American Petroleum Institute
TOX = Total Organic Halide

CO_2 = Carbon Dioxide
H_2S = Hydrogen Sulfide

300162

Table 2. Analytical Parameters for Task IIIA, Activity 2 Soil Samples. BROS Site, Phase 2 RI/FS; Bridgeport, New Jersey.

Activity and Description	Boring Designation	Location	Matrix	Number of Borings	Number of Samples	Number of Samples per Boring	Analytes	Rationale
2b - Former Lagoon Area	L-1, L-2, L-7 L-8	Former Lagoon	Soil (split spoon)	4	16	4	TCL-VOC[4], TCL-SVOC, PCBs, TAL Metals, TPH, TOC, Eh, pH	Evaluate the nature, extent and mobility of lagoon residuals/fill material.
	L-3, L-4, L-5, L-6, MW-26D, MW-27D	Former Lagoon	Soil (split spoon)	6	46	8[3]	TCL-VOC[4], TCL-SVOC, PCBs, TAL Metals, TPH, TOC, Eh, pH	Evaluate the nature, extent and mobility of lagoon residuals/fill material.
	L-1, L-2, L-4, L-6, L-8	Ash /Fill Backfill	Ash and Fill (Split Spoon)	5	10	2	TOC, Eh, pH, Cation Exchange Capacity	Evaluate the effect of fill and lime added to the ash on the chemistry of ground water.
	L-9A through L-16B	Area Surrounding Former Lagoon	Soil (split spoon)	16	64	4	TCL-VOC[4], TCL-SVOC, PCBs, TAL Metals, TPH, DRO/GRO, TOC, Eh, pH,	Evaluate the nature, extent and mobility of lagoon residuals /fill material.
	L-1, L-2, L-4, L-8, L-10A, L-12A	Former Lagoon and Surrounding Area	Soil (Shelby tube)	6	9	1 to 2	Geotechnical Parameters	Supports analysis of fate and transport, evaluate vertical hydraulic conductivity
		Biased[2]	Soil (composite)		4		Waste Classification[2]	Evaluate potential remedial action alternatives.
2b - Former Process and Storage Tank Areas	P-20 through P-44, PB-1 through PB-5	Former Process Area	Soil (split spoon)	30	98	3[3,4]	TCL-VOC[4], TCL-SVOC, PCBs, TAL Metals, TPH, TOC, Eh, pH	Evaluate nature, extent, and mobility of COPCs in soils. Screen from the presence of NAPLS
	P-20, P-23, P-26, P-28, P-31, P-36, P-41, P-43		Soil (Shelby tube)	8	12	1 to 2	Geotechnical Parameters[1]	Supports analysis of fate and transport, evaluate vertical hydraulic conductivity
		Biased[2]	Soil (composite)		4		Waste Classification[2]	Evaluate potential remedial action alternatives.

[1]Geotechnical parameters include: porosity, permeability, water content, specific gravity, plastic limits, grain size.
[2]Waste classification analysis include: TCLP VOCs, TCLP SVOCs, TCLP metals PCBs, ignitability, corrosivity, total organic halides and BTU content. Up to four samples from each of the former Lagoon Areas and former Process Areas. Sampling locations to be biased in areas of highest suspected contamination based on field screening.
[3]Surface soil samples (0-2" and 2"-12") from borings L-4, P-26, P-34 and a third location from the former Process Area to be selected in the field in addition to the number of samples per boring listed.
[4]All soil samples to be analyzed for VOCs will be preserved with methanol. An additional 20% of the samples with a maximum of 20 samples from the former Process Area and Lagoon, and 40% of the samples with a maximum of 50 samples, from areas outside of the source areas will be collected without methanol preservation and analyzed for TCL-VOCs.

TCL = Target Compound List
VOC = Volatile Organic Compounds
SVOC = Semi Volatile Organic Compounds
PCBs = Polychlorinated Biphenyls
TAL = Target Analyte List
TOC = Total Organic Carbon
DRO = Diesel Range Organics
GRO = Gasoline Range Organics
TPH = Total Petroleum Hydrocarbons
COPCs = Constituent of Potential Concern

Table 3. Sampling and Analytical Plan for Soil Samples. BROS Phase 2 RI/FS; Bridgeport, New Jersey.

SAP Section Number	Location ID	Bottom Depth	Sampling Strategy	Shelby Tube	Chemical/Geochemical/Geotechnical Analysis [1]														
					Geo-technical	TCL VOC	TCL SVOC	PCBs	Pesticides	TAL Metals	Lead	Waste	TPH	DRO/ GRO	TOC/Eh/ pH	CEC	NAPL	SPLP VOCs	SPLP Metals
7.3.1	Background																		
	MW-17D	Collect soil samples at 0 to 6 and 18 to 24 inch intervals, see also Section 7.5.1 below.				×	×	×		×									
	MW-18D	"	"			×	×	×		×									
	MW-19D	"	"			×	×	×		×									
	MW-20D	"	"			×	×	×		×									
	MW-33D	"	"			×	×	×		×									
	MW-34D	"	"			×	×	×		×									
7.3.1	Swale																		
	P-30, P-31, P-33 and P-35, see Section 7.3.2 below. Samples are being collected in conjunction with Process Area.																		
7.3.1	Peach Orchard																		
	MW-20D, see Section 7.5.1 below. PB-1and PB-2, see Section 7.3.2 below. P-20 and P-21, see Section 7.3.2 below. Samples are being collected in conjunction with Process																		
7.3.2	Process Area																		
	P-20 through P-44	Base of UPRM, up to 40' BGS	A			×	×	×		×		See Note 2	×		×				
	P-20	"	"	See Note 3	×	×	×	×		×			×		×				
	P-23	"	"	"	×	×	×	×		×			×		×				
	P-26	"	A, plus 2 surface soils (0-2/2-12 inch)	"	×	×	×	×		×			×		×				
	P-28	"	"	"	×	×	×	×		×			×		×				
	P-31	"	"	"	×	×	×	×		×			×		×				
	P-34	"	A, plus surface soils (0-2/2-12 inch)			×	×	×		×			×		×				
	P-36	"	"	See Note 3	×	×	×	×		×			×		×				
	P-41	"	"	"	×	×	×	×		×			×		×				
	P-43	"	"	"	×	×	×	×		×			×		×				
	Determine in field.	Select one additional P-boring for surface soil sample (0-2/2-12 inch).				×	×	×		×			×		×				

Table 3. Sampling and Analytical Plan for Soil Samples. BROS Phase 2 RI/FS; Bridgeport, New Jersey.

SAP Section Number	Location ID	Bottom Depth	Sampling Strategy	Shelby Tube	Chemical/Geochemical/Geotechnical Analysis [1]														
					Geo-technical	TCL VOC	TCL SVOC	PCBs	Pesticides	TAL Metals	Lead	Waste	TPH	DRO/ GRO	TOC/Eh/ pH	CEC	NAPL	SPLP VOCs	SPLP Metals
7.3.2	Pepper Building																		
	PB-1 through PB-5	2' below the water table	B			×	×	×		×			×		×				
7.3.2	Lagoon Area																		
	L-1, L-2, L-7, L-8	6' into clay below peat/mud, up to 60' BGS.	C																
	L-1	"	C, plus ash and backfill	Note 4	×	×	×	×		×			×	Note 5	Notes 6 & 7	Note 7			
	L-2	"	C, plus ash and backfill	"	×	×	×	×		×			×	"	"	"			
	L-7	"	C			×	×	×		×			×	"	Note 6			Note 8	Note 8
	L-8	"	C, plus ash and backfill	Note 4	×	×	×	×		×			×	"	Notes 6 & 7	Note 7			
	L-3 through L-6	Base of Upper Middle PRM (est 120' BGS).	D																
	L-3	"	D			×	×	×		×			×	Note 5	Note 6			Note 8	Note 8
	L-4	"	D, plus 2 surface soils (0-2/2-12 inch) and ash and backfill	Note 4	×	×	×	×		×			×	"	Notes 6 & 7	Note 7			
	L-5	"	D			×	×	×		×			×	"	Note 6			Note 8	Note 8
	L-6	"	D, plus ash and backfill	1 backfill	×	×	×	×		×			×	"	Notes 6 & 7	Note 7			
	MW-26D and MW-27D	Base of Upper Middle PRM (est 120' BGS).	D			×	×	×		×			×	Note 5	Notes 6 & 7	Note 7		Note 8	Note 8
	L-9A/B through L-16A/B	6' into clay below peat/mud, up to 60' BGS.	C			×	×	×		×			×	×	Note 6			Note 8	Note 8
	L-10A	"	"	Note 4	×	×	×	×		×			×	×	"			"	"
	L-12A	"	"	"	×	×	×	×		×			×	×	"			"	"
7.4.1	NAPL																		
	All soil borings. See soil screening flow chart (Figure 2 of SAP) and Section 7.4.2 below.																		
7.4.2	NAPL Characterization																		
	Soil samples containing NAPL - See Note 9.					×		×			×			×				Note 9	Note 9
	NAPL collected from wells.					×		×			×			×			×		

300165

Table 3. Sampling and Analytical Plan for Soil Samples. BROS Phase 2 RI/FS; Bridgeport, New Jersey.

SAP Section Number	Location ID	Bottom Depth	Sampling Strategy	Shelby Tube	Chemical/Geochemical/Geotechnical Analysis [1]														
					Geo-technical	TCL VOC	TCL SVOC	PCBs	Pesticides	TAL Metals	Lead	Waste	TPH	DRO/ GRO	TOC/Eh/ pH	CEC	NAPL	SPLP VOCs	SPLP Metals
7.5.1	Ground Water Evaluation																		
	MW-24S	7' below water table, est. 15' BGS.	E	Note 14	×	×	×	×		×									
	MW-25S	"	"	"	×	×	×	×		×									
	MW-28S	"	"			×	×	×		×									
	MW-29S	"	"			×	×	×		×									
	MW-30S	"	"			×	×	×		×									
	MW-31S	"	"	Note 14	×	×	×	×		×									
	MW-32S	"	"			×	×	×		×									
	MW-26S, I, D	See Note 10.	F	Note 15	×	×	×	×		×			×	Note 5	Notes 6 & 7	Note 7		Note 8	Note 8
	MW-27S, I, D	"	"	"	×	×	×	×		×			×	"	"	"		"	"
	MW-18D	See Note 11.	G																
	MW-17D	"	"																
	MW-19D	"	"																
	MW-33D	"	"																
	MW-34D	"	"																
	MW-4D	Base of UMPRM, estimated at 115' BGS.	H	Note 14	×	×	×	×		×									
	MW-20D	Base of UMPRM, estimated at 90 feet BGS.	H, plus background samples	"	×	×	×	×		×									
	MW-21S, L, I, D	See Note 12.	I	Note 14	×	×	×	×		×									
	MW-22S, L, I, D	"	"	"	×	×	×	×		×									
	MW-23S, I, D	"	"	"	×	×	×	×		×									
	PZ-1	See Note 13.	J	Note 16	×														
	PZ-2	"	"	"	×														

Notes

1. TCL SVOCs is base/neutral fraction only, unless noted otherwise.
Waste classification parameters are: TCLP VOCs, SVOCs, and metals; total PCBs; ignitability; reactivity; corrosivity and BTU content.
Geotechnical parameters include permeability, porosity, water content, specific gravity, plastic limits and grain size.
NAPL parameters are specific gravity, API gravity and viscosity.
2. Four samples will be collected for waste classification, biased to locations with the greatest evidence of soil impact. Samples of NAPL will be collected and characterized as discussed for Section 7.4.2 below.
3. At least two Shelby tubes will be collected from the confining layer between the UPRM and the UMPRM and two from the peat above the confining layer. Shelby tubes will be collected from the interval exhibiting the most evidence of contamination.
4. At least three Shelby tubes will be collected from each of the following: the lagoon residuals, the peat layer, the top of the clay/silt beneath the UPRM, the middle of the clay/silt beneath the UPRM.
5. All samples collected from borings L-9A/B through L-16A/B and those collected from the peat layer beneath the lagoon will be tested for DRO/GRO.
6. Lagoon residuals and samples from the peat and clay will be analyzed for TOC, Eh, and pH. In addition, other samples from near NAPL areas will be analyzed for TOC.
7. Ash and backfill samples will be analyzed for TOC, pH, EH and cation exchange capacity only. Ash and backfill samples will not be collected at MW-26 or MW-27.
8. Up to 12 samples will be collected for SPLP analysis. Samples should be taken from lagoon residuals, peat and the silt/clay layer above the UMPRM.
9. Soil samples containing NAPL (based upon soil screening) will be analyzed for the listed parameters at a minimum. Additional parameters may be selected as specified for individual borings.
SPLP testing of up to 9 samples containing NAPL will be completed, in addition to the samples described in Note 8 above.

TCL	=	Target Compound List	TOC	=	Total Organic Carbon
VOCs	=	Volatile Organic Compounds	BTU	=	British Thermal Units
SVOCs	=	Semivolatile Organic Compounds	CEC	=	Cation Exchange Capacity
PCB	=	Polychlorinated Biphenyls	DRO/GRO	=	Diesel Range Organics/Gasoline Range Organics
TAL	=	Target Analyte List	SPLP	=	Synthetic Precipitation Leaching Procedure

10. S wells will be screened in the sand backfill of the lagoon, beneath the ash layer. I wells will be screened at the top of the UMPRM. D wells will be screened at the base of the UMPRM.
11. The total depth and screened interval of these wells will be established from a pilot boring at MW-18D (including gamma logging) and slotted auger screening of ground water.
12. S wells will be screened across the water table. L wells will be screened at the base of the UPRM. I wells will be screened at the top of the UMPRM. D wells will be screened at the base of the UMPRM.
13. PZs will be installed with the top of the screen set 5 feet below the base of the pond.
14. Shelby tubes will be collected from the expected screen zone of these wells. At well clusters, shelby tubes will be collected from I and D zones only.
15. Shelby tube samples will be collected from the expected screen zones of each well and also from the silt/clay layer beneath the UPRM, if present.
16. Shelby tube samples will be collected from the first encountered firm material (as opposed to loose sediment near the base of the pond).

SAMPLING STRATEGY

A = One sample biased to zone with the greatest evidence of contamination, the second sample below the first where screening indicates substantially less evidence of contamination, the third at the base of the boring or at an alternate, shallower location where screening indicates lower concentrations of contaminants in order to establish a vertical gradient. Additional samples will be collected if NAPL is detected or to establish vertical distribution of contaminants in the confining layer.

B = One sample biased to the portion of the unsaturated zone with the greatest evidence of contamination, the second sample from immediately above the water table, the third from the base of the boring.

C = One sample from the lagoon residuals, the second from the peat layer (if present), the third from the top of the clay/silt confining layer at the base of the Upper PRM, and the fourth sample from three feet into the confining layer.

D = In the Upper PRM: One sample from the lagoon residuals, the second from the peat layer (if present), the third from the top of the clay/silt confining layer at the base of the Upper PRM, and the fourth from three feet into the confining layer.
In the Upper Middle PRM: One sample just below the confining layer, the second from an intermediate depth exhibiting the greatest evidence of contamination, the third from the top of the clay layer at the base of the Upper Middle PRM and the fourth sample from three feet into the confining layer. Additional samples will be collected if NAPL is detected or to establish vertical distribution of contaminants in the confining layer.

E = One sample from the six-inch interval above the water table and one sample from a deeper interval, based upon field screening, to evaluate the vertical distribution of contaminants. Additional samples will be collected if NAPL is detected.

F = One sample from base of the Upper PRM/former lagoon, a second sample from the top of the Upper Middle PRM, a third from an intermediate depth exhibiting the greatest evidence of contamination, the fourth from the top of the clay layer at the base of the Upper Middle PRM, and a fifth from three feet into the confining layer. Additional samples will be collected if NAPL is detected or to establish vertical distribution of contaminants in the confining layer.

G = Samples for background soil evaluation only, collect ground water samples using slotted augers for on-site VOC analysis from the following intervals: 5 feet below water table, then at 20' intervals to the base of the Upper PRM. Collect a ground water sample at the base of the Upper PRM. For the Upper Middle PRM, collect one sample 5 feet below the confining layer, then at 20 foot intervals to the base of the Upper Middle PRM. Collect one sample at the base of the Upper Middle PRM.

H = One sample from base of the Upper PRM, a second sample from the top of the Upper Middle PRM, a third from an intermediate depth exhibiting the greatest evidence of contamination, the fourth from the top of the clay layer at the base of the Upper Middle PRM, and a fifth from three feet into the confining layer. Additional samples will be collected if NAPL is detected or to establish vertical distribution of contaminants in the confining layer.

I = Upper PRM: One sample from the six-inch interval above the water table and one sample from a deeper interval, based upon field screening, to evaluate the vertical distribution of contaminants. Additional samples will be collected if NAPL is detected. Upper Middle PRM: One sample from base of the Upper PRM, a second sample from the top of the Upper Middle PRM, a third from an intermediate depth exhibiting the greatest evidence of contamination, the fourth from the top of the clay layer at the base of the Upper Middle PRM, and a fifth from three feet into the confining layer. Additional samples will be collected if NAPL is detected or to establish vertical distribution of contaminants in the confining layer.

J = Shelby tube samples only.

Table 4. Analytical Parameters for Task IIIA, Activitiy 3 NAPL Samples. BROS Site, Phase 2 RI/FS; Bridgeport, New Jersey.

Activity and Description	Sample Designation	Location	Matrix	Number of Sample Locations	Number of Samples	Number of Samples per Boring	Analytes	Rationale
3b - NAPL Delineation	[1,2]	Lagoon Area/ Process Area	Soil (split spoon)	15[3]	15[3]	1	TCL-VOCs, SPLP for VOCs and metals[4]	Delineate extent of NAPL, calculate site specific soil/water distribution coefficient.
	[3]	Lagoon Area/ Process Area	NAPL	4[3]	4[3]	1	TCL-VOCs, specific gravity, API gravity, viscosity, DRO/GRO, PCBs, and lead	Determine constituent concentrations, define fate and transport related characteristics,

[1] The samples may be combined with the soil samples collected as part of Task 3.
[2] Supplemental samples which may be collected to delineate NAPL based on the activities performed in Task 3.
[3] Actual number and locations of samples to be determined based on field observations.
[4] Up to 9 samples will be analized for SPLP for VOCs and Metals.

NAPL = Nonaqueous Phase Liquids
API = American Petroleum Institute
DRO = Diesel Range Organics
GRO = Gasoline Range Organics
TCL = Target Compound List
VOC = Volatile Organic Compounds
SVOC = Semi Volatile Organic Compounds
SPLP = Synthetic Precipitation Leaching Procedure

Table 5. Analytical Parameters for Task IIIA, Activity 4 Ground Water Investigation Samples. BROS Site, Phase 2 RI/FS; Bridgeport, New Jersey.

Activity and Description	Boring/Well Designation	Location	Matrix	Number of Borings/ Wells	Number of Samples	Number of Samples per Boring/Well	Analytes	Rationale
4a - Ground Water Quality Evaluation	MW-24S, MW-25S, MW-28S through MW-32S	Upper PRM	Soil	7	14	2	TCL-VOC[15], TCL-SVOC, PCBs, TAL Metals, Geotechnical Parameter[1,2]	Evaluate the nature and extent of compounds of concern in soil in the Upper PRM
	PZ-1, PZ-2	Upper PRM	Soil	2	4	2	TCL-VOC[15], TCL-SVOC, PCBs, TAL Metals, Geotechnical Parameter[1,2]	Evaluate the nature and extent of compounds of concern in soil in the Upper PRM
	MW-4D, MW-18D, MW-20D, MW-21D, MW-22D, MW-23D, MW-26D, and MW-27D	Upper Middle PRM	Soil	8	44[9]	5	TCL-VOC[15], TCL-SVOC, PCBs, TAL Metals, Geotechnical Parameter[1,2]	Evaluate the nature and extent of compounds of concern in soil in the Upper PRM
	Field Screening	Upper PRM, Upper Middle PRM	Water	5	50[10]	10[10]	VOCs by on-site laboratory	Real time evaluation of COPCs in ground water south of I-295
	MW-17D, MW-18D, MW-19D, MW-33D, MW-34D (Screening Round)	Upper Middle PRM	Water	5	5	1	TCL-VOCs	Confirm Field Screening Results
	First Round[3]	Upper PRM, Upper Middle PRM	Water	43	43	1	TCL-VOC[14], TCL-SVOC, TAL Metals, dissolved iron, TSS, TDS, Sulfide/Sulfate, Alkalinity, Nitrate/Nitrite Ammonia, Chloride, Silica, Orthophosphate, COD, TKN, TOC,DO*, Hardness, Eh*, pH*, Temperature*, Specific Conductance*, Ferrous Iron*, Methane Ethene, Ethane, OA, CO_2, H_2S, Waste Classification[12]	Evaluate the nature and extent of compounds of concern in ground water and the natural attenuation process
	Second Round[4]	Upper PRM, Upper Middle PRM	Water	61	61	1	Same as above with the exception of TCL-BN in place of TCL-SVOC	Evaluate the nature and extent of compounds of concern in ground water and the natural attenuation process.
	Subsequent Quarterly Monitoring[7]	Upper PRM, Upper Middle PRM	Water	TBD	TBD	1	Varies[8, 14]	Evaluate the nature and extent of compounds of concern in ground water
	Home Owners Wells	TBD	Water	TBD	TBD	1	TCL, VOCs[13], TCL-SVOCs[11], TAL-Metals[11]	Evaluate COPCs in Potential Receptors.

300169

* = Measured in the Field.
(1)Geotechnical parameters includes porosity, permeability, water content, specific gravity, plastic limits, grain size.
(2)5 samples to be selected based on field observations.
(3)First round monitoring wells = All existing MW designated wells (30 wells) plus S-1A, S-1B, S-1C, S-2A, S-2C, S-3A, S-3C, S-4, S-6, S-11A, S-11C, EPA-107 and EPA 108.
(4)Second round monitoring wells = MW-1A, S-2C, S-3C, MW-5B, MW-7A, MW-8A, MW-8B, MW-10B, S-11A, MW-11B, MW-11C, MW-13A and MW-14B plus all new monitoring wells.
(5)Third round monitoring wells =MW-1A, S-2C, S-3C, MW-5B, MW-7A, MW-8A, MW-8B, MW-10B, S-11A, MW-11B, MW-11C, MW-13A, MW-14B, MW-18D, MW-20D, MW-21D, MW-22D, MW-23D, MW-24S, MW-25S, MW-33D and MW-34D plus intermediate depth wells to be determined based on second round results.
(6)Monitoring wells MW-4D, MW-26S, MW-26I, MW-26D, MW-27S, MW-27I, MW-27D, MW-29S, MW-1A, and S-11A to be analyzed for dissolved metals.
(7)Third round wells to be sampled on a quarterly basis.
(8)Analytes include First Round parameters once a year and Third Round parameters three times a year.
(9)Surface soil samples (0-6" and 18-24") to be collected from MW-17D, MW-18D, MW-19D and MW-20D.
(10)Samples to be collected through slotted augers during well installation.
(11)Only to be analyzed from home owners wells within ½ mile of BROS Property if the constituents are likely to be present based upon the well location and ground water quality data available at the time.
(12)Waste classification analysis include: PCBs, ignitability, corrosivity, total organic halides, and BTU Content.
(13)TCL VOCs by EPA Method 500 Series.
(14)All monitoring wells will be purged and sampled using the low flow/low stress techniques. The following monitoring wells will also be sampled and purged using traditional methods and analyzed for TCL-VOCs:
First Round - S-11C, MW-5B, MW-7A, MW-8A, MW-8B, MW-10B, MW-11B, MW-14B.
Second and Third Rounds - Same wells listed for First Round plus new wells, MW-18D, MW-20D, MW-21D, MW-22D, MW-23D, MW-24S, MW-25S, MW-29S, MW-33D, MW-34D.
Subsequent Rounds - 30% of the wells or ten of the wells listed for the Second and Third Rounds, whichever is less, if needed based upon the results of the prior rounds.
(15)All soil samples to be analyzed for VOCs will be preserved with methanol. An additional 40% of the samples, with a maximum of 50 samples, from areas outside of the source areas will be collected without methanol preservation and analyzed for TCL-VOCs.

TCL = Target Compound List
VOC - Volatile Organic Compounds
SVOC - Semi Volatile Organic Compounds
PCBs = Polychlorinated Biphenyls
BN = Base Neutral Extractable Semivolatile Organic Compounds
TAL Target Analyte List
TSS = Total Suspended Solids
CO_2 = Carbon Dioxide
TDS = Total Dissolved Solids
COD = Chemical Oxygen Demand
TKN = Total Kjeldahl Nitrogen
TOC = Total Organic Carbon
DO = Dissolved Oxygen
OA = Organic Acids
TBD = To be Determined
H_2S = Hydrogen Sulfide

Table 6. Analytical Parameters for Task IIIA, Activity 5 Surface Water and Sediment Samples. BROS Site, Phase 2 RI/FS; Bridgeport, New Jersey.

Activity and Description	Sample Designation	Location	Matrix	Number of Sample Locations	Number of Samples	Number of Samples Per Location	Analytes	Rationale
5a - Gaventa and Swindell Ponds Surface Water Evaluation	GVT-1 through GVT-3 SWD-1 through SWD-3	Gaventa Pond Swindell Pond	Surface Water Surface Water	3 3	3 3	1 1	TCL-SVOC, TAL-Metals, Alkalinity, TSS, TDS, TOC, DO*, Eh*, pH*, Conductivity*, Temperature*, Ferrous Iron*, Hardness.	Confirm existing results, delineate compounds of concern in surface water.
	GVT-1 through GVT-8	Gaventa Pond	Soil	8	8	1	TCL VOC, TCL-SVOC, PCBs, TAL-Metals, TCL Pesticides(9), pH, Eh, VAS, CEC, TOC, Grain Size	Confirm existing results, delineate compounds of concern in sediments.
	SWD-1 through SWD-3	Swindell Pond	Soil	3	3	1	Arsenic, Chromium, Copper, Lead, Zinc, TCL Pesticides(9), pH, Eh, VAS, CEC, TOC, Grain Size	Confirm existing results, delineate compounds of concern in sediments.
5b - Little Timber Creek and Swamp Surface Water Quality Evaluation	LTC-1 through LTC-6, LTC-12 through LTC-18, LTC-51 through LTC-55, LTC-58 through LTC-61	Little Timber Creek and Swamp	Water	22	22	1	TCL-VOC, TCL-SVOC(1), PCBs(1), TAL-Metals(1),TPH, TSS(2), TDS(2), Sulfide/Sulfate(2), Nitrite/Nitrate(2), Chloride(2), TKN(2), TOC(1), Ammonia(2), Hardness(2), Alkalinity, Eh*, pH*, Temperature*, Conductivity*, Ferrous Iron*, DO*	Confirm existing results, delineate compounds of concerns in surface water.
	R-2, R-5, R-8, R-11, R-14	Reference Areas 1 through 5	Water	5	5	1	TCL-VOC, TCL-SVOC(1), PCBs(1), TAL-Metals(1),TPH, TSS(2), TDS(2), Sulfide/Sulfate(2), Nitrite/Nitrate(2), Chloride(2), TKN(2), TOC(1), Ammonia(2), Hardness(2), Alkalinity, Eh*, pH*, Temperature*, Conductivity*, Ferrous Iron*, DO*	Serve as background.

Table 6. Analytical Parameters for Task IIIA, Activity 5 Surface Water and Sediment Samples. BROS Site, Phase 2 RI/FS; Bridgeport, New Jersey.

Activity and Description	Sample Designation	Location	Matrix	Number of Sample Locations	Number of Samples	Number of Samples Per Location	Analytes	Rationale
	TBD	Little Timber Creek	Water	TBD	TBD	1	TBD	Additional Delineation of compounds of concern in Surface Water.
Little Timber Creek and Swamp Sediment Sampling	LTC-5, LTC-7 through LTC-11, LTC-50	de manifestis zone	Sediment	7[3]	70+[3]	10+[3]	TPH & Lead (on-site laboratory)	Assist with the selection of specific sediment sample locations for full laboratory characterization
	LTC-1 through LTC-4, LTC-6, LTC-12 through LTC-49, LTC 51 through LTC-61	intermediate and de manifestis zone	Sediment	54	108[8]	2[8]	TPH & Lead (on-site laboratory)	Assist with the selection of specific sediment sample locations for full laboratory characterization
	TBD	de manifestis, intermediate and de minimus zone	Sediment	TBD	TBD	3[7]	TCL-VOC, TCL-SVOC, PCB, TAL-Metals, TCL-Pesticides[9], Eh, pH, DO, TOC, TPH, grain size, VAS[4], CEC[4], SPLP[5] VOCs and Metals.	Confirm screening results, delineate compounds of concern in sediments.
	R-1 through R-15	Reference Areas 1 through 5	Sediment	15	30	2	TCL-VOC, TCL-SVOC, PCB, TAL-Metals, TCL-Pesticides[9], Eh, pH, DO, TOC, TPH, grain size, VAS[4], CEC[4]	Serve as background.
		Little Timber Creek	Sediment	4	4	1	Waste Classification Parameters[6]	Evaluate the remedial treatment or disposal options.
5C - Swale along U.S. Route 130	SWL-1 through SWL-2	Swale along U.S. Route 130 N.	Water	2	2	1	TCL-VOC, TCL-SVOC[1], PCB[1], TAL-metals[1], TPH	Evaluate Fate and Transport of COPCs.

Table 6. Analytical Parameters for Task IIIA, Activity 5 Surface Water and Sediment Samples. BROS Site, Phase 2 RI/FS; Bridgeport, New Jersey.

* = Measured in the field.

(1) Also analysis of dissolved constituents.

(2) 50 percent of the samples collected will be analyzed for this parameter.

(3) Samples from the de manifestis zone (LTC-5, LTC-7 through LTC-11, and LTC-50) will be collected from six-inch intervals to a depth of five feet unless NAPL is encountered or if the results of the deepest sample exceed 10,000 mg/kg TPH or 500 mg/kg lead. Samples will continue to be collected at six-inch intervals to one foot below the evidence of NAPL and analyzed for TPH and lead. This table assumes only ten depths will be analyzed per boring.

(4) 30 percent of the samples will be collected and analyzed for this parameter.

(5) Six samples collected from the intermediate zone will be analyzed for SPLP.

(6) Waste classification parameters = TCLP VOCs, SVOCs, and metals; total PCBs; ignitability; corrosivity; TOX and BTU content.

(7) Sediment samples will be collected from 0 to 6-inch interval and 0 to 1-inch interval of the first encountered substrate/sediment and from 0-6 inch interval of the first inorganic layer. Only two sediment samples will be collected in defined stream channels.

(8) A sediment sample will be collected from 0 to 6-inch interval of the first encountered substrate/sediment and from 0 to 6-inch interval of the first inorganic layer.

(9) One sediment sample from Gaventa pond (GVT-1) Swindell Pond (SWD-2)and each reference area (R-2, R-5, R-8, R-11, and R-14) and 10% of the confirmation sediment samples from Little Timber Creek and Swamp will be analyzed for this parameter.

TCL = Target Compound List
VOC = Volatile Organic Compounds
SVOC = Semi Volatile Organic Compounds
PCBs = Polychlorinated Biphenyls
TAL = Target Analyte List
SPLP = Synthetic Precipitation Leaching Procedure
TSS = Total Suspended Solids
TDS = Total Dissolved Solids
DO = Dissolved Oxygen
VAS = Volatile Acid Sulfide
CEC = Cation Exchange Capacity
TBD = To be determined

Table 7. Analytical Parameters for Task IIIA, Activity 7 Ecological Risk Assessment Samples. BROS Site, Phase 2 RI/FS; Bridgeport, New Jersey.

Activity and Description	Sample Designation	Location	Matrix	Number of Sample Locations	Number of Samples	Number of Samples Per Location	Analytes	Rationale
7 - Ecological Risk Assessment	TBD	Little Timber Creek Swamp and Reference Areas	TBD	TBD	TBD	TBD	Macroinvertebrate Identification	Identify and quantify invertebrate population.

* = Measured in the field.

TBD = To be determined.

Table 8. Projected Number of Field Samples. BROS Phase 2 RI/FS; Bridgeport, New Jersey.

Activity	Parameter	Field Samples	Field Duplicates[a]	Field Blanks[b]	Trip Blanks[c]	MS/MSD[d]	Total Laboratory Samples
2: Soils Investigation[(1)]	TCL-VOCs	302	15	15	15	15	362
	TCL-SVOCs	232	12	12	NA	12	280
	DRO/GRO	64	4	4	NA	4	76
	PCBs	232	12	12	NA	12	280
	TAL Metals	232	12	12	NA	12	280
	TOC, Eh, pH	238	12	0	NA	NA	274
	Geotechnical Parameters[e]	21	NA	NA	NA	NA	21
	Total Petroleum Hydrocarbons	232	12	12	NA	NA	256
	Cation Exchange Capacity	10	1	1	NA	NA	12
	Waste Classification Parameters	8	NA	NA	NA	NA	8
	- Ignitability						
	- Corrosivity						
	- Reactivity						
	- Toxicity (TCLP, VOCs, SVOCs, Pesticides, Metals)						
	- TOX						
	- BTU						
3: Non Aqueous Phase Liquid Evaluation							
NAPL	TCL-VOCs	4	1	0	1	1	7
	GRO/DRO	4	1	0	1	1	7
	Specific gravity	4	NA	NA	NA	NA	4
	API Gravity	4	NA	NA	NA	NA	4
	Viscosity	4	NA	NA	NA	NA	4
	Waste Classification Parameters	4	NA	NA	NA	NA	4
	- Ignitability						
	- Corrosivity						
	- Reactivity						
	- Toxicity (TCLP, VOCs, SVOCs, Pesticides, Metals)						
	- TOX						
	- BTU						
Soil	SPLP VOCs	15	1	1	1	1	19
	SPLP metals	15	1	1	NA	1	18
	TCL-VOCs	15	1	1	1	1	19

Table 8. Projected Number of Field Samples. BROS Phase 2 RI/FS; Bridgeport, New Jersey.

Activity	Parameter	Field Samples	Field Duplicates[a]	Field Blanks[b]	Trip Blanks[c]	MS/MSD[d]	Total Laboratory Samples
4a: Ground-Water Quality Evaluation							
Soil	TCL-VOCs	70	4	4	6	4	88
	TCL-SVOCs	70	4	4	NA	4	82
	PCBs	70	4	4	NA	4	82
	TAL-Metals	70	4	4	NA	4	82
	TOC, Eh, pH	70	4	0	NA	NA	74
	Geotechnical Parameters[e]	10	NA	NA	NA	NA	10
Water[f, (2)]	TCL-VOCs	19	8	8	8	8	191
	TCL-SVOCs	43	3	3	NA	3	52
	TCL-BNs	61	4	4	NA	4	73
	TAL-Metals (total)	104	6	6	NA	6	122
	TAL-Metals (dissolved)	10	1	1	NA	1	13
	Iron-dissolved	43	3	3	NA	3	52
	TOC	104	6	0	NA	0	110
	Alkalinity	104	6	0	NA	0	110
	Hardness	104	6	0	NA	0	110
	sulfide/sulfate	104	6	0	NA	0	110
	nitrite/nitrate	104	6	0	NA	0	110
	chloride	104	6	0	NA	0	110
	COD	104	6	0	NA	0	110
	TSS	104	6	0	NA	0	110
	TDS	104	6	0	NA	0	110
	TKN	104	6	0	NA	0	110
	Methane	104	6	0	NA	0	110
	Ethane	104	6	0	NA	0	110
	Ethene	104	6	0	NA	0	110
	Organic Acids	104	6	0	NA	0	110
	Orthophosphate	104	6	0	NA	0	

Table 8. Projected Number of Field Samples. BROS Phase 2 RI/FS; Bridgeport, New Jersey.

Activity	Parameter	Field Samples	Field Duplicates[a]	Field Blanks[b]	Trip Blanks[c]	MS/MSD[d]	Total Laboratory Samples
5: Surface Water Quality Evaluation[(1)] (Water[f])	TCL-VOCs	29	2	2	2	2	37
	TCL-SVOCs (total)	32	2	2	NA	2	38
	TCL-SVOCs (dissolved)	29	2	2	NA	2	35
	PCBs (total)	29	2	2	NA	2	35
	PCBs (dissolved)	29	2	2	NA	2	35
	TAL Metals (total)	35	2	2	NA	2	41
	TAL Metals (dissolved)	29	2	2	NA	2	35
	TPH	29	2	0	NA	2	33
	Hardness	19	1	NA	NA	NA	20
	Alkalinity	32	2	NA	NA	NA	34
	TSS	19	1	NA	NA	NA	20
	TDS	19	1	NA	NA	NA	20
	TOC	19	1	NA	NA	NA	20
	chloride	13	1	NA	NA	NA	14
	TKN	13	1	NA	NA	NA	14
	sulfate	13	1	NA	NA	NA	14
	sulfide	13	1	NA	NA	NA	14
	nitrate	13	1	NA	NA	NA	14
	nitrite	13	1	NA	NA	NA	14
5: Soil/Sediment Sampling[(1)]	TCL-VOCs	45	3	3	3	3	57
	TCL-SVOCs	45	3	3	NA	3	54
	PCBs	45	3	3	NA	3	54
	TAL Metals	45	3	3	NA	3	54
	TCL Pesticides	7	1	1	NA	1	10
	TPH	45	3	3	NA	3	54
	Volatile Acid Sulfide	15	1	NA	NA	NA	16
	Cation Exchange Capacity	15	1	NA	NA	NA	16
	TOC, pH, Eh	45	3	NA	NA	NA	48
	Grain Size	45	NA	NA	NA	NA	45
	Waste Classification Parameters	4	NA	NA	NA	NA	4
	- Ignitability						
	- Corrosivity						
	- Reactivity						
	- Toxicity (TCLP, VOCs, SVOCs, Pesticides, Metals)						
	- TOX						
	- BTU						
7: Ecological Evaluation Sediment	Micro-Organism Identification	TBD	TBD	TBD	NA	NA	TBD

a. Duplicates to be collected at a rate of 5% of samples collected.
b. Frequency estimates based on one blank per twenty samples, or one per day minimum.
c. The number of trip blanks is estimated based on one trip blank per cooler.
d. Matrix Spike/Matrix Spike Duplicate - one per twenty samples.
e. Includes horizontal and vertical permeability, porosity, specific gravity, water content, and grain size.
f. Field parameters include pH, Eh, conductivity, dissolved oxygen, temperature, and ferrous iron.

(1) Additional samples will be collected for analysis but the locations and number of samples will be determined as initial results warrant.

(2) Only includes samples though Second Round of sampling.

TCL	=	Target Compound List	BN	=	Base Neutral Extractable Semivolatile Organic Compounds
VOC	=	Volatile Organic Compound	COD	=	Chemical Oxygen Demand
SVOC	=	Semivolatile Organic Compound	TSS	=	Total Suspended Solids
DRO/GRO	=	Diesel Range Organics/Gasoline Range Organics	TDS	=	Total Dissolved Solids
PCB	=	Polychlorinated Biphenyls	TKN	=	Total Kjeldahl Nitrogen
TAL	=	Target Analyte List	NA	=	Not Applicable
VAS	=	Volatile Acid Sulfide	BTU	=	British Thermal Units
TOC	=	Total Organic Carbon	CEC	=	Cation Exchange Capacity
API	=	American Petroleum Institute	TOX	=	Total Organic Halides

Table 9. Project Quality Control Summary. BROS Site; Bridgeport, New Jersey.

Parameter	Matrix	Quantitation Limit[a]	Estimated Accuracy (%) *	Estimated Precision (% RPD) *	Completeness	Analysis Method
TCL Volatile Organics	Water	5 to 20 µg/L	37 – 157	30	95%	8260B[b]
TCL Semivolatile Organics	Water	10 to 100 µg/L	1 – 131	30	95%	8270C[b]
Polychlorinated Biphenyls	Water	0.05 µg/L	43 – 126	30	95%	8082[b]
Total Petroleum Hydrocarbons	Water	0.4 mg/L	50 – 146	20	90%	8015B[b]
Gasoline Range Organics	Water	0.50 mg/L	70 – 130	30	90%	8015B[b]
Diesel Range Organics	Water	0.4 mg/L	60 – 120	20	90%	8015B[b]
TAL Metals	Water	0.2 to 5000 ug/L	75 – 125	20	95%	6010B/6020/7
						470A[b]
Chemical Oxygen Demand	Water	50 mg/L	82 – 114	15	90%	410.4[c]
Dissolved Oxygen	Water	0.2 mg/L	75 – 125	20	90%	360.1[c]
Chloride	Water	1.0 mg/L	80 – 120	20	90%	325.2[c]
Alkalinity	Water	1.0 mg/L	NA	15	90%	310.1[c]
Hardness	Water	3 mg/L	81 – 116	20	90%	130.2[c]
Sulfide	Water	0.1 mg/L	43 – 137	20	90%	376.2[c]
Sulfate	Water	2 mg/L	60 – 132	20	90%	375.4[c]
Nitrite	Water	0.02 mg/L	70 – 130	20	90%	353.2[c]
Nitrate	Water	0.1 mg/L	62 – 133	20	90%	353.2[c]
Total Organic Carbon	Water	1.0 mg/L	75 – 125	20	90%	415.1[c]
Total Suspended Solids	Water	9 mg/L	NA	NA	90%	160.2[c]
Total Dissolved Solids	Water	30 mg/L	NA	NA	90%	160.1[c]
Total Kjeldahl Nitrogen	Water	0.5 mg/L	40 – 182	20	90%	351.2[c]
Orthophosphate	Water	0.02 mg/L	46 – 143	20	90%	365.2[c]
Organic Acids	Water	TBD	TBD	TBD	90%	Leenher[f]
Methane	Water	0.004 mg/L	50 – 100	30	90%	M 8000[b]
Ethane	Water	0.009 mg/L	45 – 95	30	90%	M 8000[b]
Ethene	Water	0.007 mg/L	25 – 75	30	90%	M 8000[b]
TCL Volatile Organics – Low	Soil[a]	5 to 20 µg/kg	18 – 171	30	95%	8260B[b]
TCL Volatile Organics – High	Soil[a]	250 to 1000 µg/kg	18 – 171	30	95%	8260B[b]
TCL Semivolatile Organics	Soil[a]	330 to 1600 µg/kg	1 – 158	30	95%	8270C[b]
Total Petroleum Hydrocarbons	Soil[a]	7 mg/kg	50 – 146	20	90%	8015B[b]

Table 9. Project Quality Control Summary. BROS Site; Bridgeport, New Jersey.

Parameter	Matrix	Quantitation Limit[a]	Estimated Accuracy (%) *	Estimated Precision (% RPD) *	Completeness	Analysis Method
Gasoline Range Organics	Soil[a]	1.0 mg/kg	70 – 130	30	90%	8015B[b]
Diesel Range Organics	Soil[a]	7 mg/kg	60 – 120	20	90%	8015B[b]
Polychlorinated Biphenyls	Soil[a]	17 ug/kg	64 – 127	50	95%	8082[b]
TAL Metals	Soil[a]	0.1 to 1,000 mg/kg	75 – 125	20	95%	6010B/6020/7471A[b]
Total Organic Carbon	Soil[a]	50 mg/kg	75 – 125	20	90%	415.1M[c]
PH (off site)	Soil[a]	0.01 units	0.1 unit	NA	90%	9045C Mod[b]
Eh (off site)	Soil[a]	NA	NA	NA	90%	ASTM D1498[d]
Grain Size	Soil[a]	NA	NA	NA	90%	ASTM D422-63[d]
Permeability	Soil[a]	NA	NA	NA	90%	ASTM D5084-90[d]
Specific Gravity	Soil[a]	NA	NA	20 RPD	90%	ASTM D4052[d]
Porosity	Soil[a]	NA	NA	NA	90%	Calculated
Water Content	Soil[a]	NA	NA	NA	90%	ASTM D2216[d]
Cation Exchange Capacity	Soil[a]	10 meq/100 grams	NA	20 RPD	90%	9081[b]
Acid Volatile Sulfide	Soil[a]	1 umole/gram	NA	20 RPD	90%	AVS/SEM
Gasoline Range Organics	NAPL	2.5 mg/kg	60 – 140	40	90%	8015B[b]
Diesel Range Organics	NAPL	10 mg/kg	50 – 150	50	90%	8015B[b]
Specific Gravity	NAPL	NA	NA	NA	90%	ASTM D1298[e]
API Gravity	NAPL	NA	NA	NA	90%	ASTM D1298[e]
Total Organic Halide	NAPL	NA	NA	NA	90%	5050/9253[b]
Viscosity	NAPL	NA	NA	NA	90%	ASTM D 445[d]
TCL Volatile Organics	NAPL	0.5 – 1.0 mg/kg	61 – 145	30	90%	8260B[b]
Waste Disposal Parameters	Investigation Derived Waste Soil, Water, NAPL					
-Ignitability		NA	NA	NA	90%	1010/1011[b]
-Corrosivity		NA	NA	NA	90%	1100[b]
-Reactivity		NA	NA	NA	90%	9010/9030[b]
-Toxicity		NA	NA	NA	90%	ASTM 240-87[d]
-BTU		NA	NA	NA	90%	5050[b]
VOCs		NA	NA	NA	90%	1311/8260B[b]
SVOCs		NA	NA	NA	90%	1311/8270C[b]
Pesticides		NA	NA	NA	90%	1311/8081[b]
RCRA metals		NA	NA	NA	90%	1311/6010/7470[b]

* Many of these values are statistically determined and may change daily as data points are completed.

MeCl = Methylene Chloride
TCL = Target Compound List
TAL = Target Analyte List
RPD = Relative Percent Difference
NAPL = Non-Aqueous Phase Liquids
AVS = Acid Volatile Sulfide
SEM = Simultaneously Extracted Metals
TBD = To Be Determined
µg/L = microgram per liter
mg/L = milligram per liter
µg/kg = microgram per kilogram
mg/kg = milligram per kilogram
NA = Not Applicable

a. Limits for soil are based on nominal wet weight of the sample. Dry weight limits will be higher.
b. Test Methods for Evaluating Solid Wastes.
c. Standard Methods for the Examination of Water and Wastewater.
d. American Society for Testing and Materials.
e. Aquatic Microbial Ecology Methods.
f. Comprehensive Approach to Preparative Isolation and Fractionaition of Dissolved Organic Carbon from Natural Waters and Waste Waters (Leenher, 1981).

Table 10. Field Quality Control Sample Frequency. BROS Phase 2 RI/FS; Bridgeport, New Jersey.

Parameters	Media	Trip Blank[a]	Field Blank[b]	Field Duplicates[c]	MS/MSD[d]
TCL Volatile Organic Compounds	Soil	1/20	1/20	1/20	1/20
TCL Semivolatile Organic Compounds	Soil	NA	1/20	1/20	1/20
DRO/GRO	Soil	1/20	1/20	1/20	1/20
TPH	Soil	NA	1/20	1/20	1/20
Polychlorinated Biphenyls	Soil	NA	1/20	1/20	1/20
TAL Metals	Soil	NA	1/20	1/20	1/20
Total Organic Carbon	Soil	NA	NA	1/20	NA
pH (off site)	Soil	NA	NA	1/20	NA
Eh (off site)	Soil	NA	NA	1/20	NA
Geotechnical Parameters[e]	Soil	NA	NA	NA	NA
Waste Characterization Parameters	Soil	NA	NA	NA	NA
Cation Exchange Capacity	Soil	NA	NA	1/20	NA
Acid Volatile Sulfide	Soil	NA	NA	1/20	NA
SPLP-VOCs	Soil	1/20	1/20	1/20	1/20
SPLP-Metals	Soil	NA	1/20	1/20	1/20
TCL Volatile Organics	Water	1/20	1/20	1/20	1/20
TCL Semivolatile Organics	Water	NA	1/20	1/20	1/20
TPH	Water	NA	1/20	1/20	1/20
GRO/DRO	Water	NA	1/20	1/20	1/20
Polychlorinated Biphenyls	Water	NA	1/20	1/20	1/20
TAL Metals	Water	NA	1/20	1/20	1/20
Chemical Oxygen Demand	Water	NA	NA	1/20	NA
Chloride	Water	NA	NA	1/20	NA
Alkalinity	Water	NA	NA	1/20	NA
Hardness	Water	NA	NA	1/20	NA
Sulfide/Sulfate	Water	NA	NA	1/20	NA
Nitrite/Nitrate	Water	NA	NA	1/20	NA
Ammonia	Water	NA	NA	NA	NA
Total Organic Carbon	Water	NA	NA	1/20	NA
TSS	Water	NA	NA	1/20	NA
TDS	Water	NA	NA	1/20	NA
Silica	Water	NA	NA	NA	NA
Organic Acids	Water	NA	NA	NA	NA
Total Kjeldahl Nitrogen	Water	NA	NA	1/20	NA
Orthophosphate	Water	NA	NA	1/20	NA
Methane	Water	NA	1/20	1/20	1/20
Ethane	Water	NA	1/20	1/20	1/20
Ethene	Water	NA	1/20	1/20	1/20
ph/Eh/Temperature/Specific Conductance/ Dissolved Oxygen/Turbidity	Water	NA	NA	1/20	NA
Ferrous iron	Water	NA	NA	1/20	NA
Carbon Dioxide	Water	NA	NA	1/20	NA
H_2S	Water	NA	NA	1/20	NA

Table 10. Field Quality Control Sample Frequency. BROS Phase 2 RI/FS; Bridgeport, New Jersey.

Parameters	Media	Trip Blank[a]	Field Blank[b]	Field Duplicates[c]	MS/MSD[d]
Waste Classification Parameters	Water	NA	NA	NA	NA
DRO/GRO	NAPL	1/20	1/20	1/20	NA
Specific Gravity	NAPL	NA	NA	1/20	NA
API Gravity	NAPL	NA	NA	1/20	NA
Viscosity	NAPL	NA	NA	1/20	NA
Total Organic Halide	NAPL	NA	NA	1/20	NA
Waste Classification Parameters	NAPL	NA	NA	NA	NA
TCL Volatile Organic Compounds	NAPL	1/20	1/20	1/20	1/20

a. Where applicable, one per twenty or fewer field samples, or one per shipment container (VOC only), whichever is more frequent.
b. Where applicable, one per twenty of fewer field samples, or one per day, whichever is most frequent.
c. Where applicable, one per twenty or fewer field samples.
d. Where applicable, one per twenty field samples or twice per week during sampling, whichever is more frequent.
e. Off-site analysis for permeability, grain size, specific gravity, water content, and porosity.
f. Field parameters.

TCL = Target Compound List
TPH = Total Petroleum Hydrocarbons
DRO/GRO = Diesel Range Organic / Gasoline Range Organic
TAL = Target Analyte List
TSS = Total Suspended Solids
TDS = Total Dissolved Solid
API = American Petroleum Institute
NA = Not Applicable

Table 11. Laboratory Quality Control Sample Frequency. BROS Phase 2 RI/FS; Bridgeport, New Jersey

Parameter	Media	Method Blank[a]	MS[a]	MSD[a]	Laboratory Replicate[a]	Analysis Method
TCL Volatile Organic Compounds	Soil	1/20	1/20	1/20	NA	8260B[b]
TCL Semivolatile Organic Compounds	Soil	1/20	1/20	1/20	NA	8270C[b]
Total Petroleum Hydrocarbons	Soil	1/20	1/20	1/20	NA	8015B[b]
GRO Organics	Soil	1/20	1/20	1/20	NA	8015B[b]
DRO Organics	Soil	1/20	1/20	NA	NA	8015B[b]
Polychlorinated Biphenyls	Soil	1/20	1/20	1/20	NA	8082[b]
TAL Metals	Soil	1/20	1/20	NA	1/20	6020 / 6010B / 7471a[b]
Total Organic Carbon	Soil	1/20	1/20	1/20	1/20	415.1M / 9060[b]
pH (off site)	Soil	NA	NA	NA	1/10	9045C[b]
Eh (off site)	Soil	NA	NA	NA	1/20	ASTM D1498[c]
Grain Size	Soil	NA	NA	NA	NA	ASTM D422-63[c]
Porosity	Soil	NA	NA	NA	NA	Calculated
Permeability	Soil	NA	NA	NA	NA	ASTM D5084-90[c]
Specific Gravity	Soil	NA	NA	NA	NA	ASTM D4052[c]
Water Content	Soil	NA	NA	NA	NA	ASTM D2216[c]
Cation Exchange Capacity	Soil	1/20	NA	NA	1/20	9081[c]
Acid Volatile Sulfide	Soil	1/20	1/20	1/20	1/20	AVS/SEM
SPLP-Metals	Soil	1/20	1/20	1/20	1/20	1312 / 6010B / 6020 / 7470A
SPLP-VOCs	Soil	1/20	1/20	NA	1/20	1312 / 8260B
Waste Classification Parametcr	Soil	NA	NA	NA	NA	See Below
TCL Volatile Organics	Water	1/20	1/20	1/20	1/20	8260B[b]
TCL Volatile Organics	Water	NA	NA	NA	NA	524.2 Rev. 4[f]
TCL Semivolatile Organics	Water	1/20	1/20	1/20	1/20	8270C[b]
Total Petroleum Hydrocarbons	Water	1/20	1/20	1/20	1/20	8015B[b]
GRO Organics	Water	1/20	1/20	1/20	1/20	8015B[b]
DRO Organics	Water	1/20	1/20	NA	1/20	8015B[b]
Polychlorinated Biphenyls	Water	1/20	1/20	1/20	1/20	8082[b]
TAL Metals	Water	1/20	1/20	NA	1/20	6010B / 6020 / 7470A[b]
Chemical Oxygen Demand	Water	1/20	1/20	1/20	1/20	410.4[d]
Chloride	Water	NA	1/20	1/20	1/20	325.2 / 325.3[d]
Alkalinity	Water	NA	1/20	1/20	1/20	310.1[d]
Hardness	Water	1/20	1/20	1/20	1/20	130.2[d]
Sulfide	Water	1/20	1/20	1/20	1/20	376.2[d]
Sulfate	Water	1/20	1/20	1/20	1/20	375.4[d]
Nitrite	Water	1/20	1/20	1/20	1/20	353.2[d]
Nitrate	Water	1/20	1/20	1/20	1/20	353.2[d]
Ammonia	Water	1/20	1/20	1/20	1/20	350.1[d]
Total Organic Carbon	Water	1/20	1/20	1/20	1/20	415.1[d] / 9060[b]
Organic Acids	Water	1/20	NA	NA	NA	column separation/HPLC
TSS	Water	1/20	1/20	1/20	1/20	160.2[d]
TDS	Water	1/20	1/20	1/20	1/20	160.1[d]
Total Kjeldahl Nitrogen	Water	1/20	1/20	1/20	1/20	351.2[d]
Silica	Water	1/20	1/20	1/20	1/20	370.1[d]
Orthophosphate	Water	NA	NA	1/20	1/20	365.1/365.3[d]

Table 11. Laboratory Quality Control Sample Frequency. BROS Phase 2 RI/FS; Bridgeport, New Jersey

Parameter	Media	Method Blank[a]	MS[a]	MSD[a]	Laboratory Replicate[a]	Analysis Method
Methane	Water	1/20	1/20	1/20	1/20	M8000[b]
Ethane	Water	1/20	1/20	1/20	1/20	M8000[b]
Ethene	Water	1/20	1/20	1/20	1/20	M8000[b]
Carbon Dioxide	Water	1/20	NA	NA	1/20	A4500[d]
Hydrogen Sulfide	Water	1/20	NA	NA	1/20	3810 / 8015 modified[b]
Waste Classification Parameters	Water	NA	NA	NA	NA	See Below
DRO/GRO	NAPL	1/20	NA	NA	1/20	8015[b]
Specific Gravity	NAPL	NA	NA	NA	NA	ASTM D1298/ASTM D4052[c]
API Gravity	NAPL	NA	NA	NA	NA	ASTM D1298/ASTM D287[c]
Total Organic Halide	NAPL	NA	1/20	1/10	1/10	9020B[b]
Viscosity	NAPL	NA	NA	NA	NA	ASTM
TCL Volatile Organic Compounds	NAPL	1/20	1/20	1/20	1/20	8260B[b]
Waste Classification Parameters	NAPL	NA	NA	NA	NA	See Below

a. Where applicable, one per twenty or fewer field samples, or one per analytical batch, whichever is more frequent.
b. Test Methods for Evaluating Solid Wastes.
c. American Society for Testing and Materials.
d. Standard Methods for the Examination of Water and Wastewater.
e. Aquatic Microbial Ecology.
f. Typical QC for EPA 524.2 Rev.4 is an LFB (Lab Fortified Blank) per tune period.

Waste classifications methods include: 1311 / 8260B / 8270B / 8082 / 8081A / 8151A[b] ; ignitability by 40 CFR 261.1; corrosivity and reactivity by SW-846 Chapter 7[b]; BTU by D240-87[c].

TCL = Target Compound List
TAL = Target Analyte List
DRO/GRO = Diesel Range Organics/Gasoline Range Organics
TSS = Total Suspended Solids
TDS = Total Dissolved Solids
API = American Petroleum Institute
NA = Not Applicable
MeCl = Methylene Chloride

Table 12. Field Equipment Calibration Requirements and Maintenance Schedule. BROS Phase 2 RI/FS; Bridgeport, New Jersey.

Equipment Type	Calibration Schedule	Calibration Requirements	Maintenance Schedule
Photoionization Detector	Daily	Appendix B of SAP	Recharge or replace battery. Regularly clean lamp window. Regularly clean and maintain the instrument and accessories.
pH Meter	Daily	Appendix B of SAP	Per manufacturer's specifications and as needed based on calibration checks.
Eh Meter	Daily	Appendix B of SAP	Per manufacturer's specifications and as needed based on calibration checks.
Specific Conductance Meter	Daily	Appendix B of SAP	Per manufacturer's specifications and as needed based on calibration checks.
Thermometer	Bi-weekly	Appendix B of SAP	Regularly check for breakage.
Personal Protective Equipment	Daily	Not Applicable	Integrity/function test prior to donning equipment. Visual inspection for defects/leakage for all reusable gear.
Magnetometer	Not Applicable	Not Applicable	Replace batteries as necessary.
Surveying Instruments	Annually	Return to Manufacturer	Regularly clean instrument lenses.
Interface Probe	Daily	Appendix B of SAP	Replace batteries as necessary.

Table 13. Preservation, Holding Times and Sample Containers. BROS Phase 2 RI/FS; Bridgeport, New Jersey

Parameter	Preservation	Holding Time[a]	Containers
Aqueous VOCs	HCl to pH<2, no headspace 4°C until analysis	14 days	3 x 40 ml vials w/teflon septum, glass
Aqueous VOCs (524.2)	HCl to pH<2, ascorbic acid, no headspace 4°C until analysis	14 days	4 x 40 ml vials w/teflon septum, glass
Aqueous SVOCs	$Na_2S_2O_3$ 4°C until extraction and analysis	7 days until extraction, 40 days until analysis	2 x 1000 ml amber bottles w/teflon lined lid, glass
Aqueous PCBs	$Na_2S_2O_3$ 4°C until extraction and analysis	7 days until extraction, 40 days until analysis	2 x 1000 ml amber bottles w/teflon lined lid, glass
Aqueous GRO	HCl to pH<2, 4°C, no headspace	14 days	3 x 40 ml vials, glass
Aqueous DRO	HCl to pH<2, 4°C	7 days to extraction 40 days to analysis	2 x 1000 ml amber bottles w/ teflon lid, glass
Aqueous TPH (GC/FID)	HCl to pH<2, 4°C	7 days to extraction 40 days to analysis	2 x 1000 ml amber bottles w/ teflon lid, glass
Organic Acids			
Acid Volatile Sulfide	4°C until analysis	none	4 oz glass jar w/teflon lined lid
LNAPL GRO	4°C, no headspace	14 days	2 x 40 ml vials w/teflon septum, glass, half full
LNAPL DRO	4°C, no headspace	14 days	2 x 40 ml vials w/teflon septum, glass, half full
LNAPL VOCs	4°C, no headspace	14 days	2 x 40 ml vials w/teflon septum, glass, half full
Chemical Oxygen Demand	4°C until analysis H_2SO_4 to pH<2	28 days	100 ml plastic/glass bottle
Carbon Dioxide	4°C until analysis, no headspace	N.A.	2 x 40ml vials, glass
Hydrogen Sulfide			
Sulfate	4°C until analysis	28 days	100 ml plastic/glass bottle
Sulfides	4°C until analysis N_aOH/Zn Ac	7 days	500 ml Glass bottle
Nitrate	H_2SO_4 TO pH<2, 4°C	28 days	500 ml plastic/glass bottle
Nitrite	4°C until analysis	2 days	500 ml plastic/glass bottle
Ammonia	H_2SO_4 TO pH<2, 4°C	28 days	500 ml plastic/glass bottle
Total Suspended Solids	4°C until analysis	7 days	500 ml plastic/glass bottle
Total Dissolved Solids	4°C until analysis	7 days	500 ml plastic/glass bottle
Alkalinity	4°C until analysis	14 days	200 ml plastic/glass bottle
Total Kjeldahl Nitrogen	4°C until analysis H_2SO_4 to pH<2	28 days	500 ml plastic/glass bottle
Aqueous Total Organic Carbon	4°C until analysis HCL or H_2SO_4 to pH<2	28 days	125 ml glass bottle
Hardness	HNO_3, pH <2, 4°C	180 days until analysis	100 ml plastic/glass
Methane, Ethene, Ethane	4° C until analysis	14 days until analysis	2 - 40 ml vials
Viscosity	4° C until analysis	NA	500 ml glass
Orthophosphate	Filter on site, 4° C	48 hours	100 ml plastic/glass
Chloride	4° C	28 days	500 ml plastic/glass
Dissolved Oxygen	4°C, no headspace	Analyze immediately	300 ml glass bottle
Aqueous Metals (Mercury)	HNO_3 to pH<2	180 days (28 days)	1 liter plastic bottle (included above)
Soil VOCs	4°C, no headspace	14 days[b]	4 oz glass jar w/teflon lined lid
Silica	4° C until analysis	28 days	200 ml plastic bottle
Soil VOCs	Methanol (NJDEP Method)	14 days collection to analysis	1 x 40ml vial w/methanol 10g soil into 25ml methanol w/surrogate stds.

Table 13. Preservation, Holding Times and Sample Containers. BROS Phase 2 RI/FS; Bridgeport, New Jersey

Parameter	Preservation	Holding Time[a]	Containers
Sediment VOCs	Encore® Samplers/deionized water and freezing	2 days until preservation/14 days until analysis	3-5 gram Encore® samplers with lids
Soil SVOCs	4°C until extraction and analysis	14 days until extraction[c] 40 days collection to analysis	500 ml glass jar w/teflon lined lid
Soil Metals	4°C until analysis	180 days[d]	500 ml glass jar w/teflon lined lid
(Mercury)		(26 days)[e]	(included above)
Soil PCBs	4°C until extraction and analysis	14 days until extraction[b] 40 days until analysis	500 ml glass jar w/teflon lined lid 500 ml glass jar w/teflon lined lid
Total Organic Carbon (Soils)	4°C until extraction and analysis	28 days	4 oz glass jar w/teflon lined lid
GRO – 5030 (Sediment)	4°C, no headspace	14 days[b]	4 oz jar w/teflon lined lid
GRO – 5035 (Soil)	Methanol (NJDEP)	14 days collection to analysis	1 x 40ml vial w/methanol 10g soil into 25ml methanol w/surrogate stds.
DRO	4°C until analysis	7 days extraction 40 days analysis	500 ml glass jar
TPH by GC/FID	4°C until analysis	14 days until extraction 40 days until analysis	500 ml glass jar
SPLP-VOCs	4°C until analysis	14 days[b]	4 oz glass jar w/teflon lined lid
SPLP-Metals	4°C until analysis	180 days[d]	500 ml glass jar w/teflon lined lid
(Mercury)		(28 days[e])	500 ml glass jar w/teflon lined lid
Grain Size	4°C	none	500 ml glass jar
Permeability	none	none	Shelby Tube
Porosity	none	none	Shelby Tube
Specific Gravity	none	none	500 ml glass jar
Water Content	4°C until analysis	none	4 oz glass jar w/teflon lined lid
Cation Exchange Capacity	4°C until analysis	none	500 ml glass jar
Acid Volatile Sulfides	4°C until analysis	none	500 ml water / 50 g soil
Eh	4°C until analysis	1 day	50 g glass jar
pH	4°C until analysis	14 days (soils)	50 g glass jar
Specific gravity (NAPL)	none	none	250 ml glass
API gravity (NAPL)	none	none	250 ml glass
Viscosity (NAPL)	none	none	250 ml glass
Total Organic Halide (NAPL)	none	none	50 ml glass
TCL-VOCs (NAPL)	4°C, no headspace	14 days	1 x 40 ml vial w/teflon septum, glass

[a] From collection until analysis unless otherwise specified.
[b] 14 days from field to TCLP extraction/14 days from extraction to analysis.
[c] 14 days from field to TCLP extraction/7 days from TCLP extraction to preparative extraction/40 days to analysis.
[d] 180 days from field to TCLP extraction/180 days from extraction to analysis.
[e] 28 days from field to TCLP extraction/28 days from extraction to analysis.

VOC = Volatile Organic Compounds
SVOC = Semi Volatile Organic Compounds
PCB = Polychlorinated Biphenyls
GRO = Gasoline Range Organics
DRO = Diesel Range Organics
NAPL = Non-Aqueous Phase Liquids
API = American Petroleum Institute

Note: Bottles may be modified since multiple analyses can be taken from a single bottle. This table is for single analysis only.

Table 14. Summary of Existing Monitoring Well Construction Information. BROS Phase 2 RI/FS; Bridgeport, New Jersey.

Well	Date Installed	Diameter (in)	Borehole Depth (ft BGS)	Screen Setting (ft BGS)	Initial Depth to Water Level from TOC (ft BGS)	TOC Elevation (ft ASL)	Aquifer Monitored
MW-1A	1990	2	23	2-12	6.33	10.84	Surficial/Upper PRM
MW-1C	Aug-90	2	181	132-142	6.82	9.41	Lower Middle PRM
MW-2C	Sep-90	2	138	127-137	4.62	7.24	Lower Middle PRM
MW-3A	1990	2	14	4-14	9.85	13.34	Surficial/Upper PRM
MW-3C	Jul-90	2	145	125-135	7.94	10.67	Lower Middle PRM
MW-4A	1990	2	13	2-12	7.19	11.12	Surficial/Upper PRM
MW-4C	Aug-90	2	180	168-178	8.65	10.56	Lower Middle PRM
MW-5B	Aug-90	2	135	100-110	13.50	16.63	Upper Middle PRM
MW-6A	1990	2	15	5-15	8.91	12.31	Surficial/Upper PRM
MW-6B	Aug-90	2	110	90-100	9.18	12.37	Upper Middle PRM
MW-7A	1990	2	15	5-15	6.62	10.04	Surficial/Upper PRM
MW-7B	Aug-90	2	85	62-72	6.97	10.16	Upper Middle PRM
MW-8A	1990	2	17	7-17	8.29	11.54	Surficial/Upper PRM
MW-8B	Aug-90	2	103	92-102	8.92	11.94	Upper Middle PRM
MW-9A	1990	2	16	5-15	7.06	11.14	Surficial/Upper PRM
MW-9B	Aug-90	2	100	85-95	8.22	11.23	Upper Middle PRM
MW-10A	1990	2	16	5-15	9.63	12.97	Surficial/Upper PRM
MW-10B	Sep-90	2	135	120-130	10.95	12.78	Upper Middle PRM
MW-11A	1990	2	15	4-14	6.89	10.73	Surficial/Upper PRM
MW-11A(D)	1990	2	75	65-75	5.82	9.63	Base of Upper PRM
MW-11B	Aug-90	2	145	132-142	9.57	11.82	Upper Middle PRM
MW-12A	Aug-90	2	14	4-14	5.15	8.71	Surficial/Upper PRM
MW-12B	1990	2	162	133-143	7.16	10.95	Upper Middle PRM
MW-13A	Aug-90	2	16	5-15	5.37	8.74	Surficial/Upper PRM
MW-14A	1990	2	115	105-115	18.68	16.68	Base of Upper PRM
MW-14B	1990	2	203	190-200	19.94	16.7	Upper Middle PRM
MW-15A	1990	2	118	105-115	14.84	12.79	Base of Upper PRM
MW-15B	1990	2	196	186-196	16.54	12.86	Upper Middle PRM
MW-16A	1990	2	130	120-130	13.30	9.66	Base of Upper PRM
MW-16B	1990	2	192	182-192	13.58	9.69	Upper Middle PRM
S-1A	1983/1984	4	23	13-23	5.09	8.01	Upper PRM
S-1B	1983/1984	4	30	20-30	5.24	7.82	Base of Upper PRM
S-1C	1983/1984	4	57	20-30	5.47	8.07	Upper Middle PRM
S-2A	1983/1984	4	15	5-15	8.14	--	Surficial/Upper PRM
S-2B	1983/1984	4	50	40-50	10.55	12.62	Upper Middle PRM (Top)

Table 14. Summary of Existing Monitoring Well Construction Information. BROS Phase 2 RI/FS; Bridgeport, New Jersey.

Well	Date Installed	Diameter (in)	Borehole Depth (ft BGS)	Screen Setting (ft BGS)	Initial Depth to Water Level from TOC (ft BGS)	TOC Elevation (ft ASL)	Aquifer Monitored
S-2C	1983/1984	4	116	98-108	11.38	13.41	Base of Upper Middle PRM
S-3A	1983/1984	4	15	5-15	7.50	10.16	Surficial/Upper PRM
S-3B	1983/1984	4	55	40-50	6.88	10.34	--
S-3C	1983/1984	4	102	90-100	7.95	10.75	Base of Upper Middle PRM
S-4	1983/1984	4	19	9-19	12.60	15.5	Surficial/Upper PRM
S-5	1983/1984	4	72	60-70	4.93	7.41	Upper Middle PRM
S-6	1983/1984	4	92	79-89	7.68	8.87	Base of Upper Middle PRM
S-8	1983/1984	4	85	75-85	8.73	10.81	Upper Middle PRM
S-9	1983/1984	4	52	40-50	4.95	7.58	Upper PRM
S-11A	1983/1984	4	15	5-15	3.96	8.86	Surficial/Upper Middle PRM
S-11B	1983/1984	4	95	81-91	7.29	9.22	Upper Middle PRM
S-11C	1983/1984	4	157	105-115	7.65	9.19	Base of Upper Middle PRM
EPA-101	Jun-81	2	46	35-37	4.66	7.56	Base of Upper Middle PRM
EPA-102	Jun-81	2	51	36-38	11.58	14.38	--
EPA-103	Jun-81	2	55	45-47	8.86	11.06	Upper PRM
EPA-104S	Jun-81	2	102	19-21	6.72	9.21	Upper PRM
EPA-104D	Jun-81	2	102	49-51	6.96	--	Upper Middle PRM
EPA-105	Jun-81	2	51	40-42	7.56	9.76	--
EPA-106	Jun-81	--	52	40-42	--	8.07	--
EPA-107	Jun-81	2	51	36-38	6.21	8.23	Upper Middle PRM
EPA-108	Jun-81	2	100	86-96	6.37	8.48	Upper Middle PRM
NJDEP	Oct-81	--	100	84-97	--	--	Upper Middle PRM
P-1	Dec-89	4	19	14-19	10.08	--	Surficial/Upper PRM
P-2	Dec-89	4	20	15-20	8.25	--	Surficial/Upper PRM
P-3	Dec-89	4	20	15-20	10.00	--	Surficial/Upper PRM
P-4	Jan-90	4	19	14-19	8.00	--	Surficial/Upper PRM
P-5	Dec-90	4	19	14-19	14.00	--	Surficial/Upper PRM

Notes:

Ft. BGS = Feet Below Ground Surface
TOC = Top of Casing
Ft. ASL = Feet Above Sea Level
PRM = Potomac-Raritan-Magothy Aquifer System
IN = Inches

Table 15. Justification and Screened Intervals for Proposed Monitoring Wells. BROS Phase 2 RI/FS; Bridgeport, New Jersey.

Well No.	Proposed Screen Interval (ft BGS)	Aquifer	Justification
MW-4D	105-115	Base of Upper Middle PRM	Determine presence/absence of DNAPL; Determine COPCs at base of Upper Middle PRM; Flux calculations
MW-17D through MW-19D and MW-33D and MW-34D	150-160	Base of Upper Middle PRM	Delineation of COPCs south of Route 295
MW-20D	80-90	Base of Upper Middle PRM	Evaluate western extent of VOCs; Determine upgradient conditions for model calibration
MW-21S MW-21L MW-21I MW-21D	5-15 30-40 50-60 120-130	Upper PRM Base of Upper PRM Top of Upper Middle PRM Base of Upper Middle PRM	Delineation of VOC gradient between Route 130 and Route 295; Evaluate horizontal contaminant gradient away from former lagoon; Evaluate vertical gradients beneath wetlands; Calibrate flow model; Key monitoring wells for pumping test; Obtain geochemical data
MW-22S MW-22L MW-22I MW-22D	5-15 30-40 50-60 110-120	Upper PRM Base of Upper PRM Top of Upper Middle PRM Base of Upper Middle PRM	Delineation of VOC gradient between Route 130 and Route 295; Evaluate horizontal contaminant gradient away from former lagoon; Evaluate vertical gradients beneath wetlands; Calibrate flow model; Key monitoring wells for pumping test; Obtain geochemical data
MW-23S MW-23I MW-23D	5-15 40-50 95-105	Upper PRM Top of Upper Middle PRM Base of Upper Middle PRM	Characterize surface-water/ground-water relationship between Swindell Pond and aquifer; Calibrate model; Flux calculations
MW-24S	5-15	Upper PRM	Evaluate LNAPL south of Pepper Building
MW-25S	5-15	Upper PRM	Evaluate LNAPL in swale north of former tank farm
MW-26S MW-26I MW-26D	20-30 45-55 90-100	Upper PRM Top of Upper Middle PRM Base of Upper Middle PRM	Evaluate ground-water conditions within and below former lagoon; Determine continuity of clay layer immediately underlying lagoon; Determine presence/absence of LNAPL; Determine presence/absence of DNAPL; Calibrate model; Flux calculations
MW-27S MW-27I MW-27D	20-30 45-55 90-100	Upper PRM Top of Upper Middle PRM Base of Upper Middle PRM	Evaluate ground-water conditions within and below former lagoon; Determine continuity of clay layer immediately underlying lagoon; Determine presence/absence of LNAPL; Determine presence/absence of DNAPL; Calibrate model; Flux calculations

Table 15. Justification and Screened Intervals for Proposed Monitoring Wells. BROS Phase 2 RI/FS; Bridgeport, New Jersey.

Well No.	Proposed Screen Interval (ft BGS)	Aquifer	Justification
MW-28S	5-15	Upper PRM	Determine if Pepper Building area is source of COPCs in ground-water contamination detected north of Route 130
MW-29S	5-15	Upper PRM	Evaluate LNAPL between former process area and wells MW-1A and S11A
MW-30S through MW-32S	5-15	Upper PRM	Delineate potential LNAPL in former process area; Evaluate ground-water quality in former process area
PZ-1	20-30	Upper PRM[1]	Characterize surface-water/ground-water relationship between Gaventa Pond and former lagoon; Calibrate model; Flux calculations
PZ-2	20-30	Upper PRM[1]	Characterize surface-water/ground-water relationship between Swindell Pond and aquifer; Calibrate model; Flux calculations
WMW-1 through WMW-6	1-3/4-6[2]	Upper PRM	Evaluate vertical flow gradients in Little Timber Creek Swamp; Determine ground-water quality with depth; Supplement water budget data

Notes:

[1]If there is no appreciable thickness of the Upper PRM below the base of the ponds then the well screens will be located to monitor the confining layer and/or the top of the Upper Middle PRM aquifer.

[2]A pair of monitoring wells constructed by alternative methods; one screened from 1-3 ft BGS and one screened from 4-6 ft BGS.

VOC = Volatile organic compounds
DNAPL = Dense non-aqueous phase liquids
LNAPL = Light non-aqueous phase liquids
ft BGS = Feet below ground surface
COPCs = Constituents of potential concern

Table 16. Summary of Proposed Monitoring Well Construction Details. BROS Phase 2 RI/FS; Bridgeport, New Jersey.

Well Designation	Formation Screened	Depth of Well (ft BGS)	Well Diameter (inches)	Screened Interval (ft BGS)	Well Screen Material	Well Casing Material	Filter Pack Size	Drilling Method
MW-4D	BUMPRM	115	2	105 - 115	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-17D	BUMPRM	160	2	150 - 160	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-18D	BUMPRM	160	2	150 - 160	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-19D	BUMPRM	160	2	150 - 160	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-20D	BUMPRM	90	2	80 - 90	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-21S	UPRM	15	2	5 - 15	SS - 20 Slot	SS - Type 304	Morie 1	HSA
MW-21L	BUPRM	40	2	30 - 40	SS - 20 Slot	SS - Type 304	Morie 1	HSA
MW-21I	TUMPRM	60	2	50 - 60	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-21D	BUMPRM	130	2	120 - 130	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-22S	UPRM	15	2	5 - 15	SS - 20 Slot	SS - Type 304	Morie 1	HSA
MW-22L	BUPRM	40	2	30 - 40	SS - 20 Slot	SS - Type 304	Morie 1	HSA
MW-22I	TUMPRM	60	2	50 - 60	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-22D	BUMPRM	120	2	110 - 120	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-23S	UPRM	15	2	5 - 15	SS - 20 Slot	SS - Type 304	Morie 1	HSA
MW-23I	TUMPRM	40	2	30 - 40	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-23D	BUMPRM	105	2	95 - 105	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-24S	UPRM	15	2	5 - 15	SS - 20 Slot	SS - Type 304	Morie 1	HSA
MW-25S	UPRM	15	2	5 - 15	SS - 20 Slot	SS - Type 304	Morie 1	HSA
MW-26S	UPRM	30	2	20 - 30	SS - 20 Slot	SS - Type 304	Morie 1	HSA
MW-26I	TUMPRM	55	2	45 - 55	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-26D	BUMPRM	100	2	90 - 100	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-27S	UPRM	30	2	20 - 30	SS - 20 Slot	SS - Type 304	Morie 1	HSA
MW-27I	TUMPRM	55	2	45 - 55	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-27D	BUMPRM	100	2	90 - 100	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-28S	UPRM	15	2	5 - 15	SS - 20 Slot	SS - Type 304	Morie 1	HSA
MW-29S	UPRM	15	2	5 - 15	SS - 20 Slot	SS - Type 304	Morie 1	HSA
MW-30S	UPRM	15	2	5 - 15	SS - 20 Slot	SS - Type 304	Morie 1	HSA
MW-31S	UPRM	15	2	5 - 15	SS - 20 Slot	SS - Type 304	Morie 1	HSA
MW-32S	UPRM	15	2	5 - 15	SS - 20 Slot	SS - Type 304	Morie 1	HSA
MW-33D	BUMPRM	160	2	150 - 160	SS - 20 Slot	SS - Type 304	Morie 1	MR
MW-34D	BUMPRM	160	2	150 - 160	SS - 20 Slot	SS - Type 304	Morie 1	MR
PZ-1	UPRM[1]	30	2	20 - 30	SS - 20 Slot	SS - Type 304	Morie 1	PONTOON
PZ-2	UPRM[1]	30	2	20 - 30	SS - 20 Slot	SS - Type 304	Morie 1	PONTOON
WMW-1	UPRM[1]	6	2	1-3/4-6[2]	SS - 10 Slot	SS - Type 304	Morie 0	HA
WMW-2	UPRM[1]	6	2	1-3/4-6[2]	SS - 10 Slot	SS - Type 304	Morie 0	HA
WMW-3	UPRM[1]	6	2	1-3/4-6[2]	SS - 10 Slot	SS - Type 304	Morie 0	HA
WMW-4	UPRM[1]	6	2	1-3/4-6[2]	SS - 10 Slot	SS - Type 304	Morie 0	HA
WMW-5	UPRM[1]	6	2	1-3/4-6[2]	SS - 10 Slot	SS - Type 304	Morie 0	HA
WMW-6	UPRM[1]	6	2	1-3/4-6[2]	SS - 10 Slot	SS - Type 304	Morie 0	HA

NOTES:

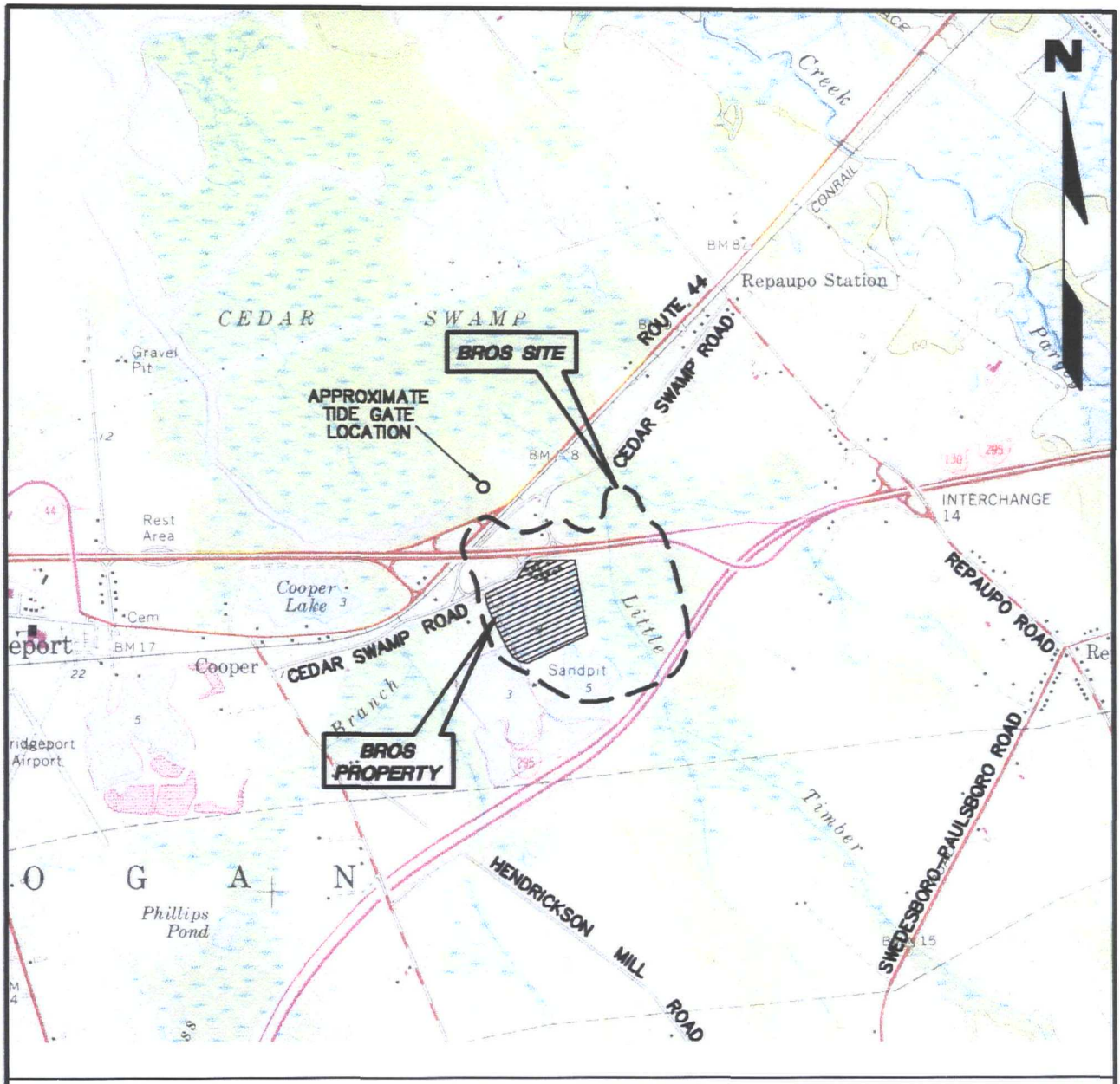
Ft BGS = Feet below ground surface.
UPRM = Upper Potomac Raritan Magothy.
BUPRM = Base of Upper Potomac Raritan Magothy.
TUMPRM = Top of Upper Middle Potomac Raritan Magothy.
BUMPRM = Base of Upper Middle Potomac Raritan Magothy.
SS = Stainless Steel.
HSA = Hollow-Stem Auger.
HA = Hand Auger.
MR = Mud Rotary.
PZ = Piezometer.
MW = Monitoring Well.

[1]If there is no appreciable thickness of the Upper PRM below the base of the ponds then the well screens will be located to monitor the top of the Upper Middle PRM aquifer.

[2]Consists of Pair of Monitoring wells constructed by alternative methods, screened from 1-3 ft BGS and one screened from 4-6 ft BGS.

300193

FIGURES



QUADRANGLE LOCATION

2,000' 0' 2,000'

LEGEND

— — — APPROXIMATE SITE BOUNDARY

APPROXIMATE PROPERTY BOUNDARY

SOURCE:

U.S.G.S. BRIDGEPORT, N.J., QUADRANGLE 1967
7.5 MINUTE SERIES (TOPOGRAPHIC)
PHOTOREVISED 1986
CONTOUR INTERVAL 10 FEET

Title:

SITE LOCATION MAP SHOWING THE APPROXIMATE BROS PROPERTY AND BROS SITE BOUNDARIES

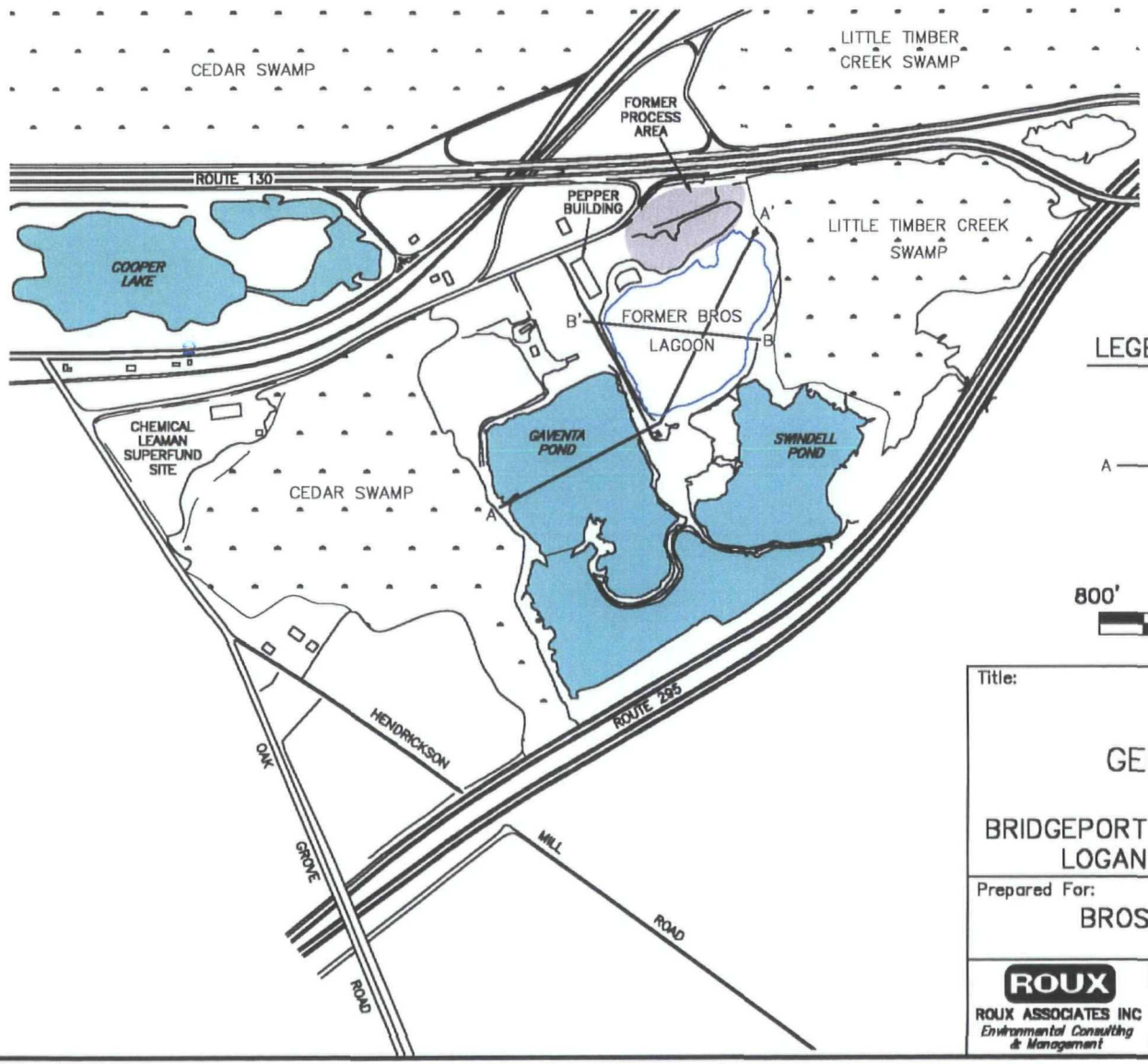
BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

Prepared For:

BROS TECHNICAL COMMITTEE

ROUX ASSOCIATES INC Environmental Consulting & Management	Compiled by: B.G.	Date: 06/30/98	Figure 1
	Prepared by: J.R.M.	Scale: SHOWN	
	Project Mgr: N.R.	Revision:	
	Proj No: 49301J05	File No: 49301017	

300195



N

LEGEND

WETLANDS

A ——— A' LINE OF CROSS SECTION

800' 0' 800'

Title:

GENERAL SITE PLAN

BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

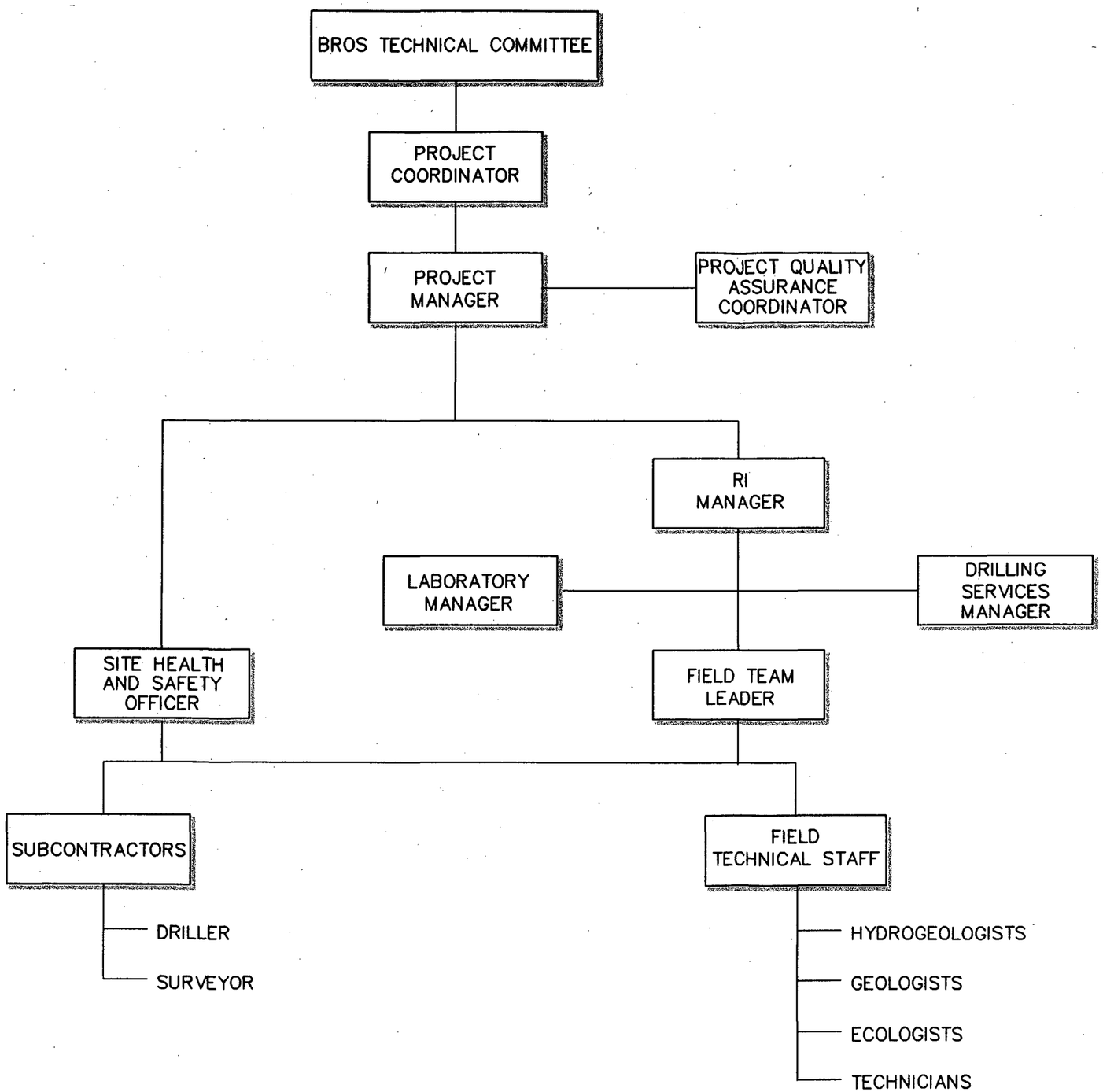
Prepared For:

BROS TECHNICAL COMMITTEE

ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management

Compiled by: B.G.	Date: 06/30/98	Figure 2
Prepared by: J.R.M.	Scale: SHOWN	
Project Mgr: N.R.	Revision:	
Proj No: 49301J05	File No: 49301023	

300196



Title:

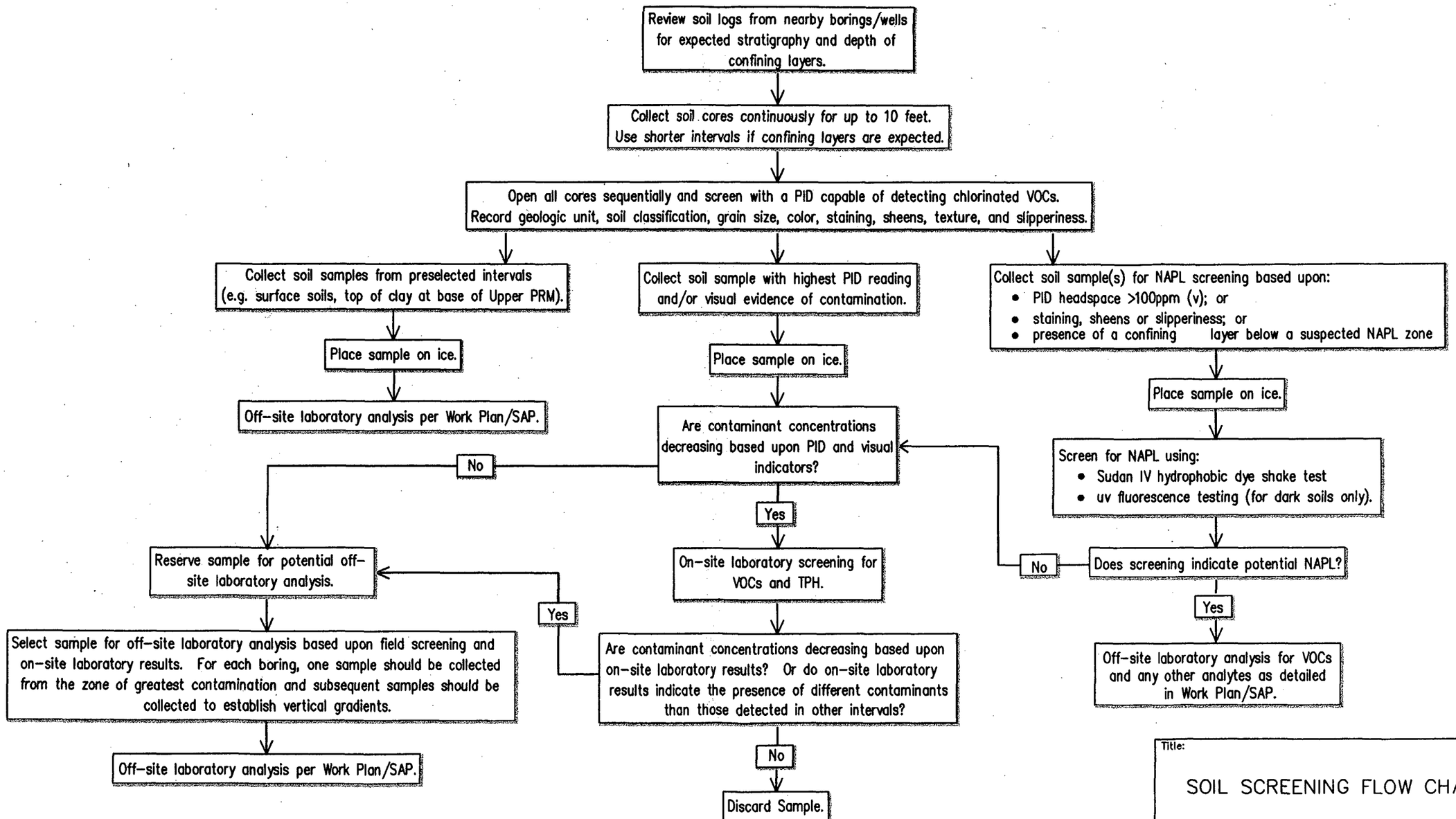
PROJECT ORGANIZATION CHART

BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

Prepared For:
BROS TECHNICAL COMMITTEE

ROUX ASSOCIATES INC Environmental Consulting & Management	Compiled by: J.A.L.	Date: 07/03/98	Figure 3
	Prepared by: J.S.G.	Scale: N.T.S.	
	Project Mgr: N.R.	Revision:	
	Proj No: 49301J05	File No: 49301043	

300197



Title:

SOIL SCREENING FLOW CHART

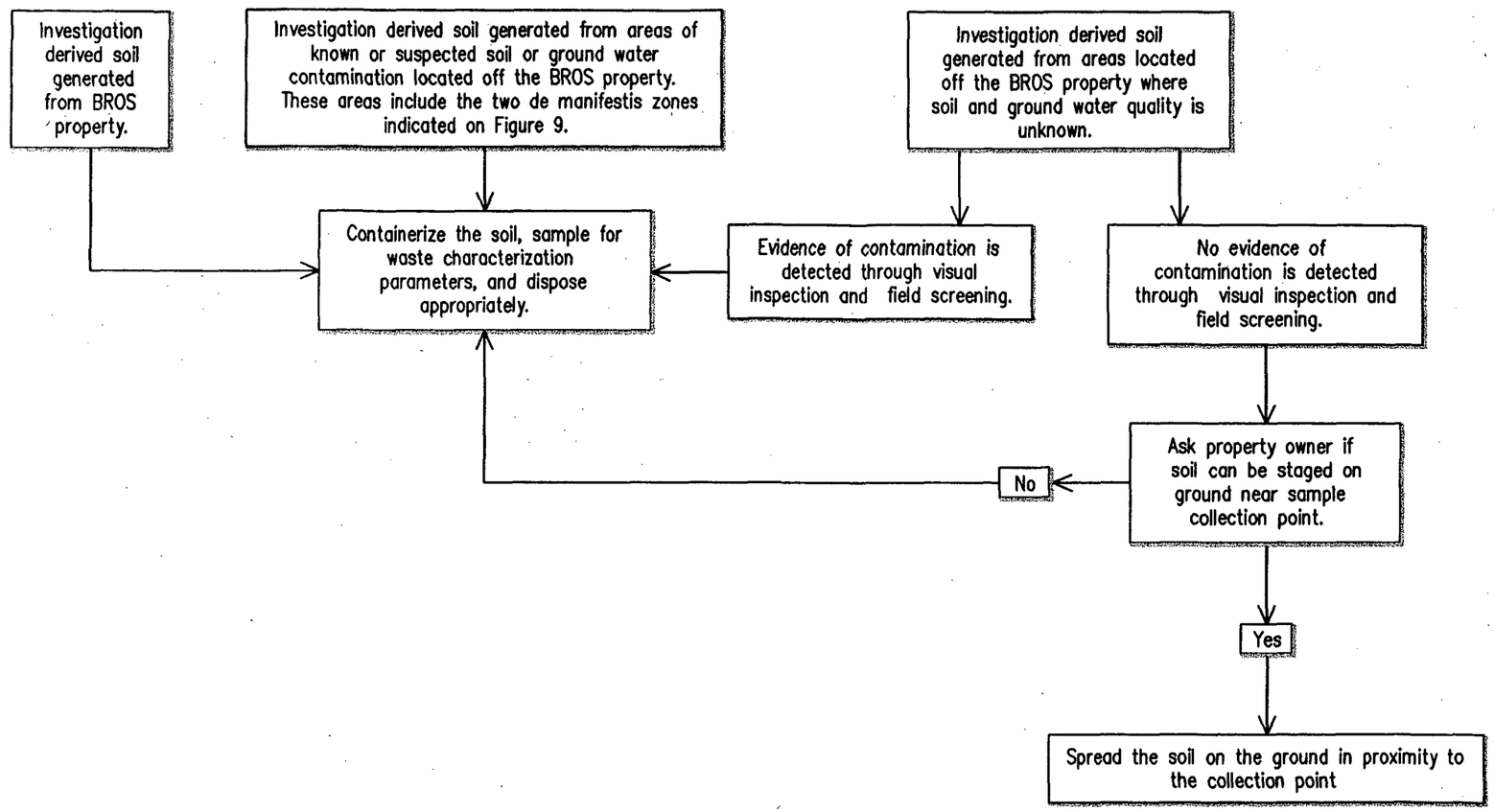
BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

Prepared For:
BROS TECHNICAL COMMITTEE

ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management

Compiled by: B.G.	Date: 07/03/98	Figure
Prepared by: J.R.M.	Scale: N.T.S.	4
Project Mgr: N.R.	Revision:	
Proj No: 49301J05	File No: 49301105	

300198



Developed from the New Jersey Department of Environmental Protection Field Sampling Procedures Manuals (1992).

Title:

MANAGEMENT OF INVESTIGATION DERIVED SOIL

BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

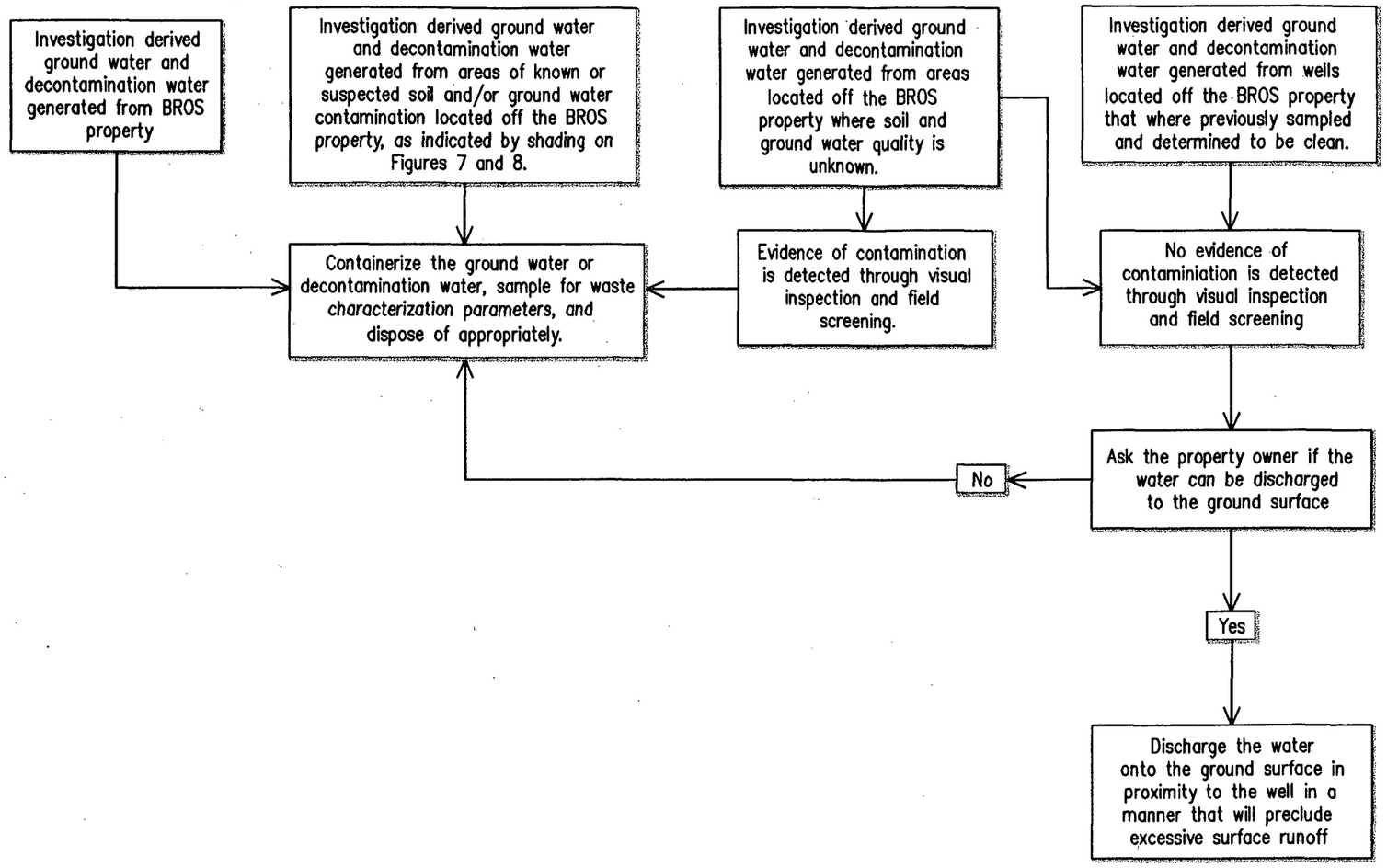
Prepared For:

BROS TECHNICAL COMMITTEE

ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management

Compiled by: B.G.	Date: 07/03/98	Figure
Prepared by: J.R.M.	Scale: N.T.S.	5
Project Mgr: N.R.	Revision:	
Proj No: 49301J05	File No: 49301107	

300199



* Purge water, development water or drilling mud.
Developed from the New Jersey Department of Environmental Protection Field Sampling Procedures Manuals (1992).

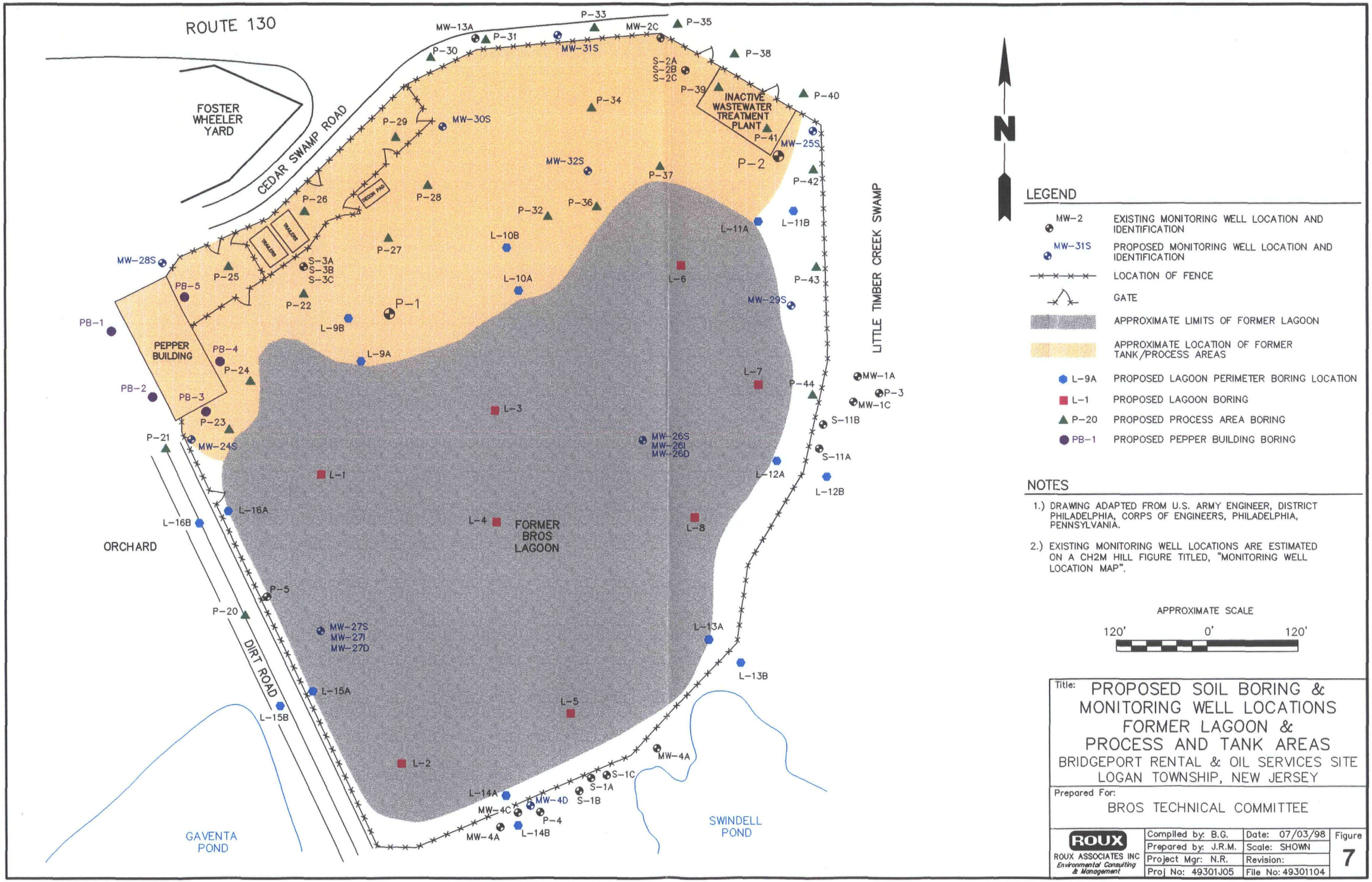
Title:
MANAGEMENT OF INVESTIGATION DERIVED GROUND WATER* AND DECONTAMINATION WATER

BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

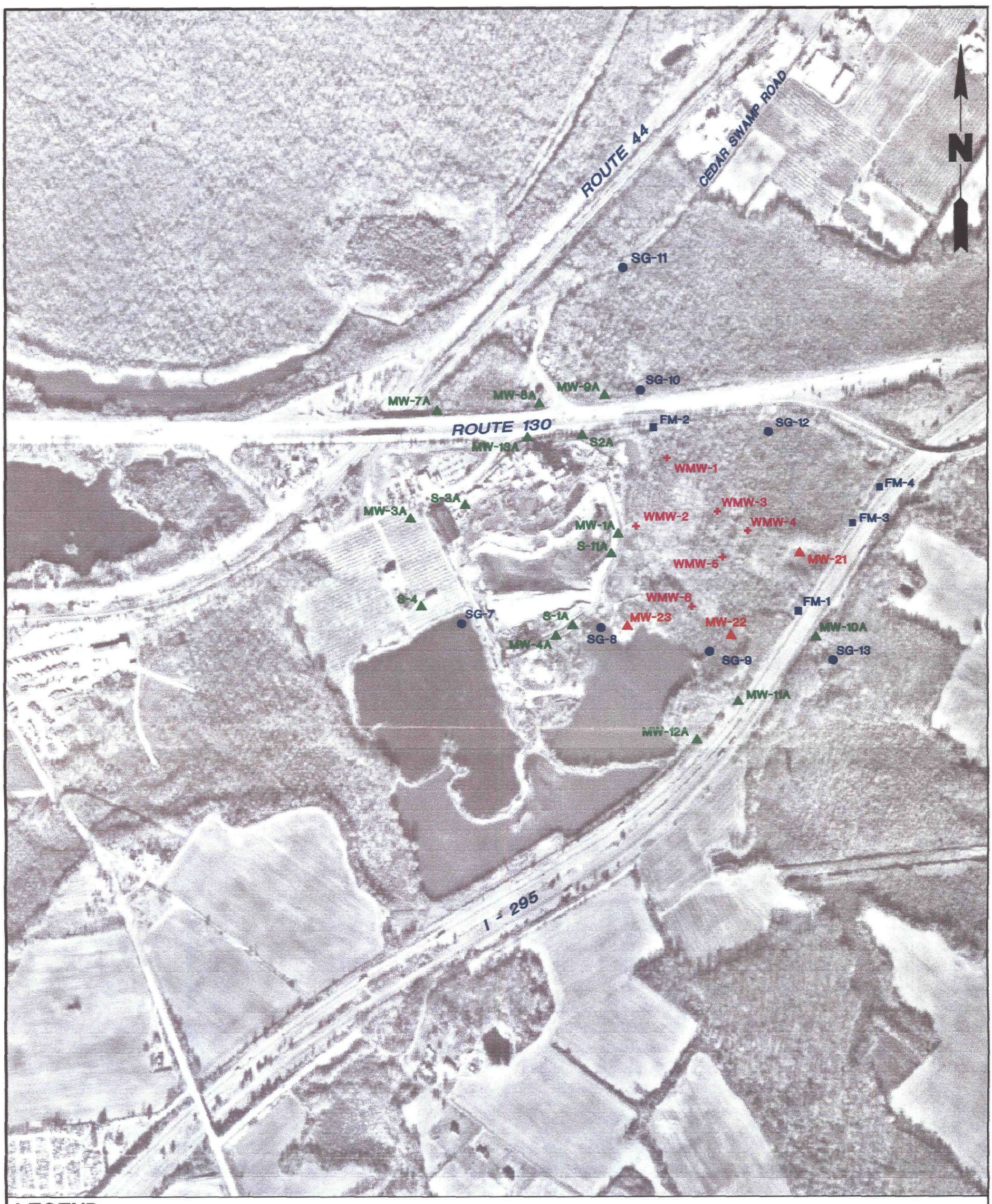
Prepared For:
BROS TECHNICAL COMMITTEE

ROUX ASSOCIATES INC Environmental Consulting & Management	Compiled by: B.G.	Date: 07/03/98	Figure
	Prepared by: J.R.M.	Scale: N.T.S.	6
	Project Mgr: N.R.	Revision:	
	Proj No: 49301J05	File No: 49301108	

300200


ROUTE 130
FOSTER WHEELER YARD
CEDAR SWAMP ROAD
INACTIVE WASTEWATER TREATMENT PLANT
TRAILERS
DECON PAD
PEPPER BUILDING
FORMER BROS LAGOON
LITTLE TIMBER CREEK SWAMP
ORCHARD
DIRT ROAD
GAVENTA POND
SWINDELL POND
N
LEGEND
MW-2 EXISTING MONITORING WELL LOCATION AND IDENTIFICATION
MW-31S PROPOSED MONITORING WELL LOCATION AND IDENTIFICATION
LOCATION OF FENCE
GATE
APPROXIMATE LIMITS OF FORMER LAGOON
APPROXIMATE LOCATION OF FORMER TANK/PROCESS AREAS
L-9A PROPOSED LAGOON PERIMETER BORING LOCATION
L-1 PROPOSED LAGOON BORING
P-20 PROPOSED PROCESS AREA BORING
PB-1 PROPOSED PEPPER BUILDING BORING
NOTES
1.) DRAWING ADAPTED FROM U.S. ARMY ENGINEER, DISTRICT PHILADELPHIA, CORPS OF ENGINEERS, PHILADELPHIA, PENNSYLVANIA.
2.) EXISTING MONITORING WELL LOCATIONS ARE ESTIMATED ON A CH2M HILL FIGURE TITLED, "MONITORING WELL LOCATION MAP".
APPROXIMATE SCALE
120' 0' 120'
Title: PROPOSED SOIL BORING & MONITORING WELL LOCATIONS FORMER LAGOON & PROCESS AND TANK AREAS
BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY
Prepared For:
BROS TECHNICAL COMMITTEE
ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management
Compiled by: B.G.
Prepared by: J.R.M.
Project Mgr: N.R.
Proj No: 49301J05
Date: 07/03/98
Scale: SHOWN
Revision:
File No: 49301104
Figure 7

300201



LEGEND

- ▲ MONITORING WELL CLUSTER
- ▲ EXISTING UPPER PRM MONITORING WELL
- + MONITORING WELL AND STAFF GAUGE CLUSTER
- ● STAFF GAUGE
- ■ FLOW MEASUREMENT STATION

600' 0' 600'

NOTES

1.) FM-3 AND FM-4 ARE LOCATED AT DRAINAGE CULVERTS ADJACENT TO ROUTE I-295.

SOURCE

1.) PHOTOGRAPH TAKEN DECEMBER 29, 1994 WHEN ON-SITE INCINERATOR WAS ACTIVE.

Title: WATER BUDGET ANALYSIS DATA POINTS FOR EVALUATION OF SURFACE WATER AND GROUND WATER EXCHANGE

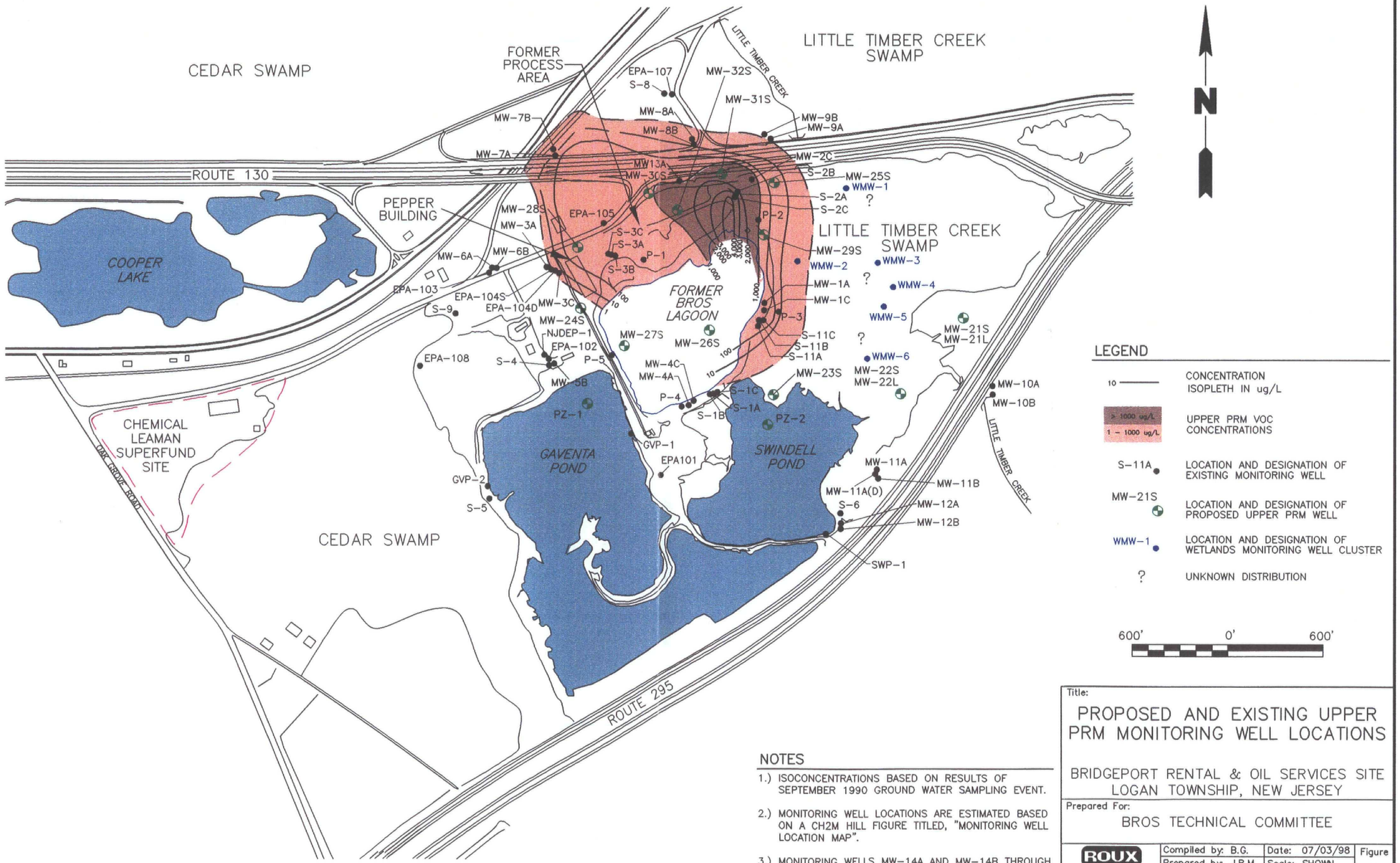
BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

Prepared For:
BROS TECHNICAL COMMITTEE

ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management

Compiled by: N.R.	Date: 12/04/98	Figure
Prepared by: J.S.G.	Scale: SHOWN	8
Project Mgr: N.R.	Revision:	
Proj No: 49301J05	File No: 49301102	

300202



NOTES

1.) ISOCONCENTRATIONS BASED ON RESULTS OF SEPTEMBER 1990 GROUND WATER SAMPLING EVENT.

2.) MONITORING WELL LOCATIONS ARE ESTIMATED BASED ON A CH2M HILL FIGURE TITLED, "MONITORING WELL LOCATION MAP".

3.) MONITORING WELLS MW-14A AND MW-14B THROUGH MW-16A AND MW-16B LOCATED TO THE SOUTHEAST ARE NOT DEPICTED.

Title:

PROPOSED AND EXISTING UPPER PRM MONITORING WELL LOCATIONS

BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

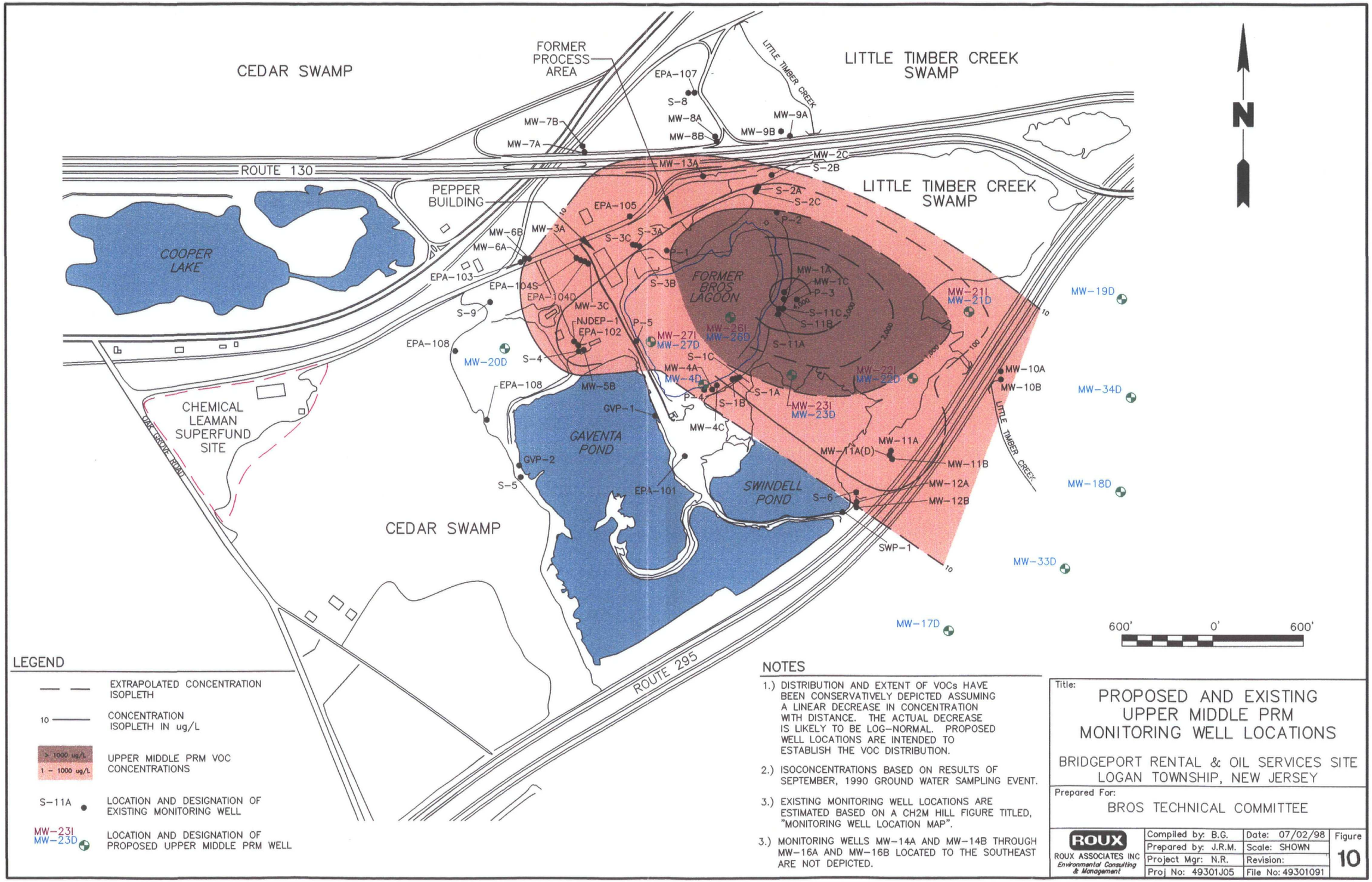
Prepared For:

BROS TECHNICAL COMMITTEE

ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management

Compiled by: B.G.	Date: 07/03/98	Figure
Prepared by: J.R.M.	Scale: SHOWN	9
Project Mgr: N.R.	Revision:	
Proj No: 49301J05	File No: 49301087	

300203



LEGEND

— —	EXTRAPOLATED CONCENTRATION ISOPLETH
10 ———	CONCENTRATION ISOPLETH IN ug/L
> 1000 ug/L 1 - 1000 ug/L	UPPER MIDDLE PRM VOC CONCENTRATIONS
S-11A ●	LOCATION AND DESIGNATION OF EXISTING MONITORING WELL
MW-23I MW-23D	LOCATION AND DESIGNATION OF PROPOSED UPPER MIDDLE PRM WELL

NOTES

1.) DISTRIBUTION AND EXTENT OF VOCs HAVE BEEN CONSERVATIVELY DEPICTED ASSUMING A LINEAR DECREASE IN CONCENTRATION WITH DISTANCE. THE ACTUAL DECREASE IS LIKELY TO BE LOG-NORMAL. PROPOSED WELL LOCATIONS ARE INTENDED TO ESTABLISH THE VOC DISTRIBUTION.

2.) ISOCONCENTRATIONS BASED ON RESULTS OF SEPTEMBER, 1990 GROUND WATER SAMPLING EVENT.

3.) EXISTING MONITORING WELL LOCATIONS ARE ESTIMATED BASED ON A CH2M HILL FIGURE TITLED, "MONITORING WELL LOCATION MAP".

3.) MONITORING WELLS MW-14A AND MW-14B THROUGH MW-16A AND MW-16B LOCATED TO THE SOUTHEAST ARE NOT DEPICTED.

Title:

PROPOSED AND EXISTING UPPER MIDDLE PRM MONITORING WELL LOCATIONS

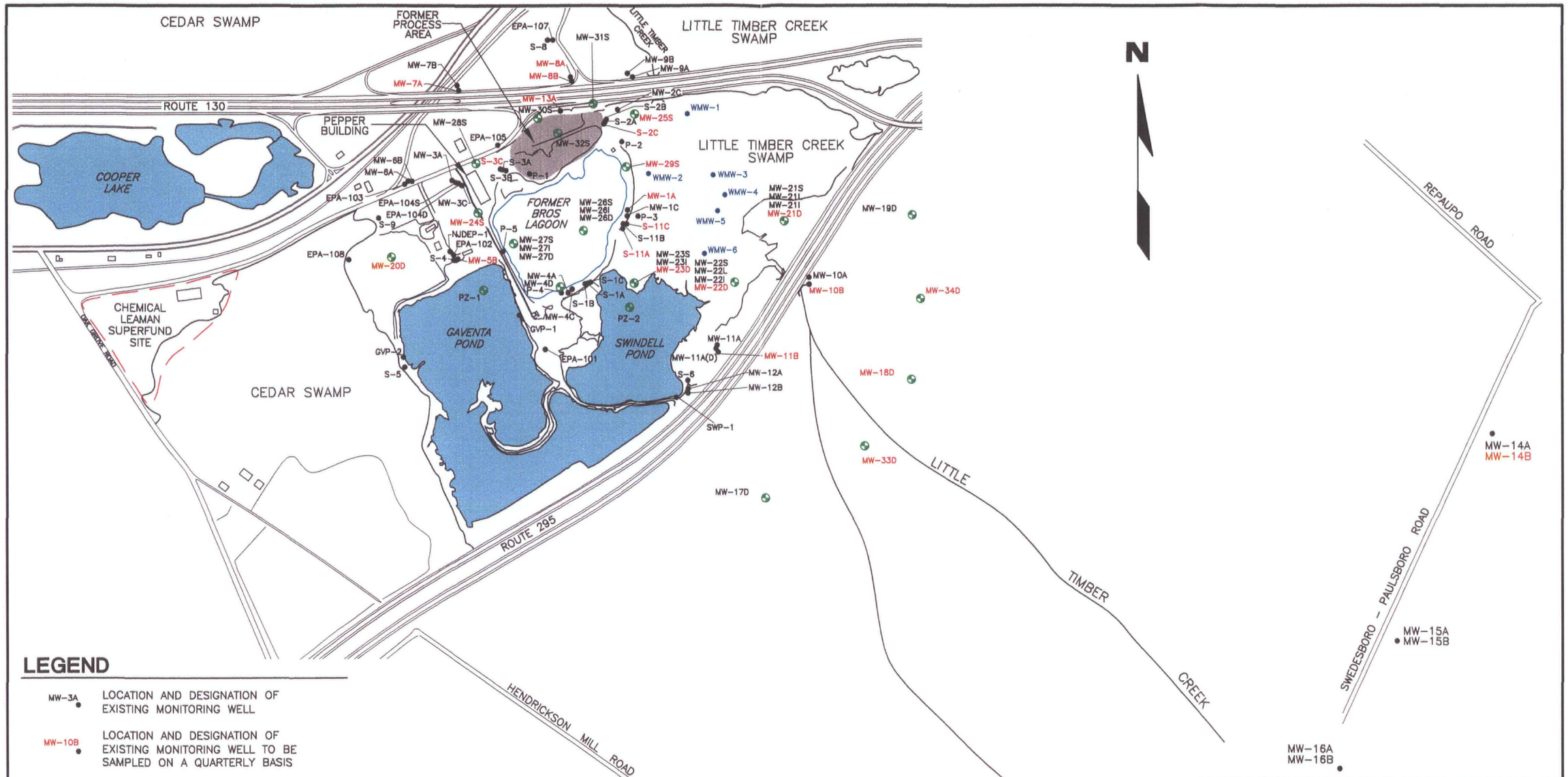
BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

Prepared For:
BROS TECHNICAL COMMITTEE

ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management

Compiled by: B.G.	Date: 07/02/98	Figure	
Prepared by: J.R.M.	Scale: SHOWN	10	
Project Mgr: N.R.	Revision:		
Proj No: 49301J05	File No: 49301091		

300204



LEGEND

MW-3A	LOCATION AND DESIGNATION OF EXISTING MONITORING WELL
MW-10B	LOCATION AND DESIGNATION OF EXISTING MONITORING WELL TO BE SAMPLED ON A QUARTERLY BASIS
MW-17D	LOCATION AND DESIGNATION OF PROPOSED WELL
MW-18D	LOCATION AND DESIGNATION OF PROPOSED WELL ANTICIPATED FOR INCLUSION IN QUARTERLY MONITORING PROGRAM
WMW-1	LOCATION AND DESIGNATION OF WETLANDS MONITORING WELL CLUSTER

NOTES

1.) MONITORING WELL LOCATIONS ARE ESTIMATED BASED ON A CH2M HILL FIGURE TITLED, "MONITORING WELL LOCATION MAP".

800' 0' 800'

APPROXIMATE SCALE

Title:

LOCATIONS OF WELLS SELECTED FOR QUARTERLY MONITORING

BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

Prepared For:

BROS TECHNICAL COMMITTEE

ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management

Compiled by: B.G.	Date: 12/01/98	Figure
Prepared by: J.R.M.	Scale: SHOWN	11
Project Mgr: N.R.	Revision:	
Proj No: 49301J05	File No: 49301090	

300205

600' 0' 600'

LEGEND

- ● SEDIMENT SAMPLE LOCATION
- ▲ SURFACE WATER AND SEDIMENT SAMPLING LOCATION

SOURCE

1.) PHOTOGRAPH TAKEN DECEMBER 29, 1994 WHEN ON-SITE INCINERATOR WAS ACTIVE.

Title:

SAMPLING LOCATIONS FOR GAVENTA AND SWINDELL PONDS

BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

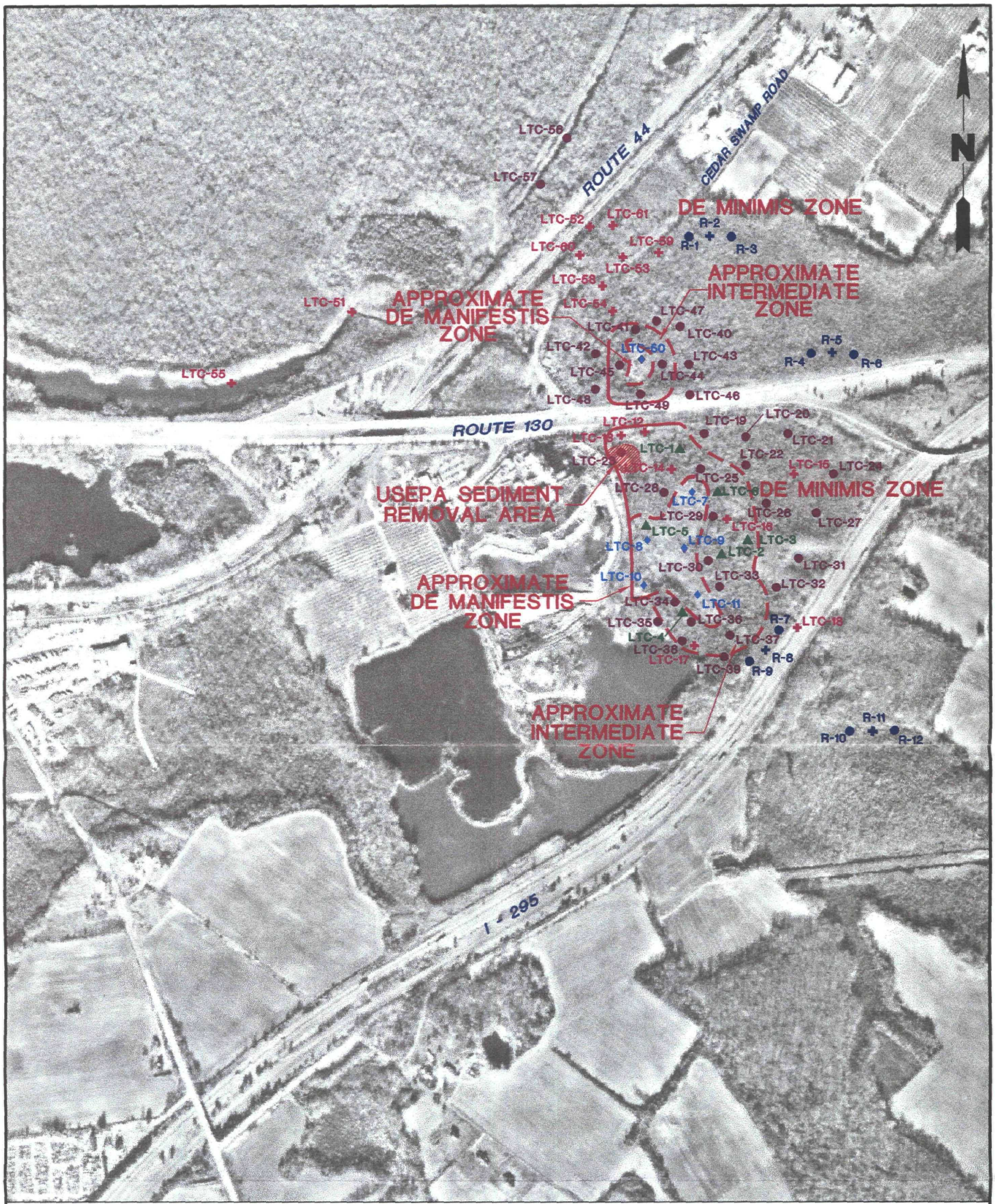
Prepared For:

BROS TECHNICAL COMMITTEE

ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management

Compiled by: N.R.	Date: 12/07/98	Figure
Prepared by: J.S.G.	Scale: SHOWN	12
Project Mgr: N.R.	Revision:	
Proj No: 49301J05	File No: 49301097	

300206



LEGEND

- ZONE BOUNDARY – DASHED WHERE APPROXIMATE
- SEDIMENT SAMPLING LOCATION (REFERENCE AREA)
- SEDIMENT AND SURFACE WATER SAMPLING LOCATION (REFERENCE AREA)
- SEDIMENT AND SURFACE WATER SAMPLING LOCATION
- SEDIMENT SAMPLING LOCATION (RISK ASSESSMENT)
- MONITORING WELL, SEDIMENT AND SURFACE WATER SAMPLING LOCATION
- SEDIMENT SAMPLING LOCATION (REMEDIAL ASSESSMENT)

SOURCE

1.) PHOTOGRAPH TAKEN DECEMBER 29, 1994 WHEN ON-SITE INCINERATOR WAS ACTIVE.

600' 0' 600'

Title:

WETLANDS SAMPLING LOCATIONS

BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

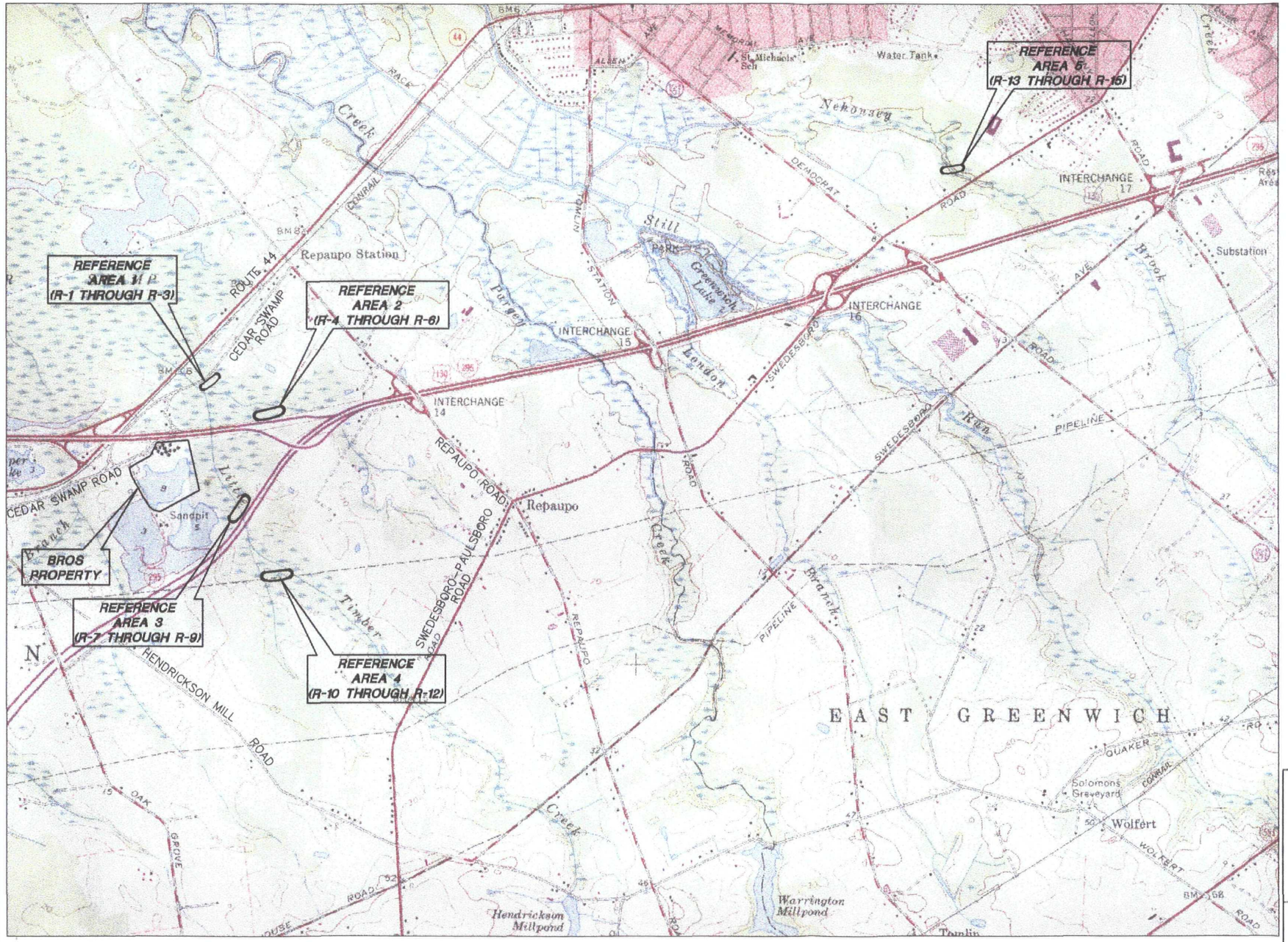
Prepared For:

BROS TECHNICAL COMMITTEE

ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management

Compiled by: N.R.	Date: 07/01/98	Figure
Prepared by: J.S.G.	Scale: SHOWN	13
Project Mgr: N.R.	Revision:	
Proj No: 49301J05	File No: 49301099	

300207



N

2000' 0' 2000'

Title:

WETLANDS REFERENCE SAMPLING AREAS

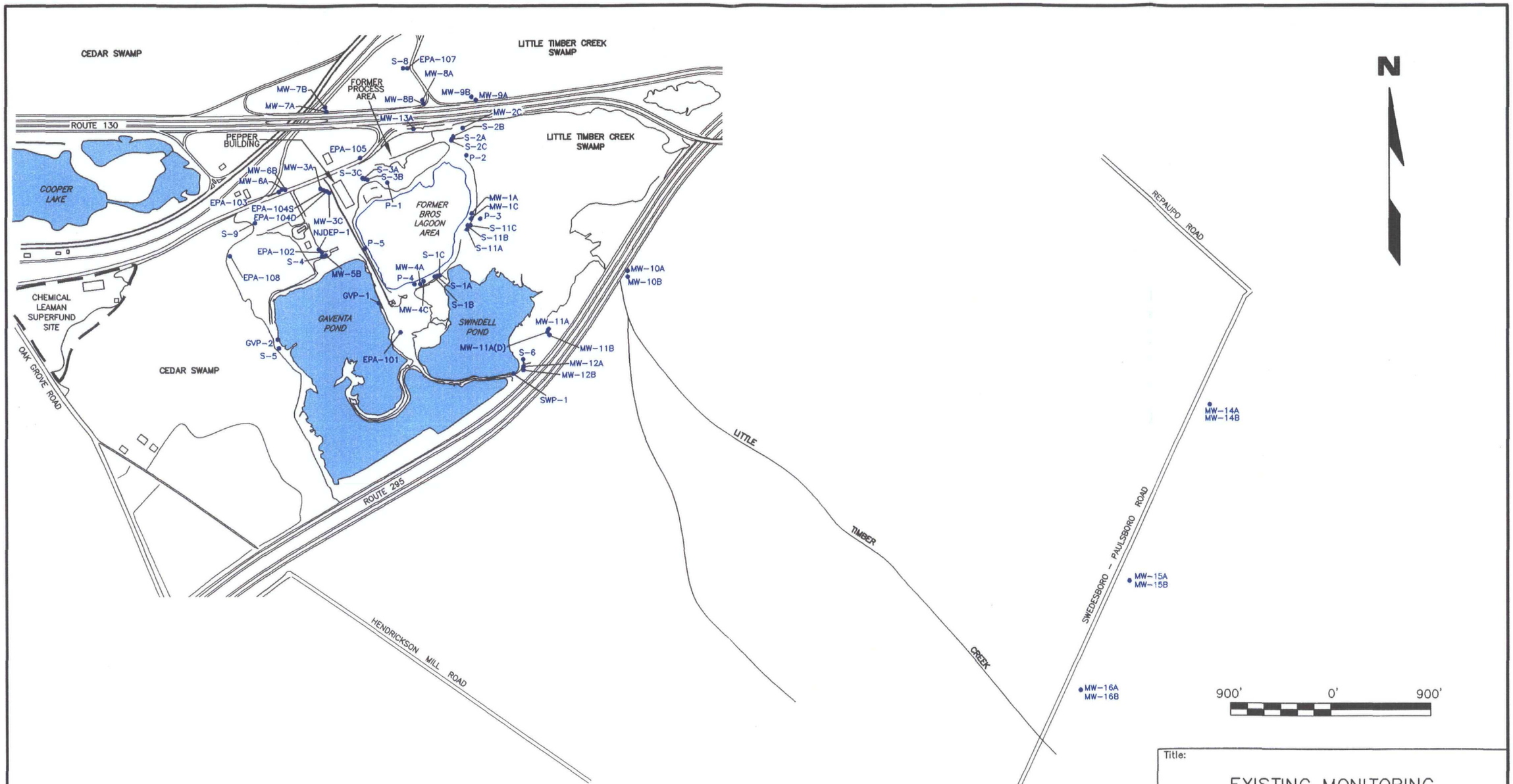
BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

Prepared For:

BROS TECHNICAL COMMITTEE

ROUX ASSOCIATES INC Environmental Consulting & Management	Compiled by: B.G.	Date: 07/06/98	Figure 14
	Prepared by: J.S.G.	Scale: SHOWN	
	Project Mgr: N.R.	Revision:	
	Proj No: 49301J05	File No: 49301111	

300208



LEGEND

MW-10A MONITORING WELL LOCATION AND IDENTIFICATION

NOTES

1.) MONITORING WELL LOCATIONS ARE ESTIMATED BASED ON A CH2M HILL FIGURE ENTITLED, "MONITORING WELL LOCATION MAP".

Title:

EXISTING MONITORING WELL LOCATIONS

BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

Prepared For:

BROS TECHNICAL COMMITTEE

ROUX ASSOCIATES INC Environmental Consulting & Management	Compiled by: B.G.	Date: 07/06/98	Figure 15
	Prepared by: J.R.M.	Scale: SHOWN	
	Project Mgr: N.R.	Revision:	
	Proj No: 49301J05	File No: 49301078	

300209

SOIL SAMPLE COLLECTED FROM BORING L-8 FROM A DEPTH OF 12 TO 14 FEET.

ENVIRONMENTAL SAMPLING SUPPLY

LCT #
SAMPLE ID L-8/SO/12-14

SAMPLED BY NRR	DATE 7/10/98
	TIME 17:00
LOCATION BROS	PRESERVATIVE —
ANALYSIS TPH	CLIENT 49301J

01 San Leandro Street, Oakland, California 94603
(510) 562-4988 (800) 233-8425

ROUX ASSOCIATES, INC. PROJECT NUMBER

TO BE ANALYZED FOR TOTAL PETROLEUM HYDROCARBONS

A FILTERED GROUND WATER SAMPLE FROM MW-10B.

ENVIRONMENTAL SAMPLING SUPP

SAMPLE ID MW-10B/GW/F

SAMPLED BY NRR	DATE 6/24/97
	TIME 14:17
LOCATION BROS	PRESERVATIVE HCL
ANALYSIS TAL METALS	CLIENT 49301J

9601 San Leandro Street, Oakland, California 94603
(510) 562-4988 (800) 233-8425

PRESERVED WITH HYDROCHLORIC ACID

TO BE ANALYZED FOR TAL METALS

Title:

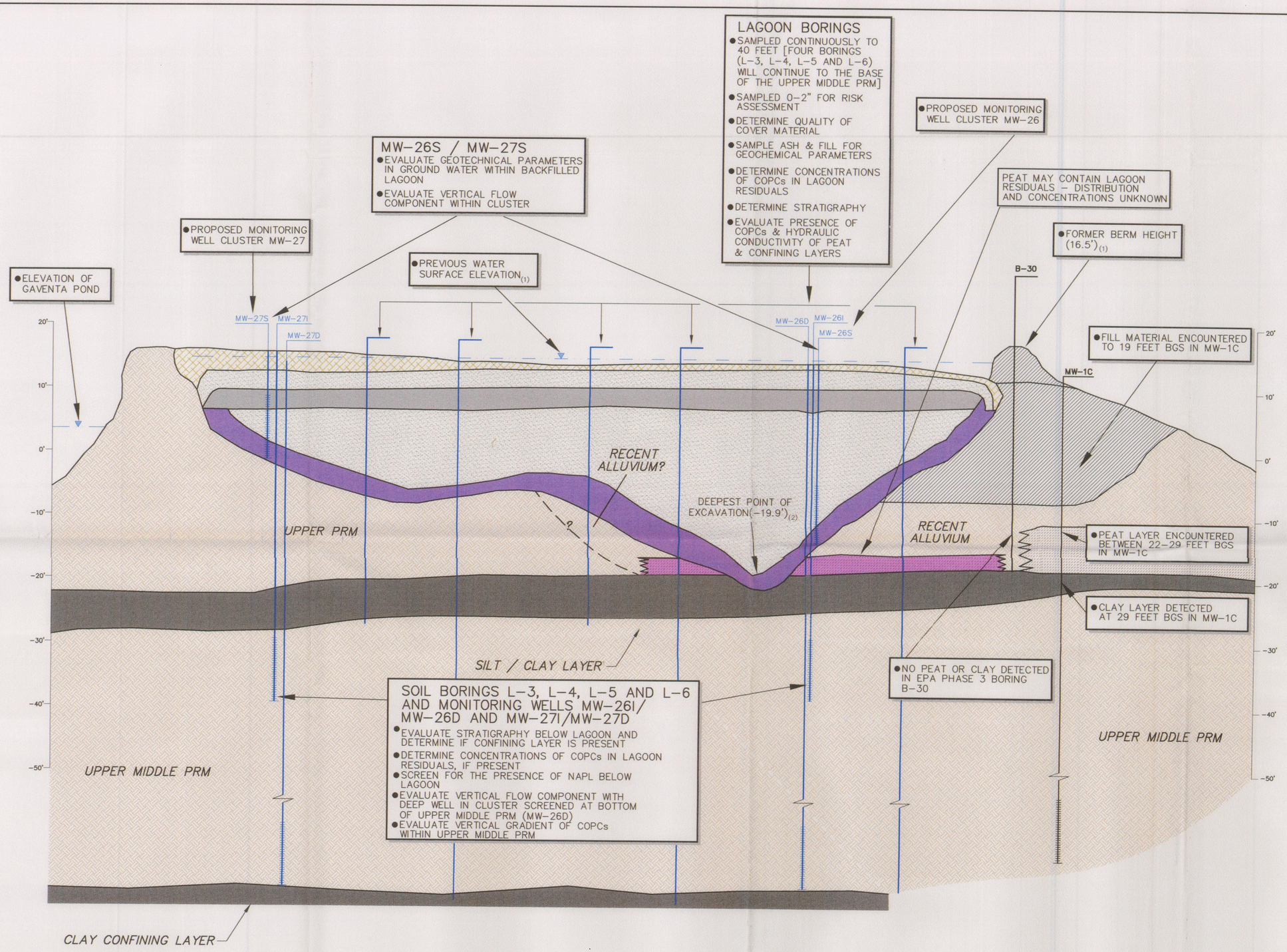
EXAMPLES OF COMPLETED SAMPLE LABELS

BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

Prepared For:
BROS TECHNICAL COMMITTEE

ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management

Compiled by: B.G.	Date: 06/06/98	Figure 16
Prepared by: J.S.G.	Scale: SHOWN	
Project Mgr: N.R.	Revision:	
Proj No: 49301J05	File No: 49301106	



LEGEND

MW-1C — LOCATION AND DESIGNATION OF EXISTING MONITORING WELL

B-30 — LOCATION AND DESIGNATION OF EXISTING SOIL BORING

MW-26D — LOCATION AND DESIGNATION OF PROPOSED MONITORING WELL

LOCATION OF PROPOSED SOIL BORING

- FILL MATERIAL
- NATIVE SAND
- SILT / CLAY
- PEAT
- COVER MATERIAL
- ASH
- LAGOON RESIDUAL
- SAND BACKFILL
- CLAY

NOTES

(1) NUS CORPORATION, 1983. TOPOGRAPHIC MAP OF BROS SITE AND SURROUNDING AREAS. DRAWING No. 0707-22-01.

(2) EBASCO CONSTRUCTORS INC., 1995. DESIGN EXCAVATION LIMITS WITH ADDITIONAL EXCAVATION LIMITS. DRAWING No. EXLIMITS.DWG.

50' 0' 50'

Title:

CONCEPTUAL ILLUSTRATION OF SAMPLING ACTIVITIES AND RATIONALE IN FORMER LAGOON

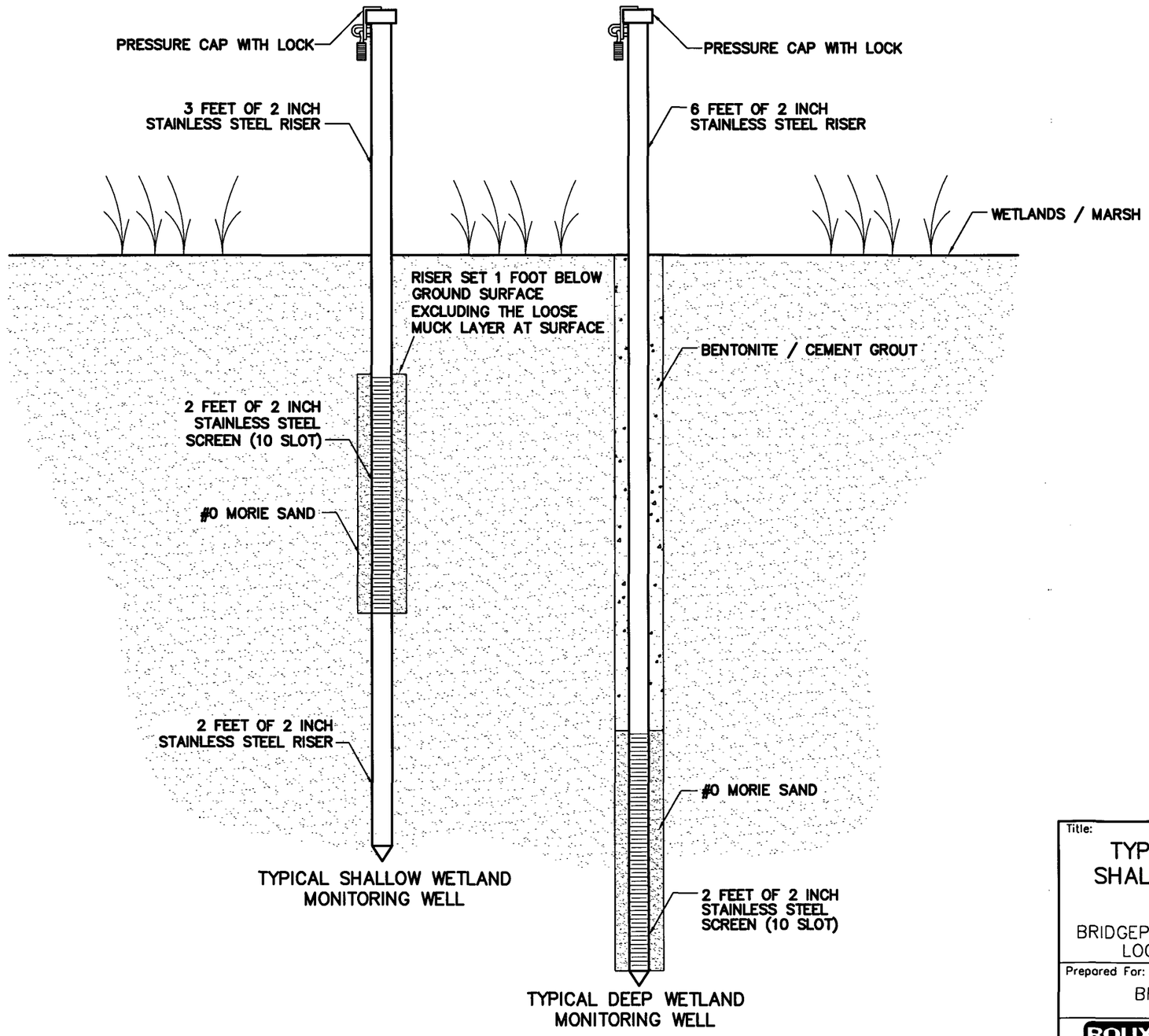
BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

Prepared For:
BROS TECHNICAL COMMITTEE

ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management

Compiled by: B.G.	Date: 07/01/98	Figure
Prepared by: J.R.M.	Scale: SHOWN	17
Project Mgr: N.R.		
Proj No: 49301J05	File No: 49301095	

300211



Title:

TYPICAL CONSTRUCTION OF SHALLOW AND DEEP WETLAND MONITORING WELLS

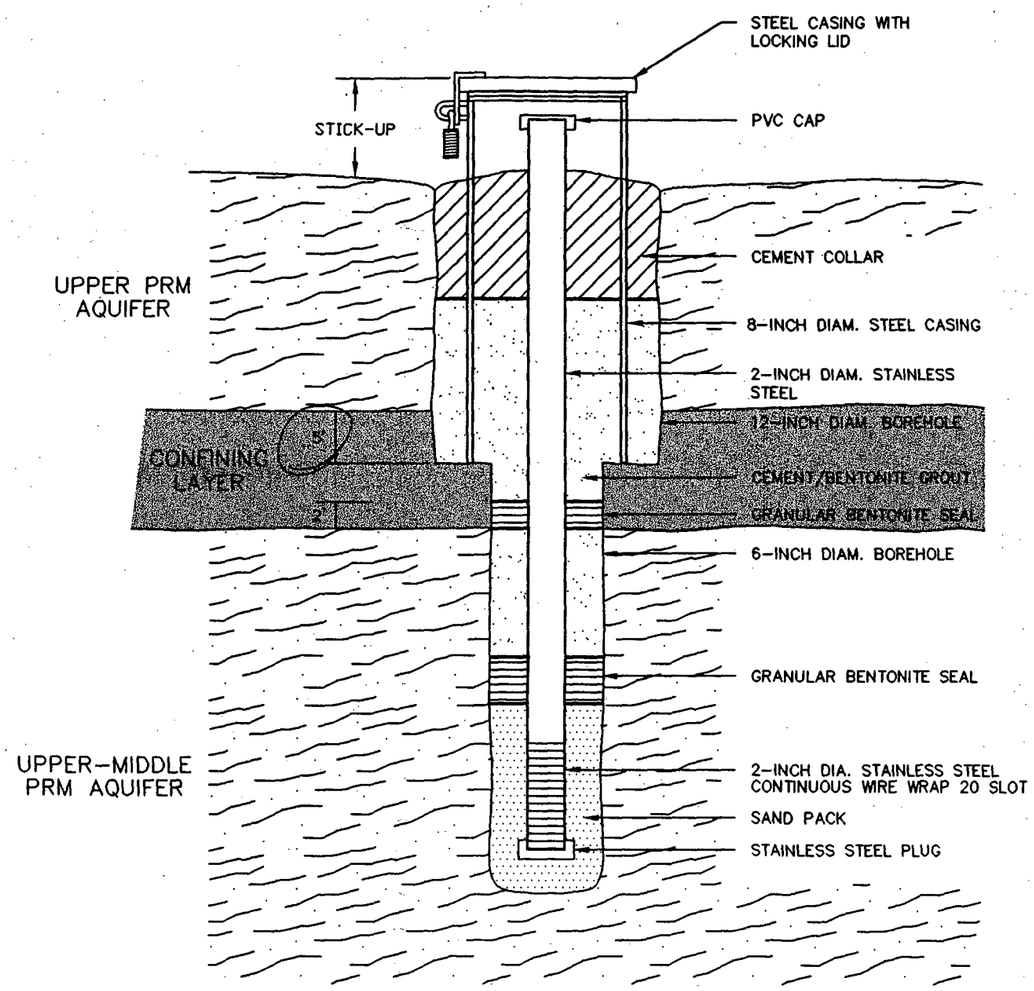
BRIDGEPORT RENTAL & OIL SERVICE SITE
LOGAN TOWNSHIP, NEW JERSEY

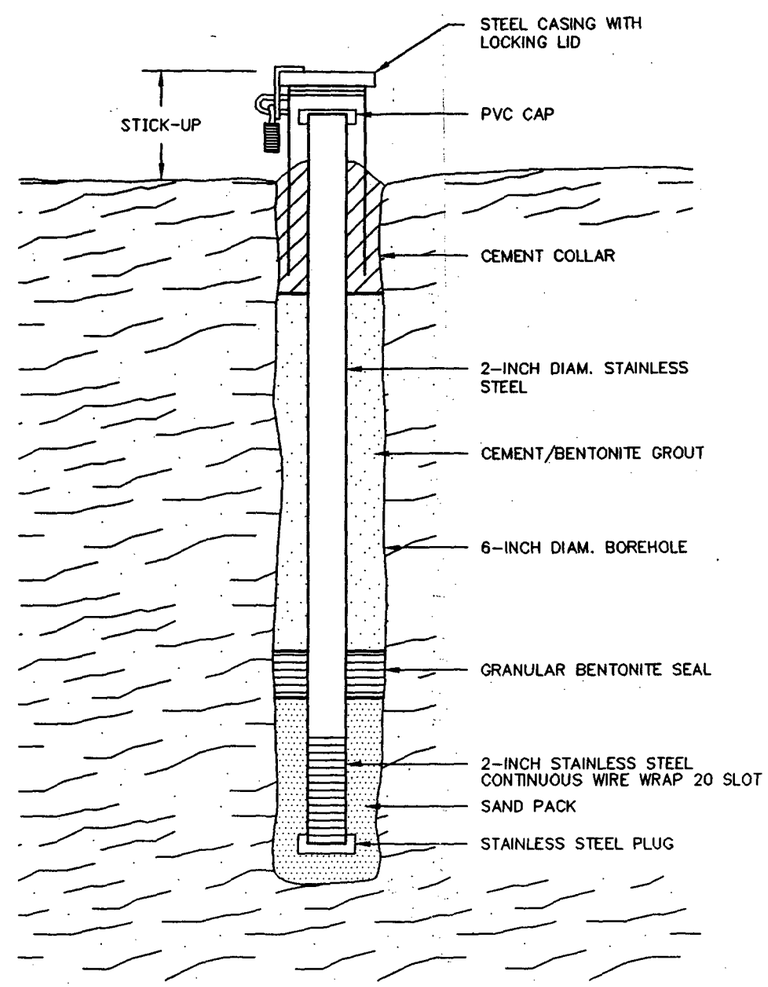
Prepared For:

BROS TECHNICAL COMMITTEE

ROUX ASSOCIATES INC *Environmental Consulting & Management*	Compiled by: B.G.	Date: 07/03/98	Figure 18
	Prepared by: J.S.G.	Scale: N.T.S.	
	Project Mgr: N.R.	Revision:	
	Proj No: 49301J05	File No: 49301045	

300212





Title:

TYPICAL SINGLE & DOUBLE-CASED MONITORING WELL CONSTRUCTION

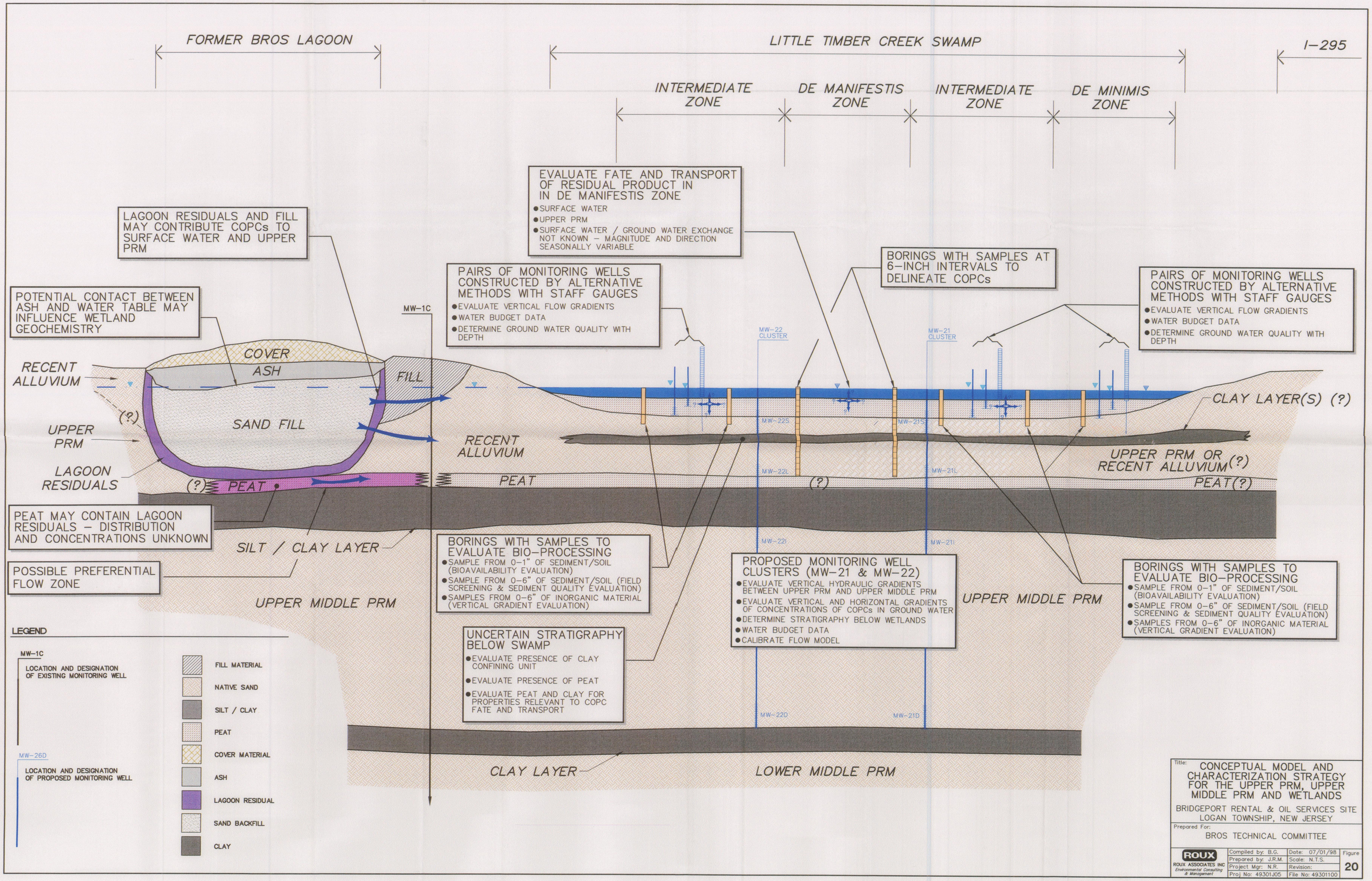
BRIDGEPORT RENTAL & OIL SERVICE SITE
LOGAN TOWNSHIP, NEW JERSEY

Prepared For:

BROS TECHNICAL COMMITTEE

ROUX ASSOCIATES INC *Environmental Consulting & Management*	Compiled by: B.G.	Date: 07/03/98	Figure 19
	Prepared by: J.R.M.	Scale: N.T.S.	
	Project Mgr: N.R.	Revision:	
	Proj No: 49301J05	File No: 49301038	

300213



Title: CONCEPTUAL MODEL AND CHARACTERIZATION STRATEGY FOR THE UPPER PRM, UPPER MIDDLE PRM AND WETLANDS

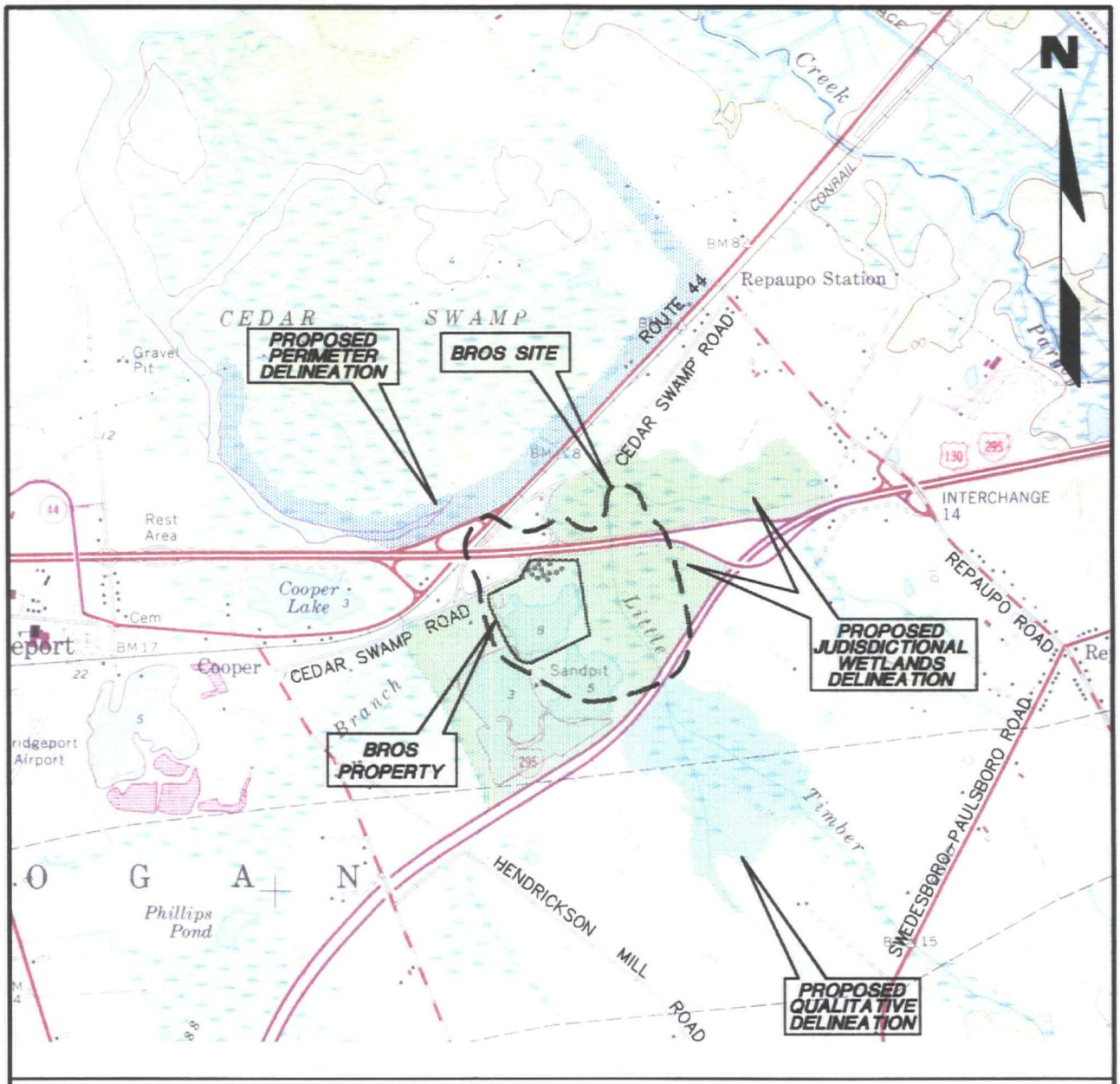
BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

Prepared For:
BROS TECHNICAL COMMITTEE

ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management

Compiled by: B.G.	Date: 07/01/98	Figure	
Prepared by: J.R.M.	Scale: N.T.S.	20	
Project Mgr: N.R.	Revision:		
Proj No: 49301J05	File No: 49301100		

300214



QUADRANGLE LOCATION

2,000' 0' 2,000'

LEGEND

— — — APPROXIMATE SITE BOUNDARY

——— APPROXIMATE PROPERTY BOUNDARY

SOURCE:

U.S.G.S. BRIDGEPORT, N.J., QUADRANGLE 1967
7.5 MINUTE SERIES (TOPOGRAPHIC)
PHOTOREVISED 1986
CONTOUR INTERVAL 10 FEET

Title:

AREAS OF PROPOSED WETLANDS DELINEATION

BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

Prepared For:

BROS TECHNICAL COMMITTEE

ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management

Compiled by: B.G.	Date: 07/02/98	Figure
Prepared by: J.R.M.	Scale: SHOWN	21
Project Mgr: N.R.	Revision:	
Proj No: 49301J05	File No: 49301110	

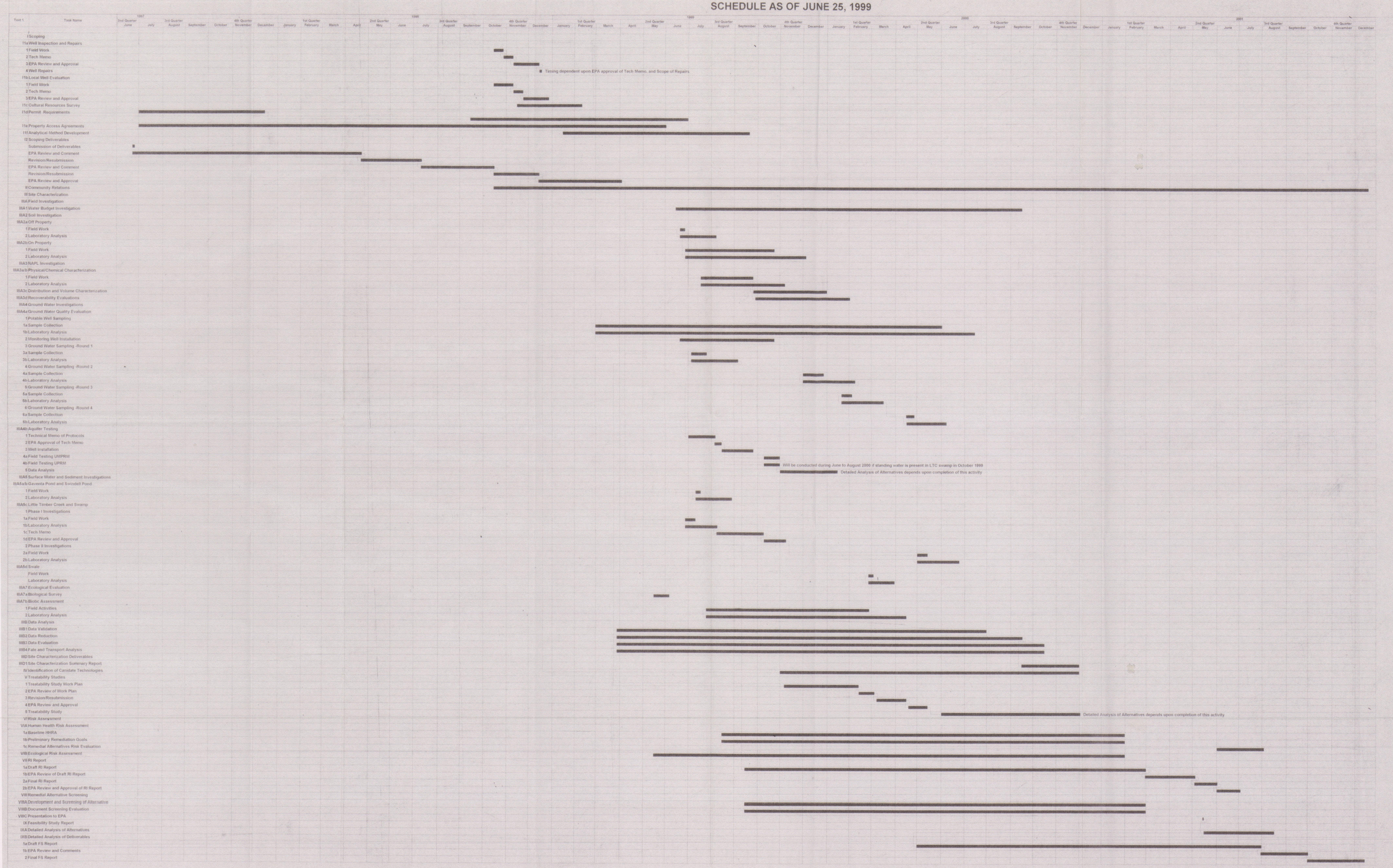
300215

PLATES

300217

PLATE 1: PHASE 2 RI/FS SCHEDULE

SCHEDULE AS OF JUNE 25, 1999



APPENDICES

APPENDIX A

RESUMES OF FIELD MANAGEMENT TEAM

Peter P. Brussock, Ph.D.

Vice President of Environmental Planning
Environmental Liability Management, Inc.

PROFESSIONAL EXPERIENCE

ENVIRONMENTAL LIABILITY MANAGEMENT, INC.

Princeton, NJ, March 1990 to Present

VICE PRESIDENT OF ENVIRONMENTAL PLANNING

Responsibilities include oversight of the environmental planning services, environmental assessment and management of contaminated sites, preparing redevelopment and land reuse plans, site-specific and regional planning evaluations, preparing public health and ecological assessments, developing risk-based corrective action plans, preparing cleanup cost allocation evaluations, as well as providing expert services to clients, especially on surface water and ground water cases; CERCLA, RCRA, NPDES Permit, New Jersey ISRA and Spill Act; Pennsylvania Land Recycling Program (Act 2) and HSCA, Clean Streams Law, and Solid Waste Act. Dr. Brussock is also responsible for technical and regulatory training of the ELM staff.

ENVIROLOGIC DATA, INC. (SUBSIDIARY OF GROUNDWATER TECHNOLOGY, INC.)

Chadds Ford, Pennsylvania, February 1989 to March 1990

PRINCIPAL SCIENTIST - responsibilities included directing all aspects of human health and ecological risk assessment services in the Mid-Atlantic states for CERCLA, RCRA and ISRA facilities.

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

Trenton, NJ, February 1986 to March 1989

SECTION CHIEF (ISRA, Formerly ECRA; CERCLA; New Jersey Spill Act) - responsible for supervision and management of up to six case managers and two supervisors in a section assigned over 200 high environmental concern industrial facilities (all sites with significant soils, surface water, and ground water contamination). Management focus on risk-based remediation reuse and redevelopment of industrial sites.

TECHNICAL COORDINATOR – responsible for technical aspects of hazardous site investigations and feasibility studies, primarily soil and water contamination problems; CERCLA, ISRA and RCRA sites. Utilized site-specific risk assessment in the context of current and future land use to develop cleanup strategies.

EDUCATION

Ph.D., University of Arkansas, Fayetteville, Arkansas
Aquatic Ecology and Water Resources, 1985

B.A., Lehigh University, Bethlehem, Pennsylvania
Biology, 1981

Drexel University, Philadelphia, Pennsylvania
Post-Graduate Coursework, 1987, 1989, 1991

Bucks County Community College, Newtown, Pennsylvania
Post-Graduate Coursework, 1989, 1990

Delaware Valley College, Doylestown, Pennsylvania
Post-Graduate Coursework, 1993, 1997

CERTIFICATIONS AND REGISTRATIONS

Certified Senior Ecologist, No. 313, Ecological Society of America

Certified Ground Water Professional, Association of Ground Water Scientists and Engineers, National Ground Water Association, CGWP #359

Certified Hazardous Materials Manager (CHMM), Institute of Hazardous Materials Management, Senior Level, No. 1795

Licensed For Tank Closure/Subsurface Investigations, New Jersey Department of Environmental Protection, UST License No. 0009939

Professional Geologist, Board of Registration for Professional Geologists, Commonwealth of Kentucky, License Number 513

Professional Wetland Scientist, Society of Wetland Scientists, Number 108

PROFESSIONAL APPOINTMENT AND REGULATORY COMMITTEES

Risk Assessment Subcommittee To The Cleanup Standards Scientific Advisory Board (Pennsylvania's Land Recycling Program)

Established by Pennsylvania Act 2, Subcommittee Member contributing to development of Medium Specific Standards, Ecological Standards, Site-Specific Standards and Regulations related to each.

Planning Commission Member

Solebury Township, Pennsylvania. Four year appointment. Responsible for review, evaluation, and recommendations on development and subdivision plans, especially those including environmental impact assessments.

Environment Advisory Task Force

Established by the New Jersey Industrial Site Recovery Act (ISRA), the Task Force will make recommendations to the NJDEP on the feasibility, development, and application of remediation standards protective of ecological receptors and the environment.

SELECT TEACHING EXPERIENCE

Adjunct Faculty

Delaware Valley College, Doylestown, Pennsylvania, 1994-1998

- Responsible for teaching Applied Toxicology and Risk Assessment course.

Professional Training Courses

Risk Assessment Under The Land Recycling Regulations and Act 2, 1995, 1996, 1997

- Directed training of Pennsylvania Department of Environmental Protection employees on Human Health and Ecological Risk Assessment/Risk Management.

PROFESSIONAL MEMBERSHIPS AND AFFILIATIONS

American Chemical Society
American Institute of Certified Planners
American Planning Association
- Division of Environment, Natural Resources and Energy

American Society for Testing & Materials (ASTM)
American Water Resources Association
Ecological Society of America
National Ground Water Association, Association of Ground Water Scientists & Engineers
North American Benthological Society
Sigma Xi, The Scientific Research Society
Society for Ecological Restoration
Society of Environmental Toxicology and Chemistry
Society for Risk Analysis
Society of Wetland Scientists
Water Environment Federation

COMPLETE CURRICULUM VITAE AVAILABLE UPON REQUEST

Neil R. Rivers
Principal Engineer

Technical Specialties:
Remedial investigations and feasibility studies at hazardous waste sites. Hazardous waste treatment and disposal technologies. Bioremediation and thermal desorption technologies. Industrial and environmental process engineering. Regulatory agency negotiations and compliance strategies.

Experience Summary:
15 years of experience: Principal Engineer for Roux Associates, Vice President at Environmental Compliance Services, Project Engineer at Roy F. Weston, and Technical Supervisor of Environmental Affairs and Process Engineering at NVF Company.

Credentials:
B.S. Biology, Widener University, 1980.
28 M.S. Credits in Env. Engineering, Univ. of Delaware (in progress).
Licensed Industrial Wastewater Treatment System Operator (N-2).

Key Projects:

- Engineer managing $1.4 million RI/FS at Southern Maryland Wood Treating NPL Site in Hollywood, Maryland. Designed and prepared RI/FS Work Plan, managed RI Field activities, authored RI Report and FS Report. The site was contaminated by PNAs, PCPs and dioxins from disposal of waste waters and sludges in several unlined lagoons. Impacted media included soils, ground water, surface water and stream sediments. Non-aqueous phase liquids were encountered in the water table aquifer. Remedial alternatives proposed for the site included incineration, sheet piling, capping, ground-water extraction, sediment removal and sediment containment.

- Engineer managing $1.6 million RI/FS at Fried Industries NPL Site in East Brunswick, New Jersey. Prepared the RI/FS Work Plan, Project Operations Plan, Quality Assurance Project Plan and Health and Safety Plan. The RI entailed characterization of volatile organic compounds and acids in soils and ground water resulting from drum disposal activities.

- Principal-in-Charge responsible for the FS and Remedial Design at an aerospace equipment manufacturing facility in central New Jersey. Volatile organic compounds and heavy metals have been detected in two water-bearing zones underlying the site. In addition, the site is located adjacent to an extensive wetland system designated by NJDEP as a Natural Area requiring special protection. Remedial measures include soil excavation and capping, ground-water extraction and sediment removal. Through the use of ecological risk assessment methods, natural remediation was approved for most of the wetlands areas.

- Principal-in-Charge responsible for a $4 million RI/FS, Remedial Design and Remedial Action at a petroleum distribution terminal in northern New Jersey. Ground water was impacted by dissolved and separate-phase petroleum compounds. The remedial program included the treatment of 18,000 cubic yards of impacted soils and sediments by thermal desorption; ground-water remediation and separate-phase product recovery; asbestos removal and the implementation of a stormwater management system.

- Principal-in-Charge of a remedial investigation for a landfill site in Logan Township, New Jersey. A disposal area, located adjacent to Maple Swamp, contains chromium sludges and other heavy metal compounds. Project activities have included landfill delineation and characterization, evaluation of ground-water quality, assessment of local and regional geology/hydrogeology and preliminary screening of remedial options.

- Principal-in-Charge for a remedial investigation and compliance program for a 1,200 acre explosives manufacturing plant in New Jersey. Site activities have included identification, evaluation and prioritization of potential Areas of Concern, development of a facility-wide Discharge Prevention, Containment and Countermeasure Plan, and preparation of a Landfill Closure Plan.

- Engineer leading technical peer review of FS Report for Shore Realty NPL Site in Glenwood Landing, New York. Volatile organic compounds were detected in soils, ground water and sediments. Risk assessment methodologies and the demonstrated effectiveness of soil vapor extraction (SVE) at the site were used to support a remedial strategy that employed SVE as opposed to incineration (NYSDEC's preferred alternative) for source removal.

- Engineer responsible for technical review of key project deliverables as part of the $40 million U.S. EPA REM II Contract. Responsible for review for strategic direction, technical accuracy, and administrative completeness. Completed technical review for the following projects/sites:
  - Bruin Lagoon; Butler, PA - RI Work Plan, Project Operations Plan, RI Report
  - Ordinance Works Disposal Site; Morgantown, WV - RI Work Plan, Project Operations Plan, RI Report
  - Drake Chemical; Lock Haven, PA - Remedial Design
  - Roebling Steel; Florence, NJ - RI Work Plan, Project Operations Plan, Health and Safety Plan
  - Henderson Road; Upper Merion, PA - Focused Feasibility Study
  - Ambler Asbestos Piles; Ambler, PA - RI Work Plan, Project Operations Plan, RI Report
  - L.A. Clarke; Spotsylvania, VA - RI Work Plan, Project Operations Plan, RI Report
  - Myers Property; Franklin Township, NJ - RI Work Plan, Project Operations Plan, RI Report
  - Tabernacle Drum Dump; Tabernacle, NJ - RI Work Plan, Project Operations Plan
  - Palmetto Wood Preserving; Dixiana, SC - Feasibility Study

- Engineer responsible for development of technical approach to RI/FS for the Bayou Bonfuca NPL site in Slidell, Louisiana. Developed and screened preliminary remedial alternatives and prepared a focused RI Work Plan to gather data for FS and remedial design. Soils and sediments within wetlands at the site have been impacted by PNAs from waste disposal lagoons.

- Principal-in-Charge of RCRA Corrective Action project at an 11 acre metals finishing facility in Florence, South Carolina. Soils, ground water, surface water and sediments are impacted by chlorinated VOCs and metals. The RCRA Facility Investigation has identified ground-water contamination in two aquifers. Interim Corrective Measures have been implemented and include landfill closure, lagoon closure and ground-water extraction. Project activities include strategic planning and management, regulatory agency negotiations, and technical review of project deliverables.

- Project Manager responsible for development and implementation of training program for consultant/contractor personnel assigned to REM II projects. Program moderator and primary instructor responsible for teaching personnel the technical and administrative procedures for conducting CERCLA projects under REM II. Instructed USEPA and contractor personnel assigned to development of CERCLIS database in remedial and removal projects.

- Lead Engineer for evaluation of process engineering, waste generation and disposal practices in support of CERCLA litigation project. Technical activities included the identification of process waste streams and fugitive waste streams; evaluation of waste characteristics; assessment of historical waste water treatment and sludge treatment and disposal methods; and evaluation of CERCLA RI/FS scope, methods and results.

- Principal-in-Charge of oversight and auditing of hazardous waste site remedial activities. Prepared reports for the contractor's pollution liability insurance carrier based upon field audits and report evaluations.

- Lead Project Engineer responsible for the identification, evaluation, and ranking of SWMUs at all stateside U.S. Army facilities. Designed program for evaluation and ranking based upon HRS model. Developed verification program to validate model.

300224

William B. Gilchrist, P.G.
Senior Hydrogeologist

Technical Specialties:
Design and implementation of soil and ground-water investigations. Management of Property Transfer/Merger/Acquisition projects. Development of ISRA compliance strategies. Preliminary design and supervision of remediation projects. Regulatory coordination and negotiations. Interpretation of Federal and State regulations. Development and implementation of multisite Phase I and II environmental assessments.

Experience Summary:
Twelve years of experience: Senior Hydrogeologist with Roux Associates, Inc.; Supervising Geoscientist with McLaren/Hart Environmental Engineering Corp.; Senior Project Geologist with EEC Environmental Inc. (now Harding Lawson Associates); Senior Geologist with New Jersey Department of Environmental Protection Bureau of Groundwater Pollution Abatement; Geologist with Texas Oil and Gas Corporation.

Conducted state-lead investigative and remedial activities under NJDEP, PADEP, NYSDEC, CDEP, and IEPA among others. Conducted USEPA-lead investigations under the jurisdiction of RCRA, CERCLA, CWA and TSCA.

Credentials:
B.A. Geology, Ohio Wesleyan University, 1983
M.S. Geology, Eastern Kentucky University, 1986
Professional Geologist in Pennsylvania, Delaware, Kentucky and Tennessee
NJDEP UST Certification for Subsurface Evaluation; 40 hour and Supervisors OSHA Health and Safety Training

Key Projects:

- Project Manager of an ISRA triggered Site Investigation/Remedial Investigation/Remedial Action at a 20-acre former electrical generating plant/battery manufacturing facility/microprocessor manufacturing facility which had 17 areas of concern (AOCs). Significant soil excavation was performed to remove soils contaminated with metals, volatiles, polynuclear aromatic hydrocarbons (PAHs), and total petroleum hydrocarbons. Where residual concentrations of contaminants were detected, the NJDEP accepted a Declaration of Environmental Restriction (DER). Ground-water contamination, primarily volatile organic compounds (VOCs) were detected in the bedrock and overburden aquifers. After a significant ground-water investigation, including use of a Geoprobe and mobile laboratory, the ground-water plume was delineated and an air sparging/soil vapor extraction AS/SVE system was designed. The installation of the AS/SVE system was proposed to eliminate the VOCs from discharging to a small creek which passed through the site. A Classification Exception Area (CEA) was proposed for low concentrations of VOCs in the bedrock aquifer. Ground-water issues were currently being implemented.

- Managed the completion of two multi-site property transfer environmental assessments at numerous industrial facilities in approximately twenty states. Activities included scheduling personnel from numerous offices having different disciplines (geologist, hydrogeologist, engineer, scientist, etc.), project direction, data review, report preparation, and negotiation assistance between purchaser and owner. In both cases a significant escrow account was negotiated to handle the many environmental issues identified during the assessments.

- Managed the field activities associated with the implementation of a Remedial Investigation (RI) of a CERCLA site in southern New Jersey. The RI included the completion of an extensive soil, ground water and soil gas sampling effort using a Geoprobe and the installation and sampling of numerous monitoring wells to delineate the source area and ground-water plume.

- Project Manager for a RCRA ground-water investigation in southeastern Pennsylvania. Ground water was impacted by chlorinated solvents in both the overburden and fractured bedrock aquifers. A Consent Order was negotiated with USEPA Region III and an Interim Measures Work Plan (IMWP) and RCRA Facility Investigation Work Plan (RFIWP) were submitted and approved. A ground-water extraction system was proposed for the overburden aquifer in the IMWP. A bedrock monitoring well network was installed which included coring and packer testing to assist with determining the hydrogeology of the site. The IM has been constructed and the bedrock investigation is continuing.

- Served as client contact for Fortune 50 conglomerate. Managed environmental investigations at manufacturing facilities in Pennsylvania, Ohio, New York, Illinois, Michigan, Texas, California and Baja California, Mexico. Environmental investigations typically included a Phase I environmental assessment and soil and ground-water investigations. Environmental investigations were completed as a corporate policy to determine environmental problems and liabilities at their sites and remediate the problems, if necessary, with the goal to get the state regulatory agencies to issue a "No Further Action Necessary" letter. Remedial activities were performed at several sites. Negotiated project scope and remedial activities with several state regulatory agencies. Worked closely with facility managers, corporate environmental managers and their counsel.

- Project Manager for a NJDEP Bureau of State Case Management site investigation and remediation performed in accordance with an ACO. The metal alloy and fabrication facility included a chlorinated solvent ground-water plume and numerous areas of concern including: a landfill, settling ponds and septic system which received industrial waste. The landfill was investigated and found to contain waste ceramic sands which had low levels of radiation. An investigation performed by a radiation physicist determined that normal contact with the landfill posed no adverse health risks. The septic system was excavated and sludges with high concentrations of metals were disposed as hazardous waste. The NJDEP approved no further excavation of soils in the vicinity of the settling ponds and septic systems with ground-water monitoring. Metals were found at a number of NJDES DSW outfalls on the site. It was anticipated that the NJDEP would accept limited hot spot removal with continued ground-water monitoring and a DER to allow leaving most of the metal contaminated sediment in place on the site.

- Performed and/or managed approximately 150 Phase I environmental assessments completed as part of property transfer due diligence process. Phase I's were performed in New Jersey, Pennsylvania, Connecticut, New York, Illinois, Wisconsin, Texas, Oklahoma, Louisiana, and California. The Phase I's were completed in accordance with ASTM standards.

John A. Lucey, P.G.
Project Geologist

Technical Specialties:
Environmental site assessments, geophysical surveys, and the investigation and remediation of ground-water and soil contamination.

Experience Summary:
10 years experience: Project Geologist at Roux Associates, Inc.; Project Geologist at Walter B. Satterthwaite Associates, Inc.; Senior Hydrogeologist at Clean Technologies, Inc.; Geologist at Roux Associates, Inc. Conducted environmental site assessments at industrial facilities, participated in ground-water and soil investigations, participated in the design and installation of remedial systems, managed subcontractors and field activities.

Credentials:
M.S. Geology, University of Delaware 1994.
B.S. Geology, University of Delaware 1985.
Professional Geologist No. PG-003138-G. Commonwealth of Pennsylvania
New Jersey-Certified Subsurface Evaluator and Closure No. 3468
OSHA 40-hour Health and Safety.
Certified Mobile Environmental Mass Spectrometer Operator

Key Projects:

- Evaluated hydrogeologic data and downgradient sentinel well locations and supervised the installation of the sentinel wells in the PRM aquifer system at the Harvey and Knotts Superfund site. Audited ground-water sampling and sample handling procedures on behalf of a PRP. Prepared the surface soil sampling plan for the Harvey and Knotts Superfund site. The sampling plan included field screening with using x-ray fluorescence and the collection of confirmatory soil samples for laboratory analysis. Contaminants of concern included heavy metals.

- Geologist responsible for evaluation of ground-water analytical results and hydrogeologic data from the Tybouts Corner Superfund site on behalf of a Potential Responsible Party (PRP). The ground-water analytical data review included data evaluation, construction of isoconcentration maps, an evaluation of potential gradients between the Columbia Formation and the PRM aquifer system; an evaluation of monitoring well construction details, and the production of ground-water flow maps. Contaminants of concern included chlorinated volatile organic compounds.

- Assisted in the preparation of a Remedial Investigation Work Plan (RIWP) and conducted hydrogeologic investigations for a former chromium pigments manufacturing facility in Pennsylvania. The RIWP included soil sampling to evaluate production areas, raw materials storage, petroleum storage, and on-site disposal areas. Hydrogeologic investigations included the analysis of slug test, pump test and ground-water elevation data to evaluate the horizontal and vertical distribution of constituents in a fractured aquifer.

- Directed multi-phase remedial investigation at a 150-acre chemical manufacturing facility in southern New Jersey. Soils investigations included the installation and sampling of over 300 soil borings, geophysical surveys, and test pitting. Ground-water investigations included the installation and sampling of monitoring wells and the sampling of industrial supply wells installed in the Potomac-Raritan-Magothy (PRM) aquifer system. Surface-water drainage investigations included surface water and sediment sampling in on-site drainage systems, retention basins and the Delaware River. Additional investigations included waste water lagoon sludge and gas sampling for remedial options analysis. Contaminants of concern at the site include polychlorinated biphenyls, petroleum fuels, volatile organic compounds and asbestos-containing material.

- Coordinated remedial investigations at a 160-acre pharmaceutical manufacturing facility in northern New Jersey. Ground-water investigations included monitoring well installation, monitoring well sampling, slug testing, step drawdown tests, and field screening using the HydroPunch® sampling techniques. Soil investigations included soil boring sampling, soil gas survey, and test pitting. Contaminants of concern include chlorinated volatile organic compounds and petroleum fuel constituents.

- Prepared a Regional Water Supply Study for an industrial facility in New Jersey that included an assessment of the regional ground-water and surface-water quality, the identification of ground-water and surface-water withdrawal points, the identification of potential sources of ground-water and surface-water contamination, an evaluation of public water supply sources within the region and the modeling of well head protection areas around public supply wells.

- Participated in ground-water and soils investigations at a former chromium ore processing facility in Pennsylvania. Ground-water investigations included the installation of and sampling of well points and the evaluation of ground-water elevation data. Soils investigations included the installation and sampling of soil borings to evaluate site conditions and support closure of a wastewater lagoon.

- Coordinated remedial investigations and remedial activities at a specialty paper manufacturing facility in central New Jersey as part of property transfer transactions. Remedial investigations and remedial activities were conducted at an accelerated pace to fulfill the requirements of the agreement of sale. Contaminants of concern included metals, PCBs, petroleum fuels and polynuclear aromatic hydrocarbons.

- Coordinated ground-water and soil investigations at industrial facilities, landfills, gasoline service stations and bulk petroleum storage facilities. Responsibilities included the selection of subcontractors and laboratories, supervising field activities, compiling work plans and sampling plans, data analysis and review, notification of regulatory agencies and the preparation of summary reports.

Brigid M. Tigani
Staff Geologist

Technical Specialties:
Investigation and remediation of ground-water and soil contamination.

Experience Summary:
3 years experience as Staff Geologist with Roux Associates, Inc. Assisted in ground-water and soil investigations, oversight of subcontractors and field activities.

Credentials:
B.S. in Geology, University of Delaware, 1995
OSHA 40-Hour Health and Safety Training

Key Projects:

- Field coordinator for remedial investigation activities at a former paint and coal tar manufacturing facility in central New Jersey. Areas of concern include abandoned USTs, buried drum and container areas, and isolated subsurface seams of coal tar. Primary constituents of concern include PAHs, VOCs, and metals. Responsibilities included subcontractor oversight, monitoring well installation, soil boring installation and geological logging, soil sampling, and data management.

- Field coordinator for site/remedial investigations for soil and ground-water conducted at a former insulation manufacturing facility in Southern New Jersey. Areas of concern include abandoned USTs, waste water treatment settling lagoons, heat transfer fluid storage and transfer areas, transformer pads, and buried asbestos disposal areas. Primary constituents of concern include PAHs, bi-phenyl and phenyl ether, VOCs, asbestos, PCSs, and metals. Responsibilities included soil borings utilizing hollow-stem auger and Geoprobe®, hot-spot removal, monitoring well installation utilizing a hollow-stem auger drilling, and ground-water sampling.

- Assistant in preparation of the Annual Report of RCRA Corrective Action project at an 11-acre metals finishing facility in Florence, South Carolina. Activities include analysis of ground-water elevations and VOC-contaminant trends, data management, and state reporting.

- Field team member for remedial investigation activities at a former pigments manufacturing facility in northeastern Pennsylvania. Activities included the installation and geological logging of over 100 soil borings using Geoprobe® techniques, soil sampling, and ground-water sampling utilizing low-flow purging techniques. Contaminants of concern include chromium and petroleum fuels.

- Participated in ground-water investigation activities for an electronics manufacturing facility in central New Jersey. Activities included assisting oversight during installation of monitoring wells utilizing hollow-stem auger techniques, ground-water sampling, aquifer testing, and data management. Contaminants of concern include VOCs and acetone.

- Project coordinator for ground-water investigations a former chemical manufacturing facility in central New Jersey. Responsibilities include development and implementation of ground-water sampling of over thirty monitoring wells, data management, and report preparation.

- Participated in a multi-phase remedial investigation at a 150-acre chemical manufacturing plant in New Jersey. Activities included the installation of monitoring wells, the installation and geological logging of soil borings, soil and lagoon sludge sampling, ground water sampling, and aquifer testing.

- Field team member for ISRA-related field activities at a former fiberglass manufacturing facility in southern New Jersey. Activities included soil boring installation utilizing Geoprobe® techniques, soil sampling, ground-water sampling, and aquifer testing.

- Assisted in site-wide screening of a 1,200-acre former explosives manufacturing facility in northern New Jersey. Activities included soil, sediment, and sludge sampling to determine contamination distribution.

- Oversight during the abandonment of monitoring wells utilizing hollow-stem auger and air rotary techniques at a former agrichemical research facility in northern Delaware.

- Utilized Hydropunch® techniques to determine extent of ground-water contamination at multiple sites throughout New Jersey.

- Conducted monitoring well gauging, purging and sampling in accordance with NJDEP's Field Sampling Procedures Manual.

- Performed geological and geophysical logging of boreholes in the coastal plains of New Jersey.

- Assisted in preparation of sampling plans for hazardous waste site in accordance with the New Jersey Technical Requirements for Site Remediation.

Joanne Yeary
Senior Hydrogeologist/Quality Assurance Officer

Technical Specialties:
Quality assurance reviews/technical editing and aquifer test analysis.

Experience Summary:
12 years of experience: Senior Hydrogeologist and Geologist with Roux Associates. Supervised several ground-water, soil and surface-water sampling programs. Assisted in ground-water modeling projects and performed aquifer test analyses. Prepared numerous hydrogeologic reports.

Credentials:
B.S. Geology, S.U.N.Y. Stony Brook, 1986.

Professional Affiliations:
National Ground Water Association

Key Projects

- Quality Assurance Officer for numerous site investigations involving soil and ground-water contamination. Responsible for assuring that statements and conclusions in final reports are supported by analytical data.
- Performed quality assurance review of a final report for a CERCLA hazardous waste site in Massachusetts (#5 on the NPL). Responsible for assuring that results of subcontractor investigations, and statements and conclusions drawn in the final report, are supportive of the analytical data.
- Quality Assurance Officer for several remedial investigation projects in Pennsylvania and North Carolina. Edited and assured accuracy of geologic logs, maps, tables, calculations, and final report text. Checked for consistency between final reports and all supporting data.
- Quality Assurance Officer on an expert report performed in support of litigation for a former industrial facility located in New Jersey.
- Performed quality assurance review on two remedial investigation workplans, including a review of subcontractor reports.
- Performed quality assurance review on both the Feasibility Study and the Focused Feasibility Study for a site with soil and ground-water contamination on Long Island, New York.
- Quality Assurance Officer for several pesticide projects. Assured that data, reports and archives adhere to EPA Good Laboratory Practice standards.
- Designed computer database for analytical data being generated at a large site in Rhode Island.
- Supervised Remedial Investigation at a CERCLA hazardous waste site on Long Island, New York.
- Supervised well installations, ground-water sampling, soil sampling and surface-water sampling at a CERCLA hazardous waste site in Massachusetts which is ranked #5 on the NPL.
- Participated in pesticide monitoring studies in ground water, soils, rivers, and streams. Projects included retrospective studies, prospective studies, and detection follow-ups. Evaluated findings of state monitoring programs. Edited sampling reports following EPA Good Laboratory Practice standards.
- Performed multiple aquifer tests at a site in Queens, New York. Analyzed slug test, constant-rate pumping test, and recovery test data to determine hydraulic coefficients of the Upper Glacial aquifer, and prepared summary report.
- Analyzed data from multiple aquifer tests (constant rate pumping tests, step tests, slug tests, recovery tests) and prepared reports summarizing hydraulic coefficients for a site in Rhode Island.
- Performed and analyzed data from multiple slug tests as part of a Remedial Investigation at a site in Nassau County, Long Island. Prepared report summarizing hydraulic coefficients.
- Participated in slug tests at a hazardous waste site in Suffolk County, Long Island as part of a Phase II investigation at a property on the NYSDEC list of inactive hazardous waste sites.
- Analyzed slug test data for three NYSDEC Phase II Investigations in Suffolk and Nassau Counties, Long Island, and prepared summary report for each.
- Wrote hydrogeologic report in support of a water allocation permit to remediate groundwater at an industrial site in New Jersey.
- Co-wrote ground-water contingency plan for a major bulk petroleum storage facility in Long Island, New York.
- Prepared Phase II Remedial Investigation final report for a railroad facility in Queens, New York. Report summarized results of a 5-year investigation of soil and ground-water quality.
- Developed, wrote and managed field sampling plan as part of a Remedial Design for a site in New York requiring soil and sediment remediation.
- Prepared report summarizing current soil conditions at an industrial site in New Jersey.
- Prepared report summarizing results of a soil and ground-water investigation performed in New York for a public water supply company.
- Wrote Phase II report in accordance with the Massachusetts Contingency Plan for a former service station in Massachusetts.

Aquifer Drilling & Testing, Inc.

H.L. Rexrode, Jr.
Resume

Len Rexrode will serve as drilling manager for this project. Mr. Rexrode has 20 years of drilling experience working within the fields of geology and hydrogeology. In 1989, he founded Aquifer Drilling and Testing, Inc. (ADT), of which he is currently President and Owner.

Mr. Rexrode holds a B.S. Degree in Geology from James Madison University, 1979, and attended Stephen F. Austin University, studying petroleum geology in 1983-1984. From 1979 until 1986, he worked as a field geologist. From 1986 to 1989, he worked as a hydrogeologist on numerous Phase I and Phase II projects involving drilling.

Since 1989, he has supervised hundreds of environmental and geotechnical drilling projects in the Midatlantic and Northeast regions of the Untied States. These projects include State and Federal Superfund jobs.

Mr. Rexrode is also Vice President of the Northeast Section of the American Institute of Professional Geologists; a Certified Professional Geologist – AIPG; and has a New Jersey Well Drillers License.

Lonnie Fallin

Mobile Lab Chemist

Mr. Fallin has over ten years of hands-on environmental laboratory experience as a chemist and laboratory manager. Mr. Fallin is a mobile lab manager for ONSITE, providing analysis at mobile lab and close support lab projects.

Prior to ONSITE, Mr. Fallin was a senior chemist for Groundwater Analytical where he analyzed soil and water samples for volatiles and semi-volatiles by GC and GC/MS, and managed the technical operations for EPA 500 series, 600 series, and 8000 series. Mr. Fallin reviewed data for VOCs, SVOCs, PCB/Pesticides, herbicides, and petroleum hydrocarbons.

At Phoenix Analytical Laboratories, Inc. in Broomfield, CO Mr. Fallin was a Laboratory Manager and Technical Advisor for three years. Mr. Fallin managed the technical operations and technical personnel, reviewed VOC and SVOC GC and GC/MS data and generated final reports. Mr. Fallin also was active in performing instrument maintenance and repair.

Prior to his lab manger position, Mr. Fallin managed the LIMS department for the laboratory, which involved maintaining and supporting a Novell network and operating optical storage drives.

Mr. Fallin was a chemist for Phoenix Analytical Laboratories for five years where he had hands-on experience performing VOC and SVOC analysis by GC/MS. Mr. Fallin also performed SVOC sample preparation and extractions. Mr. Fallin generated reports, performed QA/QC review, and trained other chemists in the operation of GC/MS systems.

Mr. Fallin is knowledgeable on a variety of software packages which includes HP Chemstation/EnviroQuant Software, PE Turbochrom, Excel, Word, and DOS.

Mr. Fallin has consulted to clients as an expert witness in preparation of data for court presentation.

Mr. Fallin holds a B.A. in Chemistry from the University of Colorado at Boulder, CO.

JAMES D. KUEHN
Director of Chemistry

EDUCATION B.S., Water Science, Northern Michigan University, 1986

EXPERIENCE **ENCOTEC, Inc. (June 1986-present)**
Ann Arbor, MI

Director of Chemistry (Jan. 1995 - present)
Direct and manage all technical function of the Inorganic and Organic Chemistry Group. Recommend staffing requirements, equipment purchases, and methods to improve productivity. Monitor productivity and timeliness of data completion for both chemistry groups. Provide technical guidance to project management staff.

Organic Department Manager/ Assistant Laboratory Manager
(Jan. 1993- Dec. 1994)
Direct and manage all technical functions of the Organic Chemistry Group. Assign projects to staff, monitor progress, and review data. Recommend to Senior Management Staff requirements, equipment purchases, and methods to improve productivity. Interview, recommend, and hire new chemists.

GC/MS Group Leader (December 1989-Jan. 1992)
Managed GC/MS group which consist of eleven people. Responsibilities include the day to day operation of the GC/MS group, scheduling of projects and assignments to personal, data review, development of new methods and new policies and their implementation in the operation of the laboratory Responsibilities also include the future projections for the group, which include loadings, staff requirements, instrument requirements, and monthly expenditures.

Assistant GC/MS Group Leader (Jan 1989-Nov. 1989)
Managed seven people that entail our group. Responsibilities also consist of those listed under Senior Chemist, however was also involved in the growth of the group This includes development of new methods, new equipment, and new people to help our group run more efficiently and produce overall better QA/QC for our clients.

JAMES D. KUEHN
Director of Chemistry

Senior Chemist GC/MS (September 1986-Nov. 1988)
Performed day to day troubleshooting and maintenance on four GC/MS/DS systems (Finnigan 3200, 4000 and two 5100). Responsibilities also entailed day to day scheduling and data review of all EPA data. Involved extensively with Appendix IX research, and also of new methods and or equipment being used today. Performed day to day analysis of environmental samples for Priority Pollutants and Hazardous Substance List compounds, and employed computer libraries and mass spectral interpretation for unknown compounds. Experienced in meeting Superfund criteria for analysis, documentation and meeting QC requirements. Utilized knowledge for routine instrument maintenance, data evaluation, and data handling by magnetic tape.

SPECIAL SKILLS

Experienced in the operation and maintenance of the Finnigan 4500, 5100, Incos-50, Incos-500, Hewlett Packard 5971A and 5972A. Help develop and implement organic wide training program and method proficiency certifications.

SPECIAL TRAINING

Finnigan MAT, Spectral Interpretation Class, December 1987

2425 New Holland Pike • Lancaster, PA 17601-5994

Rachel L. Kreamer, B.S.
Group Leader
Environmental Client Services

Current Responsibilities:

Group Leader, Environmental Client Services (1996-Present)

- Supervises a staff of 13 client service representatives and support personnel.
- Coordinates client requirements with technical groups and ensures they are met.
- Acts as a technical contact for clients on all of our analytical capabilities.
- Reviews reports before they are sent to clients.
- Audits client paperwork for incoming environmental samples.

Previous Experience:

Clerical Lab Technician, Lancaster Laboratories (1987-1988), Lab Technician (1988-1989), Technical Services Administrator (1989-1990), Technical Services Specialist (1990-1993), Client Services Specialist (1993-1995), Client Services Specialist/Coordinator (1995-1996)

Education:

B.S., Biology, Eastern Mennonite College (1980)

B

300234

APPENDIX B

STANDARD OPERATING PROCEDURES

1. *FIELD RECORD KEEPING AND QUALITY ASSURANCE/QUALITY CONTROL*
2. *DECONTAMINATION OF FIELD EQUIPMENT*
3. *MEASURING WATER LEVELS USING AN ELECTRONIC SOUNDING DEVICE (M-SCOPE)*
4. *SCREENING SOIL SAMPLES FOR VOLATILE ORGANIC VAPORS USING A PORTABLE PHOTOIONIZATION DETECTOR*
5. *SAMPLE HANDLING*
6. *COLLECTION OF SOIL SAMPLES FOR LABORATORY ANALYSIS*
7. *MEASURING THE THICKNESS OF FLOATING SEPARATE-PHASE ORGANIC LIQUIDS*
8. *HAND BAILING WELLS CONTAINING SEPARATE-PHASE ORGANIC LIQUIDS*
9. *BORING AND/OR MONITORING OR OBSERVATION WELL DRILLING, FORMATION SAMPLING AND BOREHOLE ABANDONMENT IN UNCONSOLIDATED FORMATIONS*
10. *CONSTRUCTION, DEVELOPMENT AND ABANDONMENT OF MONITORING OR OBSERVATION WELLS IN UNCONSOLIDATED FORMATIONS*
11. *COLLECTION OF QUALITY CONTROL SAMPLES FOR WATER-QUALITY DATA*
12. *PURGING A WELL*
13. *SAMPLING GROUND-WATER MONITORING WELLS FOR DISSOLVED CONSTITUENTS*
14. *COLLECTING STREAM-BED, AND POND SEDIMENT SAMPLES*
15. *SURFACE-WATER SAMPLING*
16. *MEASURING THE pH OF WATER SAMPLES*
17. *MEASURING THE CONDUCTIVITY OF WATER SAMPLES*
18. *MEASURING WATER TEMPERATURE*
19. *CONDUCTING A STEP-DRAWDOWN TEST*
20. *CONDUCTING A CONSTANT-RATE (PUMPING) TEST AND RECOVERY TEST*
21. *SAMPLING POTABLE WATER SYSTEMS*
22. *HYDROPHOBIC DYE TEST FOR DETERMINATION OF NAPL IN SATURATED SOILS AND GROUND WATER SAMPLES*
23. *SCREENING NAPL SAMPLES*
24. *DESCRIPTION OF SOILS USING THE BURMISTER SYSTEM*
25. *BENTHIC MACROINVERTEBRATE SAMPLING*
26. *QUANTITATIVE VEGETATION SURVEY PROTOCOL - TRANSECT METHOD*
27. *FISH SAMPLE COLLECTION BY BEACH SEINE*
28. *FISH ELECTROSHOCKING PROTOCOL*
29. *TRAP NETTING*
30. *FERROUS IRON FIELD SCREENING*
31. *DOCUMENTATION OF SAMPLE LOCATIONS USING GPS*
32. *SMALL MAMMEL SAMPLING PROTOCOL*
33. *THE COLLECTION OF GROUND WATER SAMPLES USING SLOTTED AUGERS*
34. *THIN-WALLED TUBE SAMPLING FOR SOILS*
35. *RING-LINES BARREL SAMPLING OF SOILS*
36. *COLLECTION OF WETLAND SEDIMENT/SOIL SAMPLES FOR LABORATORY ANALYSIS.*

FIELD RECORD KEEPING AND QUALITY ASSURANCE/QUALITY CONTROL

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide procedures and standards for record keeping and maintenance, for all field activities conducted by Roux Associates, Inc. (Roux Associates).

Strict quality assurance/quality control (QA/QC) is necessary to properly and accurately document and preserve all project-related information. Quality assurance is implemented to corroborate that quality control procedures are followed. Quality control provides a means to monitor investigation activities (e.g., sampling and laboratory performance) as a check on the quality of the data.

Valid data and information are integral to all aspects of the planned field activities. These aspects include, but are not necessarily limited to, activities that involve: drilling; sediment, sludge, and soil sampling (lithologic, and soil-quality and analysis); well construction and development; aquifer testing and analysis; water-quality sampling and analysis (surface water and ground water); free-product sampling and analysis; air-quality sampling and analysis; geophysical testing; waste removal operations; engineering installations; etc. The data will be confirmed by QA/QC methods established and set forth in the Phase 2 RI/FS Work Plan and Field Sampling Plan. Without checks on the field and analytical procedures, the potential exists for contradictory results, and associated incomplete or incorrect results from the interpretation of potentially questionable data.

Documentation will be entered in the field notebook and must be transcribed with extreme care, in a clear and concise manner, as the information recorded will become part of the permanent legal record. Because field notes are the legal record of site activities, they must be taken in a standard and consistent manner. If abbreviations are used, then they must first be spelled out for clarity (i.e., to avoid ambiguity and misunderstanding). All entries must be dated and initialed, and the time (military time) of the entry included. Field notebooks and forms must be assigned to an individual project and properly identified (i.e., client name, project number, location and name of site, individual recording information, dates, times, etc.). Change of possession of field notebooks or forms must be documented with the date and time, and initialed by both individuals. Following each day's entries, the field notebook or form must be photocopied in the event that the original documentation is lost or stolen. All field notebooks must have the company name and address legibly printed in indelible ink along with the message "If found, then please forward to Roux Associates, Inc. at the above address - REWARD OFFERED."

Information must be recorded while onsite because it may be difficult to recall details at a later date. Furthermore, information must be documented immediately as it provides unbiased information which will be used for writing the report when the field activities are completed. Project-related documentation is an irreplaceable, important record for other individuals who may become involved in the project, and provides the project manager with a complete history of project-related activities. Written information must be accompanied by maps, sketches, and

photographs where appropriate, especially if these supplemental sources of information assist in the documentation process. A new page must be used in the field notebook for each new day's entries (i.e., unused portions of a previous page must have an "X" placed through it). The end of the day's records must be initialed and dated.

2.0 MATERIALS

In order to track investigation activities, specific materials are required. These materials include the following:

a. A bound, waterproof field notebook.

b. Appropriate Roux Associates' forms (e.g., daily log, geologic log, monitoring well construction log, well sampling data form, location sketch, chain of custody, telephone conversation record, meeting notes, etc.).

c. Appropriate labels (e.g., sample, Roux Associates' Custody Seal, etc.)

d. Phase 2 RI/FS Work Plan and Field Sampling Plan

e. Health and Safety/Contingency Plan (HASCP).

f. Appropriate Roux Associates' SOPs.

g. Black pens, and indelible markers.

h. Camera and film.

3.0 DOCUMENTATION

3.1 Before the Roux Associates personnel leave the field, they must ensure that their field notes include comprehensive descriptions of the hydrogeologic conditions, and all investigation-related activities and results (onsite and offsite). This will safeguard against the inability to reconstruct and comprehend all aspects of the field investigation after its completion, and will serve to facilitate the writing of an accurate report. Properly documented information provides the QA/QC tracking (back-up) required for all Roux Associates' projects. General types of information that must be recorded (where pertinent to the investigation being conducted) include, but may not necessarily be limited to, the following:

a. List of Roux Associates personnel onsite.

b. Name, date, and time of arrival onsite by Roux Associates personnel, including temporary departures from, and returns to, the site during the work day.

c. Client and project number.

d. Name and location of study area.

e. Date and time of arrival onsite by non-Roux Associates personnel (names and affiliation) and equipment (e.g., subcontractors and facility personnel, and drilling equipment, respectively, etc.), including temporary departures from, and returns to, the site during the work day, and departure at the end of the work day.

f. List of non-Roux Associates personnel onsite.

g. Weather conditions at the beginning of the day as well as any changes in weather that occur during the working day.

h. Health and safety procedures including level of protection, monitoring of vital signs, frequency of air monitoring, and any change (i.e., downgrade or upgrade) in the level of protection for Roux Associates and other on-site personnel (e.g., subcontractors, facility personnel, etc.).

i. Health and safety procedures not in compliance with the HASCP (for all on-site personnel).

j. Site reconnaissance information (e.g., topographic features, geologic features, surface-water bodies, seeps, areas of apparent contamination, facility/plant structures, etc.).

k. Air monitoring results (i.e., photoionization detector [PID], etc. measurements).

l. Task designation and work progress.

m. Work-related and site-related discussions with subcontractors, regulatory agency personnel, plant personnel, the general public, and Roux Associates personnel.

n. Delays, unusual situations, problems and accidents.

o. Field work not conducted in accordance with thePhase 2 RI/FS Work Plan and Field Sampling Plan, and rationale and justification for any change(s) in field procedures including discussions with personnel regarding the change(s) and who authorized the change(s).

p. QA/QC procedures not conducted in accordance with the QA/QC procedures established in the Quality Assurance Project Plan and rationale and justification for any change(s) in QA/QC procedures including discussions with personnel regarding the change(s) and who authorized the change(s).

q. Equipment and instrument problems.

r. Decontamination and calibration procedures.

s. Activities in and around the site and work area by any and all on-site personnel which may impact field activities.

t. Sketches, maps, and/or photographs (with dates and times) of the site, structures, equipment, etc. that would facilitate explanations of site conditions.

u. Contamination evidenced as a result of work-related activities (e.g., visible contaminants [sheen] in drilling fluids or on drilling equipment; sheen on, or staining of, sediments; color of, or separate [nonaqueous] phase on, water from borehole or well; vapors or odors emanating from a borehole or well; etc.); make all observations as objectively as possible (e.g., grey-blue, oil-like sheen; black and orange, rust-like stain; fuel-like odor; etc.) and avoid using nontechnical or negative-sounding terms (e.g., slimy, goopy, foul-smelling).

v. Date and time of final departure from the site of all personnel at the end of the work day.

3.2 In addition to the general types of information that must be recorded (as presented in Section 3.1), task-specific information must also be properly documented. Task-specific information which is required is provided in each respective task-oriented SOP, and the documentation procedures outlined in each SOP must be followed.

DECONTAMINATION OF FIELD EQUIPMENT

DECONTAMINATION OF FIELD EQUIPMENT

1.0 PURPOSE

The purpose for this standard operating procedure (SOP) is to establish the guidelines for decontamination of all field equipment potentially exposed to contamination during drilling, and soil and water sampling. The objective of decontamination is to ensure that all drilling, and soil-sampling and water-sampling equipment is decontaminated (free of potential contaminants): 1) prior to being brought onsite to avoid the introduction of potential contaminants to the site; 2) between drilling and sampling events/activities onsite to eliminate the potential for cross-contamination between boreholes and/or wells; and 3) prior to the removal of equipment from the site to prevent the transportation of potentially contaminated equipment offsite.

To minimize decontamination efforts dedicated or disposable equipment (e.g., sample collection devices, tubing, rope) will be used where applicable. Additionally, acetone will not be used in any decontamination procedure as it has not been confirmed as a site related constituent. Separate hexane and methanol, pesticide grade or better, rinses will be used in place of the acetone rinse. Acid used in the decontamination process will be ultra-pure grade, diluted with analyte-free water. The analyte free water used during decontamination processes is distilled-deionized water, proven analyte free through analysis with a copy of the results kept by Roux.

The decontamination procedure documented below are consistent with the guidance provided in the New Jersey Department of Environmental Protection's (NJDEP) Field Sampling Procedures Manual and the United States Environmental Protection Agency's (USEPA's) Ground Water Sampling Procedure-Low Stress (Low Flow) Purging, And Sampling.

2.0 PROCEDURE FOR DRILLING EQUIPMENT

The following is a minimum decontamination procedure for drilling equipment. Drilling equipment decontamination procedures, especially any variation from the method itemized below, will be documented on an appropriate field form or in the field notebook.

2.1 The rig and all associated equipment should be properly decontaminated by the contractor before arriving at the test site.

2.2 The augers, drilling casings, rods, samplers, tools, rig, and any piece of equipment that can come in contact (directly or indirectly) with the soil, will be steam cleaned prior to the initial mobilization of the drill rig, moving the rig between off-site locations, and prior to moving the rig off-site. If possible, decontamination procedures will be conducted at the decontamination pad located on the BROS Property. However, if field conditions require, temporary decontamination pads will be constructed at remote locations to decontaminate the drill rig and associated equipment.

2.3 The same steam cleaning procedures will be followed between boreholes (at a fixed on-site location[s], if appropriate) and before leaving the site at the end of the study.

2.4 All on-site steam cleaning (decontamination) activities will be monitored and documented by a member(s) of the staff of Roux Associates, Inc.

2.5 If drilling activities are conducted in the presence of thick, sticky oils which coat drilling equipment, then special decontamination procedures may have to be utilized before steam cleaning (e.g., hexane scrub and wash).

2.6 Containment of decontamination fluids will be required (e.g., rinsate from steam cleaning) or will be required (e.g., hexane), and disposal must be in accordance with state and/or federal procedures.

3.0 PROCEDURE FOR SOIL/SEDIMENT -SAMPLING EQUIPMENT

The following is a minimum decontamination procedure required by the NJDEP's Field Sampling Procedures Manual for soil-sampling equipment (e.g., split spoons, stainless-steel spatulas). Soil-sampling equipment decontamination procedures, especially any variation from the method itemized below, will be documented on an appropriate field form or in the field notebook.

3.1 Wear phthalate free disposable gloves while cleaning equipment to avoid cross-contamination and change gloves as needed.

3.2 Steam clean the sampler or rinse with potable water. If soil-sampling activities are conducted in the presence of thick, sticky oils which coat sampling equipment, then special decontamination procedures may have to be utilized before steam cleaning and washing in detergent solution (e.g., hexane scrub and wash).

3.3 Prepare a non-phosphate, laboratory-grade detergent solution and distilled or potable water in a clean bucket.

3.4 Disassemble the sampler, as necessary and immerse all parts and other sampling equipment in the solution.

3.5 Scrub all equipment in the bucket with a brush to remove any adhering particles.

3.6 Rinse all equipment with copious amounts of potable water followed by analyte free water rinse.

3.7 Rinse equipment that will be used to collect samples for metals with 10% nitric acid (HNO_3).

3.8 Rinse equipment with hexane.

3.9 Rinse equipment with methanol.

3.10 Allow to air dry completely prior to a final rinse with analyte-free water.

3.11 Air dry and reassemble the cleaned sampler, as necessary.

3.12 Transfer the sampler to the driller (or helper) making sure that this individual is also wearing clean gloves, or wrap the equipment with a suitable material (e.g., aluminum foil.

4.0 PROCEDURE FOR WATER-SAMPLING EQUIPMENT

The following is a the decontamination procedure required by the NJDEP for water-sampling equipment (e.g., sample collection devices, pumps) for purposes other than low-flow ground water sampling. Water-sampling equipment decontamination procedures, especially any variation from the method itemized below, will be documented on an appropriate field form or in the field notebook.

4.1 Decontamination procedures for sample collection devices:

a. Wear disposable gloves while cleaning sample collection devices to avoid cross-contamination and change gloves as needed.

b. Prepare a non-phosphate, laboratory-grade detergent solution and potable water in a bucket.

c. Disassemble sample collection device (if applicable) and discard cord in an appropriate manner, and scrub each part of the bailer with a brush and solution.

d. Rinse with potable water.

e. Rinse with copious amounts of distilled and deionized water.

f. Rinse with 10% nitric acid (metal samples only)

g. Rinse with analyte free water.

h. Rinse with hexane and methanol

i. Air dry.

j. Rinse with copious amount of analyte free water.

k. Wrap equipment with aluminum foil.

4.2 Decontamination procedures for pumps follow:

a. Wear disposable gloves while cleaning pump to avoid cross-contamination and change gloves as needed.

b. Prepare a non-phosphate, laboratory-grade detergent solution and potable water in a clean bucket, clean garbage can, or suitable non-metallic container.

c. Scrub the outside of the pump and flush the pump (10 gallons for 2-inch diameter pumps and 15 gallons for 3-inch diameter pumps) with the detergent solution, and discard disposable tubing and/or cord in an appropriate manner.

d. Rinse the outside of the pump and flush the pump and discharge hose (if not disposable) with potable water.

e. Place the pump on clear plastic sheeting.

f. Wipe any pump-related equipment (e.g., electrical lines, cables, discharge hose) that entered the well with a clean cloth and detergent solution, and rinse or wipe with a clean cloth and potable water.

g. Air dry.

h. Wrap equipment with a aluminum foil.

5.0 PROCEDURES FOR LOW FLOW GROUND WATER SAMPLING EQUIPMENT

Non-disposable sampling equipment for the low flow sampling procedure, including the pump and support cable and electrical wires which contact the sample, must be decontaminated thoroughly each day before use (daily decon") and after each well is sampled ("between-well decon") in accordance with the USEPA Region II Ground Water Sampling Procedure. Dedicated, in-place pumps and tubing must be thoroughly decontaminated using "daily decon" procedures prior to their initial use. For centrifugal pumps, it is strongly recommended that non-disposable sampling equipment, including the pump and support cable and electrical wires in contact with the sample, be decontaminated thoroughly each day before use.

5.1 Daily Decon

a. Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

b. Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Alconox, for 5 minutes and flush other equipment with fresh detergent solution for 5 minutes. Use the detergent sparingly.

c. Rinse: Operate pump in a deep basin of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

d. Disassemble pump.

e. Wash pump parts: Place the disassembled parts of the pump into a deep basin containing 8 to 10 gallons of non-phosphate detergent solution. Scrub all pump parts with a test tube brush.

f. Rinse pump parts with potable water.

g. Rinse the following pump parts with distilled/ deionized water: inlet screen, the shaft, the suction interconnector, the motor lead assembly, and the stator housing.

h. Place impeller assembly in a large glass beaker and rinse with 10% nitric acid (HNO_3).

i. Rinse impeller assembly with potable water.

j. Rinse impeller assembly with analyte free water.

k. Reassemble pump.

5.2 Between-Well Decon

a. Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

b. Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Alconox, for 5 minutes and flush other equipment with fresh detergent solution for 5 minutes. Use the detergent sparingly.

c. Final Rinse: Operate pump in a deep basin of analyte free water to pump out 1 to 2 gallons of this final rinse water.

MEASURING WATER LEVELS USING AN ELECTRONIC SOUNDING DEVICE (M-SCOPE)

STANDARD OPERATING PROCEDURE FOR MEASURING WATER LEVELS USING AN ELECTRONIC SOUNDING DEVICE (M-SCOPE)

Date: December 21, 1989

Revision Number: 0

Corporate QA/QC Manager:

1.0 PURPOSE

The purpose for this standard operating procedure (SOP) is to establish the guidelines for using m-scopes. A m-scope is an electronic sounding device used to measure the depth to ground water below an established (surveyed) measuring point (MP). Measuring the depth to water (DTW) below the surveyed MP provides information for calculating ground-water elevations needed to construct ground-water elevation maps and determine the direction of ground-water flow.

M-scopes can be less accurate than a steel tape because the wire can kink, measurement increment may be obscured over time, and the tip may have been cut off and replaced without proper documentation. Thus, it is mandatory that a m-scope be calibrated before use.

2.0 DECONTAMINATION

The m-scope must be precleaned (decontaminated) using a non-phosphate, laboratory-grade solution and rinsed with copious amounts of distilled or deionized water. This process is repeated before each measurement and following the final measurement.

3.0 CALIBRATION

The m-scope must be calibrated before being used to measure water levels. Calibration is accomplished by measuring the water level with the m-scope followed by a measurement using a steel tape. This dual measurement procedure is continued until the individual is confident that measurements taken using both devices are similar and the m-scope is reliable. The calibration procedure is documented in the field notebook or on an appropriate field form, and initialed and dated.

4.0 PROCEDURE

4.1 Remove the well cap and immediately take a headspace reading using a photoionization detector. Record the PID reading in the field book.

4.2 If the well is not vented, wait several minutes after the cap is removed for the water level to equilibrate. Take several measurements to ensure that the water level measured is in equilibrium with the aquifer (i.e., not changing substantially).

4.3 The manufacturer's model must be noted because some have switches, lights, beepers, or a combination of the above.

4.4 The water-level measurement is taken by lowering the probe into the well until the instrument-specific detection method (e.g., light, beeper, or both) is activated by contacting the water.

4.5 The electrical line is held at the MP and, using a ruler (e.g., carpenter's folding ruler) or an engineer's scale, the distance from the "held" point to the nearest marked interval is measured. The distance measured is added to, or subtracted from, the marked interval reading. The result is the DTW.

4.6 Measurements will be taken accurately and to the nearest 0.01 foot.

4.7 Always remeasure at least one well, preferably the first well measured, to see if the static water level has changed (e.g., due to pumping in the area, tidal effects, etc.)

4.8 If there are previous water-level measurements available for the wells, then have these data available to compare the measurements with those just taken. Use these data to see if water levels are similar or if they have changed. If water levels have changed, then check if the changes are consistent (i.e., all up or all down) and make sense.

4.9 Water-level elevations are calculated by subtracting the DTW from the MP elevation and a water-elevation map is constructed (contoured) on a well location map. This also provides a check to evaluate if the water levels make sense (or anomalies are evidenced). Remeasure the well(s) where anomalies are found as a check on the initial measurement(s).

4.10 If anomalies persist or water-level trends are different from the historical database, then check to see if hydrogeologic conditions and/or stresses have changed (e.g., discharge areas, pumping and/or injection wells, etc.).

4.11 All pertinent data will be documented in the field notebook, and initialed and dated.

SCREENING SOIL SAMPLES FOR VOLATILE ORGANIC VAPORS USING A PORTABLE PHOTOIONIZATION DETECTOR

BROS STANDARD OPERATING PROCEDURE FOR SCREENING SOIL SAMPLES FOR VOLATILE ORGANIC VAPORS USING A PORTABLE PHOTOIONIZATION DETECTOR

Revised: July 10, 1998 Revision Number: 1

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish guidelines for screening soil samples for volatile organic vapors using a portable photoionization detector (PID). This SOP is applicable to soil samples collected from split-spoon samplers during drilling, hand auger samples, and grab samples from stockpiled soils.

2.0 CONSIDERATIONS

The primary objective of photoionization screening of soil samples is to obtain a qualitative understanding of the distribution of volatile organic compounds (VOCs) in soil. The proper design of an organic vapor screening program requires an understanding of site hydrogeology, potential source areas, and potential constituents of concern. Observations such as water, clay, and organic content should be noted to facilitate interpretation of the data. Every effort should be made to collect a representative portion of soil from the sampling device.

3.0 MATERIALS/EQUIPMENT

a. The Phase 2 RI/FS Work Plan and Field Sampling Plan which outlines photoionization screening requirements.

b. Decontamination supplies.

c. Field notebook, field form(s), and maps.

d. Sampling device (split-spoon sampler, stainless steel hand auger).

e. Steel measuring tape.

f. Plastic sheeting.

g. Photoionization detector 11.8 EMV lamp.

h. isobutylene calibration gase with regulator.

i. Disposable sampling gloves.

4.0 DECONTAMINATION

Where possible, thoroughly pre-cleaned and wrapped sampling equipment must be used and dedicated to individual sampling locations. Disposable items such as sampling gloves, aluminum foil, and sample jars will be changed after each use and discarded in an appropriate manner.

5.0 CALIBRATION

The PID must be calibrated using isobutylene calibration gas according to the manufacturer's specifications at a minimum frequency of once per day prior to collecting photoionization readings. In addition, periodic checks (e.g., every 4 hours) with the standard gas will be conducted to confirm that the calibration has not drifted. The time, date, and calibration procedure must be clearly documented in the field notebook and the calibration log. If at any time the photoionization results appear erratic or inconsistent with field observations, then the unit must be recalibrated. If calibration is difficult to achieve, then the unit's lamp should be checked for dirt or moisture and cleaned, as necessary. During humid or wet conditions, the unit should be calibrated on a more frequent basis as determined by field personnel.

6.0 PROCEDURE

6.1 A series of five two-foot split-spoon samples will be collected.

6.2 Each split-spoon sample will be screened in the order it was collected.

6.3 PID readings from the top and bottom of each split spoon will be measured and recorded in the field book.

6.4 The split-spoon samples will then be opened and the recovery measured using a steel tape.

6.5 The soil will be screened by passing the PID over the soil sample starting from the top of the spoon down. The maximum PID reading and its location within the sample will be recorded in the field book.

6.6 If a visually stained interval is present, a separate PID reading will be collected and recorded in the field book.

6.7 After field screening of the split-spoon sample is completed, a geologic description of the soil will be recorded in the field book.

6.8 The process will be repeated until all split-spoon samples have been screened.

6.9 If a bucket auger is used to collect the soil samples the auger will be advanced in six-inch intervals.

6.10 The soil from the auger will be placed on plastic sheeting if no samples are to be collected and on a precleaned, dedicated stainless steel tray if samples are to be collected.

6.11 The soil from each six-inch interval will be screened with a PID by passing the PID over the soil, immediately after collection. The maximum PID reading will be recorded in the field book.

SAMPLE HANDLING

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish guidelines for sample handling which will allow consistent and accurate results. Valid chemistry data are integral to investigations that characterize media-quality conditions. Thus, this SOP is designed to ensure that once samples are collected, they are preserved, packed and delivered in a manner which will maintain sample integrity to as great an extent as possible.

2.0 CONSIDERATIONS

Sample containers, sampling equipment decontamination, quality assurance/quality control (QA/QC), sample preservation, and sample handling are all components of this SOP.

2.1 Sample Containers

Prior to collection of a sample, considerations must be given to the type of container that will be used to store and transport the sample. The type and number of containers selected is usually based on factors such as sample matrix, potential contaminants to be encountered, analytical methods requested, and the laboratory's internal quality assurance requirements. In most cases, the overriding considerations will be the analytical methodology, or regulatory requirements because these requirements generally encompass the other factors. The sample container requirements are provided in the Quality Assurance Project Plan (QAPP).

a. Reactivity of Container Material with Sample

Choosing the proper composition of sample containers will help to ensure that the chemical and physical integrity of the sample is maintained. For sampling potentially hazardous material, glass is the recommended container type because it is chemically inert to most substances. Plastic containers are not recommended for most hazardous wastes because the potential exists for contaminants to adsorb to the surface of the plastic or for the plasticizer to leach into the sample.

In some instances, however, the sample characteristics or analytes of interest may dictate that plastic containers be used instead of glass. Because some metals species will adhere to the sides of the glass containers in an aqueous matrix, plastic bottles (e.g., nalgene) must be used for samples collected for metals analysis. A separate, plastic container should accompany glass containers if metals analysis is to be performed along with other analyses. Likewise, other sample characteristics may dictate that glass cannot be used. For example, in the case of a strong alkali waste or hydrofluoric solution, plastic containers may be more suitable because glass containers may be etched by these compounds and create adsorptive sites on the container's surface.

b. Volume of the Container

The volume of sample to be collected will be dictated by the analysis being performed and the sample matrix. The laboratory must supply bottles of sufficient volume to perform the required analysis. In most cases, the methodology dictates the volume of sample material required to complete the analysis. However, individual laboratories may provide larger volume containers for various analytes to ensure sufficient quantities for duplicates or other QC checks.

To facilitate transfer of the sample from the sampler into the container and to minimize spillage and sample disturbance, wide-mouth containers are recommended. Aqueous volatile organic samples must be placed into 40-milliliter (ml) glass vials with polytetrafluoroethylene (PTFE) (e.g., Teflon™) septums. Non-aqueous volatile organic samples should be collected in the same type of vials or in 4-ounce (oz) wide-mouth jars provided by the laboratory. These jars should have PTFE-lined screw caps.

c. Color of Container

Whenever possible, amber glass containers should be used to prevent photodegradation of the sample, except when samples are being collected for metals analysis. If amber containers are not available, then containers holding samples should be protected from light (i.e., place in cooler with ice immediately after filling).

d. Container Closures

Container closures must screw on and off the containers and form a leak-proof seal. Container caps must not be removed until the container is ready to be filled with the sample, and the container cap must be replaced (securely) immediately after filling it. Closures should be constructed of a material which is inert with respect to the sampled material, such as PTFE (e.g., Teflon™). Alternately, the closure may be separated from the sample by a closure liner that is inert to the sample material such as PTFE sheeting. If soil or sediment samples are being collected, the threads of the container must be wiped clean with a dedicated paper towel or cloth so the cap can be threaded properly.

e. Decontamination of Sample Containers

Sample containers must be laboratory cleaned by the laboratory performing the analysis. The cleaning procedure is dictated by the specific analysis to be performed on the sample. Sample containers must be carefully examined to ensure that all containers appear clean. Do not mistake the preservative as unwanted residue. The bottles should not be field cleaned. If there is any question regarding the integrity of the bottle, then the laboratory must be contacted immediately and the bottle(s) replaced.

f. Sample Bottle Storage and Transport

No matter where the sample bottles are, whether at the laboratory waiting to be packed for shipment or in the field waiting to be filled with sample, care must be taken to avoid contamination. Sample shuttles or coolers, and sample bottles must be stored and transported in clean environments. Sample bottles and clean sampling equipment must never be stored near solvents, gasoline, or other equipment that is a potential source of cross-contamination. When under chain of custody, sample bottles must be secured in locked vehicles, and custody sealed in shuttles or in the presence of authorized personnel. Information which documents that proper storage and transport procedures have been followed must be included in the field notebook and on appropriate field forms.

2.2 Decontamination of Sampling Equipment

Proper decontamination of all re-usable sampling equipment is critical for all sampling episodes. The SOP for Decontamination of Field Equipment and SOPs for method-specific or instrument-specific tasks must also be referred to for guidance for decontamination of various types of equipment.

2.3 Quality Assurance/Quality Control Samples

QA/QC samples are intended to provide control over the proper collection and tracking of environmental measurements, and subsequent review, interpretation and validation of generated analytical data. The SOPs for Collection of Quality Control Samples, for Evaluation and Validation of Data, and for Field Record Keeping and Quality Assurance/Quality Control must be referred to for detailed guidance regarding these respective procedures. SOPs for method-specific or instrument-specific tasks must also be referred to for guidance for QA/QC procedures. The number and frequency of QA/QC samples is specified in the QAPP.

2.4 Sample Preservation Requirements

Certain analytical methodologies for specific analytes require chemical additives in order to stabilize and maintain sample integrity. Generally, this is accomplished under the following two scenarios:

a. Sample bottles are preserved at the laboratory prior to shipment into the field.

b. Preservatives are added in the field immediately after the samples are collected.

Many laboratories provide pre-preserved bottles as a matter of convenience and to help ensure that samples will be preserved immediately upon collection. A problem associated with this method arises if not enough sample could be collected, resulting in too much preservative in the sample. More commonly encountered problems with this method include the possibility of insufficient preservative provided to achieve the desired pH level or the need for additional preservation due to chemical reactions caused by the addition of sample liquids to pre-preserved bottles. The use of pre-preserved bottles is acceptable;

however, field sampling teams must always be prepared to add additional preservatives to samples if the aforementioned situations occur. Furthermore, care must be exercised not to overfill sample bottles containing preservatives to prevent the sample and preservative from spilling and therefore diluting the preservative (i.e., not having enough preservative for the volume of sample).

When samples are preserved after collection, special care must be taken. The transportation and handling of concentrated acids in the field requires additional preparation and adherence to appropriate preservation procedures. All preservation acids used in the field should be trace-metal or higher-grade.

2.5 Sample Handling

After the proper sample bottles have been received under chain-of-custody, properly decontaminated equipment has been used to collect the sample, and appropriate preservatives have been added to maintain sample integrity, the final step for the field personnel is checking the sample bottles prior to proper packing and delivery of the samples to the laboratory.

All samples should be organized and the labels checked for accuracy. The caps should be checked for tightness and any 40-mℓ volatile organic compound (VOC) bottles must be checked for bubbles. Each sample bottle must be placed in an individual "zip-lock" bag to protect the label, and placed on ice. The bottles must be carefully packed to prevent breakage during transport. When several bottles have been collected for an individual sample, they should not be placed adjacent to each other in the cooler to prevent possible breakage of all bottles for a given sample. If there are any samples which are known or suspected to be highly contaminated, these should be placed in an individual cooler under separate chain-of-custody to prevent possible cross contamination. Sufficient ice should be placed in the cooler to maintain the temperature at 4 degrees Celsius (°C) until delivery at the laboratory. Please note the use of "blue ice packs" is not acceptable because the ability of "blue ice" to maintain samples at 4°C is questionable . If additional coolers are required, then they should be purchased. The chain-of-custody form should be properly completed, placed in a "zip-lock" bag, and placed in the cooler. One copy must be maintained for the project files. The cooler should be sealed with packing tape and a custody seal. The custody seal number should be noted in the field book. Samples collected from Monday through Thursday will be delivered to the laboratory within 48 hours of collection. Samples collected on Friday should be delivered to laboratory the next day. Special delivery arrangements must be made if certain analytes require a shorter delivery time. If overnight mail is utilized, then the shipping bill must be maintained for the files and the laboratory must be called the following day to confirm receipt.

3.0 EQUIPMENT AND MATERIALS

3.1 General equipment and materials may include, but not necessarily be limited to, the following:

a. Sample bottles of proper size and type with labels.

b. Cooler with ice.

c. Field notebook, appropriate field form(s), chain-of-custody form(s), custody seals.

d. Black pen and indelible marker.

e. Packing tape, "bubble wrap", and "zip-lock" bags.

f. Overnight (express) mail forms and laboratory address.

g. Health and Safety/Contingency Plan (HASCP).

h. Field Sampling Plan and the Phase 2 RI/FS Work Plan.

i. Pertinent SOPs for specified tasks and their respective equipment and materials.

3.2 Preservatives for specific samples/analytes will be specified and supplied by the laboratory. Preservatives that are not provided in pre-preserved bottles must be stored in secure, spillproof glass containers with their content, concentration, and date of preparation and expiration clearly labeled.

3.3 Miscellaneous equipment and materials that may be required include the following:

a. Graduated pipettes.

b. Pipette bulbs.

c. Litmus paper.

d. Glass stirring rods.

e. Protective goggles.

f. Disposable gloves.

g. Lab apron.

h. First aid kit.

i. Portable eye wash station.

j. Water supply for immediate flushing of spillage, if appropriate.

k. Shovel and container for immediate containerization of spillage-impacted soils, if appropriate.

i. QAPP.

4.0 PROCEDURE

4.1 Examine all bottles and verify that they are clean and of the proper type, number, and volume for the sampling to be conducted.

4.2 Label bottles carefully and clearly with project name and number, site location, sample identification, date, time, and the sampler's initials using an indelible marker.

4.3 Collect samples in the proper manner (refer to specific sampling SOPs).

4.4 Conduct preservation activities as required in QAPP, after each sample has been collected. Field preservation must be done immediately and must not be done later than 30 minutes after sample collection.

4.5 Conduct QC sampling, as required in QAPP.

4.6 Seal each container carefully and place in an individual "zip lock" bag.

4.7 Organize and carefully pack all samples in the cooler immediately after collection (e.g., bubble wrap). Insulate samples so that breakage will not occur.

4.8 Complete and place the chain-of-custody form in the cooler after all samples have been collected. Maintain one copy for the project file. If the cooler is to be transferred several times prior to shipment or delivery to the laboratory, it may be easier to tape the chain-of-custody to the exterior of the sealed cooler. When exceptionally hazardous samples are known or suspected to be present, this should be identified on the chain-of-custody as a courtesy to the laboratory personnel.

4.9 Add additional ice as necessary to ensure that it will last until receipt by the laboratory.

4.10 Seal the cooler with packing tape and a custody seal. Record the number of the custody seal in the field notebook and on the field form. If there are any exceptionally hazardous samples, then shipping regulations should be examined to ensure that the sample containers and coolers are in compliance and properly labeled.

4.11 Samples collected from Monday through Thursday will be delivered to the laboratory within 48 hours of collection. Samples collected on Friday will be delivered to the laboratory on Saturday. Check the QAPP to determine if certain analytes require a shorter delivery time.

4.12 Maintain the shipping bill for the project files if overnight mail is utilized and call the laboratory the following day to confirm receipt.

COLLECTION OF SOIL SAMPLES FOR LABORATORY ANALYSIS

Revised: July 10, 1998 Revision Number: 1

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish guidelines for the collection of soil samples for laboratory analysis. This SOP is applicable to soil samples collected from split-spoon samplers during drilling, hand auger samples, grab samples from stockpiled soils, surface samples, test pit samples, etc. If soil samples are to be preserved using methanol, refer to the SOP for methanol preservation provided in this report.

2.0 CONSIDERATIONS

Soil samples will be collected in both a random and biased manners. Random samples can be based on a grid system or statistical methodology. Biased samples can be collected in areas of visible impact, suspected source areas or areas where field screening indicates potential impact. Soil samples can be collected at the surface, shallow subsurface, or at depth. When samples are collected at depth the water content should be noted. A flow chart indicating the soil sampling rational is provided as Figure 1. Equipment selection will be determined by the depth of the sample to be collected. A thorough description of the sampling locations and proposed methods of sample collection should be included in the work plan.

Surface soil sampling refers to the collection of samples at a 0 to 1 inch depth interval as defined in the Phase 2 RI/FS Work Plan. Collection of surface soil samples is most efficiently accomplished with the use of a stainless steel trowel or scoop. For samples at greater depths a decontaminated bucket auger, power auger, or drill rig may be needed to advance the hole to the point of sample collection. When using a bucket auger to advance boring, another clean bucket auger should then be used to collect the sample. To collect samples at depths of greater than approximately six feet the use of a drill rig and split spoon samples will usually be necessary.

3.0 MATERIALS/EQUIPMENT

a. The Phase 2 RI/FS Work Plan and Field Sampling Plan, which outlines soil sampling requirements.

b. Field notebook, field form(s), maps, chain-of-custody forms, and custody seals.

c. Decontamination supplies (including: non-phosphate, laboratory grade detergent, buckets, brushes, potable water, distilled water, regulatory-required reagents, aluminum foil, plastic sheeting, etc.).

d. Sampling device (split-spoon sampler, stainless steel hand auger, stainless steel trowel, etc.).

e. Stainless steel spoons or spatulas.

f. Disposable sampling gloves.

g. Laboratory-supplied sample containers with labels.

h. Cooler with ice.

i. Plastic sheeting.

j. Black pen and indelible marker.

k. Zip-lock bags and packing material.

l. Tape measure.

m. Paper towels or clean rags.

n. Masking and packing tape.

o. Overnight (express) mail forms.

4.0 DECONTAMINATION

All reusable sampling equipment will be thoroughly cleaned according to the decontamination SOP. Where possible, thoroughly pre-cleaned and wrapped sampling equipment should be used and dedicated to individual sampling locations. Disposable items such as sampling gloves, aluminum foil, and plastic sheeting will be changed after each use and discarded in an appropriate manner.

5.0 PROCEDURE

5.1 Prior to collecting soil samples, ensure that all sampling equipment has been thoroughly cleaned according to the decontamination SOP. If samples are to be collected at depth, then the boring must be advanced with thoroughly cleaned equipment to the desired sampling horizon and a different thoroughly cleaned sampler must be used to collect the sample.

5.2 Using disposable gloves and a pre-cleaned, stainless steel spatula or spoon, extract the soil sample from the sampler, measure the recovery, and separate the wash from the true sample.

5.3 Log the sample in detail and record sediment characteristics (color, odor, moisture, texture, density, consistency, organic content, layering, grain size, etc.).

5.4 Samples to be collected for volatile organic compounds (VOCs) are to be collected and packaged immediately upon retrevial. Samples to be analyzed for VOCs must be collected prior to other constituents. For samples to be preserved with methanol, refer to the SOP for the methanol preservation of soil samples.

5.5 After the VOC samples are collected the remaining portion of the sample will be composited using the coning and quartering method.

5.6 The sample container will be labeled with appropriate information such as, client name, site location, sample identification (location, depth, etc.), date and time of collection, and sampler's initials.

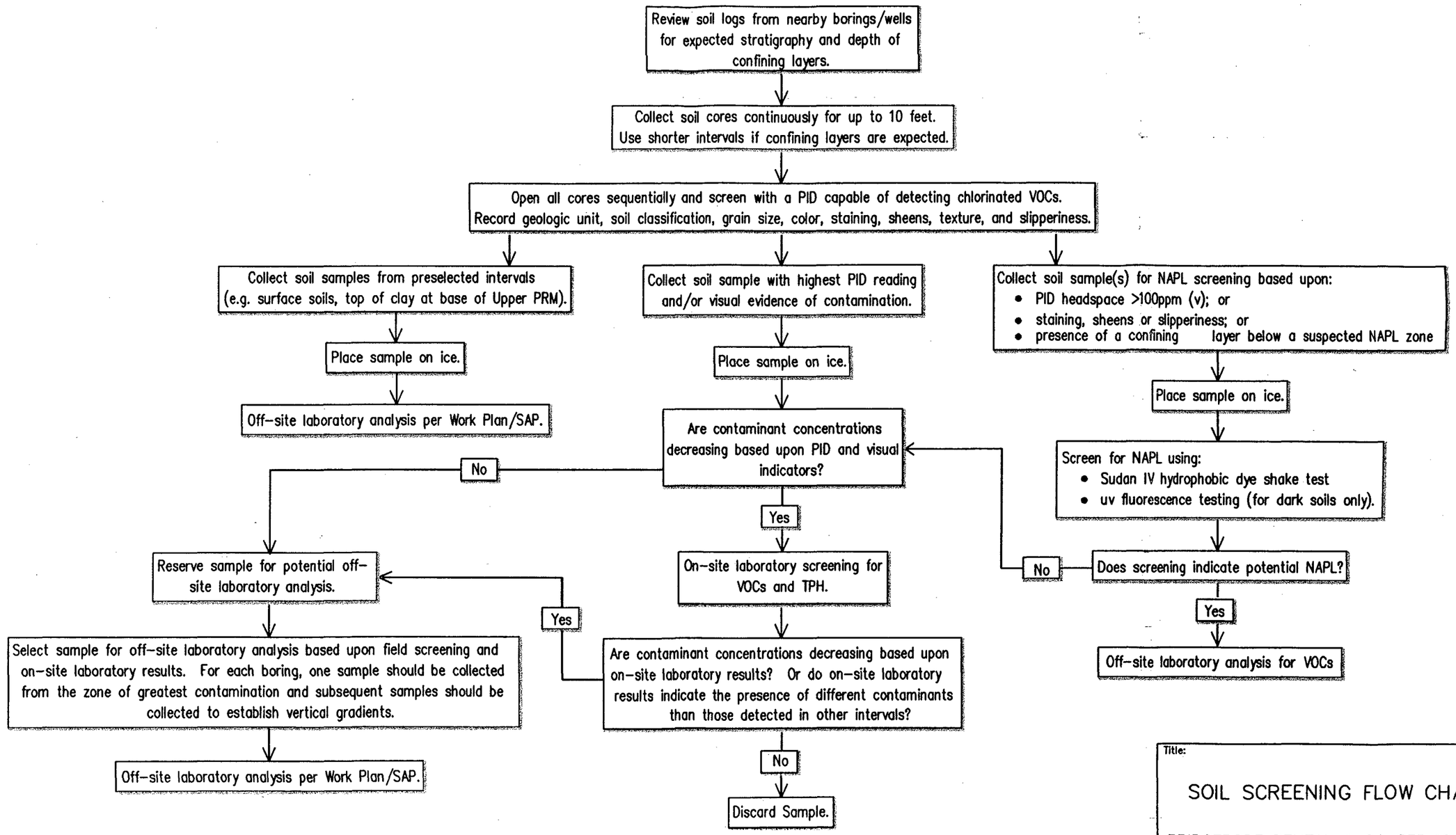
5.7 After the sample has been collected, labeled, and logged in detail, it is placed in a zip-lock bag and stored in a cooler at 4°C.

5.8 A chain-of-custody form is completed for all samples collected. One copy is retained and two are sent with the samples in a zip-lock bag to the laboratory. A custody seal is placed on the cooler prior to shipment.

5.9 Samples collected from Monday to Thursday are to be delivered to the laboratory within 48 hours of collection. Samples collected on Friday will be delivered to the laboratory by Saturday. Check the Phase 2 RI/FS Work Plan to determine if any analytes require a shorter delivery time.

5.10 The field notebook and appropriate forms should include, but not be limited to the following: client name, site location, sample location, sample depth, sample identification, date and time collected, sampler's name, method of sample collection, number and type of containers, geologic description of material, description of decontamination procedures, etc. A site map should be prepared with exact measurements to each sample location in case follow-up sampling is necessary.

5.11 All reusable sampling equipment must be thoroughly cleaned in accordance with the decontamination SOP. Following the final decontamination (after all samples are collected) the sampling equipment is wrapped in aluminum foil. Discard any gloves, foil, plastic, etc. in an appropriate manner that is consistent with site conditions.



Title:

SOIL SCREENING FLOW CHART

BRIDGEPORT RENTAL & OIL SERVICES SITE
LOGAN TOWNSHIP, NEW JERSEY

Prepared For:
BROS TECHNICAL COMMITTEE

ROUX
ROUX ASSOCIATES INC
Environmental Consulting & Management

Compiled by: B.G.	Date: 06/04/98	Figure
Prepared by: J.R.M.	Scale: N.T.S.	1
Project Mgr: N.R.	Revision:	
Proj No: 49301J05	File No: 49301105	

300265

MEASURING THE THICKNESS OF FLOATING SEPARATE-PHASE ORGANIC LIQUIDS

Revised: July 10, 1998 Revision Number: 1

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish guidelines for measuring the thickness of floating separate-phase organic liquids in a well, tank or drum. Measuring the thickness of floating, separate-phase organic liquids requires special health and safety considerations, equipment, and procedures.

Separate-phase layers can either be "floaters" or "sinkers". "Floaters" (non-aqueous phase liquids [NAPLs]) are separate-phase liquids that are less dense than water and float on the ground-water surface. "Sinkers" (dense non-aqueous phase liquids [DNAPLs]) are separate-phase liquids that are more dense than water and tend to migrate downward through aquifers due to gravitational forces until a low permeability layer is encountered (i.e., they accumulate at the bottom of the aquifer). For the purpose of this SOP, only measuring the thickness of floating separate-phase liquids will be addressed.

The objectives for measuring separate-phase organic liquids may include the following: 1) determination of the thickness of the free product in a well, tank or drum; 2) estimation of the volume of free product to be removed from a well before sampling, or from a tank or drum before removal; and 3) calculation of the "true" (non-free product depressed) elevation of the water table.

2.0 CONSIDERATIONS

The primary considerations when measuring the thickness of floating separate-phase liquids are health and safety, and proper equipment selection.

2.1 Health and Safety

All separate-phase products must be assumed to possess health and safety hazards equivalent to the most hazardous suspected on-site source. When measuring the thickness of flammable materials, it is imperative that all possible sources of ignition be eliminated. Minimum requirements include (NO EXCEPTIONS) no smoking or open flames, use of intrinsically safe downhole monitoring equipment, use of static free bailing cord (e.g., absorbent cord [cotton]), and use of properly vented and grounded product collection containers. When product collection containers will be stored onsite, the local fire code official must be consulted regarding product storage requirements (e.g. venting, grounding, labeling, permits, secondary containment, etc.). A detailed, comprehensive explanation of health and safety procedures must be outlined in the site health and safety plan (HASP).

2.2 Equipment Selection

The two preferred methods which will be employed to measure the thickness of separate-phase petroleum product in a monitoring well, tank or drum as specified in Phase 2 RI/FS Work Plan and Field Sampling Plan. These methods were selected based upon the type and consistency of the product; the level of accuracy desired; the expected depth and thickness of the product; and the diameter of the wells or sampling ports.

Measurements of floating separate-phase product thicknesses will be performed using an electronic oil/water interface probe and confirmed using a graduated, clear acrylic bailer. If conditions exist where neither method is applicable, a weighted steel measuring tape in conjunction with oil and water paste will be employed.

An oil/water interface probe is capable of providing rapid and accurate (±0.01 foot) results under most field situations. However, viscous product or oil/water emulsions may interfere with performance by coating the probe and/or disguising the interface. In these situations, a clear, acrylic bailer may be necessary.

A clear, bailer will be used to confirm the presence or absence of product and approximate product thickness in wells where the interface probe is ineffective. In certain situations (e.g., viscous product or product/water emulsions) a clear bailer may be the best available method to estimate product thickness. However, when product thicknesses are greater than approximately three feet, a bailer will be unable to provide approximate product thickness measurements. If the oil/water interface probe will not work, and the product thickness is too great to be measured by a bailer, then the best available technique may be oil and water paste.

A weighted steel tape in conjunction with oil and water paste may be necessary to estimate residual water or product in a tank or drum. This method is not recommended for use in monitoring wells because of possible cross-contamination from the paste itself. In certain situations where no other method can provide the necessary data, oil and water paste may be used in monitoring wells containing product. This method is less accurate than an oil/water interface probe, but frequently more accurate than a clear bailer.

It should be noted that erroneous data may be collected by all three methods when measurements are collected through the fill ports of tanks which are equipped with drop tubes. Whenever possible, product thickness measurements should be collected from ports with unobstructed access to the tank contents. When measurements must be collected from a fill port with a drop tube, it should be understood that there may be significant differences between the drop tube measurements and the actual thicknesses of the water and product in the tank.

3.0 CALIBRATION

3.1 Oil/Water Interface Probe

There is no specific calibration procedure for an oil/water interface probe. However, you should verify that the unit operates properly prior to taking it out in the field by testing it in a jar containing product and water. This jar should be stored in a flammable liquid cabinet and be dedicated to oil/water interface probe testing. Since most oil/water interface probes have a heavy probe assembly and a rigid graduated tape, kinking, stretching or twisting of the tape is not a significant concern. In order to ensure proper operation, the unit should be kept warm prior to use (e.g. hotel room or cab of truck).

3.2 Clear Bailer

There is no specific calibration procedure for an bailer. However, since you only get one chance to measure the thickness correctly, you should verify that the check valve operates properly with distilled water. Based on previous data, if available, you should ensure that the length of the bailer is sufficient to measure the entire thickness of the product.

3.3 Oil/Water Paste

There is no specific calibration procedure for using oil and water paste. However, these pastes may not behave reliably if they are old or have been exposed to extreme temperatures. The pastes should be tested prior to taking them out in the field to confirm they work. The weighted steel tape should be carefully examined to confirm that it is properly graduated and has not been damaged or modified.

4.0 DECONTAMINATION

4.1 Complete decontamination of a clear bailer which is dedicated to the measurement of separate-phase product thicknesses can be very difficult. Decontamination should involve removal of gross contamination before entering and exiting the site or moving to different areas of separate-phase product accumulation. Special care must be taken to make sure that a "product bailer" never enters a "clean" well which does not contain separate-phase product. This can be ensured by measuring separate-phase thickness in all wells before starting bailing operations. The oil/water interface probe must be thoroughly cleaned according to the field equipment decontamination SOP before entering each well. If historical data is available, then the order of measuring separate-phase thickness should be from the cleanest well to the dirtiest well to further reduce the potential for cross-contamination. If samples are also being collected for constituent or characterization analysis, then a disposable, dedicated bailer may be necessary for product collection.

5.0 EQUIPMENT AND MATERIALS

Depending on the method used to measure the thickness of separate-phase organic liquids, both method-specific and general equipment and materials are needed.

5.1 Regardless of the method used, general equipment and materials will include, but may not necessarily be limited to, the following:

a. Site Health and Safety/Contingency Plan (HASCP).

b. Appropriate health and safety equipment, as specified in the HASP.

c. Roux Associates' field forms and field notebook.

d. Non-phosphate, laboratory-grade detergent.

e. Distilled/deionized water.

f. Potable water.

g. Paper towels, clean rags.

h. Plastic sheeting.

i. Sorbent pads.

j. Well location and site map.

k. Well keys.

l. Disposable gloves.

m. Calculator.

n. Black pen and indelible marker.

o. Tools (e.g., pipe wrench, screw drivers, hammer, pliers, flashlight, pen knife, etc.).

p. Buckets for decontamination.

5.2 Clear Bailer - the following will also be needed:

a. Clear bailer

b. Non-static cotton cord

c. Steel tape (10 foot)

5.3 Oil/Water Interface Probe - the following will also be needed:

a. Oil/water interface probe

5.4 Oil/Water Paste - the following will also be needed:

a. Oil paste

b. Water paste

c. Graduated stick or weighted steel tape

6.0 PROCEDURE

6.1 Oil/Water Interface Probe

6.1.1 Make sure the bottom five (5) feet of the probe and measuring tape have been decontaminated according to the field equipment decontamination SOP before entering each well.

6.1.2 Based on previous data, if any, ensure that non-product wells are measured prior to product wells to reduce the possibility of cross-contamination.

6.1.3 Remove the well cap or plug and clean the top of the well with a clean rag. Place the cap or plug on clean plastic on the ground to protect it from potential contamination.

6.1.4 Slowly lower the thoroughly decontaminated probe to the product surface. A distinct tone or beep will indicate the presence and level of product. The depth to product (DTP) from the measuring point will be recorded in the field notebook and on appropriate field forms. Continue lowering the probe until the tone or beep indicates the presence of water. The oil/water interface is best measured by lowering the probe about six inches into the water and then raising it to the interface. The depth to water (DTW) from the measuring point will be recorded in the field notebook and on appropriate field forms. The product thickness is the difference between the DTW and DTP.

6.1.5 Replace locking and/or protective caps on the well.

6.1.6 Thoroughly clean the probe and the portion of the tape which entered the product according to the field equipment decontamination SOP.

6.2 Clear Bailer

6.2.1 Make sure all equipment is cleaned of gross contamination before entering and exiting the site.

6.2.2 Remove the well cap or plug and clean the top of the well with a clean rag. Place the cap or plug on clean plastic on the ground to protect it from potential contamination.

6.2.3 Slowly lower a clear, decontaminated bottom-filling bailer into the well until the bottom of the bailer contacts the fluid surface.

6.2.4 Using a reference point on the bailer line, slowly lower the bailer into the fluid a distance less than the bailer length so that at its deepest point the top of the bailer remains above the air/fluid contact.

6.2.5 Slowly raise the bailer out of the well.

6.2.6 The thickness of the floating free product will be approximated by placing a tape measure along side the bailer. The data will be documented in the field notebook and on appropriate field forms.

6.2.7 Dispose of the product in an appropriate manner as specified in the work plan. This may include draining the product back into the well or tank, or containerization if the measurement is in conjunction with bailing for removal purposes.

6.2.8 Replace locking and/or protective caps on the well.

6.2.9 Discard the cotton cord in an appropriate manner. Dispose of the bailer or clean off the gross contamination and wrap decontaminated bailer in a suitable material (e.g., clean plastic bag, aluminum foil). The decontaminated bailer will be used only in the same well or adjacent wells which have the same type of product.

6.2.10 If the free product is extensive or thicker than the height of the bailer, then an electronic interface probe should be used to measure product thickness.

6.3 Oil/Water Paste - (Generally not applicable for monitoring wells)

6.3.1 Make sure all equipment is decontaminated and cleaned before use according to the field equipment decontamination SOP.

6.3.2 Secure access to the tank or drum to be measured only after the contents are known and properly addressed in the HASCP. Attempt to estimate the depth and thickness of product and the depth to water so the entire stick or weighted steel tape does not have to be coated with oil and water paste.

6.3.3 Coat one side of the stick or steel tape with oil paste and the other with water paste. Since these are typically different colors, confusion should not result. Depending upon information needs, lower the tape to just below the water interface or to the bottom of the tank or drum.

6.3.4 If only DTP and DTW data is required, then the top of the tape is held at an even-foot increment at the measuring point (MP). This is called the "held" value, and is recorded as such. If the depth to the bottom of the tank is also required, then the held value can't be specifically selected at an even-foot increment.

6.3.5 The steel tape or graduated stick is removed and the "water cut" and "product cut" levels are recorded. The difference between the "held" value and the "product cut" value is the DTP. The difference between the "held" value and the "water cut" is the DTW. The difference between the "product cut" and the "water cut" is the product thickness. If the diameter of a horizontal tank is desired, then the difference between the "held" value (to the bottom of the tank) and the depth of the fill pipe is required.

6.3.6 All pertinent data will be recorded in the field notebook and on appropriate field forms.

6.3.7 Make sure all equipment is decontaminated before use in the next tank or drum according to the field equipment decontamination SOP. All disposable materials must be discarded in a manner consistent with site conditions.

HAND BAILING WELLS CONTAINING SEPARATE-PHASE ORGANIC LIQUIDS

300274

HAND BAILING WELLS CONTAINING SEPARATE-PHASE ORGANIC LIQUIDS

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish guidelines for hand bailing wells containing immiscible, separate-phase organic liquids. The hand bailing of immiscible, separate-phase organic liquids requires special health and safety considerations, equipment, and procedures.

Separate-phase layers can either be "floaters" or "sinkers." "Floaters" (non-aqueous phase liquids [NAPLs]) are separate-phase liquids that are less dense than water and float on the ground-water surface. "Sinkers" (dense non-aqueous phase liquids [DNAPLs]) are separate-phase liquids that are more dense than water and tend to migrate downward through aquifers due to gravitational forces until a low permeability layer is encountered (i.e., they accumulate at the bottom of the aquifer). For the purpose of this SOP, only the hand bailing of floating separate-phase liquids will be addressed.

The objectives for hand bailing wells containing floating separate-phase liquids (e.g., petroleum, petroleum products) may include the following: 1) removal of product before ground-water sampling; 2) remediation technique; 3) sampling product for constituent or characterization analysis; and 4) conducting product recharge tests to evaluate "true" versus "apparent" product thickness.

2.0 CONSIDERATIONS

The primary considerations when conducting hand bailing of wells are health and safety, and waste collection and disposal.

2.1 Health and Safety

All separate-phase products must be assumed to possess health and safety hazards equivalent to the most hazardous suspected on-site source. When bailing flammable materials, it is imperative that all possible sources of ignition be eliminated. Minimum requirements include (NO EXCEPTIONS) no smoking or open flames, use of intrinsically safe downhole monitoring equipment, use of static free bailing cord (e.g., absorbent cord [cotton]), and use of properly vented and grounded product collection containers. When product collection containers will be stored onsite, the local fire code official must be consulted regarding product storage requirements (e.g. venting, grounding, labeling, permits, secondary containment, etc.). A detailed, comprehensive explanation of health and safety procedures must be outlined in the site Health and Safety/Contingency Plan (HASCP).

2.2 Waste Collection and Disposal

All product and product-contaminated waste materials must be properly stored, characterized, and disposed. A detailed, comprehensive explanation of waste (product) collection and disposal is provided in the Phase 2 RI/FS Work Plan and the Field Sampling Plan. Minimum include:

a. Collection of solid waste materials in a Department of Transportation (DOT) approved open-top drum (17C).

b. Collection of separate-phase product in a properly grounded and vented, DOT approved closed-top drum (17E).

c. Appropriate labeling of all drums with THIS SIDE UP, FLAMMABLE, and HAZARDOUS WASTE labels in accordance with Resource Conservation and Recovery Act (RCRA) and DOT requirements.

d. Collection and analysis of product sample for characterization prior to disposal, as required.

Any bailing operations which generate more than 100 kilograms per month (or approximately half of a 55 gallon drum) or that involve the storage of more than 1,000 kg of a RCRA hazardous waste must meet additional RCRA storage and disposal requirements (see 40CFR 261.5).

3.0 EQUIPMENT AND MATERIALS

The list of equipment and materials which may be needed for hand bailing floating separate-phase product from a well includes, but may not be limited to, the following:

a. Site HASCP.

b. Appropriate health and safety equipment, as specified in the HASCP.

c. The Phase 2 RI/FS Work Plan and Field Sampling which describes bailing requirements.

d. Oil/water interface probe.

e. Clear, acrylic product bailer (graduated).

f. Absorbent, nonstatic cord (e.g., cotton).

g. Sorbent pads.

h. Disposable PVC gloves.

i. Well construction log(s).

j. Two graduated buckets and funnels (dedicated to separate-phase product activities).

k. DOT approved product collection drum(s).

l. DOT approved solid waste collection drum(s).

m. Field forms and field notebook.

n. Non-phosphate, laboratory-grade detergent.

o. Distilled/deionized water.

p. Potable water.

q. Paper towels, clean rags.

r. Calculator.

s. Black pen and indelible marker.

t. Well location and site map.

u. Tools (e.g., pipe wrench, screwdrivers, hammer, pliers, flashlight, pen knife, etc.)

v. Extra batteries (probe, flashlight).

w. Steel tape measure with 0.01-foot measurement increments, graduated measurement stick.

x. Plastic sheeting.

y. Specific gravity instruments.

4.0 DECONTAMINATION

4.1 Complete decontamination of a clear acrylic bailer which is dedicated to the removal of separate-phase product can be very difficult. When the primary task is the removal of product as a remedial technique, then decontamination should involve removal of gross contamination before entering and exiting the site or moving to different areas of separate-phase product accumulation. Special care must be taken to make sure that a "product bailer" never enters a "clean" well which does not contain separate-phase product. This can be ensured by measuring separate-phase thickness in all wells before starting bailing operations. The oil/water interface probe must be thoroughly cleaned according to the field equipment decontamination SOP before entering each well. Based on historical data, the order of measuring separate-phase thickness should be from the cleanest well to the dirtiest well to further reduce the potential for cross-contamination. If bailing is being conducted for product samples, it may be necessary to utilize a dedicated, disposable bailer as defined in the work plan.

5.0 PROCEDURE

5.1 Document, and initial and date the monitoring well identification and any problems encountered on the appropriate field form and in the field notebook.

5.2 Inspect the product collection drum or tank, and note any items of concern such as dents, holes, leaks, deformation, unauthorized access, etc. Document, and initial and date findings on an appropriate field form and in the field notebook.

5.3 Ensure that all equipment is properly decontaminated and cleaned.

5.4 Place plastic sheeting adjacent to the well to protect decontaminated equipment.

5.5 Remove the well cap and clean it off with a clean rag. Place the cap on the plastic sheeting. If fumes or gases are present, then diagnose these with the proper safety equipment. Never inhale the vapors.

Refer to Section 2.1 for the minimum health and safety considerations to prevent fire or explosion. Additional health and safety precautions based on site specific considerations must be outlined in the site HASCP.

5.6 Place sorbent pads around the well to be bailed to prevent any loss of product in the event of spillage.

5.7 Determine the depth to product (DTP), depth to water (DTW), and product thickness within the well using an oil/water interface probe. Refer to the SOP for Measuring the Thickness of Floating Separate-phase Layers for the procedure to measure product thickness.

5.8 Lower the bailer into the product zone using absorbent, nonstatic cord (e.g., cotton). Refer to the work plan/scope of work to determine the method for draining off any excess water collected in the bailer (i.e., into the well or in a bucket). Drain off the water by slightly dislodging the capture ball (check valve) from the bailer seat with your finger; PVC gloves must be worn. Drain the product only into a separate, dedicated bucket.

5.9 Continue bailing until product thickness as observed in the bailer is reduced to less than ¼ inch (0.02 feet). If possible, then bail until no product is evidenced in the well (i.e., no more product is entering the well). Verify thickness measurements in the well using an oil/water interface probe. When bailing is completed, dispose of any excess water collected according to the specifications in the work plan/scope of work.

5.10 Wipe the well cap with a clean rag, replace the well cap and protective cover (if present). Lock the protective cover.

5.11 If required in the work plan, collect specific gravity measurements on representative samples of the product collected.

5.12 Transfer the product collected in the bucket to an on-site storage vessel. Record the volume of product collected and confirm by measuring the on-site storage vessel contents with an oil/water interface probe both before and after transferring the product from the bucket.

5.13 Place all contaminated sorbent pads, cord, and other solid waste materials into the open top drum and secure the lid.

5.14 Report any significant problems or deviations in product thickness measurements immediately (e.g., significant increase in product thickness or a substantial change in appearance).

5.15 Document all data (e.g., MP, DTP, DTW, product thickness, volume of product removed and disposed) on an appropriate field form and in the field notebook, and initial and date entries.

5.16 Secure storage containers and verify integrity.

5.17 Decontaminate all equipment as discussed in the decontamination section (4.0). Wrap decontaminated equipment with aluminum foil. Discard cords, rags, gloves, etc. in a manner consistent with accepted procedures.

BORING AND/OR MONITORING OR OBSERVATION WELL DRILLING, FORMATION SAMPLING AND BOREHOLE ABANDONMENT IN UNCONSOLIDATED FORMATIONS

BROS STANDARD OPERATING PROCEDURE FOR BORING AND/OR MONITORING OR OBSERVATION WELL DRILLING, FORMATION SAMPLING AND BOREHOLE ABANDONMENT IN UNCONSOLIDATED FORMATIONS

Revised: July 10, 1998 Revision Number: 1

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to describe the considerations and procedures, and to establish the guidelines for drilling (soil borings, wells, or piezometers) and formation sampling activities in unconsolidated formations. There are several drilling techniques available which include hollow-stem auger, and hydraulic rotary. Formation (sediment/soil) sample collection includes disturbed (drill cuttings), intact (split-spoon), and undisturbed (Shelby-tube). Borehole abandonment (closure) procedures will also be addressed in this SOP.

The objective of drilling is to collect accurate subsurface information and to prepare a borehole for potential completion as a well or piezometer. Consequently, the lithologic data is the all important, most essential information that can be collected. The lithologic data characterizes subsurface conditions, describes hydrogeologic coefficients qualitatively and/or quantitatively, and identifies optimum locations for screen zones if wells are constructed.

Data can be obtained through the physical examination and testing of formation samples, as well as knowledge regarding ground-water levels. Thus, drill fluid mix, fluid loss, rate of drilling, lengths of split-spoon and Shelby-tube recovery, etc. must be monitored by the on-site hydrogeologist or geologist.

2.0 DRILLING TECHNIQUE-SELECTION

Verify that the drilling technique is the one specified in the investigation work plan, and that the drilling equipment mobilized by the driller is in good condition and proper working order. Do not permit the driller to use a drilling rig that appears to be substandard, in disrepair, etc., and/or is questionable as to whether or not the rig has the capabilities to accomplish the goals of the drilling program. The drilling rig must be capable of:

a. Penetration of all anticipated subsurface materials and formations at a desired rate, and construction of a borehole of desired diameter (for the anticipated well, if applicable, including the placement of a gravel or sand pack through a tremie pipe and necessary formation sealing material such as bentonite or cement).

b. Identification of lithology for development of a geologic log of all unconsolidated formations and materials penetrated, including physical characteristics and visual description of color, grain sizes, sorting and mineralogy.

c. Collection of samples of aquifer fluids during the drilling process and prior to well construction, while at the same time minimizing potential for cross-contamination. The method used should prevent cross-contamination between surface soils and ground water or between different hydrogeologic units.

d. Collection of intact and/or undisturbed soil samples from the center line or sidewall of the borehole. This objective requires the drilling to be halted while soil samples are taken from the bottom or side of the incomplete borehole.

e. Completion of the borehole into a well (monitoring or observation) or piezometer during the initial construction process (i.e., constructing a well or piezometer as the borehole is drilled, or constructing a well or piezometer in the borehole immediately after the drilling tools are removed).

f. Implementation of borehole geophysical logging (when applicable and possible) to enable more accurate vertical and horizontal extrapolation of borehole data to the lithology of the hydrogeologic system.

g. Completion of a well or piezometer, if applicable, in the borehole following a time lapse for interpretation of geologic or geophysical data from the borehole.

3.0 DRILLING TECHNIQUE - DESCRIPTION

3.1 Hollow-Stem Auger - This drilling method is rapid and extremely effective in most cohesive sediments but less so in loose sandy material. Penetration may be up to 150 feet below land surface (bls) depending on the size of the rig, drilling conditions, and the diameter of the auger flight; however, depths up to 250 feet bls have been achieved under compatible conditions. A major advantage of this technique is that normally no fluids are introduced into the formation. If the auger flights can be removed and the integrity of the borehole maintained, then electrical and radiation (e.g., gamma, neutron, etc.) geophysical logs can be run. If the auger flights must remain in the borehole, then only radiation geophysical logs can be run. Casing, screen, and sampling devices can then be lowered through the hollow stem by removing the removable plug at the bottom of the auger flights, and gravel packing and cementing can be accomplished within the hollow stem. However, this can be difficult especially below the water table. Auger flight outside diameters (OD) range from 5 inches (in.) to 12 in. The diameter of a well that can be constructed inside the hollow stem is limited, however, to about 4 in.

3.2 Hydraulic Rotary - This drilling method uses a rotating bit to drill (advance) the borehole. Drill cuttings are removed using a recirculating drilling fluid (mud and water). Although setting up the drilling equipment is slow, the drilling process is reasonably fast. In the mud-rotary method, drilling mud forms a cake on the borehole wall which prevents excessive loss of fluid to the formation being drilled. The hydrostatic pressure combined with the weight and density of the mud slurry keeps the hole open. This allows the drill rods to be removed from the borehole and geophysical logs (electric and radiation) to be run in the open borehole.

In mud-rotary drilling, the drilling fluid (mud) moves downward through the drill pipe and then upward through the annular space. Therefore, the borehole is held open by hydrostatic pressure and the mud cake lining the wall of the borehole. The mud-rotary method can be used to construct moderate to deep wells in unconsolidated materials. The principal disadvantage may be the difficulty in removing mud cake from the formation at the screened zone. Extensive well development may be required to remove the mud cake.

4.0 DECONTAMINATION

Drilling equipment decontamination procedures are outlined in the field equipment decontamination SOP. Proper decontamination in accordance with these guidelines must be clearly documented in the field notebook.

5.0 PROCEDURE FOR DRILLING

5.1 Document all drilling-related activities (e.g., starting, stopping, footage, problems, decontamination, etc.) on the daily log form and in the field notebook. Record dates and times of activities, and names of Roux Associates personnel providing oversight.

5.2 Monitor and record drill fluid mix, speed of rotation, pressure on the drill fluid, rate of drilling, and length of drill rods or casing in the borehole.

5.3 Confirm that the drill rods and core barrel are straight, or discontinue drilling.

5.4 Pay particular attention to the advancement of the boring because differences in the rate of drilling may be indicative of differences in subsurface geologic conditions (e.g., sand and gravel versus clay).

5.5 Maintain a continuous dialogue with the driller to track and keep informed of all drilling activities (e.g., the speed of the drill and drilling pressure, difficult and easy drilling conditions, etc.).

5.6 Collect formation samples as described below in Section 6.0. Sample jars must be labeled appropriately (e.g., project number and name, site location, boring number, date, sample interval, blow counts, and initials of Roux Associates personnel collecting sample).

5.7 Record geologic information in the geologic log form and in the field notebook.

5.8 Handle and ship split-spoon sample jars carefully to avoid breakage and handle and ship tubes or cores carefully to prevent disturbance.

6.0 PROCEDURE FOR FORMATION SAMPLING

6.1 Intact formation sampling will be implemented using split-spoon samplers (which are driven) or Shelby-tube samplers (which are pushed). If appropriate, formation samples will be retained in suitable size (e.g., 1-pint or 0.5-pint) jars for physical descriptions. The appropriately labeled jars will be stored in a safe place to avoid breakage, agitation, and freezing. Intact formation samples will be collected as described in the Phase 2 RI/FS Work Plan. Hydrogeologic information will be recorded on a geologic log form and in the field notebook. Detailed descriptions of the type(s) of intact sample(s) collected, sampling intervals and conditions, and objective(s) of the sample collection will be provided in the work plan.

6.2 Disturbed formation samples (drill cuttings) will be examined continuously throughout the entire depth of the borehole. If applicable to the study, borehole cuttings will be collected from the circulating auger flights which lift cuttings to land surface (hollow-stem auger technique) or from the recirculating drilling fluid (mudflume) which transports cuttings to land surface (mud-rotary) and examined to monitor drillers progress. If appropriate, formation samples will be retained in appropriate size (e.g., 1-pint or 0.5-pint), properly labeled jars and stored in a safe place to avoid breakage, agitation, and freezing. Hydrogeologic data will be recorded on a geologic log form and in the field notebook.

6.3 The soil cores from the wells drilled at the site will be used for lithologic identification. The first 24 inches of soil for each borehole will be collected intact using a split-spoon sampler or Shelby-tube sampler. Split-spoon samples may be collected continuously from boreholes for cluster wells. Single well and/or piezometer boreholes may also be split-spooned throughout drilling. The conditions for sampling are specified in the Phase 2 RI/FS Work Plan.

6.4 Before collecting and retaining soil and/or sediments collected with the split-spoon sampler, the top several inches may be removed from the sampler and discarded to eliminate any sediment that may have caved into the bottom of the borehole.

6.5 Sediment sampling equipment such as split-spoon samplers, spatulas, etc. (but not including Shelby-tube samplers, which area not re-usable) will be decontaminated by steam cleaning and/or a non-phosphate, laboratory-grade and distilled/deionized wash followed by a distilled/deionized water rinse. (Refer to the SOP for Decontamination of Field Equipment for a detailed description of minimum and special decontamination procedures.) Decontamination of sediment sampling equipment will take place prior to the collection of the first sample and following the collection of each subsequent sample.

7.0 BOREHOLE ABANDONMENT OR CLOSURE

7.1 Upon the completion of the investigation, a determination will be made as whether to maintain the borehole (for a well or piezometer) or to close it (i.e., abandon and seal it).

The abandonment of any borehole (or boring) will be in accordance with NJDEP regulations.

7.3 The borehole will be tremie grouted to the surface with a cement/bentonite grout. Sufficient grout should be used to allow for settling. The area around the borehole should be cleaned up as best as possible to leave the area in similar condition as it was found. If possible, the borehole should be inspected the following day and additional grout be added to the borehole, if needed, to make the abandonment flush with the surface.

7.3 For each abandoned borehole, the procedure will be documented on the appropriate field form or in the study notebook. Documentation may include, where appropriate, the following:

a. Borehole designation.

b. Location with respect to the replacement borehole, if replaced (e.g., 30 ft north and 40 ft west of Borehole B-1). A location sketch should be prepared.

c. Open depth prior to grouting and any other relevant circumstances (e.g., formation collapse).

d. Drill casing left in the borehole by depth, size, and composition.

e. A copy of the geologic log.

f. A revised diagram of the abandoned borehole using a supplemental geologic log form.

g. Additional items left in hole by depth, description, and composition (e.g., lost tools, bailers, etc.).

h. A description and daily quantities of grout used to compensate for settlement.

i. The date of grouting.

j. The level of water or mud prior to grouting and the date and time measured.

k. Any other state or local well abandonment reporting requirements.

CONSTRUCTION, DEVELOPMENT AND ABANDONMENT OF MONITORING OR OBSERVATION WELLS IN UNCONSOLIDATED FORMATIONS

CONSTRUCTION, DEVELOPMENT AND ABANDONMENT OF MONITORING OR OBSERVATION WELLS IN UNCONSOLIDATED FORMATIONS

BROS STANDARD OPERATING PROCEDURE FOR CONSTRUCTION, DEVELOPMENT AND ABANDONMENT OF MONITORING OR OBSERVATION WELLS IN UNCONSOLIDATED FORMATIONS

Revised: May 19, 1999 Revision Number: 2

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to describe the considerations and procedures for constructing ground-water monitoring or observation wells in unconsolidated (e.g., gravel, sand, silt, and clay) formations. Well development and well abandonment (closure) procedures will also be addressed in this SOP. Well construction details and abandonment methods are provided in the Phase 2 RI/FS Work Plan and Field Sampling Plan. Monitoring well construction, development and abandonment procedures will be consistent with N.J.S.A. 58:4A et seq. and the New Jersey Field Sampling Procedures Manual.

Monitoring wells will be completed in unconsolidated formations for the purposes of measuring ground-water levels and collecting ground-water samples. Ground-water level data will be used to calculate ground-water elevations which will be used, to construct water-level elevation and ground-water flow direction maps to illustrate head and flow relationships. Ground-water samples will be used to quantify water-quality conditions.

Observations wells will be completed in unconsolidated formations for the purpose of collecting water-level data from aquifer tests. Slug tests, step-drawdown tests, and constant-rate pumping tests (refer to the respective SOPs) may be conducted to qualitatively or quantitatively characterize flow system hydraulic parameters and/or intra-aquifer and inter-aquifer hydraulic connection.

2.0 PROCEDURE FOR WELL CONSTRUCTION

The installation of each unconsolidated well will begin immediately after borehole completion (and geophysical logging, if implemented). Once well installation has begun, no breaks in the process will be made until the well has been completed and secured against unauthorized access. In cases of unscheduled delays, such as personal injury, equipment breakdowns or sudden inclement weather, installation will be resumed as soon as practical.

2.1 The well will be constructed of stainless steel casing and screen and will be at least 2 inches in diameter to accommodate most water-sampling and water-level measuring devices. Specific well construction details such as well depth, casing diameter, and screen length are provided in the Phase 2 RI/FS Work Plan and Field Sampling Plan.

2.2 Fittings (couplings) will not restrict the inside well diameter, as stainless steel casing will be welded and/or flush-joint threaded. Glues, solvents, or chemical cleaners will not be used in the construction of the wells. All casings, fittings, and screens will be new material. The well screens will be fabricated and have an inside diameter equal to the well casing. The lengths of casing and screen will be measured and recorded on an appropriate field form and in the field notebook by the field hydrogeologist prior to installation.

2.3 Wells in unconsolidated formations will be installed as described below unless depth to water or total depth require modifying the thickness of emplaced materials.

a. The screen and casing will be lowered into the borehole to the appropriate depth. A bottom plug, well cap, and flush-joint sections will be used.

b. A gravel pack (quartz sand or pea gravel) will be filled in around the screen from a few feet below the bottom of the screen to several feet (approximately 2 to 3) above the screen to avoid applying the weight of the casing on the screen and to allow for settling so that the gravel pack covers the screened zone. The size of the uniformly graded gravel pack will be selected based on the grain size of the formation material in the screened interval and the size of the screen used. The placement of the gravel pack may require the use of a tremie pipe.

c. If appropriate, a 1-foot to 3-foot layer of clean, fine-grained silica sand may be placed above the selected gravel pack to isolate the coarse-grained gravel pack (below) from the fine-grained bentonite seal (above). Again, a tremie pipe may be used in the placement of the sand layer.

d. Several feet (approximately 1-3) of powdered or granular bentonite will be placed on top of the sand layer to seal the top of the gravel-packed screen zone.

e. The remainder of the annulus will be grouted to within a few feet of the land surface.

f. A locking steel protective casing or curb box will be set over the well and cemented in place or welded to the steel casing to prevent water from ponding at the top of the well or directly entering the well, and safeguard the well from accidental damage or vandalism.

2.4 Each well will be properly identified with the appropriate information (e.g., local well number, state permit number [if applicable], etc.). The top of the well casing will serve as the measuring point (MP) for ground-water level measurements. The measuring point will be surveyed to the nearest 0.01 foot relative to a common datum (e.g., mean sea level) by a professional, state-licensed surveyor as defined in the work plan.

2.5 Each well will have a location sketch, a well construction log, and a geologic log showing the casing placement and materials used to fill the annular space between the well casing and borehole. The appropriate log will show the depths of each casing material and discuss the geologic variability at the site. A description of the surface soils and unsaturated zone materials down to and including the water table is required.

The following information, if applicable, will be included on the well log:

a. Project number.

b. Date and initials of scientist documenting the well information.

c. Date and time of construction.

d. Well location.

e. Well and permit numbers.

f. Borehole diameter.

g. Well depth.

h. Casing material.

i. Screen material.

j. Screen slot size and length.

k. Gravel pack type and size (depths from _____ to _____).

l. Sand pack (depths from _____ to _____).

m. Bentonite seal (depths from _____ to _____).

n. Bentonite grout (depths from _____ to _____).

o. Cement grout (depths from _____ to _____).

p. Ground-surface elevation.

q. Measuring point elevation.

r. Well height above or depth below land surface.

s. Depth where ground water was encountered.

3.0 DESCRIPTION OF WELL DEVELOPMENT

3.1 Before a newly constructed well can be used for water-quality sampling, measuring water levels, or aquifer testing, it must be developed. Well development refers to the procedure used to clear the well and formation around the screen of fine-grained materials (sands, silts, and clays) produced during drilling or naturally occurring in the formation. Well development continues until the well responds to water-level changes in the formation (i.e., a good hydraulic connection is established between the well and formation) the well produces clear, sediment-free water to the extent

practical the following geochemical parameters have stabilized (i.e., measurements collected at five minute intervals to not vary by more than 10%): pH, specific conductivity, and temperature.

3.2 Depending on the drilling technique used, composition of the formation screened, and well diameter and construction materials, well development may include one or more of the following techniques.

a. Pumping (centrifugal, submersible, or air).

b. Surging (mechanical).

c. Air jetting (mechanical).

d. A combination of the above.

3.3 A 1-pint sample of the last water removed during development will be obtained and inspected by the field hydrogeologist for relative clarity to determine whether development is complete. A turbidimeter may be used to evaluate the clarity of the water removed from the well during development. Well development procedures will be recorded on the well construction log form and in the field notebook.

3.4 Dispersing agents, acids, disinfectants, or other additives will not be used during development nor will they be introduced into the well at any other time . If air jetting is utilized for development, an air filter will be used in-line between the air compressor and the borehole. During development, water will be removed from the entire column of water standing in the well by periodically lowering and raising the pump intake.

4.0 WELL ABANDONMENT OR CLOSURE

4.1 Upon the completion of the investigation, a determination will be made whether to maintain the well or to close it (i.e., abandon and seal it). If the client and Roux Associates agree to abandon the well, then the United States Environmental Protection Agency will be notified and a request will be presented for well abandonment. Upon approval to seal the well, appropriate New Jersey well abandonment forms will be completed. Following approval, the abandonment of any well will be in accordance with New Jersey regulations.

4.2 The protective surface casing or manhole will be removed. The top of the well will be cut off so that the casing terminates below the ground surface.

4.3 The well will be cleared of all obstructions which may impede proper sealing and decommissioning.

4.4 Either Portland cement; a Portland cement/bentonite mixture, or bentonite mixed with potable water will be tremie grouted into the well until the well is completely

full. The abandoned well shall be inspected within the 24 to 72 hour timeframe for settling. Additional material will be placed in the well to form a slab which encompasses the top of the former well.

4.5 For each abandoned well, the procedure will be documented on an appropriate field form and in the field notebook. Documentation may include, where appropriate, the following:

a. Well designation.

b. Location with respect to the replacement well, if replaced (e.g., 30 ft north and 40 ft west of Monitoring Well MW-1). A location sketch should be prepared.

c. Open depth prior to grouting and any other relevant circumstances (e.g., formation collapse).

d. Well casing left in the borehole by depth, size, and composition.

e. A copy of the geologic log.

f. A revised diagram of the abandoned well using the well construction log form.

g. Additional items left in hole by depth, description, and composition (e.g., lost tools, bailers, etc.).

h. A description and daily quantities of grout used to compensate for settlement.

i The date of grouting.

j. The level of water prior to grouting and the date and time measured.

k. The remaining casing, size, and composition above or below ground surface reported in depths or heights from ground surface.

l. Any other state or local well abandonment reporting requirements.

COLLECTION OF QUALITY CONTROL SAMPLES FOR WATER-QUALITY DATA

300294

Revised: July 10, 1998 Revision Number: 1

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to explain the quality control (QC) measures taken to ensure the integrity of the samples collected and to establish the guidelines for the collection of QC samples. The objective of the QC program is to ensure that water-quality data of known and reliable quality are developed.

Because valid water-chemistry data are integral to a hydrogeologic investigation that characterizes water-quality conditions, the data will be confirmed by QC samples. Without checks on the sampling and analytical procedures, the potential exists for contradictory or incorrect results. The acceptance of water-quality data by the United States Environmental Protection Agency (USEPA) and the New Jersey Department of Environmental Protection (NJDEP) investigations depends heavily on the proper QC program to justify the results presented. The QC sampling requirements are clearly defined in the Phase 2 RI/FS Work Plan and the QAPP. As data validation (for compliance with the USEPA regulations) is stipulated as part of the hydrogeologic investigation, QC sampling must be conducted.

2.0 QUALITY CONTROL SAMPLES

2.1 Samples taken for analysis of compounds require the use of quality control samples to monitor sampling activities and laboratory performance. Types of quality control samples may include duplicate, trip blank, field equipment blank, and matrix spike and matrix spike duplicates. A discussion pertaining to each quality control sample follows:

a. Duplicate Samples - Two types of duplicate samples will be collected, replicates and collocates. Replicate sample analysis is done to check on the reproducibility of results either within a laboratory or between laboratories. A replicate sample is called a split sample when it is collected with or turned over to a second party (e.g., regulatory agency, consulting firm) for an independent analysis. Replicate samples are aliquots (equal portions) from a sample in a common container. Collocates are independent samples collected in close proximity to one another such that they are essentially an equal representation of the parameters of interest at a given point in space and time. Collocated samples provide intralaboratory precision, information for the entire measurement system including sample collection, handling, shipping, storage presence and analysis.

To collect a duplicate sample, water from the bailer or pump will be distributed first to fill one container and then to fill the second container. Adequate water should be available to fill the bottles completely before they are capped. If the water is insufficient to fill all the bottles at once, then incrementally fill each bottle with water from two or more bailer volumes or pump cycles. Always fill sample bottles for volatile organic compounds (VOCs) analysis with one bailer volume or pump cycle, if possible.

For some test substances with the exception of VOCs, water may have to be accumulated in a common container and then decanted slowly into the sample bottles. The work plan should be checked for a description of how replicate samples are to be collected. Additionally, in the case of wells that recover slowly and produce insufficient water to fill all the replicate sample containers, the containers should be filled incrementally and kept on ice in the cooler in between filling periods.

b. Trip Blank - A trip blank sample is a sample bottle that is filled with "clean" (e.g., distilled/deionized) water in the laboratory, and travels unopened with the sample bottles. (The USEPA now uses the phrase "demonstrated analyte free water.") It is opened in the laboratory and analyzed along with the field samples for the constituent(s) of interest to detect if contamination has occurred during field handling, shipment, or in the laboratory. Trip blanks are primarily used to check for "artificial" contamination of the sample caused by airborne VOCs but may also be used to check for "artificial" contamination of the sample by a test substance or other analyte(s). One trip blank per cooler containing VOC samples, or test substance of other analyte(s) of interest would accompany each day's samples.

c. Field Equipment Blank - A field equipment blank (field blank) sample is collected to check on the sampling procedures implemented in the field. A field blank is made with "clean" (e.g., distilled/deionized/demonstrated analyte free) water by exposing it to sampling processes (i.e., the clean water must pass through the actual sampling equipment). For example, if samples are being collected with a bailer, the field blank would be made by pouring the clean water into a bailer which has been decontaminated and is ready for sampling, and then pouring from the bailer into the sample containers. If a metals equipment blank is to be made, and the water was filtered, then the sample must be filtered (i.e., exposed to the sampling process). One equipment blank would be incorporated into the sampling program for each day's collection of samples and analyzed for the identical suite of constituents as the sample. In some situations one equipment blank will be required for each type of sampling procedure (e.g., split-spoon, bailer, hand auger).

A special type of field blank may be needed where ambient air quality may be poor. This field blank sample would be taken to determine if airborne contaminants will interfere with constituent identification or quantification. This field blank sample is a sample bottle that is filled and sealed with "clean" (e.g., distilled/deionized/demonstrated analyte free) water in the analytical laboratory, and travels unopened with the sample bottles. It is opened in the field and exposed to the air at a location(s) to check for potential atmospheric interference(s). The field blank is resealed and shipped to the contract laboratory for analysis.

d. Matrix Spike and Matrix Spike Duplicate - Spikes of compounds (e.g., standard compound, test substance, etc.) may be added to samples in the laboratory to determine if the ground-water matrix is interfering with constituent identification or quantification, as well as a check for systematic errors and lack of sensitivity of analytical equipment. Samples for spikes are collected in the identical manner as for standard analysis, and shipped to the laboratory for spiking. Matrix spike duplicate sample collection, and laboratory spiking and analysis is done to check on the reproducibility of matrix spike results.

2.2 The Quality Assurance Project Plan must be referred to for details regarding the type of QC samples to be collected and the QC sample collection method.

3.0 PROCEDURE

3.1 Implement QC sampling as outlined above, depending on the type of QC sample(s) specified in the work plan.

3.2 Ensure unbiased handling and analysis of duplicate and blank QC samples by concealing their identity by means of coding so that the analytical laboratory cannot determine which samples are included for QC purposes. Attempt to use a code that will not cause confusion if additional samples are collected or additional monitoring wells are installed. For example, if there are three existing monitoring wells (MW-1, 2 and 3), do not label the QC blank MW-4. If an additional monitoring well were installed, confusion could result.

3.3 Label matrix spike QC samples so that the analytical laboratory knows which samples are to be spiked in the laboratory.

3.4 Verify that each sample is placed in an individual "zip-lock" bag, wrapped with "bubble wrap," and placed in its appropriate container (holder) in the cooler, and that the cooler has sufficient ice to preserve the samples for transportation to the analytical laboratory.

3.5 Document the QC samples on the appropriate field form and in the field notebook. On the chain-of-custody form, replicate and blank QC samples will be labeled using the codes (Number 3.2, above), and matrix spike and field fortification QC samples will be identified as such (Number 3.3, above).

3.6 Follow standard shipping procedures for samples (i.e., retain one copy of the chain-of-custody form, secure the cooler with sufficient packing tape and a custody seal, forward the samples via overnight [express] mail or hand deliver to the designated analytical laboratory. Samples collected from Monday through Thursday will be delivered to the laboratory within 48 hours. Samples collected on Friday will be delivered to the laboratory by Saturday. However, check the site QAPP for information on the analyte(s), as some have shorter holding times.

PURGING A WELL

Revised: July 10, 1998

Revision Number: 1

1.0 PURPOSE

The purpose for this standard operating procedure (SOP) is to establish the guidelines for purging a well prior to the collection of a conventional ground-water sample. The procedures for low-flow ground water sampling are provided as a separate appendix. Purging (evacuating) a well involves the removal of the standing column of water in the well to allow "fresh" (representative) formation water to enter the well. The conventionally used method for well purging is the discharge of a specified number of casing volumes of water. Wells must be purged prior to sampling to ensure the collection of representative formation ground water for water-quality analysis.

Select monitoring wells will be sampled using the conventional ground-water sampling protocol as part of comparability analysis for the new low-flow sampling technique. The select wells are provided in the Phase 2 RI/FS Work Plan. Conventional ground-water sampling will proceed immediately after samples are collected using the low-flow sampling technique.

2.0 EQUIPMENT AND MATERIALS

2.1 The following equipment may be needed to purge a monitoring well before sampling:

a. Bailers.

b. Centrifugal pumps.

c. Electrical submersible pumps.

d. Peristaltic pumps.

e. Positive gas-displacement devices.

f. Bladder pumps.

g. Hand-operated diaphragm or bilge pump(s).

h. Teflon™ tape, electrical tape.

i. Tape measure (stainless steel, steel, fiberglass) with 0.01-foot measurement increments and chalk (e.g., blue carpenter's) or m-scope.

j. Appropriate discharge hose and valves.

k. Appropriate discharge tubing (e.g., polypropylene) if using a peristaltic pump.

l. Appropriate compressed gas if using bladder-type or gas-displacement device.

m. Extension cord(s) or portable generator (and fuel) if using an electric submersible pump.

n. Non-absorbent cord (e.g., polypropylene, etc.), cotton (absorbent) cord.

o. Water Well Handbook.

p. Health and safety monitoring equipment as required by the Health and Safety/Contingency Plan (HASCP).

q. Flow meter.

2.2 Centrifugal or peristaltic pumps are recommended for shallow, small diameter monitoring wells. For deep wells, or large diameter wells, a submersible pump is recommended.

3.0 DECONTAMINATION

Each piece of equipment that is used to evacuate wells (e.g., pumps, hoses) will be decontaminated thoroughly prior to the introduction of the equipment into the well and prior to leaving the site. Additionally, disposable items (e.g., cord, tubing) will be changed between each well purged and discarded in an appropriate manner.

4.0 PROCEDURE

4.1 The depth to water (DTW) is measured and subtracted from the sounded (total) depth of the well to calculate the length of the column of standing water in the well (in feet).

4.2 The volume of the standing water in the well is calculated by multiplying the length of standing water by a coefficient which equates the diameter of the well to gallons per linear foot. (Refer to the attached table from the Water Well Handbook for the coefficient or use the following equation [V=(7.48 gal/ft^3)(r2h), where V is volume of water in gallons, r is the radius of the well casing in feet, and h is the height of the water column in the well in feet].)

4.3 A minimum of three casing volumes are to be purged.

4.4 If wells are screened in low permeability formations, then the well may go dry prior to removing the specified volume of water. If the recovery rate is fairly rapid and time allows, then remove more than one casing volume; otherwise, the evacuation of one casing volume may suffice.

4.5 Evacuation will occur from the top of the water column in the well to ensure that "fresh" formation water enters the bottom of the well through the screen,

moves up as standing water is removed from the top, and all standing water is removed (i.e., only representative formation water is in the well).

4.6 The volume of water purged from the well must be measured and can be calculated directly by discharging into containers of known volume or can be calculated by multiplying rate of flow by time.

4.7 If a submersible or centrifugal pump is used, then the intake is set just below the dynamic (pumping) water level in the well. The rate of flow in gallons per minute (gpm) can be measured using a calibrated bucket (e.g., 5-gallon) if the rate is relatively low, or a 55-gallon drum if the rate is relatively high, and a watch capable of measuring time in second intervals. A precalibrated flow meter may also be used if available.

4.8 After the specified number of casing volumes have been evacuated from the well, the pump intake is lifted slowly until it breaks suction to confirm that any standing water above the intake has been purged.

4.9 Water purged from the well will be disposed of in accordance with the appropriate methods outlined in the Phase 2 RI/FS Work Plan.

SAMPLING GROUND-WATER MONITORING WELLS FOR DISSOLVED CONSTITUENTS

SAMPLING GROUND-WATER MONITORING WELLS FOR DISSOLVED CONSTITUENTS

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish guidelines for the sampling of ground-water monitoring wells for dissolved constituents using conventional methods. Sampling procedures for samples to be collected using low-flow techniques are detailed in the SOP for low-flow sampling, which is provided as a separate appendix. As part of the SOP for the sampling of ground-water monitoring wells using conventional methods, sample collection equipment and devices must be considered, and equipment decontamination and pre-sampling procedures (e.g., measuring water levels and purging wells) must be implemented. Sampling objectives are provided in the Phase 2 RI/FS Work Plan.

Valid water-chemistry data are integral to a hydrogeologic investigation that characterizes ground-water quality conditions. Water-quality data are used to evaluate both current and historic aquifer chemistry conditions, as well as to estimate future conditions (e.g., trends, migration pathways). Water-quality data can be used to construct ground-water quality maps to illustrate chemical conditions within the flow system, to generate water-quality plots to depict conditions with time and trends, and to perform statistical analyses to quantify data variability, trends, and cleanup levels.

2.0 EQUIPMENT AND MATERIALS

2.1 In order to sample ground water from monitoring wells using conventional methods, specific equipment and materials are required. The equipment and materials list may include, but not necessarily be limited to, the following:

a. Dedicated, disposable Teflon™ bailers.

b. Pumps (centrifugal, peristaltic, bladder, electric submersible).

c. Gas-displacement device(s) (e.g., compressed gas, air compressor), if required.

d. Air-lift device(s), if required.

e. Teflon™ tape, electrical tape.

f. Appropriate discharge tubing.

g. Teflon™ lined discharge tubing if using a peristaltic pump.

h. Portable generator and gasoline or alternate power supply if using an electric submersible pump or electric powered air compressor.

i. Non-absorbent cord (e.g., polypropylene, etc.).

j. Plastic sheeting.

k. Electronic water-level indicators (e.g, m-scope, etc.) or electric water-level/product level indicators.

l. Non-phosphate, laboratory-grade detergent.

m. Distilled/Deionized water.

n. Potable water.

o. Paper towels, clean rags.

p. Roux Associates' field forms (e.g., daily log, well inspection checklist, sampling, etc.) and field notebook.

q. Well location and site map.

r. Well keys.

s. Stop watch, digital watch with second increments, or watch with a second hand.

t. Calculator.

u. Black pen and water-proof marker.

v. Tools (e.g., pipe wrenches, screwdrivers, hammer, pliers, flashlight, pen knife, etc.).

w. Appropriate health and safety equipment, as specified in the site Health and Safety/Contingency Plan (HASCP).

x. Water quality meter(s) and associated calibration fluids.

y. 0.45 micron filters.

z. Filtration apparatus, filters, pre-filters.

aa. Plasticware (e.g., premeasured buckets, beakers, flasks, funnels).

bb. Disposable gloves.

cc. Laboratory-supplied sample containers with labels.

dd. Cooler(s).

ee. Ice.

ff. Masking, duct, and packing tape.

gg. Chain-of-custody form(s) and custody seal(s).

hh. Phase 2 RI/FS Work Plan and Field Sampling Plan.

ii. Site Health and Safety/Contingency Plan (HACSP).

jj. Packing material (e.g., bubble wrap).

kk. "Zip-lock" plastic bags.

ll. Overnight (express) mail forms.

3.0 DECONTAMINATION

3.1 Make sure all equipment is decontaminated and cleaned before use (refer to the SOP for Decontamination of Field Equipment for detailed decontamination methods. Use new, clean materials when decontamination is not appropriate (e.g., non-absorbent cord, disposable gloves). Document, and initial and date the decontamination procedures on the appropriate field form and in the field notebook.

4.0 CALIBRATION OF FIELD ANALYSIS EQUIPMENT

Calibrate field analysis equipment before use (e.g., thermometers, pH and conductivity meters, etc.). Refer to the manufacturer's instructions for calibration for each respective piece of equipment. Document, and initial and date the calibration procedures on the appropriate field form, in the field notebook, and in the calibration log book.

5.0 PROCEDURE

5.1 Document, and initial and date well identification, pre-sampling information, and problems encountered on the appropriate field form and in the field notebook as needed.

5.2 Inspect the protective casing of the well and the well casing, and note any items of concern such as a missing lock, or bent or damaged casing(s).

5.3 Place plastic sheeting around the well to protect sampling equipment from potential cross contamination.

5.4 Remove the well cap or plug and, if necessary, clean the top of the well off with a clean rag. Place the cap or plug on the plastic sheeting. If the well is not vented, allow several minutes for the water level in the well to equilibrate. If fumes or gases are present, then diagnose these with the proper safety equipment. Never inhale the vapors.

5.5 Measure the depth to water (DTW) from the measuring point (MP) on the well using a steel tape and chalk or an electronic sounding device (m-scope). Refer to the specific SOPs for details regarding the use of a steel tape or a m-scope for measuring water

levels. Calculate the water-level elevation. Document, and initial and date the information on the appropriate field form and in the field notebook.

5.6 Measuring the total depth of the well from the MP with a weighted steel tape. Calculate and record the volume of standing water in the well casing on the appropriate field form and in the field notebook.

5.7 Decontaminate the equipment used to measure the water level and sound the well with a non-phosphate, laboratory-grade detergent solution followed by a distilled/deionized water rinse.

5.8 Purge the well prior to sampling (refer to the SOP for Purging a Well). The well should be pumped to remove three volumes of water If the well is purged dry, then all the standing water has been removed and upon recovery the well is ready for sampling. However, depending on the rate of recovery and the time needed to complete the sampling round, one of the following procedures may have to be implemented: 1) the well may have to be sampled over a period of more than one day; 2) the well may not yield enough water to collect a complete suite of samples and only select (most important) samples will be collected; or 3) the well may not recover which will preclude sampling. Regardless of the option that must be followed, the sampling procedure must be fully documented. When preparing to conduct a sampling round, review drilling, development and previous sampling information (if available) to identify low-yielding wells in order to purge them first, and potentially allow time for the well to recover for sampling.

5.9 Record the physical appearance of the water (i.e., color, turbidity, odor, etc.) on the appropriate field form and in the field notebook, as it is purged. Note any changes that occur during purging.

5.10 If a bailer is used to collect the sample, then:

a. Tie the non-absorbent cord (polypropylene) to the bailer with a secure knot and then tie the free end of the bailer cord to the protective casing or, if possible, some nearby structure to prevent losing the bailer and cord down the well.

b. Lower the bailer slowly down the well and into the water column to minimize disturbance of the water surface. If a bottom-filling bailer is used, then do not submerge the top of the bailer; however, if a top-filling bailer is used, then submerge the bailer several feet below the water surface When removing the bailer from the well, do not allow the bailer cord to rest on the ground but coil it on the protective plastic sheeting placed around the well. The sample will be collected from the first bailer volume removed from the well.

5.11 If a peristaltic pump is used to collect the sample, then use the same pump used to purge the well and, if need be, reduce the discharge rate to facilitate filling sample containers and to avoid problems that can occur while filling sample containers.

Alternately, the purge pump may be removed and a thoroughly decontaminated bailer can be used to collect the sample.

5.12 Remove each appropriate container's cap only when ready to fill each with the water sample, and then replace and secure the cap immediately.

5.13 Fill each appropriate, pre-labeled sample container carefully and cautiously to prevent: 1) agitating or creating turbulence; 2) breaking the container; 3) entry of, or contact with, any other medium; and 4) spilling/splashing the sample and exposing the sampling team to contaminated water. Immediately place the filled sample container in a ice-filled cooler for storage. Ice is should be repackaged in zip-lick bags to help keep the cooler dry and the sample labels secure.

5.14 "Top-off" containers for volatile organic compounds (VOCs) and tightly seal with Teflon™-lined septums held in place by open-top screw caps to prevent volatilization. Ensure that there are no bubbles by turning the container upside down and tapping it gently.

5.15 Filter water samples collected for dissolved metals analysis prior to preservation to remove the suspended sediment from the sample. If water samples are to be collected for total metals analysis, then collect a second set of samples without field filtering.

5.16 Add any necessary preservative(s) to the appropriate container(s) prior to, or after, the collection of the sample, unless the appropriate preservative(s) have already been added by the laboratory before shipment.

5.17 Collect quality control (QC) samples as required in the work plan to monitor sampling and laboratory performance. Refer to the SOP for Collection of Quality Control Samples.

5.18 Conduct field analyses after sample collection is complete by measuring and recording the temperature, conductivity, pH, etc. Note and record the "final" physical appearance of the water (after purging and sampling) on an appropriate field form and in the field notebook.

5.19 Wipe the well cap with a clean rag, replace the well cap and protective cover (if present). Lock the protective cover.

5.20 Verify that each sample is placed in an individual "zip-lock" bag, wrapped with "bubble wrap," placed in the cooler, and that the cooler has sufficient ice to preserve the samples for transportation to the analytical laboratory.

5.21 Decontaminate pumps as discussed in the decontamination SOP. Wrap decontaminated equipment with aluminum foil. Discard cords, rags, gloves, etc. in a manner consistent with site conditions.

5.22 Complete all necessary field forms, field notebook entries, and the chain-of-custody forms. Retain one copy of each chain-of-custody form. Secure the cooler with sufficient packing tape and a custody seal.

5.23 Samples collected from Monday through will be delivered to the laboratory within 48 hours of collection. Samples collected on Friday should be delivered to the laboratory by Saturday. Consult the Quality Assurance Project Plan to determine if any of the analytes require a shorter delivery time.

COLLECTING STREAM-BED, AND POND SEDIMENT SAMPLES

COLLECTING STREAM-BED, AND POND SEDIMENT SAMPLES

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish guidelines for stream-bed, and pond sediment samples. The specific procedure and equipment selection will be dependent upon the data objectives of the sampling program. The sampling procedure can range from one grab sample to many samples at different horizontal and vertical locations. The sampling requirements are described in the Phase 2 RI/FS Work Plan.

The objective of sediment sampling is to collect samples which are representative of the area of interest. Frequently this objective can be quite easy and routine such as one "grab" sample for a small stream with uniform stream-bed conditions. Other times, the nature of the site-specific conditions make collection of a representative sample more difficult. Consideration of such variables as stream flow velocity, pond depth, turbulence, access, health and safety, water composition, tidal fluctuation, surface runoff, factory outfalls, tributaries, etc. is essential before collection of the sample.

In collecting sediment samples, care must be taken to minimize disturbance and sample washing as it is retrieved through the liquid column above. Sediment fines may be carried out of the sample during collection if the liquid above is flowing or deep. This may result in collection of a nonrepresentative sample due to the loss of contaminants associated with these fines. While a sediment sample is usually expected to be a solid matrix, the sampler should avoid placing the sample in the bottle then decanting off the excess liquid. If the sample is collected properly, then any liquid that enters into the bottle is representative of sediment conditions.

As with liquid sampling, a determination of tidal influence on the location being sampled should be made and its effect on the sample collection should be detailed in the work plan. At a minimum, the stage of the tide at the time of sample collection must be recorded.

2.0 CONSIDERATIONS

Collecting sediment samples from surface-water bodies and impoundments requires special considerations regarding general safety and sampling location.

2.1 Health and safety is a key aspect of all sampling procedures and therefore must be addressed when selecting a sampling location. In most instances sediment sampling will require entering the water. Therefore, the Site-Specific Health and Safety/Contingency Plan (HASCP) must be referred to regarding the implementation of health and safety procedures (for compliance with the Occupational Safety and Health Administration [OSHA] and for general safety for sampling personnel). If entering the water body is necessary, then the water velocity, depth, sediment type and uniformity, tidal stage, and water chemistry must be evaluated. If any potential hazard is identified, then the sampler must use a safety harness and life jacket, and a buddy system must be employed. A raft or boat (vessel) may be necessary to collect samples. Depending upon the geographic location and season, considerations such as water

temperature, snakes, rats, ticks, etc. may be important. Thus, the site-specific HASCP must address all possible contingencies and allow flexibility for revision if unanticipated conditions arise.

2.2 The location of a sediment sampling point is the first consideration for a sediment sampling program. The general sediment sampling locations have been selected and are provided in the Phase 2 RI/FS Work Plan an Field Sampling Plan. The specific sampling location should be selected where flow and turbulence are uniform, the sediment conditions seem representative, and access is favorable (i.e., shallow section with good footing).

The sampling location should avoid tributaries, parking lot runoff, factory outfalls, and obstructions unless these inputs are of specific interest. Sampling from the boundaries of the surface-water body should generally be avoided, except where these regions are of direct interest. For flowing surface-water bodies sampling should proceed from downstream locations to upstream locations so that disturbance related to sampling does not effect downstream sample quality. If liquid samples will be collected at the same locations as sediment samples, then the liquid samples must be collected first so that sediment sampling does not create turbulence that may alter water-quality conditions at the sampling location.

2.3 The factors that contribute to the selection of a sampling device include: 1) the width, depth, flow and the bed characteristics of the surface-water body to be sampled; 2) the required depth below the sediment surface; 3) whether the sample will be collected from the shore or a vessel; and 4) the objectives of the program. These factors are addressed in the Phase 2 RI/FS Work Plan.

The sampling of stream-bed sediments will be accomplished through the use of one of the following samplers:

a. Scoop or trowel.

b. Bucket auger.

c. Soil coring device.

d. Shelby tube.

e. Split spoon sampler.

f. Ponar or Eckman dredge.

g. Other commercially available sampler of proper construction material.

2.4 Sampling from on-shore or off-shore (wading or vessel) locations will be dependent on the site-specific sampling conditions as follows:

a. If liquid flow and depth is minimal and sediment is easy to reach, then a trowel or scoop may be used to collect the sediment sample. However, where the liquid above the sediment collection point is either flowing or greater than 4 inches in depth, a corer or other device that eliminates sample washing must be used to collect the sample in an attempt to minimize washing the sediment as it is retrieved. One of the coring devices listed above will allow the collection of an undisturbed core of sediment. It may be necessary to decant standing water from the top of the core. This should be done carefully and prior to transfer to the sample bottle. A decontaminated stainless-steel trowel, spoon, or spatula must be utilized to transfer the sample from the sampler directly into the samplebottle or stainless steel bowl for homogenization.

b. In some instances, the dimensions of the stream require that a vessel (e.g., a boat, raft, etc.) must be used. The device used for sample collection in this case will, again, depend upon the depth and flow of the liquid above the sample location and the stream-bed characteristics. Generally, trowels or scoops cannot be used in an off-shore situation. Instead, cores or dredges are more efficient means for sample collection. The vessel must be positioned just upstream of the desired sample location. As the corer or dredge is lowered it may be carried slightly downstream, depending upon the force of the flow. Upon retrieval, immediately transfer the contents of the corer or dredge directly into the sample bottle or stainless steel bowl for homogenization using a decontaminated stainless-steel trowel, spoon, or spatula.

3.0 EQUIPMENT AND MATERIALS

In order to sample stream-bed sediments, specific equipment and materials are required. The equipment and materials list may include, but necessarily be limited to, the following:

a. The Phase 2 RI/FS Work Plan and Field Sampling Plan.

b. A Health and Safety/Contingency Plan.

c. Decontamination supplies.

d. Field notebook and appropriate field form(s).

e. Maps (topographic and road/county).

f. Cooler and ice.

g. Sample bottles (including as necessary: appropriate field blanks, trip blanks, duplicates, extra bottles for breakage, proper size and type for analyte, labels, etc.).

h. Plastic sheeting.

i. Meters (pH, as modified for soil/sediment analysis), thermometer, and calculator.

j. Wading rod and current meter.

k. Calibration equipment/materials for all meters or devices.

l. Sampler (including as necessary: scoop, trowel, spatula, sampling tier, bucket auger, soil-coring device, Shelby tube, split-spoon sampler, Eckman dredge sampler, and Ponar dredge).

m. Disposable sampling gloves.

n. Health and safety equipment (including as necessary: proper level of protection [OSHA], rubber boots, hip waders, chest waders, safety harness, rope, life jacket, life preserver, air horn, two-way communication, etc.).

o. Measuring tapes (100-foot, weighted and 10-foot, steel).

p. Camera and film.

q. Hand sledge hammer.

r. Pipe wrenches (14 inches long, 2 required).

s. Miscellaneous tools (e.g., screwdrivers, hammer, pliers, flashlight, pen knife, etc.).

t. Black pen and indelible marker.

u. Paper towels, clean rags.

v. Masking and packing tape.

w. Packing material (e.g., "bubble wrap") and "zip-lock" plastic bags.

x. Chain-of-custody form(s) and custody seals.

y. Overnight (express) mail forms.

4.0 DECONTAMINATION

When possible thoroughly pre-cleaned and wrapped sampling equipment should be used and dedicated to individual sampling locations. Disposable items such as cord, tubing, and gloves will be changed between each use and discarded in an appropriate manner. If a non-disposable item is to be reused during a sampling event, it will be thoroughly cleaned according to the field equipment decontamination SOP. Appropriate field, equipment and trip blanks will be collected as outlined in the work plan to demonstrate proper decontamination procedures.

5.0 CALIBRATION OF FIELD ANALYSIS EQUIPMENT

Calibrate field analysis equipment before use (e.g., thermometers and meters, etc.). Refer to the specific SOPs for field analysis for each respective piece of equipment. Equipment such as

current meters must have the manufacturer's manual maintained with the instrument and must be referred to for use, repair, maintenance, trouble-shooting, or calibration, if required. Document, and initial and date the calibration procedures on the appropriate field form, in the field notebook, and in the calibration log book.

6.0 PROCEDURE

6.1 Identify each location to be sampled based upon requirements of the Phase 2 RI/FS Work Plan. If any of the considerations outlined in Section 2.0 impact the proposed sampling method, then contact the Project Manager to get authorization to modify as necessary.

6.2 Record the site and sample location, weather conditions, date, and time of the selected sampling point in the field notebook and on any field forms being used, and initial the entry.

6.3 Describe the surface-water body or impoundment characteristics including: width (feet [ft]), depth (ft), flow (none, low, intermediate or flood; or measured velocity, if possible), turbidity (clear, turbid, very turbid), turbidity or flow variations, tributary locations and distances, surface runoff impacts, and adjacent land use. A photograph of each sampling location should be included as part of the documentation.

6.4 Evaluate health and safety concerns and take appropriate measures to eliminate potential hazards.

6.5 Prepare sample containers for collection by organizing, labeling, and verifying proper preservation methods.

6.6 Ensure all sampling equipment has been thoroughly decontaminated and is operational.

6.7 Place plastic sheeting on the ground or on the floor of the vessel to protect sampling materials from potential cross contamination.

6.8 Ensure all meters to be used are operational and have been calibrated.

6.9 Remove each appropriate container's cap only when ready to fill each with the sample, and then replace and secure the cap immediately.

6.10 Collect the sample utilizing the selected sampling method and immediately place the portion of sample to be analyzed for VOCs into pre-labeled, laboratory-supplied containers. The remaining portion of the sample should be placed in a stainless steel bowl and composited using the coning and quartering method. Fill each of the remaining sample containers with the remaining soil. All sample bottles should be filled carefully and cautiously to prevent: 1) excessive agitating; 2) breaking the container; 3) entry of, or contact with, any other medium; and 4) spilling the sample and exposing the sampling team to contaminated sediment. Immediately place the filled sample containers in a ice-filled cooler for storage.

6.11 Collect quality control (QC) samples to monitor sampling and laboratory performance as required in the work plan. Refer to the SOP for collection of QC samples for a detailed discussion of proper methods.

6.12 Analyze samples for field parameters (e.g., pH, etc.) immediately after collecting samples for laboratory analysis. Whenever possible, sufficient volume should be collected in the initial sample to complete all laboratory and field parameters.

6.13 Verify that each sample is placed in an individual "zip-lock" bag, wrapped with "bubble wrap," and placed in its appropriate container (holder) in the cooler, and that the cooler has sufficient ice to preserve the samples for transportation to the analytical laboratory.

6.14 Thoroughly clean all reusable sampling equipment as discussed in the field equipment decontamination SOP. Wrap decontaminated equipment with aluminum foil. Discard cords, rags, gloves, etc. in a manner consistent with accepted procedures.

6.15 Complete field forms, field notebook entries, and the chain-of-custody forms. Retain one copy of each chain-of-custody form. Secure the cooler with sufficient packing tape and a custody seal.

6.16 Samples collected from Monday through Thursday will be delivered to the laboratory within 48 hours of collection. Samples collected on Friday will be delivered to laboratory by Saturday. Check the Quality Assurance Project Plan to determine if certain analytes require a shorter delivery time.

SURFACE-WATER SAMPLING

SURFACE-WATER SAMPLING

Revised: December 3, 1998 Revision Number: 2

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish guidelines for surface-water sampling. The specific procedure and equipment selection will be dependent upon site conditions at the time of sampling. This SOP presents the sampling approach that will be required for all surface water sampling events.

The objective of surface-water sampling is to collect samples which are representative of the entire surface-water body. Consideration of such variables as flow velocity, turbulence, access, health and safety, water composition, tidal fluctuation, surface runoff, outfalls, tributaries, has been incorporated into the Phase 2 RI/FS Work Plan and Field Sampling Plan.

2.0 CONSIDERATIONS

Collecting samples from surface-water bodies require special considerations regarding sampling location and general safety.

2.1 The location of a surface-water sampling point is the first consideration for a surface-water sampling program. The general sampling location will be selected based on the Phase 2 RI/FS Work Plan. The specific sampling location should be selected where flow and turbulence are uniform and access is favorable (i.e., a bridge or shallow section for a river or pond, respectively).

The sampling location should avoid tributaries, surface water runoff areas, outfalls, and obstructions unless these inputs are of specific interest. Sampling from the boundaries of the surface-water body should generally be avoided, except where these regions are of direct interest. Sampling must proceed from downstream locations to upstream locations (unless site-specific conditions preclude this order) in order that disturbance related to sampling does not affect downstream sample quality. If sediment samples will be collected at the same locations as liquid samples, then the liquid samples must be collected first.

2.2 Health and safety is a key aspect of all sampling procedures and therefore must be addressed when selecting a sampling location. Therefore, the Health and Safety/Contingency Plan (HASCP) Health and Safety/Contingency Plan HASCP must be referred to regarding the implementation of health and safety procedures (for compliance with the Occupational Safety and Health Administration [OSHA] and for general safety for sampling personnel). An USGS gauging station or a bridge are often the most desirable locations because they eliminate the need for entering the water body. If entering the water body is necessary, then the water velocity, depth, sediment type and uniformity, tidal stage, and water chemistry must be evaluated. If any potential hazard is identified, the sampler must use a safety harness and life jacket, and a buddy system must be employed. A vessel (e.g., raft, boat, etc.) may also be necessary to collect samples. Depending upon the geographic location and season, considerations such as water temperature, snakes, rats, ticks, etc. may be important.

Thus, the site-specific HASCP must address all possible contingencies and allow flexibility for revision if unanticipated conditions arise.

3.0 EQUIPMENT AND MATERIALS

In order to sample surface water, specific equipment and materials are required. The equipment and materials list may include, but not necessarily be limited to, the following:

a. The Phase 2 RI/FS Work Plan and Field Sampling Plan.

b. A Health and Safety/Contingency Plan Health and Safety/Contingency Plan.

c. Decontamination supplies.

d. Field notebook and field form(s).

e. Maps (topographic and road/county).

f. Cooler and ice.

g. Sample bottles (including as necessary: appropriate field blanks, trip blanks, duplicates, preservatives, extra bottles for breakage, proper size and type for analyte, labels, etc.).

h. Plastic sheeting.

i. Meters, field test kits (including as necessary: pH, conductivity, turbidity, eH, dissolved oxygen, iron, manganese, etc.), thermometer, and calculator.

j. Calibration equipment/materials for all meters or devices.

k. Wading rod and current meter.

l. Sampler (including as necessary: laboratory sample bottles, bailer, pond sampler, weighted-bottle sampler, Wheaton dip sampler, Kemmerer depth sampler, Bacon Bomb sampler, etc.).

m. Disposable sampling gloves.

n. Health and safety equipment (including as necessary: proper level of protection [OSHA], rubber boots, hip waders, chest waders, safety harness, rope, life jacket, life preserver, air horn, two-way communication, etc.).

o. Measuring tape (100-foot, weighted).

p. Non-absorbent cord (e.g., polypropylene) to lower samplers.

q. Camera and film.

r. Filtering apparatus, filters, pre-filters.

s. Paper towels, clean rags.

t. Black pen and indelible marker.

u. Tools (e.g., screwdrivers, hammer, pliers, flashlight, pen knife, etc.)

v. Masking and packing tape.

w. Packing material (e.g., "bubble wrap") and "zip-lock" plastic bags.

x. Chain-of-custody form(s) and custody seals.

y. Overnight (express) mail forms.

4.0 DECONTAMINATION

Where possible, thoroughly pre-cleaned and wrapped sampling equipment should be used and dedicated to individual sampling locations. Disposable items such as cord, tubing, and gloves will be changed between each use and discarded in an appropriate manner. If a non-disposable item is to be reused during a sampling event, it will be thoroughly cleaned according to the field equipment decontamination SOP. Appropriate field, equipment and trip blanks will be collected as outlined in the Quality Assurance Project Plan to demonstrate proper decontamination procedures.

5.0 CALIBRATION OF FIELD ANALYSIS EQUIPMENT

Calibrate field analysis equipment before use (e.g., thermometers, pH and conductivity meters, etc.). Refer to the specific SOPs for field analysis for each respective piece of equipment. Equipment such as current meters must have the manufacturer's manual maintained with the instrument and must be referred to for use, repair, maintenance, trouble-shooting, or calibration, if required. Document, and initial and date the calibration procedures on the appropriate field form, in the field notebook, and in the calibration log book.

6.0 PROCEDURE

6.1 Identify each location to be sampled based upon requirements of the Phase 2 RI/FS Work Plan. If any of the considerations outlined in Section 2.0 impact the proposed sampling method, then contact the project manager to get authorization to modify as necessary.

6.2 Record the site and sample location, weather conditions, date, and time of the selected sampling point in the field notebook and on any field forms being used, and initial entry.

6.3 Describe the surface-water body characteristics including as pertinent: width (feet [ft]), depth (ft), flow (none, low, intermediate or flood; or measured velocity, if possible), turbidity (clear, turbid, very turbid), turbidity or flow variations across the surface-water body, tributary locations and distances, surface runoff impacts, and adjacent land use. A photograph of each sampling location should be included as part of the documentation.

6.4 Evaluate health and safety concerns and take appropriate measures to eliminate potential hazards.

6.5 Prepare sample containers for collection by organizing, labeling, and verifying proper preservation methods. Ensure that bottles used for volatile organic compounds contain hydrochloric acid, which will be prepared by the laboratory.

6.6 Ensure all sampling equipment has been thoroughly decontaminated and is operational.

6.7 Place plastic sheeting on ground to protect sampling materials from potential contamination.

6.8 Ensure all meters to be used are operational and have been calibrated.

6.9 Remove each appropriate container's cap only when ready to fill each with the water sample, and then replace and secure the cap immediately.

6.10 Collect the sample utilizing the selected sampling method and immediately place into pre-labeled, laboratory-supplied containers. Fill each appropriate, pre-labeled sample container carefully and cautiously to prevent: 1) agitating or creating turbulence; 2) breaking the container; 3) entry of, or contact with, any other medium; and 4) spilling/splashing the sample and exposing the sampling team to contaminated water. Immediately place the filled sample container in a ice-filled cooler for storage.

6.11 "Top-off" sample containers for volatile organic compounds (VOCs) and tightly seal with Teflon™-lined septums held in place by open-top screw caps to prevent volatilization. Ensure that no bubbles are present by turning the container upside down and tapping gently.

6.12 Filter water samples collected for dissolved metals analysis prior to preservation to remove the suspended sediment from the sample. If water samples are to be collected for total metals analysis, then collect a second set of samples without field filtering.

6.13 Add the appropriate preservative to each container, if required, prior to, or after , the collection of the sample, unless the appropriate preservative(s) have already been added to the container(s) by the laboratory before shipment.

6.14 Collect quality control (QC) samples to monitor sampling and laboratory performance as required in the Quality Assurance Project Plan. Refer to the SOP for collection of QC samples for a detailed discussion of proper methods.

6.15 Analyze samples for field parameters (e.g., temperature, pH, conductivity, turbidity, etc.) immediately after collecting samples for laboratory analysis. Whenever possible, sufficient volume should be collected in the initial sample to complete all laboratory and field parameters.

6.16 Verify that each sample is placed in an individual "zip-lock" bag, wrapped with "bubble wrap," and placed in its appropriate container in the cooler, and that the cooler has

sufficient ice (wet ice or blue packs) to preserve the samples for transportation to the analytical laboratory.

6.17 Thoroughly clean bailers, hoses, and samplers as discussed in the field equipment decontamination SOP. Wrap decontaminated equipment with a suitable material (e.g., clean plastic bag or aluminum foil). Discard cords, rags, gloves, etc. in a manner consistent with accepted procedures.

6.18 Complete field forms, field notebook entries, and the chain of custody forms. Retain one copy of each chain-of-custody form. Secure the cooler with sufficient packing tape and a custody seal.

6.19 Samples collected from Monday through Friday will be delivered to the laboratory within 48 hours of collection. Samples collected on Friday will be delivered to the laboratory by Saturday. Check the Quality Assurance Project Plan to determine if certain analytes require a shorter delivery time.

MEASURING THE pH OF WATER SAMPLES

Revised: July 10, 1998 Revision Number: 1

1.0 PURPOSE

The purpose for this standard operating procedure (SOP) is to establish the guidelines for measuring the pH of water in the field. The pH is measured in the field using a pH meter which should have the ability to compensate for temperature (automatically or manually). The pH will be measured in standard units (SU) and can be recorded with or without the SU designation. The conventional means of recording a pH value is without a unit designation (e.g., 7.0); however, the SU designation may be used provided the term is defined as standard units when first referenced. The manufacturer's instrument manual for each particular pH meter, which is maintained with the instrument, will be referred to for calibration, use, repair, maintenance, or trouble-shooting operations.

The pH is measured in the field to provide the pH of the water under ambient (in situ) conditions. The pH is a measure of acidic (<7.0) or basic (>7.0) nature of the water and is used to assist in evaluating the mobility of contaminants. In addition, pH measurements can be used during well purging to help determine when sufficient ground water has been purged (removed) from a well (i.e., the standing water in the well has been removed and replaced with "fresh" water from the aquifer). The determination is made when pH readings have achieved stabilization or near-stabilization. Please note that in general the pH of ground water and surface water in the region is generally less than 7.0.

2.0 CALIBRATION

2.1 Calibration of the pH meter is to be performed at the beginning and end of each day's use in accordance with the manufacturer's specific instructions. Usual procedures are given below.

2.2 Recalibration must occur if: 1) the pH of the samples being measured is outside the previous calibration range; 2) the procedure or use conditions warrant frequent calibrations; 3) four or more hours have elapsed; or 4) the instrument has been moved from one area to another (e.g., offsite or out of the study area).

2.3 Two buffer calibrations bracketing the expected pH range of samples are to be performed prior to its use in a study. Three pH buffers (4.0, 7.0, and 10.0) are read after standardization at pH of 7.0 to evaluate the linearity and electrodes.

2.4 The measurements of sample and buffers are made while stirring. The samples and buffers are measured at the same temperature; therefore, the pH meter must be temperature compensated. If not, then record the temperature.

2.5 The following information is documented in the calibration logbook at the time of calibration:

a. Date.
b. pH meter identification.
c. Calibration results using pH standards.
d. Initials of the individual performing calibration.

300326

3.0 PROCEDURE

3.1 A warm-up period may or may not be necessary for the instrument, depending on instrument requirements. The manufacturer's instrument manual must be followed.

3.2 The pH electrodes must be kept in good working order as follows:

a. Proper levels of electrolyte solution are maintained. The electrolyte solution level should be at least 1 inch above the solution being measured.

b. The electrodes must be carefully rinsed with distilled or deionized water before each measurement.

3.3 The water sample (approximately 500 milliliters [ml]) is placed in a clean container and the temperature and pH are measured immediately.

3.4 The temperature of the sample is measured and the pH meter is compensated for the water temperature. If compensation is not possible, then record the temperature.

3.5 The electrodes are immersed in a water sample and stirred continuously until the pH reading equilibrates. The pH will be measured and recorded in increments of 0.1 or 0.1 SU.

3.6 Pertinent data are documented in the field notebook or appropriate field form, and initialed and dated.

3.7 The electrodes are rinsed with distilled or deionized water and the unit stored properly in accordance with the manufacturer's instructions (e.g., capping and storing in a buffer such as altex electrode storage solution). The electrodes are not to be stored in potable water, or distilled or deionized water.

MEASURING THE CONDUCTIVITY OF WATER SAMPLES

300328

Revised: July 10, 1998 Revision Number: 1

1.0 PURPOSE

The purpose for this standard operating procedure (SOP) is to establish the guidelines for measuring the electrical conductance (conductivity) of water in the field. The conductivity is measured in the field using a conductivity meter which compensates for temperature (automatically or manually). Some conductivity meters measure directly in micromhos/ centimeter (µmhos/cm) while others have to be converted to this unit. Conductivity will be recorded in µmhos/cm. The manufacturer's instrument manual of each particular conductivity meter, which is maintained with the instrument, will be referred to for calibration, use, repair, maintenance, or trouble-shooting operations.

The specific conductivity is measured in the field as a measure of the total dissolved solids (TDS) in the ground water or surface water. TDS data can then be used as a qualitative measure of contamination and to assist in evaluating electrical resistivity and borehole geophysical data. In addition, specific conductivity measurements can be used during well purging to help determine when sufficient ground water has been purged (removed) from a well (i.e., the standing water in the well has been removed and replaced with "fresh" water from the aquifer). The determination is made when conductivity readings have achieved stabilization or near-stabilization.

2.0 CALIBRATION

2.1 Calibration is in accordance with the manufacturer's specific directions.

2.2 Calibration of the conductivity meter is to be performed at the beginning and end of each day's use.

2.3 Recalibration must occur if: 1) the specific conductivity of samples being measured is outside the calibration standard solution range; or 2) the instrument has been moved from one area to another (e.g., offsite or out of the study area).

2.4 Review previous site data for the area of the site where the site investigations are being conducted and choose a conductivity calibration solution that is near the conductivity of the water samples to be measured.

2.5 Select the appropriate conductivity calibration solution and adjust the span on the instrument to the conductivity calibration solution value.

2.6 Rinse the probe in distilled or deionized water and store the probe according to the manufacturer's specifications (e.g., distilled or deionized water, or a buffer solution).

2.7 The following information is documented in the calibration logbook:

a. Date.

b. Conductivity meter identification.

c. Initials of individual performing calibration.

d. Calibration results.

3.0 PROCEDURE

3.1 The conductivity electrodes must be kept in good working order as specified by the manufacturer.

3.2 The water sample is placed in a clean, appropriate container(s) and the temperature and conductivity are measured immediately.

3.3 The temperature of the sample is taken and the conductivity meter is compensated for the water temperature.

3.4 The probe is immersed in a water sample until the meter equilibrates.

3.5 In reading the conductivity meter scale, one or more of the following may have to be considered:

a. The reading may have to be multiplied appropriately (e.g., the reading is expressed in micromhos/centimeter).

b. If the conductivity meter is not capable of compensating for temperature differences, then note that the conductance measurements are not temperature compensated and document the temperatures.

c. If the conductivity meter can be compensated for temperature, then adjust the temperature control before reading the conductance measurement. (Some meters automatically compensate for temperature, and this should be documented.)

3.6 Conductivity measurements are recorded in the field notebook and on the appropriate field form, and initialed and dated. Units of µmhos/cm are used to represent conductivity.

3.7 The probe will be cleaned with distilled or deionized water after each use and will be stored according to the manufacturer's specifications (e.g., conductivity cells may have to be stored in distilled or deionized water, or a buffer solution).

MEASURING WATER TEMPERATURE

300331

Revised: July 10, 1998 Revision Number: 1

1.0 PURPOSE

The purpose for this standard operating procedure (SOP) is to establish the guidelines for measuring water temperature in the field. Temperature measuring devices may include thermometers, and pH and/or conductivity meters equipped with a temperature probe. The temperature measuring device must be rapidly equilibrating, precision-grade, and meet or exceed National Bureau of Standards (NBS) specifications for accuracy. Temperature will be measured and recorded in degrees Celsius/Centigrade (° C). If the temperature measuring device is a meter, then the manufacturer's instrument manual, which is maintained with the instrument, will be referred to for calibration, use, repair, maintenance, or trouble-shooting operations.

Temperature data is collected in the field to determine the temperature of the water sample under ambient (in situ) conditions. Temperature data can be used to evaluate the mobility of compounds in ground water and flow conditions. In addition, temperature measurements can be used during well purging to help determine when sufficient ground water has been purged (removed) from a well (i.e., the standing water in the well has been removed and replaced with "fresh" water from the aquifer). The determination is made when temperature readings have achieved stabilization or near-stabilization.

2.0 CALIBRATION

2.1 Calibration of thermometers and temperature measuring meters will be performed before entering the field and checked upon return to the office.

2.2 Temperature measuring devices will be calibrated against a NBS-traceable thermometer.

2.3 If a thermometer is used to measure temperature, then the thermometer must read within 1° C to 1.5° C of the NBS-traceable thermometer. If the thermometer does not read within this range and the thermometer cannot be calibrated, then it will not be used for temperature measurements and will be disposed of in an appropriate manner. If the thermometer does not read within this range and the thermometer can be calibrated, then the thermometer will be calibrated to the NBS-traceable thermometer.

2.4 If a temperature measuring meter is used to measure temperature, then the meter must read within 1° C to 1.5° C of the NBS-traceable thermometer. If the meter does not read within this range and the meter cannot be calibrated, then it will not be used for temperature measurements and will be sent to the manufacturer for service and repair. If the meter does not read within this range and the meter can be calibrated, then the meter will be calibrated to the NBS-traceable thermometer.

2.5 The following information is documented in the calibration logbook at the time of calibration:

a. Date.

b. Thermometer and/or Meter identification.

c. Calibration results relative to NBS-traceable thermometer.

d. Initials of individual performing calibration.

3.0 PROCEDURE

3.1 The water sample (approximately 500 milliliters [ml]) is placed in a clean container and the temperature is measured immediately.

3.2 If a thermometer is used, then the thermometer is first rinsed with distilled or deionized water and is then immersed in water until the temperature equilibrates. The temperature is read in °C. The thermometer is rinsed again after measuring the temperature.

3.3 If a temperature measuring meter is used, then the probe is first carefully rinsed with distilled or deionized water. The probe is then immersed in water according to the manufacturer's specifications (e.g., specified submergence, stirred) until the temperature equilibrates. The temperature is read in °C. The probe is rinsed again after measuring the temperature.

3.4 Temperature data are recorded in the field notebook or appropriate field form, and initialed and dated.

CONDUCTING A STEP-DRAWDOWN TEST

300334

Revised: July 10, 1998 Revision Number: 1

1.0 PURPOSE

The purpose for this standard operating procedure (SOP) is to describe the methods to be used for conducting step-drawdown (step) tests. The step tests will be used to select an appropriate pumping rates for the 48-hour constant-rate (pumping) tests.

Pumping is started at a low discharge rate (based on the results of well development) and is then increased in steps to stress the aquifer. It is important that the water level equalizes during each step and that a fairly wide range in pumping rates be developed from the first step to the last step. Water-level behavior in the pumping well should be closely watched during the test. If at a second or third step, the pumping water level drops sharply and approaches the maximum available drawdown, then clearly the pumping rate has exceeded the capacity of the formation and the long-term pumping rate must be reduced accordingly.

2.0 EQUIPMENT AND MATERIALS

2.1 The following items may be needed for conducting a step-drawdown test:

a. Electronic sounding device (m-scope).

b. Data loggers and pressure transducers.

c. Field forms (i.e., Daily Log, Pumping Test, and Well Inspection Checklist) and study notebook.

d. Rain gauge.

e. Barometer.

f. Stop watch or watch with second display/hand.

g. Pump.

h. Generator and fuel/power supply.

i. Water-level recorders (e.g., Stevens type).

j. Flashlights/illumination.

k. Stream gauge and/or tide gauge.

l. Shelter.

m. In-line flow meter and/or orifice and manometer.

n. Valve(s).

o. On-site holding tanks or tank trucks, or treatment capability.

p. Discharge line (leak free).

q. Water-quality meters (pH, conductivity, temperature).

r. Extra batteries (flashlight, meters).

s. Non-absorbent cord (e.g., polypropylene).

t. Portable personal computer (PC), appropriate cables, software, and floppy disks.

u. Five-gallon bucket.

v. Clean cloth or paper towel.

w. Non-phosphate, laboratory-grade detergent solution.

x. Distilled or deionized water and potable water.

y. Required health and safety monitoring equipment.

3.0 DECONTAMINATION

3.1 Make sure all equipment that enters the well(s) is(are) decontaminated and cleaned before use. Use new, clean materials when decontamination is not appropriate (e.g., non-absorbent cord, disposable gloves). Document, and initial and date the decontamination procedures on the appropriate field form (e.g., Daily Log) and in the field notebook. Refer to the SOP for the decontamination of field equipment for specific proceedures.

4.0 PROCEDURE

4.1 Inspect the protective casings of the wells and the well casings, and note any items of concern such as a missing lock, or bent or damaged casing(s). Complete a Well Inspection Checklist for each well, and initial and date upon completion.

4.2 Enter all pertinent data concerning the pumping well, piezometers and/or observation wells, to be measured on the Pumping Test form, appropriate field forms (e.g. Daily Log form) and in the field notebook. Use one Pumping Test form for each well measured.

4.3 Measure water levels (the depth to water below the predetermined measuring point [MP]) in the test well, and all piezometers and/or observation wells to be monitored during the test (synoptic round of water-level measurements) to an accuracy of 0.01 foot prior to the step test. Document the water levels, and initial and date data entries. The synoptic round of water-level measurements will include wells and piezometers inside and outside of the influence (impact) of the area tested.

4.4 Sound (measure the total depth) the test well, and each observation well and/or piezometer measured in the synoptic round to an accuracy of 0.01 foot. Document

the sounded depth, and initial and date data entries. Compare the sounded depth to the as-built total depth of the well/piezometer to ensure no appreciable sanding or silting (clogging) has occurred. If appreciable clogging has taken place, then the well or piezometer must be redeveloped to re-establish good hydraulic connection between the well or piezometer and the aquifer. Wells and piezometers must respond quickly to changes in water levels.

4.5 Determine if the step test is to be conducted in an area where water levels can fluctuate during the course of the test (e.g., near pumping or recharge wells, tidal influences, shallow aquifers subject to quick response to precipitation events, etc.); if so, then establish a background well(s) or piezometer(s) to measure water-level trends outside the influence of the test well. Water-level fluctuation data may be needed to correct step-test data.

4.6 Set up a rain gauge, a continuous recording barometer, and/or a continuous recording stream or tide gauge to measure, respectively, precipitation, barometric pressure, and/or surface-water elevation, if site conditions warrant monitoring these parameters (i.e., if any of these stresses have the potential to affect test results). If needed, data from these instruments will be used to correct step-test data for changes in ground-water levels associated with recharge from precipitation, barometric pressure, and/or changes in surface-water elevation.

4.7 Ensure that the pumping system selected for the test is properly installed including the power supply and leak-free discharge line complete with a valve(s), flow meter, and manometer and orifice.

4.8 Water generated during the step-drawdown test will be stored in aboveground tanks and disposed after the tests are completed. More detailed disposal procedures will be outlined in a technical memorandum prior to starting the tests.

4.9 Make sure that the proper transducers (data loggers) and gear ratios (water-level recorders) are used to measure the full anticipated range of drawdown in the well(s) and/or piezometer(s).

4.10 Install a precleaned transducer (which is preferred over manual measurement devices, e.g., steel tape and chalk or m-scope) in the test well, connect it to the data logger, and verify that the equipment is working. Program the data logger accordingly, using the PC and appropriate software.

4.11 Install precleaned transducers and program data loggers, and/or install precleaned floats/probes and set up recorders in select piezometers and/or observation wells to be monitored during the test (e.g., those impacted by the test, those serving as background), and verify that the equipment is working.

4.12 Synchronize all watches prior to the test (if more than one individual is involved in the test).

4.13 Begin the step test on the hour or half-hour and pump at a constant, low rate (e.g., 25 percent of the estimated capacity determined during development).

4.14 Maintain the pumping rate until the water level approaches or achieves stabilization (which usually, but not necessarily, occurs within one to four hours).

4.15 Collect water-level (drawdown) measurements to an accuracy of 0.01 foot on a specified schedule. This schedule will be established based on the response (drawdown versus time) of the well to the pumping stress.

4.16 Check the drawdown measurements obtained with the automated water-level measuring devices (on a regular basis) manually using a m-scope and/or a steel tape and chalk to an accuracy of 0.01 foot. If recorders are used, then "tick" the recorder and document the time next to each "tick" on the chart. Record this data on the Pumping Test form and in the field notebook, and initial and date data entry.

4.17 Check the discharge rate using a 5-gallon bucket and stopwatch or watch with second display/hand, the in-line flow meter and/or manometer (depending on the set-up and pumping rate) on a regular basis. Record readings and adjustments (if made) on the Pumping Test form and in the field notebook, and initial and date data entry.

4.18 Measure temperature, pH, and conductivity of discharged water on a periodic, regular basis. Record data on the Pumping Test form and the field notebook, and initial and date data entry.

4.19 Note any changes, throughout the step test, that are pertinent to the test such as changes in water color or turbidity, time and length of any temporary pump shut down, effects of any nearby pumping wells, precipitation events, etc. Document these notes on the Pumping Test form and in the field notebook, and initial and date data entry.

4.20 Increase the discharge rate incrementally after stabilization or near-stabilization is achieved and maintain the increased rate for the same length of time, if the well can sustain the increased rate. In general, four or more incremental steps follow, such as two, three, four (100 percent of the estimated capacity), and greater than four times the initial rate. The key factors are that the steps be of equal duration and that a fairly wide range in pumping rates be developed from the first step to the last.

4.21 Shut down the step test after the last step and/or the capacity of the well has been exceeded, or when sufficient data has been collected to analyze the step test. Close the valve closest to the pump as quickly as possible to prevent back flow of water into the pumping well.

4.22 Measure recovery (rise in water levels) to an accuracy of 0.01 foot until water levels return as close as possible to pretest levels. The identical measurement schedule followed for the drawdown phase should be followed during the recovery phase. Automated water-level recorders may be left in the test well and select wells/piezometers to monitor water levels for an extended period of time (one or more days) depending on the data collected or data base required. If observation wells and/or piezometers were also monitored during the step test, then collect at least one round of synoptic water-level measurements after water levels have recovered following the test.

300338

4.23 Transfer the data to the PC, if the pressure transducer(s) and data logger were used, on a periodic basis during the test and before monitoring water levels for an extended period of time. This will prohibit loss of test data and "wrapping" (writing over) of data if the storage capacity of the data logger is exceeded.

4.24 Secure the test well, and observation wells and/or piezometers if used, after the collection of water-level data is completed (i.e., replace cap and/or cover, and lock).

4.25 Clean (decontaminate) all test equipment that came in contact with the ground water according to the appropriate protocol given in Section 3.0. Dispose of all materials that cannot be decontaminated in an appropriate manner (e.g., discharge hose, etc.).

CONDUCTING A CONSTANT-RATE (PUMPING) TEST AND RECOVERY TEST

300340

1.0 PURPOSE

The purpose for this standard operating procedure (SOP) is to describe the methods to be used for conducting constant-rate (pumping) tests and recovery tests. Constant-rate tests are designed to measure the response of an aquifer to stress imposed on it (i.e., pumping or injection of water). In the constant-rate test, the well is pumped or recharged at a constant rate for a significant period of time, usually 24 hours or longer. Pumping tests are conducted to quantify hydraulic coefficients and characterize boundary conditions. Pumping tests can also be used to qualitatively or quantitatively evaluate the degree of hydraulic connection between and within flow systems which is particularly applicable to bedrock ground-water systems where hydraulic parameter determination may not be possible.

Drawdown is measured throughout the test at preselected time intervals to provide the data necessary to quantitatively characterize the aquifer. Automatic water-level records may be used which provide a detailed, continuous drawdown record and are periodically checked by manually measuring the water level with a steel tape and chalk or an electronic sounding device (m-scope).

Pumping tests are generally the easiest aquifer tests to interpret, and can provide the most accurate, quantitative information; thus pumping tests are favored when conditions are suitable (i.e., when hydrogeologic conditions are such that the system can sustain a properly designed constant-rate pumping test).

Measurements of water-level recovery after the pump is shutdown may be used to confirm the results of the drawdown test. Additionally, problems such as those created by a fluctuating pumping rate and corresponding drawdown measurements during the drawdown phase can be eliminated during the recovery phase (which is not effected by pumpage). Therefore, data loggers and/or the automatic recorders should remain in operation to measure the extended recovery period of the water levels to provide a suitable database in the event that recovery data analysis is undertaken.

2.0 EQUIPMENT AND MATERIALS

2.1 The following items may be needed for aquifer testing:

a. Electronic sounding device (m-scope).

b. Steel tape (in 0.01-foot increments) and chalk (e.g., blue carpenter's).

c. Data loggers and pressure transducers.

d. Field forms (i.e., Daily Log, Pumping Test, and Well Inspection Checklist) and study notebook.

e. Rain gauge.

300341

f. Barometer.

g. Stop watch or watch with second display/hand.

h. Pump.

i. Extension cord(s) or generator and fuel/power supply.

j. Water-level recorders (e.g., Stevens type).

k. Flashlights/illumination.

l. Stream gauge and/or tide gauge.

m. Shelter.

n. In-line flow meter and/or orifice and manometer.

o. Valve(s).

p. On-site holding tanks or tank trucks, or treatment capability.

q. Discharge line (leak free).

r. Water-quality meters (pH, conductivity, temperature).

s. Extra batteries (flashlight, meters).

t. Non-absorbent cord (e.g., polypropylene).

u. Portable personal computer (PC), appropriate cables, software, and floppy disks.

v. Five-gallon bucket.

w. Clean cloth or paper towel.

x. Non-phosphate, laboratory-grade detergent solution.

y. Distilled or deionized water and potable water.

3.0 DECONTAMINATION

3.1 Make sure all equipment that enters the well(s) is(are) decontaminated and cleaned before use. Use new, clean materials when decontamination is not appropriate (e.g., non-absorbent cord, disposable gloves). Document, and initial and date the decontamination procedures on the appropriate field form (e.g., Daily Log) and in the field notebook. Refer to the SOP for the decontamination of field equipment for the specific decontamination procedures.

300342

4.0 PROCEDURE

4.1 Inspect the protective casings of the wells and the well casings, and note any items of concern such as a missing lock, or bent or damaged casing(s). Complete a Well Inspection Checklist for each well, and initial and date upon completion.

4.2 Enter all pertinent data concerning the pumping well, piezometers and/or observation wells, to be measured on the Pumping Test form, appropriate field forms (e.g. Daily Log form) and the study notebook.

4.3 Measure water levels (depth to water below a predetermined measuring point [MP]) in the pumping well and all piezometers and/or observation wells (synoptic round of water-level measurements) to an accuracy of 0.01 foot at least one day prior to the pumping test. Document the water levels, and initial and date data entries. The synoptic round of water-level measurements will include wells and piezometers inside and outside of the influence (impact) of the area tested.

4.4 Sound (measure the total depth) the test well and each well and/or piezometer measured in the synoptic round to an accuracy of 0.01 foot. Document the sounded depth, and initial and date data entries. Compare the sounded depth to the as-built total well/piezometer depth to ensure no appreciable sanding or silting (clogging) has occurred. If appreciable clogging has taken place, then the well or piezometer must be redeveloped to re-establish good hydraulic connection between the well or piezometer and the aquifer. Wells and piezometers must respond quickly to changes in water levels.

4.5 Establish background wells and/or piezometers to measure water-level trends outside the influence of the pumping well.

4.6 Install precleaned transducers and program data loggers, and/or install precleaned floats/probes and set up recorders on several, select wells and/or piezometers for an extended period of time prior to the test to monitor water-level trends throughout the test area. At least two hours of readings at quarter-hour to half-hour intervals should be collected immediately prior to start-up of the test. If water levels in the aquifer are fluctuating, then more readings will be necessary. Water-level fluctuation data may be needed to correct aquifer test data.

4.7 Obtain as many pretest (nonpumping), synoptic water-level readings as possible to provide a sound background water-level data base. If available, dedicate an individual to collect continuous, synoptic water-level measurements on the day of the test, from the time of arrival onsite to the start of the test.

4.8 Set up a rain gauge onsite to measure precipitation before, during, and after the test. Monitor the rain gauge on a regular basis, particularly if the tested aquifer is shallow. If precipitation is occurring at the beginning of the test, then the test should be postponed until optimum meteorological conditions prevail and water levels, if changing, return to static conditions. If needed, precipitation data collected during the test (after start-up) will be used to correct aquifer test data affected by recharge.

4.9 Set up a continuous recording barometer onsite to measure barometric pressure before, during, and after the test. If needed, data from this instrument will be used to correct aquifer test data for changes in barometric pressure during the pumping test.

4.10 Install a stream or tide gauge to measure changes in stream stage or tidal fluctuations before, during, and after the test if the pumping test site is located near a surface-water body. If needed, this data will be used to correct aquifer test data for changes in surface-water body elevations.

4.11 Ensure that the pumping system selected for the test is properly installed including the power supply and leak-free discharge line complete with a valve(s), flow meter, or manometer and orifice.

4.12 Water generated during the pumping tests will be stored in aboveground tanks and disposed after each test is completed. More detailed disposal procedures will be outlined in a technical memorandum prior to starting the tests.

4.13 Make sure that the proper transducers (data loggers) and gear ratios (water-level recorders) are used to measure the full anticipated range of drawdown in the wells and/or piezometers.

4.14 Install a precleaned transducer (which is preferred over manual measurement devices, e.g., steel tape and chalk or m-scope) in the test well, connect it to the data logger, and verify that the equipment is working. Program the data logger accordingly, using the PC and appropriate software.

4.15 Install precleaned transducers and program data loggers, and/or install precleaned floats/probes and set up recorders in select piezometers and/or observation wells to be monitored during the test (e.g., those impacted by the test, those serving as background). Verify that the equipment is working.

4.16 Conduct a step-drawdown (step) test several days before the scheduled constant-rate pumping test to check the performance of the pumping well and establish the pumping rate to be used for the final test. (Refer to the SOP for conducting a step-drawn test.) Use both automatic and manual water-level measuring devices to measure water levels in the wells and record appropriate measurements on the Pumping Test form and in the field notebook. The rate chosen for the pumping test will be the maximum rate the well can produce and sustain in order to stress the aquifer as much as possible.

4.17 Set the discharge line valve(s) so they will be preset and marked for the desired pumping rate (obtained from the step test).

4.18 Check that the in-line flow meter and/or manometer is indicating that the pumping rate is the same as that selected from the step test. It is preferred to use both devices to measure and monitor discharge to provide a check and a back up.

4.19 Begin the pumping test only after the water level in the aquifer has returned to the nonpumping (static) conditions observed prior to the step test.

4.20 Check that all equipment is functioning properly before starting the test (e.g., transducers and data loggers, automated water-level recorders, m-scopes, valves in proper position, generator running properly and sufficient fuel [if needed], power supply, etc.)

4.21 Synchronize all watches prior to the test.

4.22 Begin the pumping test on the hour or half-hour and pump at a constant rate until sufficient data is collected to analyze the test (at least 24 hours or longer if needed). Some pumping tests may require several days (sometimes up to and exceeding 1 week) to collect the data needed to analyze the test.

4.23 Measure water levels (drawdown) on a specified schedule. An example of the frequency of measurements to produce a uniform plot of water-level data on a logarithmic scale follows:

Elapsed Time (minutes)	Frequency of Measurement
0 - 1	Every 15 seconds
1 - 5	Every 30 seconds
5 - 10	Every minute
10 - 30	Every 2 minutes
30 - 60	Every 5 minutes
60 - 120	Every 10 minutes
120 - 180	Every 20 minutes
180 - 360	Every 30 minutes
360 - 1,440	Every hour
1,440 - 2,880	Every 2 hours
2,880 - end of test	Every 4 hours

4.24 Check the drawdown measurements obtained with the automated water-level measuring devices (on a regular basis) manually using a m-scope and/or a steel tape and chalk to an accuracy of 0.01 foot. If a recorder is used, then "tick" recorders and document the time next to each "tick" in the chart. Manual measurements should be made as close to the established schedule as possible. However, if a reading is missed, then take a measurement as soon as possible after the scheduled reading and record the actual time. This will maintain the time versus drawdown relationship needed to analyze the test data. Record water-level data on the Pumping Test form, and initial and date data entry.

4.25 Check the discharge rate using the in-line flow meter and/or manometer on a regular basis. If adjustments have to be made to maintain the constant pumping rate, then adjust the valve. Record readings and adjustments (if made) on the Pumping Test form and the field notebook, and initial and date data entry.

4.26 Measure temperature, pH, and conductivity of discharged water on a periodic, regular basis. Record data on the Pumping Test form and in the field notebook, and initial and date data entry.

4.27 Note any changes, throughout the pumping test, that are pertinent to the test such as changes in water color or turbidity, time and length of any temporary pump shut down, effects of any nearby pumping wells, precipitation events, etc. Document these notes on the Pumping Test form and in the field notebook, and initial and date data entry.

4.28 Measure water levels in the pumping well and as many piezometers and/or wells as practical (to an accuracy of 0.01 foot) following recovery procedures if there is a shutdown, no matter how brief.

4.29 Measure water levels together during a change in personnel for at least one period of measurement to ensure consistency. Note the personnel change and time on the Pumping Test form and in the field notebook, and initial and date data entry.

4.30 Begin plotting the drawdown verses time data, when time allows, on the appropriate graph paper (semi-logarithmic and/or full logarithmic) to perform a preliminary analysis of the data for hydraulic coefficients and determine if the pumping test can be terminated or has to be extended. Correct drawdown data as needed before plotting (e.g., for dewatering, barometric efficiency, tidal fluctuations, regional trends, etc.)

4.31 Shut down the pumping test at the specified time or when sufficient data has been collected to analyze the pumping test data. Shut down should occur on the hour or half-hour so that recovery starts on the hour or half-hour.

4.32 Close the valve (closest to the pump) as quickly as possible to prevent back flow of water into the pumping well.

4.33 Measure recovery (rise in water levels) to an accuracy of 0.01 foot until water levels return as close as possible to pretest levels. The identical measurement schedule followed for the drawdown phase should be followed during the recovery phase. Automated water-level recorders should be left in select wells and/or piezometers (same ones monitored during pretest) to monitor water levels for an extended period of time (one or more days).

4.34 Collect at least one round of synoptic water-level measurements after water levels have recovered following the test.

4.35 Secure all wells and/or piezometers after the collection of water-level data is completed (i.e., replace cap and/or cover, and lock).

4.36 Clean (decontaminate) all test equipment that came in contact with the ground water according to the appropriate protocol given in Section 3.0. Dispose of all materials that cannot be decontaminated in an appropriate manner (e.g., discharge hose, etc.).

SAMPLING POTABLE WATER SYSTEMS

300347

Revised: July 10, 1998

Revision Number: 1

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish guidelines for sampling potable water systems.

2.0 CONSIDERATIONS

The objectives of sampling potable water systems is the evaluation of individual potable water supplies. The potable wells to be sampled are provided in the Phase 2 RI/FS Work Plan. Photographs of all potable water systems will be taken so that sampling results can be properly assessed.

Sampling personnel should contact the homeowner in advance of the planned sampling, unless an on-going sampling schedule has been established. Plumbing modifications must not be made without prior approval of the project manager and the homeowner. If influent quality is desired, then the sampling point must be prior to any treatment equipment or filters. During drought conditions, homeowners may be concerned about the waste of the purge water. In these situations, the field personnel should estimate and purge at least one storage volume, offer to direct the purge water to a useful location (e.g., watering trough, garden, etc.), and bring any purging discrepancies (e.g., unknown well construction, purge volume less than standard, etc.) to the attention of the project manager.

3.0 MATERIALS/EQUIPMENT

a. The Phase 2 RI/FS Work Plan and Field Sampling Plan.

b. Field notebook, field form(s), maps, chain-of-custody forms, custody seals.

c. Laboratory-supplied sample containers with labels.

d. Water quality meters.

e. Cooler with ice.

f. Disposable sampling gloves.

g. Zip-lock bags and packing material.

h. Black pen and indelible markers.

i. Masking and packing tape.

j. Overnight (express) mail forms.

4.0 DECONTAMINATION

Decontamination is typically not necessary, since samples are generally collected directly into laboratory-supplied sample containers. If, however, site conditions require that samples be collected in containers and transferred to sample bottles, then all reusable collection equipment must be of proper construction material and thoroughly cleaned according to the decontamination SOP. The field parameter meters are cleaned by triple-rinsing with distilled water.

5.0 CALIBRATION

The only instruments which require calibration are the field meters. Refer to the manufacturing specifications for specific calibration requirements.

6.0 PROCEDURE

6.1 Estimate the volume of water to be purged from the system. The object is to purge all standing water in pipes, storage tanks, the well, etc., and collect a representative sample of ground water. Make sure the sample is collected before treatment or filtration; do not sample from existing garden hoses; and remove any aeration screens in faucets.

6.2 Measure the temperature, pH, and conductivity, at 5 minute intervals during the purging process. Purge until pH, specific conductivity, and temperature have effectively stabilized for at least 5 minutes. Be sure that all discharge water is directed to a location which is satisfactory to the homeowner.

6.3 After the purge is complete, adjust the discharge rate to obtain a manageable, non-turbulent flow from the desired sampling port.

6.4 Collect the sample directly into the pre-cleaned, laboratory-supplied container. Do not actually touch the sample containers to the sampling port. Do not overfill and wash any preservatives that may be needed out of the container. Volatile organic containers must be filled to the top creating a convex surface with no air bubbles present. Ensure that no bubbles are present by turning the container upside down and tapping gently.

6.5 Label all bottles with client name, site location, sample identification, date and time collected, and sampler's initials.

6.6 After the samples have been collected, labeled, and described, they are placed in zip-lock bags and stored in a cooler at 4°C.

6.7 A chain-of-custody form is completed for all samples collected. One copy is retained and two are sent with the samples in a zip-lock bag to the laboratory. A custody seal is placed on the cooler prior to shipment.

6.8 Samples collected from Monday through Thursday will be delivered to the laboratory within 48 hours of collection. Samples collected on Friday will be delivered to

laboratory by Saturday. Check the Quality Assurance Project Plan to determine if any analytes require delivery in a shorter period of time.

6.9 The field notebook and appropriate forms should include, but not necessarily be limited to the following: client name, site location, sample location, sample identification, date and time collected, sampler's name, purge procedure and volume, method of sample collection, number and type of containers, description of sample quality (e.g., odor, color, etc.), description of decontamination procedures, field measurements (e.g., pH), etc.

6.10 Discard any gloves, foil, plastic, etc. in an appropriate manner that is consistent with site conditions.

HYDROPHOBIC DYE TEST FOR DETERMINATION OF NAPL IN SATURATED SOILS AND GROUND WATER SAMPLES

Field Analysis Manual

State of New Jersey
Christine Todd Whitman
Governor

New Jersey Department of Environmental Protection
Robert C. Shinn, Jr.
Commissioner

July, 1994

The Field Analysis Manual (July, 1994) has been printed on recycled paper.

300352

TITLE: Hydrophobic Dye Test for Determination of NAPL in Saturated Soils and Groundwater Samples (12/93)

I. SUMMARY

The hydrophobic dye test may be used to determine the presence of non-aqueous phase liquids (NAPL) in saturated soils and groundwater. The sample is placed into a polypropylene tube, centrifuged to separate the solid and liquid phases, a hydrophobic dye is added and the mixture is agitated. The liquid phase is then observed to determine whether a NAPL phase is present. The mixture may then be centrifuged again to allow better separation of the liquid phases. Detection capabilities increase as the percent (%) of NAPL increases from one percent to two percent (1% - 2%) or greater. The Data Quality Levels on pages two through ten (2 - 10) should be read prior to using this method.

II. PURPOSE AND SCOPE

To define the minimum standards for a hydrophobic dye test proposal consistent with the Data Quality Levels on pages two through ten (2 - 10).

III. RESPONSIBILITY

The project team is responsible for the review and revision of all site delineation proposals.

IV. METHOD OVERVIEW

A. Application & Advantages

1. Field Screening of Saturated Soils.

2. Field Screening of Groundwater.

3. Provides field personnel with real-time information which may be used in making field decisions regarding site delineation.

4. This method is recommended for site screening when clear, colorless NAPL contamination is of concern.

5. This method expedites the screening process while providing better site definition at a reduced cost.

B. Interferences and Limitations

1. Restrictions of Method

a. The dye test will not identify dissolved contamination in the aqueous phase. Therefore, conventional laboratory methods

should be employed for dissolved contamination.

b. Up to ten percent (10%) false positives and up to fifty percent (50%) false negatives can be expected in samples with less than one percent (<1%) NAPL. False negatives decrease as the NAPL percentage increases. Samples with greater than one percent (>1%) NAPL indicated only two to eight percent (2% - 8%) false negatives. Therefore, conventional laboratory tests should be used where contamination is suspected but the hydrophobic dye test does not indicate the presence of NAPL.

2. Disadvantages of Method

a. The dye is not analyte-specific but should dissolve in organic NAPL without dissolving in the aqueous phase.

b. Sample matrix may cause false positives.

C. Capabilities

1. Compounds Detected: Non-Aqueous Phase Liquids (NAPL)

2. Matrix: Saturated Soils - Screening
Water - Screening

3. Achievable Quantitation Limits: Dependent on sample conditions, one percent (1%) or less NAPL can be detected.

4. The information obtained is qualitative (i.e. presence or absence of NAPL); however, the density of NAPL relative to water can be determined and the volume of NAPL in the sample can be estimated.

5. Effective Use of this technology requires the project team to select appropriate samples for laboratory confirmation. The goal of the laboratory confirmation is to determine that NAPL has been correctly delineated and identified.

D. Instrumentation

1. This method requires polypropylene tubes and a hydrophobic dye (i.e. Sudan IV, an oleophilic dye, from Aldrich Chemical Co.). A centrifuge is required for saturated soils analysis and is optional for groundwater samples. Therefore, the method may not be a true field method for saturated

soils given that centrifuges are generally not field portable.

E. Practical Considerations

1. Cost per Sample (Approximate): less than $10.00

2. Time Required per Sample: less than 15 minutes

3. Quality of Data (Level): Level 1

4. Difficulty of Procedure: Simple

5. Laboratory Method Equivalent: None Certified

V. METHOD PROCESS

A. Sampling Considerations

1. This method may be used only for screening purposes during the initial characterization sampling and monitoring phase to determine the presence of NAPL. Confirmation of the absence of NAPL may be required in accordance with the Technical Requirements for Site Remediation, N.J.A.C. 7:26E, section 2.1.

2. Delineation sampling frequency should be in accordance with the Technical Requirements for Site Remediation, N.J.A.C. 7:26E.

3. The results produced by this method are qualitative; however, the density relative to water and approximate volume of NAPL in the sample can be determined.

B. Sampling Procedures

1. Collect one hundred and seventy-five (175) ml of solid or thirty-five (35) ml of liquid sample.

2. Samples should be collected with teflon or stainless steel utensils and placed into polypropylene tubes.

3. Set samples aside for preparation.

C. Field Operations

1. Prepare samples via weighing, centrifuging (soil samples), adding hydrophobic dye and shaking the tubes. Note: Centrifugation may preclude performance in the field.

2. Observe the samples directly for evidence of two

(2) phases (i.e. one [1] dyed phase and one [1] clear, colorless phase).

3. Centrifuge the liquid phase and observe the samples directly for evidence of two (2) phases. Note: Centrifugation may preclude performance in the field.

D. Quality Assurance/Quality Control

1. A brief method summary is required.

2. The sample location, depth and matrix should be documented along with the sample collection time and date and field analysis time and date.

3. Collection and analysis of uncontaminated samples from site matrix should be performed each day to document matrix interference.

4. Sample duplicates should be performed in the field to document method repeatability at the rate of at least one (1) for every twenty (20) samples.

5. Confirmation of field analysis should be provided in accordance with the Technical Requirements for Site Remediation, N.J.A.C. 7:26E.

6. One (1) method blank and rinsate blank should be field analyzed daily.

7. One (1) blank standard should be performed daily.

VI. DATA INTERPRETATION AND REPORTING

A. A hard copy of all observations of liquid phases should be included as a QA/QC Section Deliverable.

B. A field data log should include: date, time, matrix description (i.e. soil type or groundwater description), temperature, location, depth, field technician's name, field analyst's signature (certifying results), and observations of liquid phases.

C. Data summary sheets should be included as a separate section of the site assessment report. These sheets should include: sample location, sample depth, observation of liquid phases, and laboratory confirmation results (where applicable).

D. All results should be plotted on a scaled area (or site) map.

E. Required QA/QC Deliverables

1. Chain of custody or sample tracking documentation for every sample collected and analyzed in the field. Documentation should be provided at the end of the final data report.

2. Sample Data Packages should contain the following information: Sample results, sample matrix results and blank results.

VII. Health and Safety Considerations

A. Potential Physical Hazards - The instrumentation utilized pose no unusual physical health or safety considerations; however, all manufacturer warnings and cautions should be observed.

B. Potential Chemical Hazards - There are no unusual chemical health or safety considerations specifically pertaining to the use of the hydrophobic dye test; however, the toxicity or carcinogenicity of the compounds used in this method are not always defined precisely. Therefore, each chemical compound should be treated as a potential health hazard. Exposure to these chemicals should be reduced to the lowest possible level by whatever means available. The analytical team is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of material safety data sheets (MSDS) should also be made available to all personnel involved in the chemical analysis.

VIII. References

1. Cohen, R. M., Bryda, A. P., Shaw, S. T., Spalding, C. P. "Evaluation of Visual Methods to Detect NAPL in Soil and Water", GWMR, Fall 1992. pp. 132-139

2. Cohen, R. M., Mercer, J. W. "DNAPL Site Evaluation", USEPA/600/R-93/022, February, 1993. pp. 7.6, 9.31 and 9.38 - 9.46

SCREENING NAPL SAMPLES

Date: July 10, 1998

Revision Number: 0

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish the guidelines for field screening soil and water samples for NAPL. The field screening results will be used to make decisions concerning sample locations and well screen intervals.

The rationale for selecting samples for field screening is provided in the Field Sampling Plan. Two types of field screening will be conducted; a hydrophobic dye test and an ultraviolet (UV) fluorescence test.

2.0 DECONTAMINATION

All sampling equipment and reusable laboratory equipment used in the field screening process must be decontaminated in accordance with the SOP for the decontamination of field equipment.

3.0 PROCEDURE

3.1 The sample will first be screened using New Jersey Department of Environmental Protection's SOP for the *Hydrophobic Dye Test for Determination of NAPL in Saturated Soils and Ground Water*. A copy of this SOP is provided in Appendix A of this report.

3.2 If the hydrophobic dye test indicates the presence of NAPL, note the results of the test in the field book.

3.3 If the hydrophobic dye test is positive, no further field screening is required.

3.4 If the hydrophobic dye test is negative and the sample is an aqueous sample or is composed of a dark soil (i.e., dark brown, dark gray, black or dark olive) the sample will be screened using UV fluorescence. If the sample is a soil sample that is light in color (i.e., pale olive, light brown, light gray) UV fluorescence will not be effective and therefore will not be screened using the UV fluorescence method.

3.5 If the sample being screened is a soil sample, place a portion of the sample in a clear plastic bag.

3.6 In a dark room, place the bag under a UV light and manipulate the sample with your hands. If the sample fluoresces, the presence of NAPL is confirmed. If there is no fluorenscense it is unlikely that NAPL si present in the sample.

3.7 Record observations in the field book.

3.8 If the sample is a water sample, place it in a clear glass jar and place the jar under the UV light. If the sample fluoresces, NAPL is present.

3.9 If the sample does not fluoresce, shake the sample and re-screen the sample under the UV light. If the sample does not fluoresce, it is unlikely that there is NAPL in the sample.

3.10 Record all observations in the field book.

4.0 MATERIALS/EQUIPMENT

4.1 Hydrophobic Dye Shake Test

Refer to the NJDEP hydrophobic dye shake test procedure provided in Appendix A for the necessary equipment.

4.2 UV Fluorenscence

a. Field Sampling Plan.

b. Health and Safety/Contingency Plan

c. Field notebook.

d. Decontaminationsupplies.

e. Stainless steel spoon to handle samples.

f. Plastic bags.

g. Clear glass jars.

h. Gloves.

i. Sample labels.

j. Broad-spectrum UV lamp.

k. Dark area to screen samples.

DESCRIPTION OF SOILS USING THE BURMISTER SYSTEM

BROS STANDARD OPERATING PROCEDURE FOR THE DESCRIPTION OF SOILS USING THE BURMISTER SYSTEM

Date: July 10, 1998 Revision Number: 0

1.0 PURPOSE

The purpose of the Standard Operating Procedure (SOP) is to establish guidelines for the description soils. These guideline will result in consistent descriptions of the site soils when logged by more than one individual. The SOP is applicable to drill cuttings, split spoon samples, surface soil samples and hand auger cuttings.

2.0 PROCEDURE

Start the description with the color, first letter of first color capitalized (e.g., Brown, Yellow brown, Yellow and brown). The color should be the same as field description, since with oxidation the color sometimes changes between the time the sample is recovered and when it is viewed in the laboratory.

Determine the primary component (e.g. sand, gravel, or silt) and whether the component represents 50% (by weight) or more of the sample.

2.1 If more than 50% sand, the word sand gets fully capitalized. Preceding the word sand, are the terms coarse, medium and/or fine as follows:

a. If there are approximately equal amounts of coarse, medium and fine sand, the description reads "coarse to fine SAND". If there is more coarse sand, the description reads "coarse (+) to fine SAND". The same hods true to the fine sand predomination. If medium sand predominates, the description reads "coarse medium (+) to fine SAND". In order for a term coarse, medium or fine to be included in a description, it must represent at least 10% of the sand. For example, if a sample contains 70% sand, the sample must contain at least 7% of coarse sand for the word coarse to be included in the description. The above usage of coarse, medium and fine applies to gravel as well as sand.

b. The differentiation between coarse and fine silt shall not be made.

c. A comma always appears immediately after the word sand. Next comes the adjective giving the approximate percentage of soil by weight passing the #200 sieve as follows:

and:	35-50%	some:	20-35%
little:	10-20%	trace:	1-10%

with a (+) sign indicating the upper third of percentage, a (-) sign indicating the lower third of percentage, and no sign indicating the middle third of percentage. Next comes a descriptive of the soil passing the #200 sieve, based exclusively on plasticity as follows:

PI	Description	Organic
0 - 1%	Silt	(Non-Plastic)
1 - 5%	Clayey Silt	(Slight P.I.)
5 - 10%	Silt and Clay	(Low P.I.)
10 - 20%	Clay and Silt	(Medium P.I.)
20 - 40%	Silty Clay	(High P.I.)
40% and more	Clay	(Very High P.I.)

If the soil is organic, the term Organic Silty is used instead of the terms listed under "Description" and the terms listed under "Organic" are used at the very end of the full description (in parenthesis).

a. A comma is placed immediately after the term describing the soil passing the #200 sieve (e.g. Silt and Clay). Next the usage of and, some, little or trace (with a (+) or (-) if needed) is used to indicate the percent of gravel, followed by the use of coarse, medium and/or fine to describe the gravel gradation, with the word gravel always using a capital "G".

b. An illustration of description of a soil having more that 50% sand is as follows:

Brown coarse to fine SAND, little Clayey Silt, some (-) medium to fine (+) Gravel.

2.2 If the major component is less than 50% of the total sample, the description is written exactly as above (with sand coming first), except that in the word sand, only the S is capitalized rather than the full word.

2.3 <u>If there is more than 50% gravel</u>, the description once more starts with the color, followed by the applicable terms of coarse, medium and fine, followed by the word GRAVEL in all capitals.

a. The adjective giving the percentage of all the soil except gravel is placed after the word gravel, and then a comma (e.g. if there is 62% gravel, a partial description would be "Brown medium to fine (+) GRAVEL and (-),...."). The sand is then described by coarse, medium and/or fine without its own percent adjective (with only the S in sand being capitalized). A comma is placed immediately after the word Sand, after which the soil passing the #200 sieve is indicated with the adjective for percentage as given in Item 1b above.

b. An example is: Gray medium to fine (+) GRAVEL and (-), coarse to fine Sand, trace Silt.

2.4 If there is more than 50% passing the #200 sieve, the description once more starts with the color, followed by the #200 description based exclusively on plasticity as follows:

PI	Description	Organic
0 - 1%	Silt	(Non-Plastic)
1 - 5%	Clayey Silt	(Slight P.I.)
5 - 10%	Silt & Clay	(Low P.I.)
10 - 20%	Clay & Silt	(Medium P.I.)
20 - 40%	Silty Clay	(High P.I.)
40% and more	Clay	(Very High P.I.)

If the soil is organic, the term Organic SILT is used instead of the terms listed under "Description", and the terms listed under "Organic" are used at the very end of the full description (in parentheses).

a. The description is written as discussed in Section 3, with sand preceding gravel.

b. An example is: Brown Clayey SILT some (+), coarse to fine Sand, trace fine Gravel.

c. In the foregoing example, if the fines are organic the identification would be:

d. Brown Organic SILT some (+), coarse to fine Sand, trace fine Gravel (Slight P.I.).

2.5 If pockets, layers, etc., of other soil are present in the sample, include it at the end of the previously written description with a comma at the end of the previously written description.

2.6 If closely layered (partings, seams, or layers) soils, such as varied clays, are involved, each layer must be completely identified along with a sketch in the remarks column showing layer thickness.

2.7 Organic soils are identified as Organic Silt (as previously described) or as Peat.

a. Characteristics of Organic Silt are:

(1) Usually light gray to very dark gray (or black) color

(2) Odor caused by decomposition of plant or animal life imparting H_2S, CO_2 and other organic gases

(3) Plastic properties, usually very compressible

(4) May contain shells and fragments of partly decayed vegetable matter

b. Characteristics of Peat are:

(1) Fibrous aggregate of undecayed or partially-decayed vegetable matter, found in swamps

(2) Frequently contains organic silt

(3) Usually light brown to black in color

(4) Distinctive odor, as for organic silt

3.0 MATERIALS

a. Phase 2 RI/FS Work Plan and Field Sampling Plan

b. Health and Safety/Contingency Plan

c. Hand Lens

d. Rock Color Chart

e. Gloves

f. Stainless steel spoons or spatulas

BENTHIC MACROINVERTEBRATE SAMPLING

1.0 PURPOSE

The following procedure will be used to collect benthic macroinvertebrate samples for community or laboratory analysis. Documentation of each sampling event will be recorded in a bound field book and will include: location, date, time, weather, sampler's names, sampling equipment, field measurements, and sample descriptions. Benthic macroinvertebrate samples are collected from sediment grabs which are collected according to the sediment sampling protocol presented in the SOP for collecting stream bed and pond sediment samples.

2.0 PROCEDURE

2.1. Cover hands with protective disposable gloves.

2.2. Collect a sediment sample and place it into a 5 gallon bucket.

2.3. Add surface water to the bucket and swirl to suspend the sediments in a slurry.

2.4. Sieve the slurry through a U.S. Standard No. 30 sieve to separate the macroinvertebrates from these diments.

2.5. For sample collection for laboratory chemical body burdens, follow steps 6 through 13; for samples for community analysis, follow steps 14 through x

2.6. Empty the final sieve contents into a white pan for ease of final separation.

2.7. Separate macroinvertebrates from the sediment samples using stainless-steel forceps.

2.8. Separate macroinvertebrates into groups of target species.

2.9. Place individuals of a target species into a single plastic bag, labeled with the date, time, location, species, and samplers' initials.

2.10. Weigh each sample to evaluate quantity requirements for analysis.

2.11. Continue sediment collection and sieving until sufficient quantity of target organisms is obtained for analysis, if practical. Record the total number of dredge samples collected to assist in benthic macroinvertebrate population estimates.

2.12. Begin the chain-of-custody record.

2.13. Preserve samples in the field by storing them on wet ice but for no more than 24 hours. Freeze samples for shipment to the laboratory for analysis.

2.14. Transfer the macroinvertebrates into pre-labeled plastic containers and preserve with 5-10% formalin.

2.15. Transport samples to laboratory for taxonomic identification

2.16. Decontaminate sampling equipment that contacts samples using decontamination procedures outlined in the QAPP.

2.17. Store the decontaminated sampling equipment in oil-free aluminum foil until next use.

QUANTITATIVE VEGETATION SURVEY PROTOCOL - TRANSECT METHOD

BROS STANDARD OPERATING PROCEDURES FOR QUANTITATIVE VEGETATION CENSUS PROTOCOL - TRANSECT METHOD

1. Transects will be established within representative areas of the selected covertypes. The number of transects to be established will be based on the area of the covertype.

2. Each transect will be delineated with the required length of rope, string or equivalent tied at approximately breast height (above grade) to trees or staking. An alternative is to use flagging tape, tied to vegetation, placed at distances of ten ft for the required transect length. Rope or flagging tape will be numbered or otherwise labeled with the appropriate pre-selected intervals and transect identification.

3. Establish 30 feet by 30 feet sample plots along each transect. Divide each quadrant into four quadrants.

4. Within each quadrant, record dominant species and numbers of individuals in three strata: tree, sapling, and seedling. Trees are defined as any nonclimbing, woody plant that has a diameter at breast height (DBH) > 3.0 inches, regardless of height. Saplings are defined as any woody plant having a height greater than 3.2 feet, but a stem diameter of less than 3 inches, exclusive of woody vines. Record, on a field data form, the species and number of individuals of each species within the sampling plot.

5. Create a representative photograph log of each transect.

FISH SAMPLE COLLECTION BY BEACH SEINE

FISH SAMPLE COLLECTION BY BEACH SEINE

A beach seine is used as an active sampling device or to block fish from escaping areas being sampled by other capture fish methods. A beach seine consists of a net vertically suspended between a float line on top and a weighted line at the bottom. Each end of the net is fastened to a metal or wooden pole. The following procedure will be used to collect free-swimming fish from shallow bodies of water. Documentation of each sampling event will be recorded in a bound field book and will include: location, date, time, weather, sampler's names, sampling equipment, substrate composition, water depth, pH, conductivity, dissolved oxygen, water temperature, and sample descriptions.

1. Identify area to be sampled.

2. With one person holding each end of the seine, the net is quickly swept through the sampling area. Make sure the weighted line drags along the substrate so that fish cannot escape under the net.

3. An optional third person can follow behind the seine as it is being pulled, to free the net from any snags that are encountered.

4. When the end of the sampling segment is reached, the second person swings the outer end of the seine shoreward and continues moving the seine toward the shore until both ends meet at the shoreline.

5. Pull the remainder of the seine toward shore, making sure to keep the lead line dragging along the substrate.

6. Cover hands with protective disposable gloves.

7. Identify fish to species, count, and separate collected organisms by hand into groups of target species.

8. For each individual, record species, total length (in mm), weight (in grams), and observed condition (record noticeable abnormalities or tumors). If more than 25 individuals of a species are collected, the additional fish will not be measured and weighed.

9. Record the total area seined and mean depth for fish density estimates.

10. For individuals that require confirmatory identification in the laboratory, preserve in 70% formalin in the field and replace with 70% ethyl alcohol in the laboratory.

11. Clean the seine by stretching it out in the water and lifting the net out of the water and submerging it three times. Do not use chemicals or soap on the seine.

12. Store the cleaned seine in a plastic bag until next use.

FISH ELECTROSHOCKING PROTOCOL

FISH ELECTROSHOCKING PROTOCOL

Electroshocking is used as an active sampling method to sample fish within prescribed segments of shallow streams, ponds, and lakes for population estimation and chemical analysis. Electroshocking sends an electric current through the water, temporarily stunning the fish. The stunned fish are collected using a scap net. Because an electric current is generated during sampling, several safety precautions must be taken when using an electroshocker to avoid being electrocuted. Electroshocking should not be conducted without knowledge of the safety procedures described below and all equipment should be maintained and operated according to the manufacturer's instructions.

The following procedure will be used to collect fish samples from freshwater surface water bodies. Documentation of each sampling event will be recorded in a bound field book and will include: location, date, time, weather, sampler's names, sampling equipment, substrate composition, water temperature, water depth, pH, conductivity, dissolved oxygen, and sample descriptions.

Safety Precautions

1. All persons in the sampling crew must wear hip boots or chest waders.
2. The person operating the shocker must be familiar with its use and wear rubber insulated gloves protective to 5000W.
3. People, livestock, or pets must not be in the water either upstream or downstream from the sampling site.
4. The electroshocker must not be used during an electrical storm or periods of heavy rainfall.
5. Bare hands should never be allowed to contact water during shocking.
6. If a person slips in the water, turn of the electroshocker immediately.
7. When electroshocking, proceed upstream at a slow pace. Do not chase the fish.

Sampling Procedures

1. Mark off the area to be sampled. For population estimates, block off the upstream and downstream portion of a 25 m segment to reduce potential for immigration and emigration during sampling.
2. Set up the electroshocking equipment according to the manufacturer's instructions (i.e., attach the anode and cathode to the battery)
3. Have all members of the sampling crew put on hip boots or chest waders.
4. Have one person (i.e., the "shocker") operate the backpack or base station electroshocker unit.
5. Adjust the voltage and ampere settings to the appropriate levels for the conductivity and velocity of the water that will be sampled and the size range of the target fish.
6. Adjust the setting for the electroshocker timer to zero.
7. Have the crew members that will collect the shocked fish (i.e., the "scappers") stand by with scap nets.
8. Have all members of the sampling crew enter the water at the downstream end of the stream segment that will be sampled.
9. Facing upstream, the "shocker" moves the cathode through the water by extending it in an upstream direction and pulls it back in a downstream direction. At the same time, the "scappers" position themselves on either side of the "shocker" to capture the shocked fish, and transfer them to collection buckets.

10. The sample crew proceeds in an upstream direction, while moving back and forth across the stream, until the end of the sampling segment is reached. All fish shocked are collected and transferred to the collection bucket.
11. When the end of the sampling segment is reached, the number of electroshocker seconds elapsed during sampling is recorded.
12. Cover hands with protective disposable gloves.
13. Identify fish to species and separate by hand into groups of target species.
14. On each individual, record total length (in mm), weight (in grams), and observed condition (record noticeable abnormalities or tumors).
15. Continue shocking until sufficient quantities of target organisms are obtained for analysis, if practical. For population estimation, prior to returning fish from the first sample collection, shock the same area again and collect all fish. If total number of fish collected during the second collection exceeds the number collected in the first collection, perform a third sampling collection in the same area. If the second collection is less than the first collection, a third sampling is not necessary. Following processing of fish, return fish to water, unless chemical analysis is required.

TRAP NETTING

1.0 PURPOSE

The following procedure will be used to collect free-swimming fish samples from shallow bodies of water. Documentation of each sampling event will be recorded in a bound field book and will include: location, date, time, weather, sampler's names, sampling equipment, field measurements, and sample descriptions.

2.0 PROCEDURE

2.1. Attach a label to the trap net which includes name, address and phone number of samplers, sampling permit number, and date of trap set.

2.2. Fill a porous bag with appropriate bait for the target fish species (bread, cheese, fish, meat, or cake) and attach it in the center of the trap.

2.3. Close the trap and anchor it in the portion of the water body to be sampled and leave in place for a 12 to 24 hour period.

2.4. To collect samples, cover hands with protective disposable gloves and remove the trap from the water. Record the duration of the trap set to assist in population estimation.

2.5. Open the trap by disassembling the halves of the trap and remove the trapped organisms.

2.6. Begin the chain-of-custody record.

2.7. Weigh and measure the total length of target organisms collected and wrap fish for chemical analysis in oil-free aluminum foil.

2.8. Place samples into a plastic bag labeled with the date, time, location, species, and samplers' initials.

2.9. Preserve samples in the field by storing them on wet ice but for no more than 24 hours. Freeze samples for shipment to the laboratory for analysis.

2.10. Decontaminate sampling equipment which contacts samples using decontamination procedures outlined in the QAPP.

2.11. Store the decontaminated sampling equipment in oil-free aluminum foil until next use.

FERROUS IRON FIELD SCREENING

FERROUS IRON FIELD SCREENING

ISO 9001 Certified

HACH COMPANY
PO Box 389 • Loveland, Colorado 80539-0389
970-669-3050 • Fax: 970-669-2932
www.hach.com

The Hach Total Iron (FerroVer Method) pocket colorimeter can be used for the analysis of both total iron and ferrous iron. Instructions are included in the instrument manual for the analysis of total iron. Instructions for the analysis of ferrous iron are not included in the instrument manual. The attached page shows the procedure for ferrous iron analysis in the range of 0-3.00 mg/L using the DR2010 spectrophotometer. The procedure for the pocket colorimeter is nearly identical to this. The user adds a Ferrous Iron Reagent Powder Pillow to a 25 mL sample, waits 3 minutes, zeros the instrument on sample, and reads the reacted sample. The Total Iron pocket colorimeter will read out in units of mg/L iron. If the Ferrous Iron Reagent is used, this will be interpreted to read as mg/L ferrous iron.

The Method Detection Limit (MDL) for the LO range mode is approximately 0.02 mg/L iron. The MDL for the HI range mode is approximately 0.2 mg/L iron. The procedure used to calculate the MDL is in accordance with USEPA's definition in 40 CFR, Part 136, Appendix B. It is important for the user to establish their own detection limit.

Barbara Martin
Technical Support Specialist

300380

Facility Location: 5600 Lindbergh Drive • Loveland, Colorado 80538 USA

METHOD PERFORMANCE

Note: The iron procedures will give the most accurate results when the same two sample cells are used for zeroing and measuring and when a user-calibration has been completed using these same cells.

Precision

LO Range: In a single laboratory using a standard solution of 2.0 mg/L iron and two representative lots of reagents, a single operator obtained a standard deviation of 0.01 mg/L iron on seven replicates for both powder pillow and AccuVac® reagents.

HI Range: In a single laboratory using a standard solution of 4.0 mg/L iron and two representative lots of reagents, a single operator obtained a standard deviation of 0.15 mg/L iron on seven replicates.

Method Detection Limit (MDL)

The MDL for the LO range mode using either powder pillow or AccuVac reagents is 0.02 mg/L iron.

The MDL for the HI range mode using either powder pillow or AccuVac reagents is 0.2 mg/L iron.

The procedure used to calculate the MDL is in accordance with USEPA's definition in 40 CFR, Part 136, Appendix B (7-1-94 edition).

300381

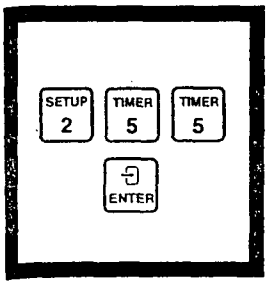
IRON, FERROUS (0 to 3.00 mg/L)

For water, wastewater, and seawater

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

Cat. No.
..... 620-11
..... 21145-00
..... 26-00
... 21846-00
... 17205-00
... 41578-00
... 19700-01
... 21856-96
..... 515-40
..... 515-41
.... 14651-00
..... 563-00
.... 19400-00
.... 19400-10

Using Powder Pillows



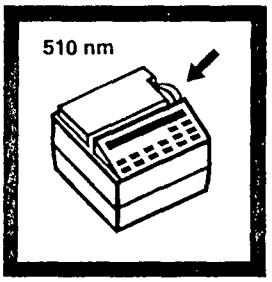
1. Enter the stored program number for ferrous iron, (Fe^{2+})-powder pillows.

Press: **2 5 5 ENTER**

The display will show:

Dial nm to 510

Note: The Pour-Thru Cell can be used with this procedure.



2. Rotate the wavelength dial until the small display shows:

510 nm

When the correct wavelength is dialed in, the display will quickly show: **Zero Sample**

then: **mg/L Fe^{2+}**

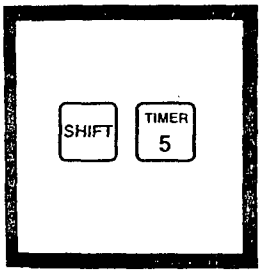
3. Fill a sample cell with 25 mL of sample.

Note: Analyze samples as soon as possible to prevent oxidation of ferrous iron to ferric, which is not determined.

4. Add the contents of one Ferrous Iron Reagent Powder Pillow to the sample cell (the prepared sample). Swirl to mix.

Note: An orange color will form if ferrous iron is present.

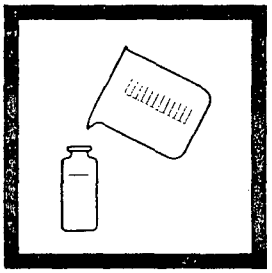
Note: Undissolved powder does not affect accuracy.



5. Press:

SHIFT TIMER

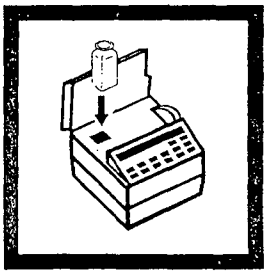
A three-minute reaction period will begin.



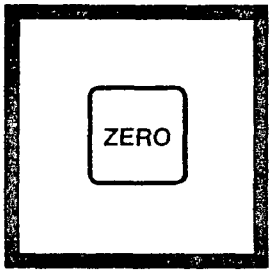
6. When the timer beeps, the display will show:

mg/L Fe^{2+}

Fill a second sample cell with 25 mL of sample (the blank).



7. Place the blank into the cell holder. Close the light shield.



8. Press: **ZERO**

The display will show:

Zeroing...

then: **0.00 mg/L Fe^{2+}**

* Adapted from *Standard Methods for the Examination of Water and Wastewater.*

300382

DOCUMENTATION OF SAMPLE LOCATIONS USING GPS

Documentation of Sample Locations using GPS

GPS is a locating system based on a constellation of 24 satellites orbiting the earth at very high altitude. The satellites transmit radio signals and act as reference points from which ground-based GPS receivers can triangulate their position. The satellites can act as reference points because their orbits are very accurately monitored by ground stations. By measuring the time of travel of radio signals transmitted from the satellites, a GPS receiver on the ground can determine its distance from each satellite. With distance measurements from at least three different satellites, a GPS receiver can calculate its land-based coordinates (e.g., latitude and longitude).

A stand-alone GPS receiver can by itself be used to obtain accuracy's to approximately 100 meters. This accuracy limitation is due to a combination of error factors such as satellite errors, atmospheric interference, local obstructions which distort signals, and most significantly intentional error introduced to the system by the US Department of Defense.

In order to reduce the 100 meter accuracy limitation, differential GPS (DGPS) will be utilized during mapping of sampling points for the Ecological Assessment. DGPS utilizes a stationary reference GPS receiver (reference station) to tie all the satellite measurements into a very accurately surveyed local reference point. The reference station receives the satellite signals and uses its known position to calculate a correction factor for the signals. The reference station then transmits the correction factor to "roving" GPS receivers.

Equipment
In order to use DGPS for locating the sampling locations in Tasks 6c and 9 the following equipment will be utilized:

- a GPS receiver (a hand held unit measuring approximately 4x8x1 inches; and
- a DGPS correction receiver (the size of a "beeper").

The DGPS correction signal is broadcast locally in the Philadelphia area on a sub-band of a local radio station. The DGPS correction receiver then transmits the correction through a wire connection to the GPS receiver. The GPS receiver then uses the correction data to process the satellite signals and determine location coordinates.

Verification of Accuracy and Correction Factor
In order to determine the accuracy of the DGPS system described above, the equipment will be used to obtain coordinates of several monitoring wells at the site. Since the monitoring wells at the Site have been surveyed by New Jersey licensed surveyor to an accuracy of ±1 foot, a comparison of the accuracy of the DGPS system can be made.

The DGPS system will be used to obtain sets of coordinate readings for monitoring wells at the site. The coordinate readings will be stored in memory of the GPS receiver and then subsequently downloaded to a computer spreadsheet file. The latitude and longitude coordinates downloaded from the GPS receiver are expressed in Degrees and Minutes.

To facilitate the comparison of DGPS coordinates with the surveyed monitoring well coordinates, a geographic information system (GIS) will be utilized. In order to use the GIS to determine the

distance of the DGPS coordinates relative to the surveyed well locations, the DGPS coordinates will be converted to decimal degrees. The GIS will then be used to compute the distance from each DGPS point to the corresponding surveyed well. It is anticipated that the sampling locations can be obtained to within ten feet of true location with a 95% confidence level using GPS technology.

SMALL MAMMEL SAMPLING PROTOCOL

Date: July 10, 1998 Revision Number: 0

1.0 PURPOSE

Small mammals will be collected using Sherman live traps according to the procedure outlined below. Documentation of each sampling event will be recorded in a bound field book; notes will include; location covertype description, transect number, date, time, weather, sampler's names, species, sex, weight, and sampling equipment.

1.1 Establish traplines along transects in areas of ground cover of the target sampling area. Mark each trap with sample location and date. space live-traps at approximately 10 m intervals. Transects should include at least 10 stations.

1.2 Set Sherman live traps (size: 2 × 2.5 × 6.5", folding) in the evening. baited with approximately one ounce of either long-cooking rolled oats or a mixture of peanut butter and long-cooking rolled oats.

1.3 Mark the trap location with flagging tape and indicate location on a field map.

1.4 When tending traps, disposable gloves will be worn. Check traps each morning and late afternoon. Rebait and resent any sprung traps that are empty. Identify species in successful traps and release unwanted species. Place traps containing target species in a one lite sealable plastic bag with approximately four ounces of dry ice and eliminate as much air space as possible prior to sealing. Place bag in cooler for at least one hour to asphyxiate.

1.5 After asphyxiation period, weigh, measure, and record data for each sample.

1.6 Wrap individuals of a target species in oil-free foil and place into a single plastic bag labeled with the date, time, location, species, and samplers' initials.

1.7 Complete chain-of-custody record for field activities.

1.8 Preserve samples in the field by storing them on wet ice but for no more than 24 hours. Freeze samples for shipment to the laboratory for analysis.

1.9 Continue trapping until target quantities of organisms are obtained for analysis.

1.10 Record the total number of trapping events required to obtain final sample weight and to assist in population estimates.

THE COLLECTION OF GROUND WATER SAMPLES USING SLOTTED AUGERS

BROS STANDARD OPERATING PROCEDURE FOR THE COLLECTION OF GROUND WATER SAMPLES USING SLOTTED AUGERS

Date: July 10, 1998 Revision Number: 0

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish guidelines for the collection of ground water samples using slotted auger techniques for the purpose of optimizing the placement of monitoring well screen zones for select areas of the BROS Site.

2.0 EQUIPMENT

2.1 The Phase 2 RI/FS Work Plan, Field Operations Plan and Health and Safety/ Contingency Plan.

2.2 Field notebook, maps, chain-of-custody forms and custody seals.

2.3 Decontamination supplies (non-phosphate detergent, buckets, brushes, potable water, distilled water, regulatory required reagents, aluminum foil, plastic sheeting, etc.).

2.4 Disposable latex gloves.

2.5 Dedicated Teflon® bailer.

2.6 Polypropylene rope.

2.7 Laboratory supplied sample containers.

2.8 Cooler with ice.

2.9 Black pen and indelible marker.

2.10 Dedicated, disposable tubing.

2.11 Submersible pump.

2.12 Inflatable packer.

3.0 DECONTAMINATION

All reusable sampling and drilling equipment will be thoroughly cleaned according to the decontamination SOP. Where possible, thoroughly pre-cleaned and wrapped sampling equipment should be used and dedicated to individual sampling locations. Disposable items such as sampling gloves, bailers, tubing, and plastic sheeting will be changed after each use and discharged in an appropriate manner.

4.0 PROCEDURE

4.1 Installation of Slotted Augers:

a. The required slotted auger sampling depths will be preselected based on the information obtained during the installation of a pilot boring, existing boring logs, the depth to water, and the requirements of the Phase 2 RI/FS Work Plan.

b. The cutting end of the slotted auger will be sealed to prevent the infusion of sand into the auger. As such, split spoon samples will not be collected in conjunction with the advancement of the boring.

c. The slotted auger will be advanced to the desired depth and a sample will be collected as described in Section 4.2 of this SOP.

d. The slotted auger will then be advanced to the next sampling zone.

e. When the confining layer between the Upper Middle Potomac-Raritan-Magothy aquifer is reached, a surface casing will be grouted in place. The grout will be allowed to harden before the boring is completed.

f. After the all sampling activities are completed, the boring will be abandoned in accordance with Section 4.3.

4.2 Sample Collection:

a. The depth to water within the auger string will be measured and the volume of standing water will be calculated.

b. A packer will be placed at the top of the screened auger and inflated.

c. A submersible pump will then be lowered into the mid portion of the slotted auger.

d. Three volumes of standing water will be pumped from the lead auger and packer piping.

e. The submersible pump will be removed and the tubing will be properly disposed.

f. Ground water samples will be collected using a dedicated disposable bailer and transferred into laboratory supplied containers.

g. The samples will be placed in a cooler with ice and cooled to 4°C.

4.3 Borehole Abandonment:

a. After all sampling activities are completed the borehole will be tremie grouted to the surface with a cement/bentonite grout. Sufficient grout should be used to allow for settling. The area around the borehole should be cleaned up as best as possible to leave the area in similar condition as it was found. If possible, the borehole should be inspected the following day and additional grout be added to the borehole, if needed, to make the abandonment flush with the ground surface.

b. For each abandoned borehole, the procedure will be documented on the appropriate field form or in the field notebook. Documentation may include, where appropriate, the following.

i) Borehole designation.

ii) Location with respect to existing site features. A location sketch should be prepared.

iii) The total depth of the borehole prior to grouting and any other relevant circumstances (e.g., formation collapse).

iv) Surface casing left in the borehole by depth, size, and composition.

v) A copy of the geologic log.

vi) A revised diagram of the abandoned borehole using a supplemental geologic log form.

vii) Additional items left in hole by depth, description, and composition (e.g., lost tools, bailers, etc.).

viii) A description and daily quantities of grout used to compensate for settlement.

ix) The date of grouting.

x) The level of water or mud prior to grouting and the date and time measured.

xi) Any other state of local well abandonment reporting requirements.

THIN-WALLED TUBE SAMPLING SOILS

Standard Practice for Thin-Walled Tube Sampling of Soils[1]

This standard is issued under the fixed designation D 1587; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This practice has been approved for use by agencies of the Department of Defense and for listing in the DOD Index of Specifications and Standards.

1. Scope

1.1 This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of structural properties. Thin-walled tubes used in piston, plug, or rotary-type samplers, such as the Denison or Pitcher, must comply with the portions of this practice which describe the thin-walled tubes (5.3).

NOTE 1—This practice does not apply to liners used within the above samplers.

2. Referenced Documents

2.1 *ASTM Standards:*

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

3. Summary of Practice

3.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil, removing the soil-filled tube, and sealing the ends to prevent the soil from being disturbed or losing moisture.

4. Significance and Use

4.1 This practice, or Practice D 3550, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of structural properties or other tests that might be influenced by soil disturbance.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment may be used that provides a reasonably clean hole; that does not disturb the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

5.2 *Sampler Insertion Equipment,* shall be adequate to provide a relatively rapid continuous penetration force. For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

5.3 *Thin-Walled Tubes,* should be manufactured as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. and be made of metal having adequate strength for use in the soil and formation intended. Tubes shall be clean and free of all surface irregularities including projecting weld seams.

5.3.1 *Length of Tubes*—See Table 1 and 6.4.

5.3.2 *Tolerances,* shall be within the limits shown in Table 2.

5.3.3 *Inside Clearance Ratio,* should be 1 % or as specified by the engineer or geologist for the soil and formation to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled. See Fig. 1 for definition of inside clearance ratio.

5.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating. Tubes which will contain samples for more than 72 h shall be coated. The type of coating to be used may vary depending upon the material to be sampled. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, and others. Type of coating must be specified by the engineer or geologist if storage will exceed 72 h. Plating of the tubes or alternate base metals may be specified by the engineer or geologist.

5.4 *Sampler Head,* serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube, comprises the thin-walled tube sampler. The sampler head shall contain a suitable check valve and a venting area to the outside equal to or greater than the area through the check valve. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

6. Procedure

6.1 Clean out the borehole to sampling elevation using whatever method is preferred that will ensure the material to be sampled is not disturbed. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the sampling operation.

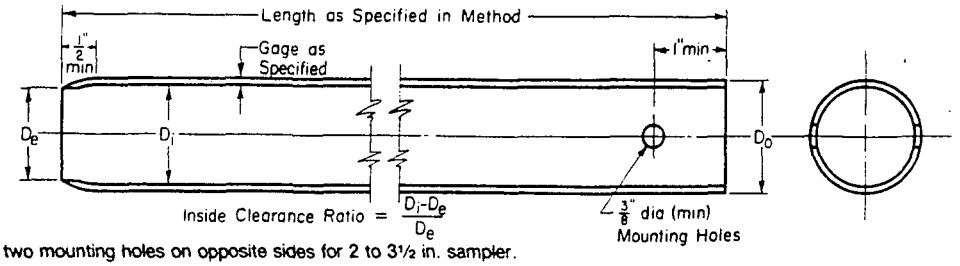
6.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted. Remove loose material from the center of a casing or hollow stem auger as carefully as

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved Aug. 17, 1983. Published October 1983. Originally published as D 1587 - 58 T. Last previous edition D 1587 - 74.

[2] *Annual Book of ASTM Standards,* Vol 04.08.

300393



NOTE 1—Minimum of two mounting holes on opposite sides for 2 to 3½ in. sampler.
NOTE 2—Minimum of four mounting holes spaced at 90° for samplers 4 in. and larger.
NOTE 3—Tube held with hardened screws.
NOTE 4—Two-inch outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for "undisturbed samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalents

in.	mm
⅜	6.77
½	12.7
1	25.4
2	50.8
3½	88.9
4	101.6

FIG. 1 Thin-Walled Tube for Sampling

TABLE 1 Suitable Thin-Walled Steel Sample Tubes[A]

Outside diameter:			
in.	2	3	5
mm	50.8	76.2	127
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.24	1.65	3.05
Tube length:			
in.	36	36	54
m	0.91	0.91	1.45
Clearance ratio, %	1	1	1

[A] The three diameters recommended in Table 1 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

TABLE 2 Dimensional Tolerances for Thin-Walled Tubes

Size Outside Diameter	Nominal Tube Diameters from Table 1[A] Tolerances, in.		
	2	3	5
Outside diameter	+0.007	+0.010	+0.015
	−0.000	−0.000	−0.000
Inside diameter	+0.000	+0.000	+0.000
	−0.007	−0.010	−0.015
Wall thickness	±0.007	±0.010	±0.015
Ovality	0.015	0.020	0.030
Straightness	0.030/ft	0.030/ft	0.030/ft

[A] Intermediate or larger diameters should be proportional. Tolerances shown are essentially standard commercial manufacturing tolerances for seamless steel mechanical tubing. Specify only two of the first three tolerances; that is, O.D. and I.D., or O.D. and Wall, or I.D. and Wall.

possible to avoid disturbance of the material to be sampled.

NOTE 2—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

6.3 Place the sample tube so that its bottom rests on the bottom of the hole. Advance the sampler without rotation by a continuous relatively rapid motion.

6.4 Determine the length of advance by the resistance and condition of the formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays.

NOTE 3—Weight of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 1.

6.5 When the formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. Other methods, as directed by the engineer or geologist, may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

6.6 In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3 in. for sludge-end cuttings.

NOTE 4—The tube may be rotated to shear bottom of the sample after pressing is complete.

6.7 Withdraw the sampler from the formation as carefully as possible in order to minimize disturbance of the sample.

7. Preparation for Shipment

7.1 Upon removal of the tube, measure the length of sample in the tube. Remove the disturbed material in the upper end of the tube and measure the length again. Seal the upper end of the tube. Remove at least 1 in. of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube if so directed by the engineer or geologist.

NOTE 5—Field extrusion and packaging of extruded samples under the specific direction of a geotechnical engineer or geologist is permitted.
NOTE 6—Tubes sealed over the ends as opposed to those sealed with expanding packers should contain end padding in end voids in order to prevent drainage or movement of the sample within the tube.

7.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample. Assure that the

300394

markings or labels are adequate to survive transportation and storage.

8. Report

8.1 The appropriate information is required as follows:

8.1.1 Name and location of the project,

8.1.2 Boring number and precise location on project,

8.1.3 Surface elevation or reference to a datum,

8.1.4 Date and time of boring—start and finish,

8.1.5 Depth to top of sample and number of sample,

8.1.6 Description of sampler: size, type of metal, type of coating,

8.1.7 Method of sampler insertion: push or drive,

8.1.8 Method of drilling, size of hole, casing, and drilling fluid used,

8.1.9 Depth to groundwater level: date and time measured,

8.1.10 Any possible current or tidal effect on water level,

8.1.11 Soil description in accordance with Practice D 2488,

8.1.12 Length of sampler advance, and

8.1.13 Recovery: length of sample obtained.

9. Precision and Bias

9.1 This practice does not produce numerical data; therefore, a precision and bias statement is not applicable.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103. known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

300395

RING-LINES BARREL SAMPLING OF SOILS

300396

Standard Practice for Ring-Lines Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 3550; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

$^{\epsilon 1}$ NOTE—Section 8 was added editorially in November 1991.

1. Scope

1.1 This practice covers a procedure for using a ring-lined barrel sampler to obtain representative samples of soil for identification purposes and other laboratory tests. In cases where it has been established that the quality of the sample is adequate, this practice provides shear and consolidation specimens that can be used directly in the test apparatus without prior trimming. Some types of soils may gain or lose significant shear strength or compressibility, or both, as a result of sampling. In cases like these, suitable comparison tests should be made to evaluate the effect of sample disturbance on shear strength and compressibility.

1.2 This practice is not intended to be used as a penetration test; however, the force required to achieve penetration or a blow count, when driving is necessary, is recommended as supplemental information.

1.3 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

3. Significance and Use

3.1 This practice is used where soil condition and resistance to advance of the sampler do not permit the use of a thin-wall tube (Practice D 1587) and where the formation does not require diamond coring (Practice D 2113).

4. Apparatus

4.1 *Drilling Equipment*—Any drilling equipment may be used that provides a reasonably clean hole before insertion of the sampler and that does not disturb the soil to be sampled. However, in no case shall a bottom-discharge bit be permitted. Side-discharge bits are permissible.

4.2 *Drive Weight Assembly*—Any drive weight assembly that will provide penetration in the range from 1 to 20 blows per foot (65 blows per metre) may be used. Whenever possible, soils are to be sampled by pushing instead of driving (see Section 5).

4.3 *Ring-Lined Barrel Sampling Assembly*—This shall consist of a shoe, sampler, and waste barrel, as shown in Fig. 1.

4.4 *Ring-Lined Sampler*—Test specimens shall be obtained using a suitable one piece or split sampling barrel lined on the inside with removable rings. These rings shall be thin-walled and shall conform to the size requirements of the particular laboratory test determinations employed. They shall fit snugly inside the sampler with no discernible free play in any direction. The sampler may be sectionalized to allow end-to-end make up of sections as necessary. Each section shall be designed so that addition or removal of sections will not loosen, permit movement, or otherwise adversely affect retention of the rings within the sampler. The sampler and rings shall be free of bumps, dents, scratches, rust, dirt, and corrosion.

NOTE 1—It is recommended that the sampler contain at least six rings in order to provide samples for a variety of tests.

4.5 *Waste Barrel*—A waste barrel that can be removed from the sampler in the field shall be provided to contain space for disturbed soil originally at the bottom of the hole. The length of the waste barrel shall be at least three times its interior diameter, and the inside diameter shall be the same, or slightly larger than, the inside diameter of the rings.

4.5.1 An attachment, check valve, and one or more vents is required. The design of these items is optional.

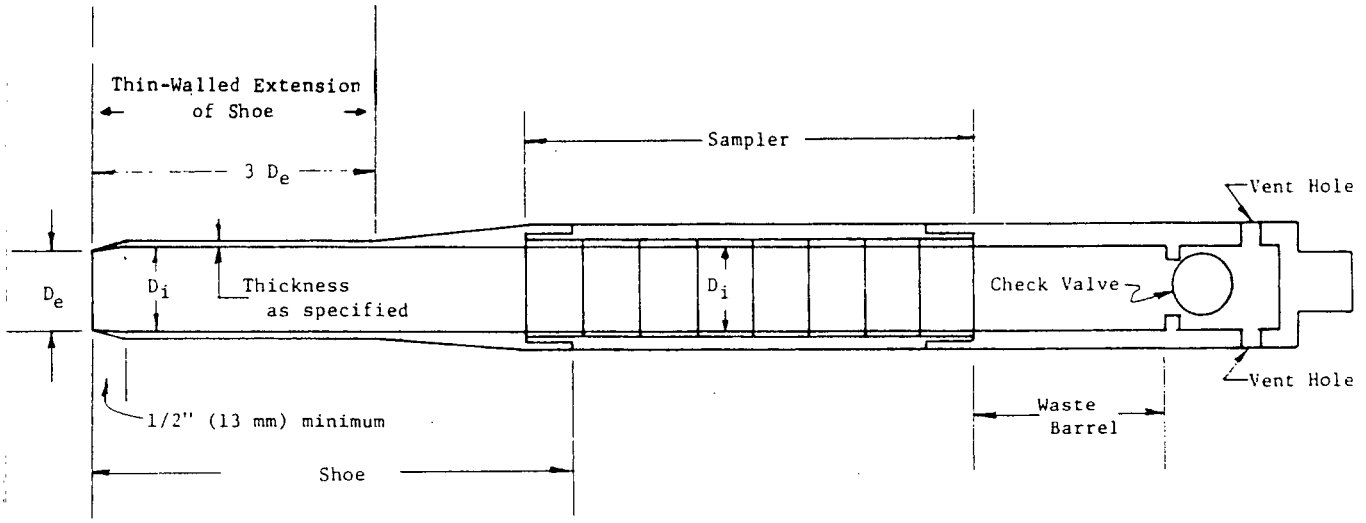
4.6 *Shoe*—The shoe shall be machined as shown in Fig. 1. The inside of the assembled shoe and ring-lined sampler shall be smooth, straight, and uniform. The thin-walled extension of the shoe shall be 2 to 4 in. (51 to 102 mm) in outside diameter and made of any materials of adequate strength and resistance to corrosion. The length of the thin-walled extension shall be equal to three times the diameter of its opening, but shall not exceed 8 in. (203 mm). The inside clearance ratio shall be between 0.5 and 3.0 %. (See Fig. 1 for

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved Jan. 27, 1984. Published April 1984. Originally published as D 3550 - 77. Last previous edition D 3550 - 77$^{\epsilon 1}$.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

300397



NOTE 1—Inside clearance ratio = $(D_i - D_e)/D_e$
NOTE 2—Dimensional tolerance of D_i = ±0.003 in. (±0.08 mm)

FIG. 1 Ring-Lined Barrel Sampling Assembly

inside clearance ratio formula.) The wall thickness of the thin-walled extension shall conform to Table 1.

4.6.1 The thin-walled extension of the shoe shall be perfectly round. Shoes that have become out-of-round for any reason shall not be used. If the thin-walled extension of the shoe deforms during sampling, the sample obtained shall not be used for tests, such as shear strength, where soil disturbance is a factor.

NOTE 2—The thin-walled extension of the shoe is not suitable for stiff or gravelly soils. In cases such as these, a shoe similar to the type specified in Method D 1586 is required for penetration. The use of this type of shoe, however, may result in excessive disturbance of the soil so that it is no longer suitable for shear or consolidation determinations, or both.

4.7 *Sample Extractor*—Specimen-filled rings shall be removed from the sampler by pressing them out or alternatively by the use of a split barrel. The extractor disk shall be at least 0.5 in. (13 mm) thick and shall bear solidly against the sample rings at all points. It shall slide easily inside the sampler barrel without jamming and without free play.

4.8 *Containers for Specimen-Filled Rings*—These shall be snug fitting, tightly sealed (watertight), rigid containers that will not permit movement of the specimen-filled rings inside. They shall be noncorrosive.

4.9 *Miscellaneous Equipment*—This includes a pipe vise, pipe wrenches, spatulas, cleaning brushes, buckets, rags, data sheets, transporting boxes, etc. Water must be available for cleaning the equipment.

5. Procedure

5.1 Clean the hole to sampling elevation using whatever method is preferred that will ensure that the material to be sampled is not disturbed. In saturated sands and silts, withdraw the drill bit slowly to prevent loosening of the soil around the hole. When casing is used, it shall not be driven below sampling elevation. Water or drilling liquid within the boring must be maintained at all times at or above the natural ground water level; it is preferable to keep the hole filled.

5.2 Keep a careful record of drill penetration and sampler depth to ensure that the soil being sampled is the original soil at the bottom of the hole and is not contaminated by soil falling down from the sides of the hole. If there is any significant tendency for soil to fall from the sides of the hole to the bottom, use water, drilling mud, or casing, as necessary, in order to prevent this from happening. The process of jetting through an open-tube sampler and then sampling when the desired depth is reached shall not be permitted. The use of bottom-discharge bits shall not be allowed.

5.3 Assemble the sampling assembly and lower it carefully into the hole. With the cutting edge of the shoe resting on the bottom of the hole and the water level in the boring at the ground water level or above, push the sampling assembly into the soil by a continuous and rapid motion without impact or twisting. Push the assembly in far enough so that all cuttings, sludge, and soil disturbed by drilling are in the waste barrel; however, in no case push the assembly farther than the total length of the shoe, sampler, and waste barrel. Take care that none of the sample is lost due to improper operation of the check valve.

5.4 When the soils are so hard that they cannot be penetrated by pushing, using generally acceptable field procedures, and where recovery by pushing in sands is poor, use a driving hammer to drive the sampling assembly. In such a case, record the hammer weight, height of drop, and number of blows.

5.5 Carefully disassemble the sampling assembly in such a manner as to minimize soil disturbance as much as possible. Trim the soil flush with the ends of the sampling barrel, and remove the specimen (consisting of soil plus rings). Slip the container over the specimen-filled rings and cap both ends. Be certain that there is no movement of the specimen-filled rings inside the container and that the specimen was not disturbed while being removed from the barrel and placed in the container. Label the container in a suitable manner. If the soil in the bottom end ring does not protrude from the ring after removing the shoe, do not use the soil in the

300398

bottom ring for tests other than soil classification and moisture content. If the top ring or rings contain voids, depressions, or any material other than the soil which is being sampled, do not use the soil in this ring (or rings) for any purpose whatsoever. The filling of depressions in the end rings with additional soil shall not be permitted. Discard samples that appear to be disturbed or questionable.

5.6 Examine the soil remaining in the shoe for structure, consistency, color, and condition. Record these observations and include them in the report (see 6.1.8).

NOTE 3—The soil remaining in the shoe is relatively undisturbed and therefore may be suitable for a variety of laboratory tests.

6. Report

6.1 Data obtained in each boring shall be recorded in the field and shall contain the following:

6.1.1 Name and location of job,

6.1.2 Date of boring and times of start and finish,

6.1.3 Boring number and location,

6.1.4 Surface elevation, if available,

6.1.5 Sample number and depth,

6.1.6 Method of advancing sampler, penetration, and recovery lengths,

6.1.7 Description and size of sampler,

6.1.8 Description of soil (see Practice D 2488),

6.1.9 Thickness of layer,

6.1.10 Depth to water table or depth of overlying water and time of reading,

6.1.11 Size of casing, depth of cased hole,

6.1.12 Type of drilling equipment—description,

6.1.13 Names of personnel: crewman, field engineer, technician, etc.,

6.1.14 Weather conditions, and

6.1.15 General remarks.

7. Precision and Bias

7.1 This practice does not produce numerical or repeatable data and therefore a precision and bias statement is not applicable.

8. Keywords

8.1 consolidation; direct shear; identification; liner; representative; ring; sampling

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

300399

COLLECTION OF WETLAND SEDIMENT/SOIL SAMPLES FOR LABORATORY ANALYSIS

Revised: May 20, 1999 Revision Number: 1

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish guidelines for the collection of wetland sediment/soil samples for laboratory analysis. This SOP is applicable to sediment/soil samples collected from hand auger samples, grab samples from sediment, etc.

2.0 CONSIDERATIONS

Wetland sediment/soil samples will be collected in both a random and biased manners. Random samples can be based on a grid system or statistical methodology. Biased samples can be collected in areas of visible impact, suspected source areas or areas where field screening indicates potential impact. Wetland sediment/soil samples can be collected at the surface, shallow subsurface, or at depth. When samples are collected at depth the water content should be noted. Equipment selection will be determined by the depth of the sample to be collected. A thorough description of the sampling locations and proposed methods of sample collection are included in the work plan.

Collection of surface sediment/soil samples is most efficiently accomplished with the use of a stainless steel trowel or scoop. For samples at greater depths a decontaminated bucket auger may be needed to advance the hole to the point of sample collection. When using a bucket auger to advance boring, another clean bucket auger should then be used to collect the sample.

3.0 MATERIALS/EQUIPMENT

a. The Phase 2 RI/FS Work Plan and Field Sampling Plan, which outlines wetland sediment/soil sampling requirements.

b. Field notebook, field form(s), maps, chain-of-custody forms, and custody seals.

c. Decontamination supplies (including: non-phosphate, laboratory grade detergent, buckets, brushes, potable water, distilled water, regulatory-required reagents, aluminum foil, plastic sheeting, etc.).

d. Sampling device (stainless steel hand auger, stainless steel trowel, etc.).

e. Stainless steel spoons or spatulas.

f. Disposable sampling gloves.

g. Laboratory-supplied sample containers with labels.

h. Encore™ sampling containers with labels and Encore™ T handle.

i. Cooler with ice.

j. Plastic sheeting.

k. Black pen and indelible marker.

l. Zip-lock bags and packing material.

m. Tape measure.

n. Paper towels or clean rags.

o. Masking and packing tape.

p. Overnight (express) mail forms.

4.0 DECONTAMINATION

All reusable sampling equipment will be thoroughly cleaned according to the decontamination SOP. Where possible, thoroughly pre-cleaned and wrapped sampling equipment should be used and dedicated to individual sampling locations. Disposable items such as sampling gloves, aluminum foil, and plastic sheeting will be changed after each use and discarded in an appropriate manner.

5.0 PROCEDURE

5.1 Prior to collecting wetland sediment/soil samples, ensure that all sampling equipment has been thoroughly cleaned according to the decontamination SOP. If samples are to be collected at depth, then the boring must be advanced with thoroughly cleaned equipment to the desired sampling horizon and a different thoroughly cleaned sampler must be used to collect the sample.

5.2 Using disposable gloves and a pre-cleaned, stainless steel spatula or spoon, extract the wetland sediment/soil sample from the hand auger and place it in a decontaminated stainless steel bowl. If volatile organic compound (VOC) samples are to be collected they should be from the bottom of the hand auger before the sediment/soil is removed from the hand auger for inspection. See item 5.4 below for the description on the collection of VOC sediment samples.

5.3 Log the sample in detail and record sediment/soil characteristics (color, odor, moisture, texture, density, consistency, organic content, layering, grain size, etc.).

5.4 Samples to be collected for VOCs are to be collected and packaged immediately upon retrevial. Samples to be analyzed for VOCs must be collected prior to other constituents. Samples to be analyzed for VOCs will be collected in three Encore™ 5 gram size samplers. The samples will be attached to the Encore™ T handle and collected by pushing the sampler into the sediment. It is important to collect as much mass of sample in the Encore™ sampler as possible for the laboratory to accurately analyze the sample. Therefore, a decontaminated stainless steel spoon may be used to assist in filling the sampler, especially in organic rich sediments, to ensure that the weight of the filled sampler is maximized. Personnel should remove

roots or grass which will prevent a tight seal on the Encore™ sampler and should carefully inspect the closed sampler to confirm that it is properly closed.

5.5 After the VOC samples are collected the remaining portion of the sample will be composited using the coning and quartering method.

5.6 The sample container will be labeled with appropriate information such as, client name, site location, sample identification (location, depth, etc.), date and time of collection, and sampler's initials.

5.7 After the sample has been collected, labeled, and logged in detail, it is placed in a zip-lock bag and stored in a cooler at 4°C.

5.8 A chain-of-custody form is completed for all samples collected. One copy is retained and two are sent with the samples in a zip-lock bag to the laboratory. A custody seal is placed on the cooler prior to shipment.

5.9 Samples collected from Monday to Thursday are to be delivered to the laboratory within 48 hours of collection. Samples collected on Friday will be delivered to the laboratory by Saturday. Check the Phase 2 RI/FS Work Plan to determine if any analytes require a shorter delivery time.

5.10 The field notebook and appropriate forms must include, but not be limited to the following: client name, site location, sample location, sample depth, sample identification, date and time collected, sampler's name, method of sample collection, number and type of containers, geologic description of material, description of decontamination procedures, etc. A site map must be prepared with exact measurements to each sample location in case follow-up sampling is necessary.

5.11 All reusable sampling equipment must be thoroughly cleaned in accordance with the decontamination SOP. Following the final decontamination (after all samples are collected) the sampling equipment is wrapped in aluminum foil. Discard any gloves, foil, plastic, etc. in an appropriate manner that is consistent with site conditions.

300404

APPENDIX C

TARGET COMPOUND AND ANALYTE LIST PARAMETERS

Appendix C. Target Compound and Analyte List Parameters. BROS Site; Bridgeport, New Jersey.

TCL Volatiles		
Acetone	Chloromethane/Methyl chloride	Methylene chloride
Benzene	Dibromochloromethane	4-Methyl-2-pentanone/MIBK
Bromodichloromethane	1,1-Dichloroethane	Styrene
Bromoform	1,2-Dichloroethane	1,1,2,2-Tetrachloroethane
Bromochloromethane/ Methyl bromide	1,1-Dichloroethene	Tetrachloroethene
2-Butanone/MEK	1,2-Dichloroethene (total)	Toluene
Carbon disulfide	1,2-Dichloropropane	1,1,1-Trichloroethane
Carbon tetrachloride	cis-1,3-Dichloropropene	1,1,2-Trichloroethane
Chlorobenzene	trans-1,3-Dichloropropene	Trichloroethylene
Chloroethane	Ethylbenzene	Vinyl chloride
Chloroform	2-Hexanone	Xylenes (Total)

TCL Semivolatiles		
Acenaphthene	Di-n-butyl phthalate	Hexachlorocyclopentadiene
Acenaphthylene	Dibenz[a,h]anthracene	Hexachloroethane
Anthracene	Dibenzofuran	Indeno[1,2,3-cd]pyrene
Benzo[a]anthracene	1,2-Dichlorobenzene	Isophorone
Benzo[b]fluoranthene	1,3-Dichlorobenzene	2-Methylnapthalene
Benzo[k]fluoranthene	1,4-Dichlorobenzene	Naphthalene
Benzo[ghi]perylene	3,3'-Dichlorobenzidine	2-Nitroaniline
Benzo[a]pyrene	Diethyl phthalate	3-Nitroaniline
bis(2-Chloroethoxy)methane	Dimethyl phthalate	4-Nitroaniline
bis(2-Chloroethyl)ether	2,4-Dinitrotoluene	Nitrobenzene
bis(2-Ethylhexyl)phthalate	2,6-Dinitrotoluene	n-Nitrosodiphenylamine
Butyl benzyl phthalate	Di-n-octyl phthalate	n-Nitrosodipropylamine
Carbazole	Fluoranthene	2,2'-Oxybis (1-chloropropane)
4-Chloroaniline	Fluorene	Phenanthrene
2-Choronaphthalene	Hexachlorobenzene	Pyrene
Chrysene	Hexachlorobutadiene	1,2,4-Trichlorobenzene

TCL PCBs
Aroclor 1016
Aroclor 1221
Aroclor 1232
Aroclor 1242
Aroclor 1248
Aroclor 1254
Aroclor 1260

TAL Metals		
Aluminum	Cobalt	Potassium
Antimony	Copper	Selenium
Arsenic	Iron	Silver
Barium	Lead	Sodium
Beryllium	Magnesium	Thallium
Cadmium	Manganese	Vanadium
Calcium	Mercury	Zinc
Chromium	Nickel	

APPENDIX D

FIELD FORMS

WELL INSPECTION CHECKLIST
WELL MONITORING LOG
TEST BORING LOG
MONITORING WELL CONSTRUCTION LOG
CHAIN OF CUSTODY
WELL SAMPLING DATA FORM

WELL INSPECTION CHECKLIST

Client:

Inspected by:

Site Location:

Signature:

Date:

	Well Number																			
	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
1. Cement Seal																				
Intact																				
Cracked																				
Missing																				
2. Ponded Water Around Cement Seal																				
3. Protective Steel Pipe Intact (if stick-up)																				
4. Manhole Cover Intact (if flush-mount)																				
5. PVC Casing Intact																				
6. Cap Sealed																				
7. Lock Intact																				
8. Designated Measuring Point Clearly Marked																				
9. Well is Clearly Labled																				

Comments:

300409

WELL MONITORING LOG

Client:_____ **Date:**_____

Site Location:_____ **Time In:**_____ **Time Out:**_____

Project Number:_____ **Weather Conditions:**_____

Well #	Casing Elev. (ft)	Depth to Product (ft)	Depth to Water (ft)	Product Thick. (ft)	Corrected Water-Table Elevation	Observations

Depth in Holding Tank Before Bailing (ft): *Product:* NA *Water:* NA *Total:* NA

Depth in Holding Tank After Bailing (ft): *Product:* NA *Water:* NA *Total:* NA

Comments:_____

_____

_____

Additional Equipment and/or Services Required During Next Monitoring Visit:_____

_____

_____

Name/Signature: _____ **Date:** _____

300410

TEST BORING LOG

Project Number: _____
Project: _____
Location: _____

Boring: _____
G.S. Elevation: _____
Page ___ of ___

Ground-Water			
First Encountered			
Depth	Hour	Date	Elapsed Time

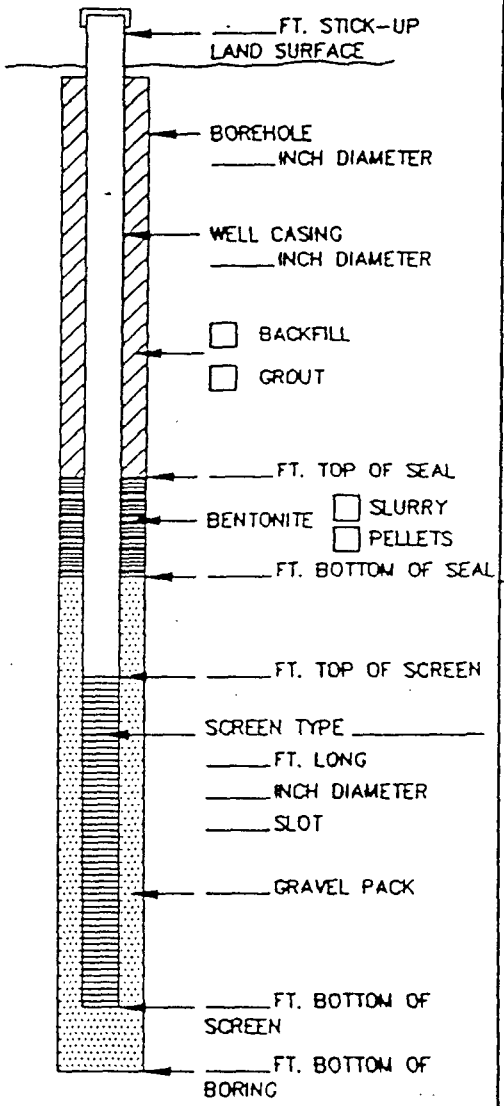
Logged By: _____
Driller: _____
Type of Rig: _____
Date Started: _____
Date Completed: _____

Depth	Blows	Recovery (ft)	Description	Remarks	OVM (ppm)
5					
10					
15					
20					
25					
30					
35					

300411

ROUX ASSOCIATES, INC.
Consulting Ground-Water Geologists

MONITORING WELL CONSTRUCTION LOG



NOTE:
ALL DEPTHS IN FEET BELOW GROUND SURFACE.

PROJECT NAME _____ NUMBER _____
WELL NO. _____ PERMIT NO. _____
TOWN/CITY _____
COUNTY _____ STATE _____
WELL LOCATION _____
LAND-SURFACE ELEVATION _____ ☐ SURVEYED ☐ ESTIMATED
MEASURING POINT ELEVATION _____ ☐ SURVEYED ☐ ESTIMATED
MEASURING POINT LOCATION _____

INSTALLATION DATE(S) _____
DRILLING METHOD _____
DRILLING CONTRACTOR _____
DRILLING FLUID _____

DEVELOPMENT TECHNIQUES(S) AND DATE(S)

FLUID LOSS DURING DRILLING _____ GALLONS
WATER REMOVED DURING DEVELOPMENT _____ GALLONS
STATIC DEPTH TO WATER _____ FEET BELOW M.P.
PUMPING DEPTH TO WATER _____ FEET BELOW M.P.
PUMPING DURATION _____ HOURS
YIELD ____ GPM DATE _____
SPECIFIC CAPACITY _____ GPM/FT.
WELL PURPOSE _____

REMARKS _____

SIGNATURE _____

300412

ROUX

CHAIN OF CUSTODY

№ 02126 J

ROUX ASSOCIATES INC
Environmental Consulting & Management
1222 FOREST PARKWAY, SUITE 190
WEST DEPTFORD, NEW JERSEY 08066
(609) 423-8800 FAX. (609) 423-3220

ANALYSES

PAGE OF

PROJECT NAME

PROJECT NUMBER

PROJECT LOCATION

SAMPLER(S)

SAMPLE DESIGNATION/LOCATION	DATE COLLECTED	TIME COLLECTED	SAMPLE MATRIX						TOTAL BOTTLES	NOTES

RELINQUISHED BY: (SIGNATURE)	FOR	DATE	TIME	SEAL INTACT Y OR N	RECEIVED BY: (SIGNATURE)	FOR	DATE	TIME	SEAL INTACT Y OR N
RELINQUISHED BY: (SIGNATURE)	FOR	DATE	TIME	SEAL INTACT Y OR N	RECEIVED BY: (SIGNATURE)	FOR	DATE	TIME	SEAL INTACT Y OR N
RELINQUISHED BY: (SIGNATURE)	FOR	DATE	TIME	SEAL INTACT Y OR N	RECEIVED BY: (SIGNATURE)	FOR	DATE	TIME	SEAL INTACT Y OR N

DELIVERY METHOD

ANALYTICAL LABORATORY

COMMENTS

300413

WELL SAMPLING DATA FORM

DATE:_____ WELL NUMBER:_____

CLIENT:_____ NJDEP PERMIT NO.:_____

PROJECT NO.:_____ TYPE OF WELL:_____

LOCATION:_____

WEATHER:_____

SAMPLED BY:_____

CEMENT SEAL INTACT:_____ DEPTH TO BOTTOM OF WELL:_____ FT.

WATER IN MANHOLE:_____ DEPTH TO WATER:_____ FT.

MANHOLE COVER INTACT:_____ WATER COLUMN:_____ FT.

PVC CASING INTACT:_____ VOLUME OF WATER IN WELL:_____ GAL.

CAP SEALED:_____ VOLUME OF WATER TO REMOVE:_____ GAL.

LOCK INTACT:_____ VOLUME REMOVED:_____ GAL.

MEASURING POINT MARKED:_____ TIME OF START:_____

PID MEASUREMENT:_____ PPM TIME OF FINISH:_____

RATE OF PURGE:_____ GPM

METHOD OF PURGE:_____

METHOD OF SAMPLE COLLECTION:_____

PHYSICAL APPEARANCE/COMMENTS:_____

FIELD MEASUREMENTS:

BEFORE PURGE:		AFTER PURGE:		AFTER SAMPLING:	
pH:	_____	pH:	_____	pH:	_____
COND:	_____	COND:	_____	COND:	_____
TEMP:	_____	TEMP:	_____	TEMP:	_____
ORP:	_____	ORP:	_____	ORP:	_____
DO:	_____	DO:	_____	DO:	_____

TIME OF SAMPLE COLLECTION:_____

TYPES OF SAMPLES COLLECTED:

LABORATORY NAME & LOCATION:

APPENDIX E

NJDEP METHODOLOGY FOR THE FIELD EXTRACTION/PRESERVATION OF SOIL SAMPLES WITH METHANOL

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

METHODOLOGY FOR THE FIELD EXTRACTION/PRESERVATION OF SOIL SAMPLES WITH METHANOL FOR VOLATILE ORGANIC COMPOUNDS FEBRUARY 1997

1.0 Scope and Application

1.1 This method describes the container preparation, field sampling and field extraction/preservation procedure to be used in conjunction with the analysis of soil samples for volatile organics. The applicable analytical methods are SW-846 methods 8010B, 8015A, 8020A, 8021A, 8240B and 8260A found in the most recently promulgated edition of USEPA's Test Methods For Evaluating Solid Waste and the most current version of the Statement of Work for Organic Analysis, Multi-Media, Multi-Concentration, USEPA Contract Laboratory Program.

1.2 It is the laboratory's responsibility when analyzing samples obtained by this method to demonstrate internally that all NJDEP soil cleanup criteria for VOC's (last revised on 2/3/94, as contained in the April 1994 NJDEP Site Remediation News, Volume 6, Number 1, pages 13, 17-19) have been achieved. Should a laboratory know or suspect it has inadequate analytical sensitivity to meet any of the cleanup criteria, the laboratory shall not accept any samples unless the Department is notified in advance and the laboratory obtains approval.

2.0 Method Summary

2.1 Soil samples collected for volatile organic analysis must be handled in a manner which will minimize the loss of contaminants due to volatilization and biodegradation. Department experience and open literature indicate that, for the analysis of volatile organic compounds in soil, field extraction/preservation with methanol must be conducted to ensure that contaminants do not degrade or volatilize during sample handling and transport.

2.2 A small diameter soil core sampling device is used to collect a 10 gram (g) soil sample. The sample is extruded into a tared sample container, supplied by the laboratory performing the analysis, containing purge and trap grade methanol and surrogate compounds. The ratio of volume of methanol to weight of soil is 2.5:1. A portion of the methanol extract is combined with organic free reagent water and analyzed by purge and trap GC or GC/MS.

3.0 Sample Containers

3.1 The recommended sample containers are a 60 ml (2 oz.) wide mouth packer bottle, a 60 ml straight sided wide mouth bottle and a 40 ml or 60 ml VOA vial. All sample containers should have a

open-top screw cap and a silicone rubber coated with Teflon^R septa or other similar sample container. Some similar containers with Teflon^R lined screw caps have shown to be susceptible to leakage. The type of container used should be tested to ensure leakage will not occur during shipment.

The use of larger volume containers will cause the layer of methanol over the sample to be minimized, making it difficult to extract an aliquot of methanol for analysis.

3.2 The standard 40ml or 60ml VOA vial can be used, but the small mouth may not accommodate some core samplers. The VOA vial is also unstable and susceptible to spillage.

4.0 Sample Container Preparation

4.1 Label each sample container with a unique numerical designation.

4.2 Fill the sample container with 25 mls of demonstrated analyte free purge and trap grade methanol.

4.3 An actual analysis should be traceable to the methanol used in the sample containers on the day the sample containers were prepared.

4.4 Record the lot number of the methanol used in the preparation of the sample containers. This information can be used for future reference in the event of suspected contamination of the methanol.

4.5 Employing a syringe, add the appropriate surrogate compounds to the methanol based on the analytical method. For methods 8010B, 8015A, 8020A, and 8021A, add each surrogate compound to the methanol yielding a concentration of approximately 1500 ug/l in each sample container. For methods 8240B, 8260A and the Medium Level Soil/Sediment Sample procedure of the Contract Laboratory Program Statement of Work, add each surrogate compound to the methanol yielding a concentration of approximately 2500 ug/l in each sample container.

4.6 Immediately cap the container tightly and gently swirl.

4.7 Variations of the surrogate compounds may be used depending upon expected sample matrix interferences and contaminants.

4.8 Weigh each labeled sample container with the 25 mls of methanol and surrogate compounds to the nearest one tenth (0.1g) of a gram.

4.9 Record the weight in a bound logbook and on the chain of custody record with its corresponding numerical designation.

4.10 All sample containers must be supplied by the laboratory performing the analysis.

4.11 The prepared sample containers must be stored at 4° "2°C before shipment. The sample containers should be prepared no more than fourteen (14) days prior to shipment. It will be the responsibility of the laboratory to ensure the integrity of the sample containers remain contaminant free.

5.0 Sample Collection Methodology

5.1 Soil sample collection for volatile organic analysis must be performed with the use of a decontaminated small diameter coring device. A modified 10-30 ml disposable syringe or commercially available small diameter tube/plunger sampler is acceptable. The small diameter coring device must be capable of collecting the required amount of sample from larger diameter core samplers (split spoons, etc.) or from freshly exposed soils.

5.2 Selection of the sample location for volatile organics must be based on the methods in the NJDEP Field Sampling Procedures Manual, May, 1992 and the site specific sampling plan.

5.3 If a modified disposable syringe is used it can be prepared in-house by cutting off the injection tip. Depending upon the construction of the syringe, small air vents must be cut into the plunger or the rubber tip and retaining post must be removed. These alterations to the plunger will prevent air from being forced through or around the soil plug during subcoring and sample extrusion.

5.4 The small diameter core sampler must be capable of delivering the sample directly into the sample container. The outer diameter of the core sampler must be smaller than the inner diameter of the sample container to avoid loss of sample and ease the soil transfer process. **The sample from the small diameter core cannot be transferred to a secondary container such as another sample bottle, zip lock bag, aluminum foil, etc. prior to placement into the sample container with the methanol preservative.**

5.5 Use a small electronic balance or manual scale for measuring the weight of the soil in the syringe. The scale must be calibrated before use, and intermittently the calibration should be checked during the sampling day to ensure accuracy of the weight measurements.

5.6 Tare weigh the small diameter core sampler.

5.7 Once the sampling interval has been selected, trim off the surface soils of the sample interval to expose a fresh soil surface. The loss of volatile organics from the surface soils will occur if the soil has been exposed for a short period of time (during screening, etc.). The removal of the surface soils can be accomplished by scraping the soil surface using a decontaminated spatula or trowel. The sampling procedure must commence immediately once a fresh soil surface has been exposed.

5.8 Using a decontaminated coring device, collect 10g "2g (8-12grams) of sample (wet weight). Wipe the outside of the subcoring device to remove any adherent soil. The plunger of the coring device can be pulled back or completely removed allowing the open barrel of the subcore to be inserted into the soil. Depending upon the soil texture, depth or moisture content, the subcore can be inserted

straight into the soil, on an angle or multiple insertions can be performed to obtain the required sample weight.

5.9 Quickly weigh the sample while contained in the small diameter core sampler. Excess soil sample can be removed from the coring device by extruding a small portion of the core and cleaning away with a decontaminated trowel or spatula. **If soil weight is below the weight limit, obtain additional sample. Reweigh after each addition or removal of sample to the subcore until the target weight is attained (8-12g). Analytical results from a sample exceeding the weight maximums and minimums may be rejected and thus require resampling**.

5.10 When sampling soils consisting of similar textures and water content, sample weight can be estimated based on volume of previously weighed samples from sampling or practice core sampling to determine sample weights.

5.11 Immediately open the sample container and slowly extrude the soil core into the preweighed and prenumbered sample container supplied by the laboratory performing the analysis. Avoid splashing methanol out of the sample container. Do not insert the small diameter coring device into the mouth of small diameter sample containers (40ml or 60ml VOA vials) or immerse the small diameter soil coring device into the methanol.

5.12 Ensure the threads on the sample container and cap are free of soil particles. Use a clean brush or paper towel to remove the particles off the threads. The presence of soil particles compromises the seal of the container resulting in loss of methanol which may invalidate the sample.

5.13 Secure the lid of the sample container. Gently swirl the sample to mix and break up the soil aggregate until soil is covered with methanol. **Do not shake.**

5.14 Do not attach any additional adhesive backed labels or tape to the sample containers. Record sample numbers on container avoiding covering laboratory identification number. Labels with wire or rubber band attachments may be used provided they can be removed easily for sample weighing. Record laboratory and field identification numbers on chain of custody and field notes.

5.15 The actual weight of soil will be determined by the laboratory performing the analysis.

5.16 Do not use or submit samples for analysis if any methanol has spilled from a sample container during shipment to the site or during sampling. Extra sample containers can be made available by the laboratory in case of accidental spillage of methanol in the field. The sample containers must be prepared in accordance with Section 4.0.

5.17 After sample collection, immediately return the containers to an iced cooler in an upright position. Sample containers can be placed in separate ziplock bags to protect other containers in case of leakage during transport. The laboratory sample number or field sample identification number may be placed on the bag and crossed referenced on the Chain of Custody. Do not place additional adhesive backed labels or tape on the sample containers. If any methanol is lost from a sample container upon arrival at the laboratory, the sample is invalid and resampling must be performed.

6.0 Moisture Determination

6.1 To report the sample results on a dry weight basis, collect one duplicate sample **not preserved with methanol** from each sample location for moisture determination. Tightly seal the container to prevent the loss of soil moisture. This sample does not require to be weighed or preserved with methanol. A small volume sample container (15 mls or less) may be used for this sample to avoid possible sample shortages.

6.2 Weigh a 5-10g portion of the sample in a tared crucible.

6.3 Dry the sample overnight at 103-105 °C. Allow to cool in a desiccator before reweighing.

6.4 Determine percent dry weight by the following formula:

$$\% \text{ dry weight} = \frac{\text{g of dry sample}}{\text{g of sample}} \times 100$$

6.5 Calculate sample concentration on a dry weight basis.

7.0 QA/QC Sample and Decontamination Requirements

7.1 Ambient Blank

7.1.1 An Ambient Blank is a QA/QC sample which will determine the potential contamination from ambient air during sampling procedures. This sample will provide a means to evaluate non-sample related contamination.

7.1.2 The Ambient Blank is prepared in the same manner as the sample containers described in Section 4.0. During sample collection, it is opened at the same time and next to the sample container and remains open during sample collection. It is closed at the same time as the sample container. It is performed at only one sample location in an area suspected of having the highest ambient contamination.

7.1.3 **The collection of an Ambient Blank is not required when sampling is performed using the methanol extraction/preservation technique**. It will be optional at the discretion of the site investigation team, or will be required on a site specific basis if previous elevated analytical results are suspected due to contamination from the sampling environment.

7.1.4 If Ambient Blanks are employed, the frequency of collection should be one (1) per day or at the discretion of the investigation team based on site conditions.

7.1.5 Results of the Ambient Blank must be reported as a solid sample where a sample weight of 10g and 100% dry weight is assumed.

7.2 Field Blank

7.2.1 A Field Blank is a QA/QC sample which will determine potential contamination from sampling equipment used to collect and transfer samples from the point of collection to the sample container.

7.2.2 A Field Blank is performed by pouring demonstrated analyte free **water** from one sample container, over each piece of sampling equipment required for sample collection and into a separate set of identical sample containers. Additional information on Field Blanks can be found in the NJDEP Field Sampling Procedures Manual, May 1992.

7.2.3 **A Field Blank is not required when sampling with the methanol extraction/preservation technique.** It is optional, or will be required on a site specific basis if previous elevated analytical results are suspected due to cross contamination from sampling equipment.

7.3 Trip Blanks

7.3.1 A Trip Blank is a QA/QC sample which will determine additional sources of contamination that may potentially influence the samples. The sources of the contamination may be from the lab, sample bottles or during shipment.

7.3.2 A Trip Blank is prepared at the same time and in the same manner as the sample containers as described in Section 4.0. The Trip Blank must accompany the sample containers to the field and back to the laboratory along with the collected samples for analysis. It must remain sealed at all times until it is analyzed at the laboratory.

7.3.3 **A Trip Blank is required when sampling with the methanol extraction/preservation technique.** It will be required due to potential cross contamination from sample shipment or from handling at the laboratory.

7.3.4 The frequency of collection for the Trip Blank must be at a rate of one (1) per sample shipment.

7.3.5 Results of the Trip Blank must be reported as a solid sample where a sample weight of 10g and 100% dry weight is assumed.

7.4 Duplicate Samples

7.4.1 Perform duplicate samples at a rate of five (5) percent (1 per 20 samples).

7.4.2 Duplicate samples must be obtained from the same location and soil type to minimize location as a potential source of variation in the analytical results. Separate core samples should be obtained for the sample and duplicate sample.

7.5 Sample and Sample Container Handling Time

7.5.1 Sample handling time is to control the length of time bottles are shipped to the site and held on site. The standard four (4) day handling time for sample containers and samples remains the same. Obtain additional information on handling times from Chapter 2 in the NJDEP Field Sampling Procedures Manual, May 1992.

7.5.2 As stated in N.J.A.C. 7:26E-2.1(a)15, samples must be delivered to the laboratory no later than 48 hours after sample collection.

7.6 Decontamination of Sampling Equipment

7.6.1 All equipment used for sampling must be decontaminated prior to use.

7.6.2 Decontamination of sampling equipment must follow the procedures in the NJDEP Field Sampling Procedures Manual, May 1992 for soil sampling equipment. If modified disposable syringes are utilized, they should be discarded if the three step cleaning procedure will not remove the contamination since exposure to acetone may damage the sampling tool.

7.7 General Quality Assurance

7.7.1 Quality assurance requirements have been established to maintain sample integrity. Their primary objectives are to maintain the physical form and chemical composition of the sample and to prevent contamination from other sources or cause changes in contaminant concentrations. Chapter 2 in the NJDEP Field Sampling Procedures Manual, May 1992 may be consulted for further details on other sampling QA/QC criteria and procedures.

8.0 Field Analysis

8.1 Field analytical methods may be employed during an investigation to aid in the selection or elimination of samples for laboratory analysis. When collecting samples for field analysis, collect a duplicate sample for laboratory analysis. This prevents returning to a sample location and resampling at a later time. Any methanol preserved samples not submitted for laboratory analysis are a hazardous waste and must be disposed of on-site or by the laboratory according to State and Federal regulations. To avoid this problem, the following procedure can be used:

8.1.1 Using the sampling method in section 5.0, use an EnCore^{R} core sampler to obtain a duplicate sample for laboratory analysis. Store the soil for laboratory analysis in the core sampler by sealing the end(s) of the core with the end caps supplied with the EnCore^{R} sampler. **Eliminate headspace in the sampler.**

8.1.2 Label the core for lab analysis and immediately cool the sample. The core sample may be stored at 4EC on ice for a maximum of six (6) hours prior to preserving with methanol. This intermediate storage method can only be used if samples are field analyzed.

8.1.3 Perform the selected field analytical procedure on the duplicate sample and document the field analysis in accordance with the NJDEP Field Analysis Manual, July 1994.

8.1.4 If soil from a sample location is selected for laboratory analysis, preserve the iced core sample with methanol. Samples must be preserved with methanol within the six (6) hour field holding time.

8.1.5 **Use this procedure only when performing field analysis of the samples (i.e. Field GC, Immunoassay, etc.).**

9.0 Laboratory Analysis

9.1 Upon arrival of the sample at the laboratory, weigh the sample container to the nearest one tenth (0.1g) of a gram to determine the weight of soil placed in the sample container.

9.2 Subtract the weight of the container, methanol and surrogates from the total weight of the sample container with the soil sample. This gives the wet weight of the soil sample.

9.3 Proceed with the analysis of the sample using the "high concentration" methodology of the requested SW-846 analytical method or the "Medium Level Soil/Sediment Samples" procedure of the USEPA Contract Laboratory Program Statement of Work. In both instances, start the analytical procedure at the point where approximately 1ml of methanol extract is to be transferred to storage.

9.4 Using the non-methanol preserved duplicate sample, determine the dry weight of the sample.

10.0 Shipping Procedures

10.1 Methanol is considered a hazardous material therefore shipping of the sample containers is regulated by the U.S. Department of Transportation and the International Air Transport Association (IATA). The rules of shipment set in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179) and the current edition of the IATA Dangerous Goods Regulation must be followed when shipping methanol between the laboratory and the field. Consult the above documents or the shipping company for additional information.

10.2 The shipment of the quantity of methanol used for the sample preservation falls under the exemption for small quantities. A summary of the requirements for shipping samples follows. Refer to the code for a complete review of the requirements.

10.2.1 The maximum volume of methanol in a sample container is limited to thirty (30) mls.

10.2.2 The sample container must not be full of methanol.

10.2.3 The sample container must be stored upright and have the lid held securely in place. The mechanism used to hold the cap in place must be able to be completely removed so weight is not added to the sample container.

10.2.4 Sample containers must be packed in a sorbent material capable of absorbing spills from leaks or breakage of the sample containers.

10.2.5 The maximum sample shuttle weight must not exceed 64 pounds.

10.2.6 The maximum volume of methanol per shipping container is 500mls.

10.2.7 The shipper must mark the sample shuttle in accordance with shipping dangerous goods in acceptable quantities.

10.2.8 The package must not be opened or altered until no longer in commerce.

11.0 Safety

11.1 Methanol is a toxic and flammable liquid. Therefore, methanol must be handled with all safety precautions related to toxic and flammable liquids. Inhalation of methanol vapors must be avoided. Vials should be opened and closed quickly during the sample preservation procedure. Methanol must be handled in a ventilated area. Use protective gloves when handling the methanol vials. Store methanol away from sources of ignition such as extreme heat or open flames. The vials of methanol should always be stored in a cooler with ice at all times.

12.0 References

(1) ASTM Recommendations for Handling and Sampling Soil VOCs. Underground Tank Technology Update, Vol. 7 #5, 1993. University of Wisconsin - Madison.

(2) Hewitt, A.D. Comparison of Sample Collection and Handling Practices for The Analysis of Volatile Organic Compounds in Soils. National Symposium on Measuring and Interpreting VOCs in Soils: State of the Art and Research needs, Las Vegas, NV, January 12-14, 1993.

(3) Hewitt, A.D. Review of Current and Potential Future Sampling Practices for Volatile Organic Compounds in Soil. National Symposium on Measuring and Interpreting VOCs in Soils: State of the Art and Research Needs, Las Vegas, NV, January 12-14, 1993.

(4) Hewitt, A.D.; Jenkins, T.F; Grant, C. Collection, Handing and Storage: Keys to Improved Data Quality for Volatile Organic Compounds in Soil. American Environmental Laboratory, February, 1995.

(5) Hewitt, A.D.; Miyares, P.H.; Leggett, D.C.; Jenkins, T.F. Comparison of Analytical Methods for Determination of Volatile Organic Compounds in Soil. National Symposium on Measuring and Interpreting VOCs in Soils: State of the Art and Research Needs, Las Vegas, NV, January 12-14, 1993.

(6) Jenkins, R.A.; Bayne, C.K.; Maskaranec, M.P.; Johnson, L.H.; Holladay, S.K.; Tomkins, B.A. Experimental Determination of Pre-Analytical Holding Times for Volatile Organics in Selected Soils. National Symposium on Measuring and Interpreting VOCs in Soils: State of the Art and Research Needs, Las Vegas, NV, January 12-14, 1993.

(7) Jackson, J.; Thomey, N.; Dietlein, L. Degradation of Hydrocarbons in Soil Samples Analyzed Within Accepted Analytical Holding Times. 5th Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring, and Geophysical Methods, Las Vegas, NV, May 13-16, 1991: 567-76.

(8) King, P. Evaluation of Sample Holding Times and Preservation Methods for Gasoline in Fine-Grained Sand. National Symposium on Measuring and Interpreting VOCs in Soils: State if the Art and Research Needs, Las Vegas, NV, January 12-14, 1993.

(9) Lewis, T.E; Crockett, A.B.; Siegrist R.L.; Zarrabi K. Soil Sampling and Analysis for Volatile Organic Compounds. EPA/540/4-91/001, February, 1991.

(10) Parr, J.L.; Walters, G.; Hoffman, M. Sampling and Analysis of Soils for Gasoline Range Organics. Proceedings from West Coast Conference on Hydrocarbon Contaminated Soils and Ground Water, Newport Beach, CA, February 21, 1990.

(11) Sawhney, B.L.; Pignatello J.J.; Stienberg, S.M. Determination of 1,2 - Dibromoethane (EDB) in Field Soils: Implications for Volatile Organic Compounds. Environmental Quality, Vol 17, #1, 1988.

(12) Siegrist, R.L. Volatile Organic Compounds in Contaminated Soils: The Nature and Validity of The Measurement Process. Journal of Hazardous Materials, 29 (1992) 3-15 Elsevier Science Publishers B.V. Amsterdam.

(13) Siegrist, R.L.; Jensson, P. Evaluation of Sampling Method Effects on Volatile Organic Compound Measurements in Contaminated Soil. Env. Sci. and Tech, Vol 24 #9, 1990. American Chem. Society.

(14) Standard Practice for Sampling Waste and Soils for Volatile Organics, ASTM D4547-91.

(15) Turriff, D. Performance of a New Soil Sampling Tool for use with Methanol Preservation of Samples Containing Volatile Organic Compounds. National Symposium on Measuring and Interpreting VOCs in Soils: State of the Art and Research Needs, Las Vegas, NV, January 12-14, 1993.

(16) Turriff, D.; Klopp, C. Studies of Sampling, Storage and Analysis of Soils Contamination with Gasoline and Diesel. PUBL-SW-513-95, Wisconsin Department of Natural Resources, 10/95.

(17) Urban, M.; Smith, J.; Schultz, E.; Dickinson, R. Volatile Organic Analysis for a Soil, Sediment or Waste Sample. Proceeding from Fifth Annual Waste Testing and Quality Assurance Symposium, July 24-28 Washington, DC.

(18) USEPA, 1986. Test Methods for Evaluating Solid Waste, Vol. 1B, No. SW846. Washington, DC: US Environmental Protection Agency, 1986.

(19) Hewitt, Alan D.; Lukash, Nicole J.E. Sampling for In-Vial Analysis of Volatile Organic Compounds in Soil. American Environmental Laboratory, August, 1996, pp15-19.

(20) Hewitt, Alan D. Chemical Preservation of Volatile Organic Compounds in Soil Subsamples. SR 95-5, U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, 1994.

(21) Hewitt, Alan D. Comparison of Methods for Sampling Vadose Zone Soils for the Determination of Trichloroethylene. Journal of AOAC International, Vol 77, No. 2, 1994.

(22) West, Olivia; Siegrist, RobertL.; Mitchell, Toby J.; Jenkins, Robert A. Measurement Error and Spatial Variability Effects on Characterization of Volatile Organics in the Subsurface. Environ. Sci. Technology, 1995, 29, pp647-656.

(23) Hewitt, Alan D. Evaluation of Methanol and $NaHSO_4$ for Preservation of Volatile Organic Compounds in Soil Subsamples. American Env. Lab. 8/95, pp16-18.

(24) Schuring, John R.; Jurka, Valdis; Jiuan Wu, Chwen. An Alternative Technique for Sampling Soils Containing VOC's. Madison Waste Conference, 1991.

APPENDIX F

BAIL DOWN TEST PROTOCOL

Two Techniques for Determining the True Hydrocarbon Thickness in an Unconfined Sandy Aquifer

BY

John P. Hughes

Chevron U.S.A., Inc
P.O. Box 97
El Segundo, California 90245

Clay R. Sullivan and Ronald E. Zinner

Riedel Environmental Services, Inc
Los Angeles Region
20280 S. Vermont Ave., Suite 200
Torrance, California 90502

ABSTRACT

In unconfined sandy aquifers, the hydrocarbon thickness in a monitoring well exceeds - sometimes by a large amount - the "true" thickness of the mobile hydrocarbon layer in the formation. This paper presents two techniques designed to provide a more accurate estimate of the true thickness. A companion paper in this volume (Sullivan et. al) presents a descriptive model for the occurrance of hydrocarbon on an unconfined aquifer.

The opening sections of the present paper provide a straightforward explanation of the exaggeration theory, and discuss a number of practical reasons why it's important to obtain accurate information on the true thickness of the mobile hydrocarbon layer in the formation. There are a number of ways in which using the apparent well thickness can create problems. The efficient design and placement of recovery wells, and the calculation of realistic estimates of the volume of liquid hydrocarbon beneath a site both depend on knowing the actual thickness of the mobile hydrocarbon layer. The search for the true thickness, therefore, becomes more than simply an academic exercise. It can also have in impact on the overall costs of the site assessment and clean-up.

The remainder of the paper is devoted to examining several methods of making a more accurate estimate of the true thickness of the mobile hydrocarbon layer in the formation. The first method involves well test techniques Two types of well tests are described. The first is conducted in wells that have been pumped to establish steady-state conditions. The second is equivalent to a slug test and is appropriate for use where hydrocarbon accumulations are thin. Data on the hydrocarbon recharge rates generated by the test are first evaluated graphically and then combined with simple algebraic equations to calculate the true hydrocarbon thickness in the formation. The interpretation of the test data is based on the model presented in Sullivan et. al.. The well tests can easily be repeated in the future to track changes in the hydrocarbon thickness with time.

The second method of estimating the true thickness of hydrocarbon in the well, involves continuous coring through the zone of interest. This provides a "snap-shot in time" look at the hydrocarbon saturated interval. In addition to the standard core analysis techniques, we have

found that the natural fluorescence of hydrocarbons provides an additional method of delineating the contaminated zone and making a qualitative estimate of the saturation present, when the core is examined under an ultraviolet light.

1.0 INTRODUCTION

Those involved in groundwater contamination work have long accepted the concept that the hydrocarbon thickness in a monitoring well exceeds - sometimes by a large amount - the "true" thickness of the mobile hydrocarbon layer in the formation (CONCAWE, 1979, Blake and Hall, 1984, Hall et. al., 1984, and Gruszczenski,1987). This causes a series of problems when the monitoring well data is used to make decisions about such things as the most efficient place to locate recovery wells or the volume of hydrocarbon in place beneath the site. A relatively simple method of measuring the thickness in the formation, however, has, for the most part, remained elusive. As a result, people in the field simply use the monitoring well data but note that it is probably an overestimate of the true thickness.

Except for the fact that it has something to do with the "capillary fringe", the theory behind the exaggeration phenomenon has not always been well understood. A companion paper in this volume (Sullivan et. al.) includes a detailed discussion of the theory behind the exaggeration and some implications for hydrocarbon recovery. The present paper approaches the subject from a somewhat more applied perspective. We begin by providing a simple explanation of the exaggeration theory. Next, we look at why using the apparent monitoring well thickness as a basis for decisions can cause a variety of problems. Finally, we examine a couple of relatively straightforward techniques designed to give us a closer approximation of the true thickness of the mobile hydrocarbon layer in the formation. A third technique, involving the use of a dielectric logging tool, is the subject of another paper in this volume (Keech).

2.0 EXAGGERATION THEORY

2.1 The Capillary Zone

The liquid hydrocarbon thickness in a monitoring well is different than the true thickness of the mobile hydrocarbon layer in the aquifer because hydrologic conditions in the well are different than those in the aquifer. In unconfined sandy aquifers, a capillary zone forms above the water table, in which water is drawn up into the soil column by surface tension forces. Capillary rise is a common phenomenon in our everyday lives. In an oil lamp, for example,it causes the oil from the lower reservoir to rise up the wick so that it can be burned in the flame.

The height of the capillary zone above the water table depends primarily on the size of the pores in the formation - that is, the size of the open spaces between the sand grains. In a well sorted sand, the size of the pores is directly related to the size of the grains. -the larger the grains, the larger the pores. Consequently, the finer the grain size the higher the capillary rise and the coarser the grain size, the smaller the capillary rise.

The removal of the formation matrix during the drilling and installation of a well, in effect, creates one large "macro pore" (the size of the casing diameter) inside the well. As a result, there is virtually no capillary rise inside the casing. By installing the well we have, therefore, created an anomalous zone in the aquifer. Outside the well a capillary fringe exists but inside the casing the capillary fringe is missing. It

is this missing capillary fringe inside the well that allows an exaggerated thickness of hydrocarbon to accumulate in the well.

When a well is installed in an unconfined aquifer containing no hydrocarbon, water will rise in the casing until it reaches the elevation of the water table. This horizon represents the surface in both the aquifer and the well at which the pressure is equal to the atmospheric pressure. As you move down (or deeper) below the water table in either the aquifer or the well, the pressure steadily increases. As you move up (or shallower) in the aquifer above the water table, the pore pressure steadily decreases, until the top of the capillary zone is reached. There is a pressure discontinuity at the top of the capillary zone caused by interfacial tension forces. The pressure in the water filled pores just below the interface is at some value less than atmospheric - the magnitude of that amount being proportional to the height of the interface above the water table. The pressure in the air filled pores just above the interface is atmospheric and from that point on up the pore pressure remains constant. Pressure in the well at any elevation above the water table remains constant at atmospheric pressure. Figure 2-1 illustrates these ideas, showing pressure diagrams for vertical slices through both the formation (A) and the well (B). Notice that the water from the capillary zone does not flow into the well. Yet the the pores in the capillary zone are full of water which can flow between the sand grains within the formation. The solution to this apparent contradiction, lies in the fact that different pressures exist on the opposite sides of the well casing. Figure 2-1 (pressure diagram B), shows that the pressure in the well anywhere above the water table is equal to atmospheric pressure. On the opposite side of the slots in the capillary zone (Figure 2-1,pressure diagram A), the pore pressure is less than the ambient pressure. Since the pressure in the well is higher than the pressure in the formation, water from the capillary fringe cannot flow into the well. The edge of the well, therefore, acts as a pressure barrier preventing this capillary water from flowing into the well. As a result, the water level in the well will be lower than the top of the water saturated zone in the formation.

2.2 The Exaggeration Mechanism

2.2.1 *General* The capillary forces outside the well support a portion of the weight of the liquid hydrocarbon pool above the water table (Figure 2-2). Inside the well there are no capillary forces to support the hydrocarbon, and the product, therefore, rests directly on the water table. The top of the hydrocarbon layer in the well will rise to the same elevation as the top of the mobile hydrocarbon layer in the formation. (For the

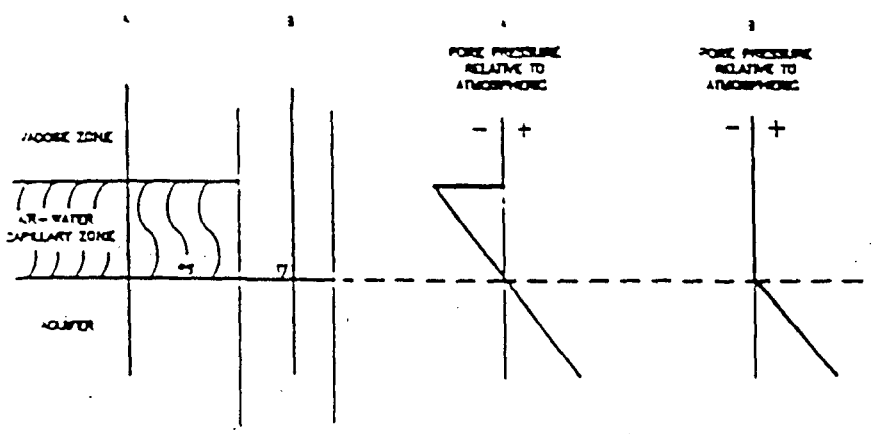


FIGURE 2-1 PRESSURE RELATIONSHIPS.

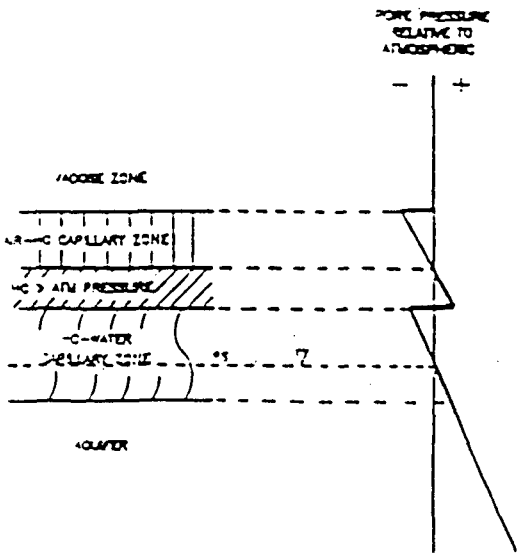


FIGURE 2-2 FLUID DISTRIBUTION AND PRESSURE PROFILE IN A HOMOGENEOUS ISOTROPIC FORMATION.

purposes of this paper, we will use the term "mobile hydrocarbon" to refer to that portion of the hydrocarbon pool which is at greater than atmospheric pressure.] The bottom of the the hydrocarbon/water contact, however, will initially be lower in the well than in the formation (Figure 2-3a). A thicker column of hydrocarbon can accumulate in the well,therefore, than in the formation. This thicker column of hydrocarbon in turn displaces some additional water in the well resulting in an even thicker column of hydrocarbon in the casing. Eventually this thickening in the well stabilizes when the weight of the hydrocarbon above the hydrocarbon/water interface is exactly balanced by the buoyant forces of the water below the hydrocarbon/water interface (Figure 2-3b).

It may help to better understand this situation if we look at the opposing forces acting on the hydrocarbon/water interface. In the formation there are three forces (indicated by the arrows in Figure 2-4) acting on this contact. The weight of the hydrocarbon (Phc) naturally pushes down. The buoyant force of the water (Pw) resists the downward push of the hydrocarbon and presses up on the interface. The capillary pressure (Pc) also pushes up against the weight of the hydrocarbon. In a stabilized system, therefore, Pw and Pc work together to exactly balance Phc. When a monitoring well is installed, however, the capillary forces are removed and consequently, the value of Pc goes to zero. Pw is therefore left on its own to bear the full weight of the hydrocarbon (Phc). It is unsuccessful in this effort, however, and the hydrocarbon/water interface in the well slowly "retreats" (i.e. falls) in the face of the greater force (Phc). As the water is displaced, more hydrocarbon flows into the well to take its place. This retreat of the hydrocarbon/water interface and the thickening of the hydrocarbon column in the well, continues until the weight of the water that is being displaced exactly balances the extra column of hydrocarbon in the well. In other words, the hydrocarbon column in the well will continue to thicken until Pw in the well equals Phc in the well.

2.2.2 *After the Initial Exaggeration* At this point, the effects of the missing capillary zone have been compensated for, and the initial exaggeration process is essentially complete. From here on out, any additional hydrocarbon reaching the area will accumulate in both the formation and the well in equal proportions. If an extra foot of

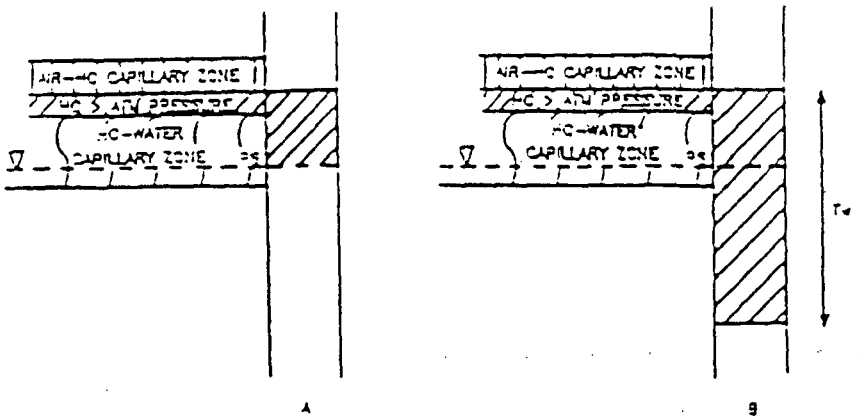


FIGURE 2-3 EXAGGERATION MECHANISM.

hydrocarbon is added to the formation (i.e. a new or continued leak), the gauged well thickness will also increase by one foot. Note that something interesting now begins to happen to the ratio of the thickness of hydrocarbon in the well compared to the thickness of the mobile hydrocarbon layer in the formation. Let us say that at the moment when the initial exaggeration completes, this ratio is 5:1. In other words, there is only one foot of mobile hydrocarbon in the formation but 5 feet of gauged hydrocarbon in the well. Let's now assume, that because of a new leak, an additional foot of hydrocarbon accumulates in the formation. Because the exaggeration process is already complete, the monitoring well thickness also increases by just one foot. The ratio of the well thickness to formation thickness is now 6:2 or 3:1. Where the well formally showed 5 times the

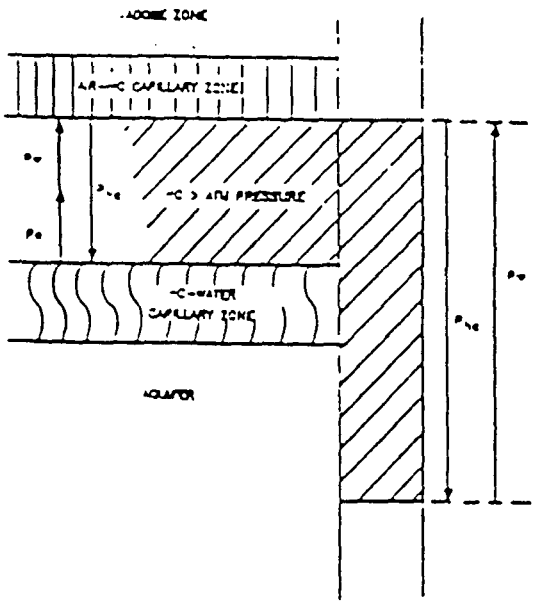


FIGURE 2-4 BALANCE OF FORCES IN THE FORMATION AND IN THE WELL.

thickness that was in the formation, it is now showing only three times the formation thickness. If the leak continues and 2 more feet of hydrocarbon accumulates in the formation (thereby adding 2 more feet to the well), the ratio of well thickness to formation thickness now drops to 8:4 or 2:1. If 4 more feet are added to both the formation and well the ratio becomes 12:8 or 1.5:1. Figure 2-5 shows a plot of the situation just described here. Note that the curve drops steeply in the beginning as new hydrocarbon is added, then flattens out as it approaches - but never quit reaches - a ratio of 1:1.

Now consider what happens when you begin recovering hydrocarbon. Let us use the same conditions that we had at the end of the last example. The initial exaggeration has occurred (5:1) and then sufficient additional hydrocarbon has accumulated so that there is now 12 feet in the well but only 8 feet of mobile hydrocarbon in the formation (a ratio of 1.5:1). After a certain period of time the recovery well(s) will have pulled enough hydrocarbon from the subsurface to reduce the thickness of the mobile hydrocarbon layer in the formation from 8 feet to 4 feet. This would also result in a 4 foot decrease in the gauged hydrocarbon thickness in the monitoring well, and we'd be back up to a 2:1 ratio. As recovery continued, you would work your way back along the curve in Figure 2-5, through a 3:1 and then to a 5:1 ratio. At this point, even though there is only a thin mobile hydrocarbon layer in the formation, there would still be 5 feet of gauged hydrocarbon in the well. Clearly then, the amount of exaggeration (i.e. the ratio of the thickness of hydrocarbon in the well to the thickness of the mobile hydrocarbon layer in the formation) will vary depending on where you are along the curve shown in Figure 2-5.

2.2.3 *Factors Controlling the Amount of Exaggeration* It is the presence of a capillary zone in the formation and its absence in the well that initiates the exaggeration process. It seems reasonable, therefore, that the thickness of the capillary zone in the formation is one factor that determines the amount of exaggeration that initially develops in the well. The greater the thickness of the capillary zone, the greater the exaggeration. The other factor that controls the ultimate exaggeration is the specific gravity of the

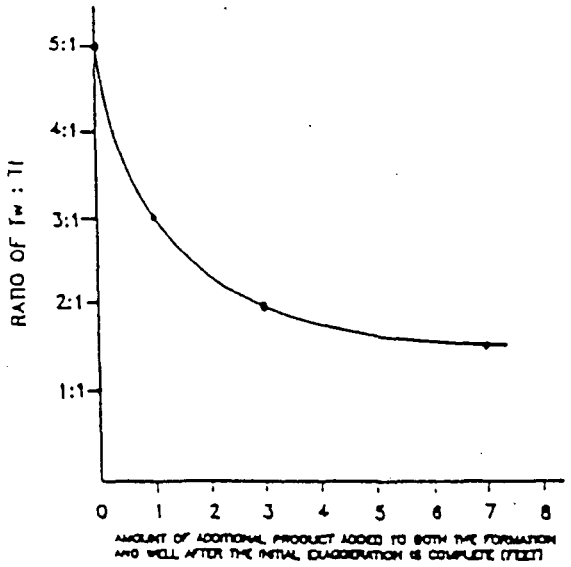


FIGURE 2-5 CHANGES IN THE EXAGGERATION FACTOR (RATIO) OVER TIME.

hydrocarbon that displaces the water, as the former enters the well. A foot of gas oil (with a specific gravity of say 0.91) weighs more than a foot of gasoline (which has a specific gravity of something on the order of 0.75). In a standard 4 inch observation well, this foot of gas oil would weigh roughly a pound more than a foot of gasoline. The extra weight would push down on the hydrocarbon/water interface with a greater force. Consequently, a longer column of water will have to be displaced from the well before the weight of that displaced water equals the weight of the heavier column of gas oil.

2.3 Miscellaneous Implications

2.3.1 *A Cross Section of a Plume* Sullivan et. al. (this volume, Figure 1) presented a sequence showing the accumulation of hydrocarbon in a monitoring well. It assumed that the well was in place prior to hydrocarbon reaching the water capillary zone, and then traced the development of the initial exaggeration of hydrocarbon in the well. Figure 2-6 (this paper) shows a cross sectional view of a portion of a hydrocarbon plume. It represents a situation in which the hydrocarbon pool has formed and stabilized prior to the installation of the monitoring wells. Well "A" might represent the initial well, in which the hydrocarbon is "discovered". Wells "B","C", and "D" would then indicate"step-out" wells drilled in order to find the "limit and extent" of the hydrocarbon pool. Notice that there are large variations in the ratio of well : formation hydrocarbon thickness. If a single "correction" factor (based on data from any one well) was used to correct gauging data from all the other wells in the pool, large errors would result. Not surprisingly, the ratio is smallest (i.e. closer to 1:1) near the center of the pool where the thickness of the layer of hydrocarbon at greater than atmospheric pressure is the largest. Toward the edge of the pool, where the thickness of the layer of hydrocarbon at greater than atmospheric pressure decreases, the ratios are noticeablly greater. Well "C" represents an extreme case, in which the layer of hydrocarbon at greater than atmospheric pressure is so thin , that there is only sufficient hydrocarbon to allow the initial exaggerated thickness to form in the well. Figure 2-6 supports the common assumption that the exaggeration is greater near the edge of the plume, and smaller (i.e. closer to 1:1) near the center of the pool.

2.3.2 *Too Little Hydrocarbon in the Well* If the system we have described is correct, then another rather intriguing question has just been raised. If the presence of even a modest capillary fringe and a thin mobile hydrocarbon layer in the formation can result in a several foot accumulation of hydrocarbon in a monitoring well, how is it possible to have a well with just a few inches or perhaps a foot of gauged hydrocarbon? Given these conditions, it would seem unlikely that you could have such a small accumulation in the well. For simplicity's sake, we have ignored the effects of the filter pack envelope around the well in our previous discussions. It appears, however, that the presence of a filter pack between the formation and the well can alter the natural conditions sufficiently to allow a small amount of normally "immobile" hydrocarbon from the air/hydrocarbon capillary fringe, to enter the well. Sullivan *et. al.* (this volume) describes this phenomenon which permits some hydrocarbon into the well even before sufficient hydrocarbons have accumulated to allow the formation of a mobile hydrocarbon layer in the aquifer.

2.4 Summary

There are a number of factors which contribute to the amount of hydrocarbon which accumulates in a monitoring well, only one of which is the actual thickness of the

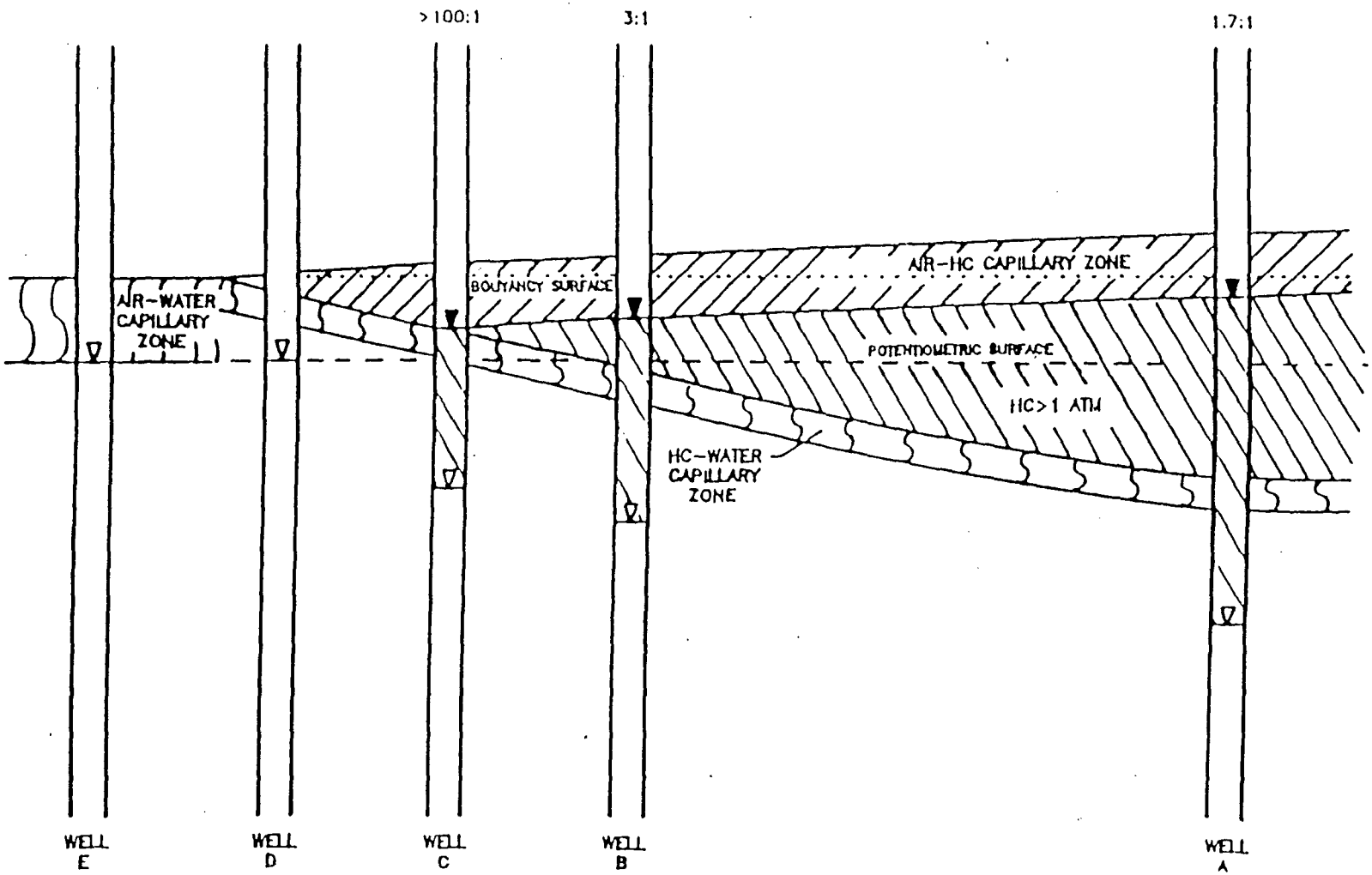


FIGURE 2-6 WELL TO FORMATION HYDROCARBON THICKNESS RATIOS IN A CROSS-SECTION OF A HYDROCARBON POOL.

mobile hydrocarbon layer in the formation. In summary, it is the presence of a capillary zone outside the well and the absence of a capillary zone inside the well which allows a thicker column of hydrocarbon to initially accumulate inside the well, than exists in the formation. Once the initial exaggeration occurs, additional hydrocarbon that reaches the area is added to both the formation and the well in equal proportions. Even if you were successful in calculating the amount of the initial exaggeration factor (say 4:1), it would only remain valid as long as there were no increases or decreases in the actual thickness of the mobile hydrocarbon layer in the formation. And yet these kinds of changes could be caused by any number of events, such as new spills or continuing leaks or the pumping that occurs during hydrocarbon recovery efforts. Consequently, taking the gauged thickness from a monitoring well and always dividing that thickness by the same calculated exaggeration factor (4 in this case), could lead to potentially large errors over time. Also, keep in mind that some large sites may have a variety of grain sizes and, hence, a variety of capillary zone thicknesses. They may also have a range of hydrocarbon types and, hence, a range of specific gravities. In such cases, you'd have to calculate a different initial exaggeration factor for each capillary zone/specific gravity pair. You couldn't simply divide all monitoring well thicknesses by a common exaggeration factor. We are left, then, with the realization that not only might we have a different exaggeration factor (ratio) for every well, each of those factors could vary over time. Attempting to accurately "correct" monitoring well data with calculated exaggeration factors should probably be avoided. The "corrected" hydrocarbon thicknesses could potentially be as much in error as are the "raw" gauging data. The danger in using "corrected" data, therefore, lies in the fact that you mistakenly believe that the resulting hydrocarbon thicknesses are accurate. With "raw" monitoring well data, at least you know the thicknesses are wrong.

A monitoring well has many uses. It provides access deep into the aquifer allowing, among other things, the measurement of fluid levels, the calculation of the potentiometric surface, the detection of hydrocarbon, and the collection of hydrocarbon and water samples for fingerprinting and analysis. What it does not provide, however, is an accurate measurement of the true mobile hydrocarbon thickness in the formation.

In spite of their short comings, however, wells remain the best all around tool for monitoring what is going on in the aquifer. The authors believe that the recharge technique described later in this paper is one method of overcoming the complications just discussed. It provides a way of estimating the true mobile hydrocarbon thickness in the formation, without having to deal with "correction" factors.

3.0 SOME IMPACTS OF USING THE EXAGGERATED WELL THICKNESSES

An accurate estimate of the hydrocarbon thickness is essential for knowing both the magnitude of the problem at a site, and designing an effective hydrocarbon recovery system.

3.1 Locating Recovery Wells

Experience with several liquid hydrocarbon skimming wells at our site suggested that areas with at least 5 to 7 feet of gauged hydrocarbon would make good locations for additional wells (i.e. would produce reasonable quantities of hydrocarbon). [Note: Although dual pump wells provide the bulk of the recovery at the site, limits on our ability to handle large quantities of produced water mean that skimmer wells will continue to be an integral part of our clean up efforts, for at least the foreseeable future.] Additional skimmer wells were installed in several areas of the site with between 5 and 7 feet of gauged hydrocarbon thickness. All of the wells were installed

carefully and showed similar (water) pumping test results. It turned out, however, that there were wide variations in the rate of liquid hydrocarbon recovered, with production ranging from 30 to almost 300 gallons per day - an order of magnitude difference. Apparently not all areas of 5 to 7 feet of gauged hydrocarbon thickness are created equal - at least in terms of their ability to produce reasonable quantities of hydrocarbon.

The results of the well tests described later showed that in one case, 7 feet of gauged thickness translated into 3.5 feet of actual thickness in the formation (a 2:1 exaggeration). In another case, however, 5 feet of gauged thickness turned out to be less than 8 inches of actual mobile liquid hydrocarbon thickness in the formation. The skimmers with poor production had apparently been inadvertently located in areas with very little actual mobile hydrocarbon. Clearly, then, the use of gauged hydrocarbon thicknesses to pick locations for skimming wells leaves something to be desired. A recovery well - including the costs of drilling, materials, piping and equipment - can be rather expensive. Consequently, the desire to know the true thickness of the plume, has more driving it than simply academic interest. It is also a matter of dollars and cents.

3.2 Estimating Volumes.

Knowing the true thickness of the hydrocarbon column in the aquifer also allows one to make more accurate estimates of how large a volume of hydrocarbon exists beneath the project site. There are at least two reasons for wanting this information. Firstly, only by knowing the actual volume of hydrocarbon in place, can all parties (clients, regulatory agencies,etc.) understand the true magnitude of the problem with which they are dealing. As a example, assume that the "raw" (i.e. gauged) monitoring well data at a site indicates that the apparent volume of mobile hydrocarbon in place is something on the order of a million gallons. That sort of number tends to make frightening headlines in local papers. It doesn't help much that somewhere in the middle of the article, the reporter mentions the fact that well thicknesses are usually exaggerated, and that the real volume may be much less. By that time, the damage is probably already done. Ideally then, we need something better than raw monitoring well data to estimate the actual volume of hydrocarbon beneath a site, before that volume is widely reported.

The second reason for wanting an accurate volume estimate has to do with one of the requirements appearing with increasing frequency in regulatory directed clean-up orders. This clause requires the agent responsible for the clean up to "show evidence of a substantial reduction in hydrocarbon volume" by a certain date. It's easy to understand the difficulty you would have in meeting this requirement if you weren't even sure of how much hydrocarbon you had to begin with! Using the example numbers from the preceding paragraph, let's say that over a certain period of time, pumps at the site recover 100,000 gallons of hydrocarbon from the sub-surface. That amounts to only 10% of the one million gallons apparently beneath the site based on the "raw" monitoring well data - hardly a "substantial reduction". Suppose, however, that the true volume beneath the site is more like 200,000 gallons (i.e. a 5 : 1 exaggeration). In that case, 50% of the volume in place would have been recovered- a much more significant reduction.

3.3 Summary.

With an understanding, then, of why exaggerated thicknesses occur in monitoring wells and with an appreciation of the variety of practical problems that those exaggerations can cause, the remainder of this paper will be devoted to examining some practical methods of calculating a more accurate estimate for the actual thickness of mobile hydrocarbon in the formation. The first technique involves recharge and/or

bail-down tests in either existing monitoring or production wells. The second method consists of analysis of cores cut during either the installation of a well or as part of a separate reconnaissance effort.

4.0 WELL TESTS

4.1 General

The basic problem one encounters in trying to use gauging data from a monitoring well to determine the actual thickness of mobile hydrocarbon in the formation is illustrated in Figure 2-2b. The top of the hydrocarbon column (hydrocarbon/air interface) in the well corresponds to the top of the mobile hydrocarbon layer in the formation. Because of the exaggeration of liquid hydrocarbon in the well, however, the bottom of the hydrocarbon zone (hydrocarbon/water interface) in the well does not correspond to the bottom of the mobile hydrocarbon zone in the formation. What we need then, is either some method of locating the hydrocarbon/water interface in the formation, or else a method of calculating the true hydrocarbon thickness without knowing the location of that interface.

Two procedures are described for estimating the true thickness of hydrocarbon in the formation. The first method is a recharge test which allows us to estimate the true hydrocarbon thickness without knowing the elevation of the hydrocarbon/water interface. Under the right conditions, the bail-down test method described second, can be used to directly estimate the thickness of mobile hydrocarbon, because it locates the hydrocarbon/water interface in the formation. The basis for the interpretation of the recharge tests and the assumptions and limitations of the tests are discussed in Sullivan et. al. (this volume).

4.2 Recharge Test

4.2.1 *Theory* Figure 4-1 shows the relationship between a column of hydrocarbon in a well and the regional potentiometric surface. The column of hydrocarbon has settled

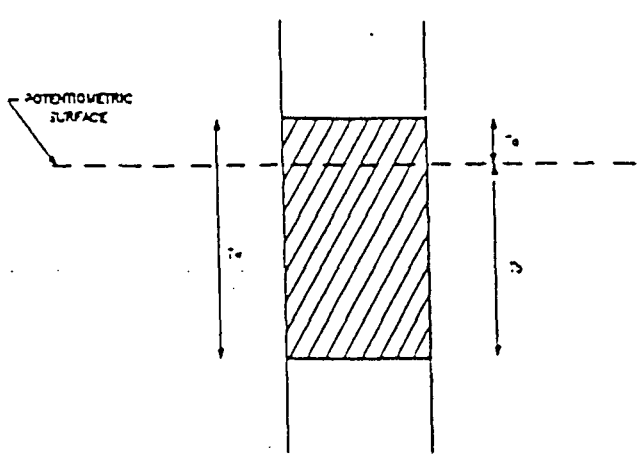


FIGURE 4-1 HYDROCARBON BUOYANCY IN A WELL

part way below the potentiometric surface displacing the water, in much the same way that an ice cube settles part way below the fluid level in a drink. The amount of settlement depends on the relative densities of the hydrocarbon and water. For the purposes of this paper, we will assume that the density of water is equal to 1.0 g/cm^3. In the future, therefore, we will substitute the term "specific gravity" for "density". Figure 4-1 shows the ratio of the height of the hydrocarbon column above and below the potentiometric surface for hydrocarbon with a specific gravity of 0.80. Table 4-1 shows some examples of this ratio for various other hydrocarbon types. Ice, by the way, has a specific gravity of roughly 0.91 in fresh water, or about the same specific gravity as gas oil. The Ta/Tb ratio for an ice cube, therefore, would be a bit more than 1:10

Table 4-1

Comparison of Ratios of the Amount of Hydrocarbon
Above and Below the Potentiometric surface,
for Products with Varying Specific Gravities

Specific Gravity of the Product (SGhc)	Ta	Tb*
0.70	1	2.33
0.75	1	3.00
0.80	1	4.00
0.85	1	5.67
0.90	1	9.00
0.95	1	19.00

*Tb = {(Ta) [(SGhc)/(SGw - SGhc)]}

As hydrocarbon is either added or removed from the well, the relative amounts above and below the potentiometric surface will be maintained. For example, if 5 feet of additional .8 gravity hydrocarbon is added to the well, 1/5th of that amount (or 1 foot) will be added above the potentiometric surface while 4/5ths (or 4 feet) will settle below the potentiometric surface.

One of the common uses of this relationship is in correcting the elevation of the water found in a monitoring well, in order to calculate the potentiometric surface (i.e. the level to which the water would rise in the well if there were no liquid hydrocarbon present). In that application, you typically start with the elevation of the hydrocarbon/water interface as gauged in the well. You then add to that elevation, an amount equal to Tb, where:

$$Tb = [(Tw) (SGhc)] \qquad (1)$$

which is the distance that the total column of hydrocarbon (Tw) has displaced the original water surface in the well. Note, however, that you could just as easily (and just as correctly) have started with the gauged elevation of the top of the hydrocarbon in the well and then <u>subtracted</u> an amount equal to Ta, where:

$$Ta = [(Tw) (1 - SGhc)] \qquad (2)$$

which is the amount of the total column of hydrocarbon above the potentiometric surface. It also follows that if you knew the thickness of the hydrocarbon column above the potentiometric surface, (Ta), and the specific gravity of the hydrocarbon, you could calculate the total thickness of hydrocarbon, (Tw), by the simple equation:

$$Tw = Ta / (1 - SGhc) \qquad (3).$$

It is just this sort of calculation that will allow us to estimate the true mobile hydrocarbon thickness in the formation without knowing the location of the bottom of the oil/water interface.

The hydrocarbon column in the formation forms around a buoyancy datum just as it does in a well. The potentiometric surface defines this datum in the well and we will refer to the equivalent datum in the formation as the buoyancy surface. Just as with the potentiometric surface in the well, hydrocarbon that is added (or removed) from the formation will be added (or removed) above and below the buoyancy surface according to the ratios shown in Figure 4-1 and Table 4-1. As an illustration, Figure 4-2a shows a stable hydrocarbon pool and a non pumping skimming well. In Figure 4-2b, the liquid hydrocarbon skimming pump has been turned on and the fluid levels allowed to restabilize. [Note that these diagrams assume homogeneous conditions.] As hydrocarbon is removed from the well, a small drawdown cone forms in the hydrocarbon layer in the formation near the well. At the same time, the hydrocarbon/water interface in both the well and the formation rebound in response to the removal of the hydrocarbon. During this process, the elevation of both the top and bottom surfaces of the mobile liquid hydrocarbon layer in the formation, always maintain the proper relative distances from the buoyancy surface and converge on that plane, intersecting it at the well. That intersection point ("X") is the entry point of hydrocarbon into the well during continued skimming. Using the same sort of relationships developed in the previous section for hydrocarbon, water and the potentiometric surface in a well, we can say that the distance

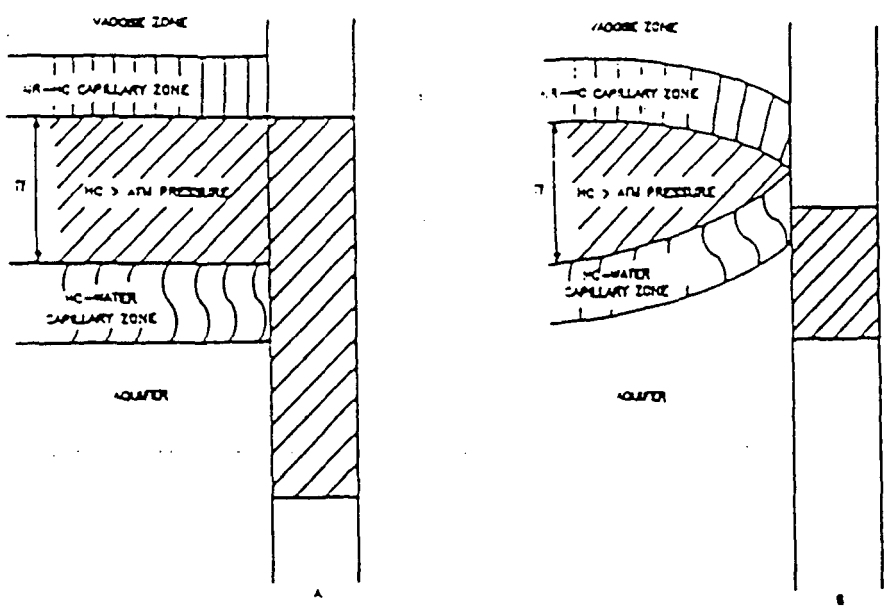


FIGURE 4—2 RESPONSE OF A THREE PHASE AQUIFER SYSTEM TO PUMPING.

from the buoyancy surface to the base of the mobile liquid hydrocarbon layer in the formation is given by Td, where:

$$Td = [\ (Tf)\ (SGhc)\ ] \qquad (4)$$

and that the distance from the buoyancy surface to the top of the mobile liquid hydrocarbon layer in the formation is defined as Tc, where:

$$Tc = [\ (Tf)\ (1 - SGhc)\ ] \qquad (5).$$

These relationships are shown in Figure 4-3. Rearranging this equation gives:

$$Tf = Tc\ /\ (1 - SGhc) \qquad (6).$$

Note that this is very similar to equation 3. The only difference is that equation 3 calculates the thickness of the liquid hydrocarbon column in the well (Tw), while equation 6 computes the thickness of the mobile hydrocarbon zone in the formation (Tf). If we can calculate Tc, the distance between the top of the mobile hydrocarbon layer and the buoyancy surface, then assuming the specific gravity of the hydrocarbon is known, the "true" thickness of the mobile hydrocarbon layer in the formation may be calculated.

In order to calculate the distance Tc, we need to know the elevation of the top of the mobile hydrocarbon layer, as well as the elevation of the buoyancy surface (which is defined by "X", the hydrocarbon entry point into the well). The top of the mobile liquid hydrocarbon layer can be readily obtained simply by gauging the well for the air/hydrocarbon interface prior to turning on the skimmer pump. All that remains is to figure out a method of locating point "X", and we can then calculate the true formation thickness (Tf) from equation 6. The recharge test technique provides us such a method.

The recharge test involves pumping hydrocarbon from the well until steady state conditions are reached, and then recording the elevation of the air/hydrocarbon interface over time as hydrocarbon recharges into the well. These data are then plotted on a graph, as shown in Figure 4-3, with the slope of the resulting curve being the recharge rate of the liquid hydrocarbon into the well. All other things being equal, this recharge rate will be controlled primarily by the height of the mobile hydrocarbon column (i.e. the "head") above the entry point (X). That head, and consequently the recharge rate will remain constant until the air/hydrocarbon interface rises to the hydrocarbon entry

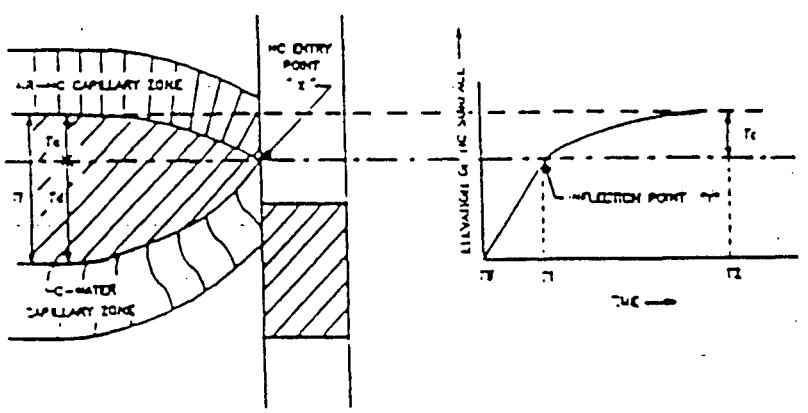


FIGURE 4-3 DIAGRAMMATIC RECHARGE TEST PLOT.

point (Figure 4-4). As the air/hydrocarbon interface rises beyond the entry point, the head steadily decreases with the result that the recharge rate also decreases. In Figure 4-3, the constant recharge part of the recovery appears as the straight line portion from TØ to T1. Point"Y", the inflection point on the curve corresponds with the elevation of the hydrocarbon entry point (X) in the well. The curved portion of the plot, from T1 to T2 represents the steadily decreasing hydrocarbon recharge rate as the air/hydrocarbon interface rises from the hydrocarbon entry point toward the pre-pumping level, which is equal to the top of the mobile hydrocarbon layer in the formation. Point "Y" corresponds to the elevation of the hydrocarbon entry point into the well (X) and consequently, the elevation of the buoyancy surface. The distance "Z", which can be measured from the graph in Figure 4-3, is, therefore, equal to Tc in equation 6. We now have all the information we need to calculate the "true" thickness of mobile hydrocarbon in the formation.

Given an ideal, homogeneous formation, the recharge method could be used to calculate the exact thickness of mobile hydrocarbon. In naturally occurring situations (i.e. non-homogeneous conditions), however, the method provides only an estimate of the true hydrocarbon thickness. Noise in the recharge data may make it difficult to pick the inflection point ("Y") exactly. In addition, the pressure of the hydrocarbon in the formation at the elevation of "Y" may not be atmospheric (Sullivan et. al., this volume), and the result of equation (6) would, therefore, not be the exact thickness of the mobile hydrocarbon layer. Nevertheless, even in situations where this is the case, the recharge method can be used to accurately track the change in hydrocarbon thickness. This is because, by definition, the elevation of the buoyancy surface -and hence the hydrocarbon entry level - of a particular well will not change as the hydrocarbon thickness in the vicinity of the well changes.

4.2.2 *Test procedure*

Step 1 : Pump hydrocarbon from the well, and continue the pumping until steady state conditions (i.e. Figure 4-2b) have been reached. Maintain the thinnest amount of hydrocarbon in the well as possible, without pumping any water.

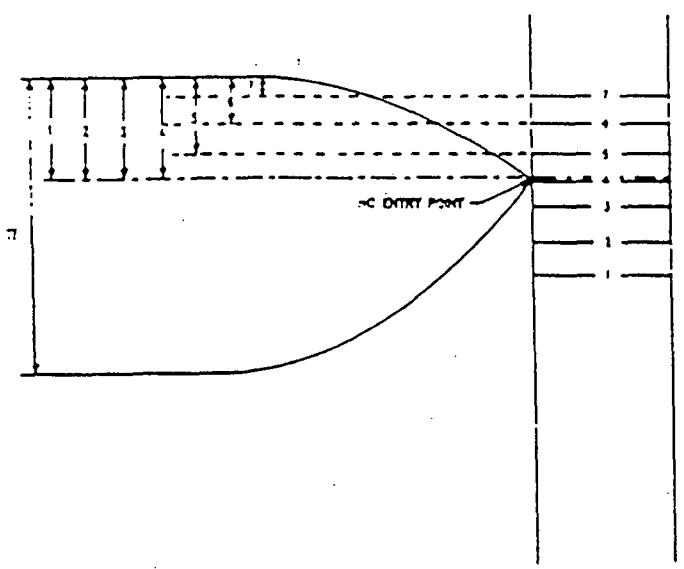


FIGURE 4—4 CHANGE IN THE PRESSURE HEAD DRIVING HYDROCARBON TOWARD A WELL DURING A RECHARGE TEST.

Step 2 : Shut off the pump and record the top of the liquid hydrocarbon surface (air/hydrocarbon interface) in the well as the hydrocarbon recharges. Although a hydrocarbon/water interface probe can be used, we recommend the use of a pressure transducer linked to an automatic recording device. Continue to record data until the well is fully recharged.

Step 3 : Plot the elevation of the top of the hydrocarbon surface in the well vs time.

Step 4 : Pick the point (Y), at which the recharge rate begins to decline. This corresponds to the elevation of the hydrocarbon entry point (and hence the buoyancy surface) on the curve. Scale off the distance "Z", which is equal to "Tc" in Figure 4-3. Equation 6 can then be used to calculate the actual thickness of hydrocarbon in the formation.

4.2.3 *Recharge Test Results* Recharge tests have been conducted in eight skimming wells. The wells all have 12-inch stainless steel, wire-wrapped screen and are constructed and developed in a similar manner. Hydrocarbon ranging from gasoline products to gas oil is produced from a highly uniform, fine to medium sand. All of the wells have been in operation at least 60 days prior to testing, and production rates and well thicknesses were held relatively constant for a minimum of four days preceding a test. Recharge tests were conducted twice in two of the wells, to assess the reproducibility of the results. In both cases, the recharge curves for the two tests were very similar.

Figure 4-5 shows 6 annotated recharge test plots. Table 4-2 shows the results of calculating Tf using these plots and equation 6. Also shown for comparison, is Tw for each well (as gauged just before the test), the ratio of Tw to Tf and the average hydrocarbon production rate, where appropriate.

Table 4-2
Well Test Results

WELL	Tw (feet)	Tf (feet)	EXAGGERATION (Tw / Tf)	AVERAGE PRODUCTION RATE (gpm)
Recharge Test Results				
WW- 47	6.70	2.75	2.4:1	220
WW-124	7.09	3.52	2.0:1	280
WW-126	5.41	0.88	6.2:1	60
WW-133	17.72	7.11	2.5:1	160
WW-130	5.81	1.55	3.8:1	30
WW-131	18.00	9.43	1.9:1	170
Bail-Down Tests				
ROW-143	4.97	0.61	8.1:1	N/A
ROW-189	12.50	0.29	43.0:1	N/A
ROW-129	0.94	0.0*	N/A	N/A

* Capillary oil only

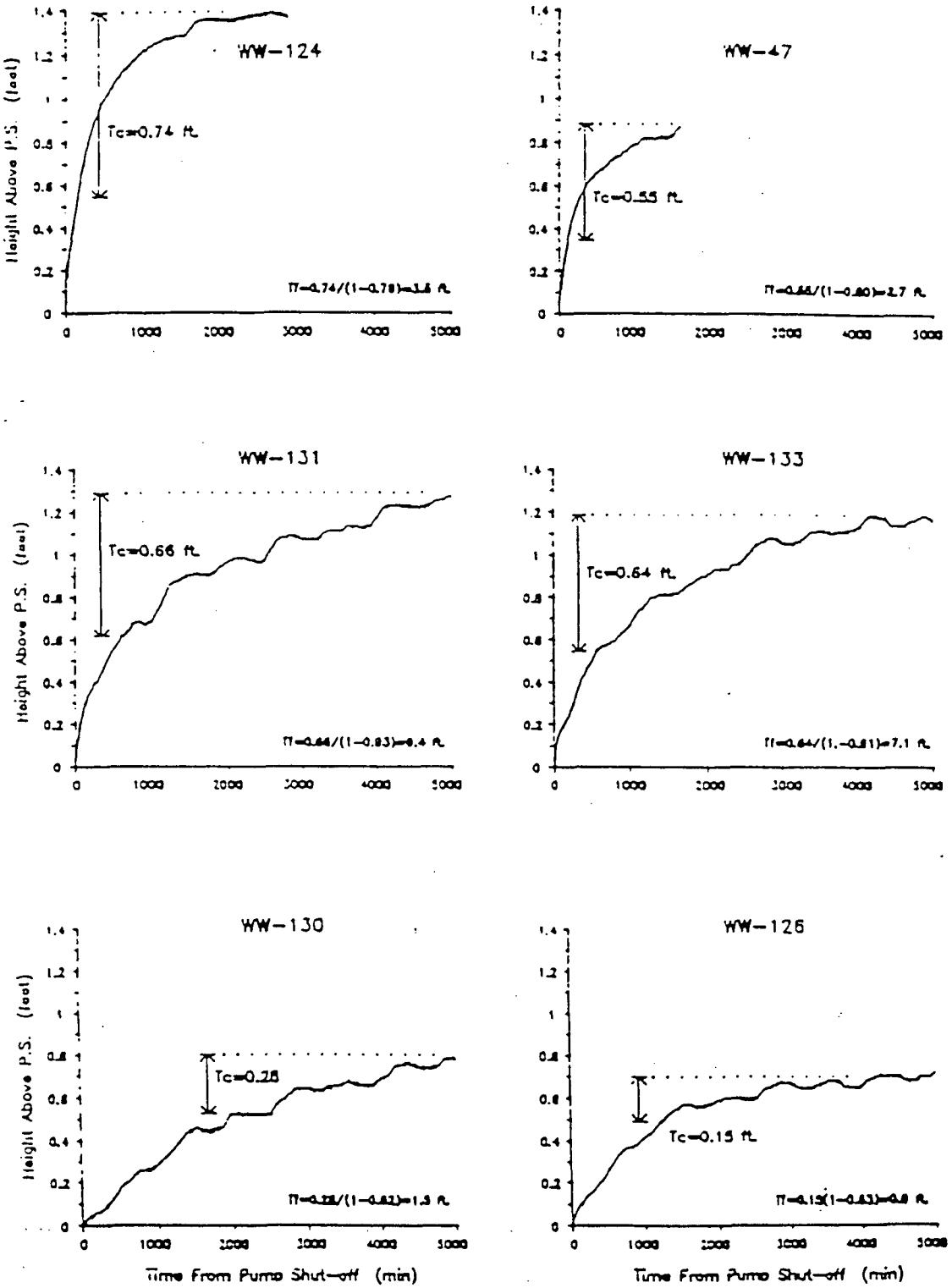


FIGURE 4-5 RESULTS OF RECHARGE TESTS IN SIX WELLS.

4.3 Bail-Down Tests

4.3.1 *General* Under certain circumstances, the true thickness of the mobile hydrocarbon layer in the formation can be determined by using a simple bail-down technique. The test may be used in areas whether the hydrocarbon/water interface is above the potentiometric surface, and the recharge rate of hydrocarbon into the well is slow.

The elevation data generated by the test are plotted against time and interpretations made based on the characteristics of the recharge curve. Figure 4-6 shows the "type curves" for three possible situations. If the base of the hydrocarbon in the formation is above the potentiometric surface, the well will recharge at a constant rate to that level, and then begin to recharge at at steadily decreasing rates as the well continues to fill. This is similar to what happens in a recharge test. Recall that in a recharge test the inflection point "Y" between the straight line (constant rate) and the curved (decreasing rate) portions of the plot, represented by the elevation of the buoyancy surface in the mobile hydrocarbon layer. That is because the well had been pumped sufficiently long to allow a draw-down cone to form in the hydrocarbon pool, and to allow the hydrocarbon/water interface to rebound in response to the removal of the hydrocarbon (i.e. until steady-state conditions had been reached. In a bail-down test, however, the only hydrocarbon that is removed is essentially what existed in the well. A draw-down cone is not formed in the hydrocarbon pool, consequently, the hydrocarbon/water interface does not rebound toward the buoyancy surface. The shape of the mobile hydrocarbon zone in the formation, therefore, remains as shown in figure 4-6a. Given these conditions, the inflection point "Y" represents not the elevation of the buoyancy surface, but rather the base of the mobile hydrocarbon layer in the formation. The thickness of the mobile hydrocarbon layer (Tf) is then the distance from "Y" to the top of the hydrocarbon in the well under static conditions, and may be scaled directly off the plot. This interpretation is based on the assumption that the thickness of hydrocarbon in the formation does not change during the test.

From the discussion in the previous paragraph,if the level of the hydrocarbon in the formation is below the potentiometric surface, the recharge curve produced from the bail-down test will show a steadily decreasing rate of flow into the well from the very beginning (Figure 4.6b). Given these conditions, the bail-down test will not yield any information that can be used to calculate the true mobile hydrocarbon thickness. A recharge test will yield useable results regardless of whether the hydrocarbon/water interface is located above or below the potentiometric surface. Consideration should,

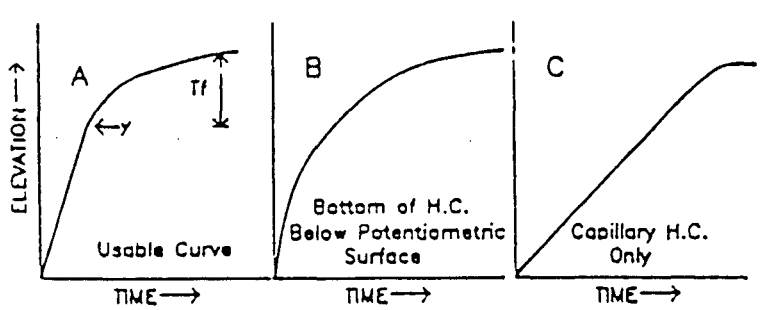


Figure 4-6. Type recharge curves for bail-down tests.

therefore, be given to conducting a recharge test at locations where the bail-down test yields the type of curve shown in Figure 4.6b.

The third type of curve that may be generated from a bail-down test (Figure 4.6c) shows a constant rate of recharge from the beginning of the test until the top static hydrocarbon level in the well is reached (i.e. during the entire test). Again based on our previous discussions, this would seem to indicate that the "head" driving the hydrocarbon into the well remained the same throughout the test. In other words, the recharging hydrocarbon surface in the well apparently reached the top of the mobile hydrocarbon zone before it reached the base of the mobile hydrocarbon zone. The solution to this apparent dilemma would seem to be that a zone of mobile hydrocarbon simply does not exist in the formation. This type of recharge could result if the filter pack around the well is allowing hydrocarbon at less than atmospheric pressure, to accumulate and enter the well (see section 2.3.2)

4.3.2 *Bail-Down Test Procedure* The bail-down test consists of the following steps:

Step 1 : Gauge the well and calculate the potentiometric surface.

Step 2 : Bail the hydrocarbon from the well rapidly.

Step 3 : Gauge the well again, and if the thickness of the hydrocarbon is acceptable (0.1 to 1.0 feet), calculate the potentiometric surface. It should be within approximately 0.05 feet of the first value, before beginning to record the recharging hydrocarbon elevations in the well

Step 4 : Record the top of the hydrocarbon surface in the well as it recharges. Continue until the well is fully recharged.

4.3.3 *Bail-Down Test Results*.. The results of three bail-down tests are summarized in Table 4-2.

4.4 Summary

The choice of which well test technique to use will depend on a number of considerations. If we compare these tests to the standard water well tests, we find that the recharge test is similar to a water pumping test, while the bail-down technique is more closely related to a "slug test". One of the main advantages of the recharge test method, therefore, is that it is more accurate than the bail-down tests. The recharge test also has the advantage of being able to yield useable results regardless of the location of the hydrocarbon/water interface in relation to the potentiometric surface. The main disadvantage of this technique, is that it is more complicated to conduct and, therefore, more time consuming and costly.

The bail-down test, on the other hand, has the advantage of being relatively cheap and quick to run since it doesn't require a pump, storage for the large volumes of hydrocarbon recovered, etc.. The bail-down test has two main disadvantages. First, since it is more like a slug test than a pumping test, the results will be less accurate than those from a recharge test. Second, the bail-down test will only work if the hydrocarbon/water interface is above the potentiometric surface. In deciding which technique to use, consideration should be given to initially trying the bail-down method. If this technique fails to yield acceptable results, then the recharge test method could be employed.

5.0 CORES

Coring through the contaminated zone is another method of obtaining a more accurate estimate of the true thickness of mobile hydrocarbon in the formation. If the cores are taken continuously (i.e. one right after another, without a break), they can be laid end to end for a close up look at a relatively undisturbed cross section of the formation. Ideally, once the approximate depth of the contaminated zone is known, any new holes would be cored from a little above the top of the air/hydrocarbon interface through the mobile hydrocarbon layer and into the water saturated section. This would allow a complete look at the zone of interest. Several things must be kept in mind when considering whether to core, how best to core, and in evaluating the results of the coring.

5.1 Lost Core

While continuous split spoon sampling (with standard sample lengths of 12 to 18 inches) is probably acceptable, as a general rule, the longer a core you can cut at a time, the more accurate the information will be. Each time you drive say an 18 inch core in front of the bit, then pull the core out, drill down 18 inches and then drive another sampler, you run the risk of loosing perhaps a few inches of the section. It's very difficult for the driller to stop the whirling bit at an exact depth. In fact, an accuracy of a few inches would generally be considered quite good. Over a long coring interval those "few inches" from each sample can add up quickly. The impact of this "slop" in measurement is magnified if the actual contaminated zone is rather thin. As an example, let's say you cut three 12 inch cores in a row. Let's also say that the visibly contaminated zone starts 4 inches above the bottom of the upper core, continues through the entire middle core and extends 8 inches into the bottom core. The apparent length of the contaminated interval is, therefore, 24 inches. If we have lost (or gained) just three inches between each sample, then the actual contaminated interval could be between 18 an 30 inches long. In other words, the apparent length could be off by as much as 25%.

5.2 Dry vs Wet

A dry coring method (i.e. augers or air rotary) is preferred over a mud coring system. The presence of the mud interferes with determining the depth at which fluid is first encountered. Also, retaining the core in the sample barrel is sometimes more difficult in a mud rotary hole.

5.3 Uncontaminated Samples

Cored samples of the formation are preferable to the ground-up and mixed together cuttings obtained from conventional augering or mud/air rotary systems because the former are relatively undisturbed. Also, since they are encased in the split spoon or core barrel, the samples cannot become "contaminated" by foreign material on the way up to the surface.

5.4 Depth Control

Core samples are depth discrete while auger cuttings are not. If holes must be logged based on auger cuttings, care should be taken not to confuse the cuttings that have just arrived at the surface with what the formation looks like at the tip of the bit. Consider, for example, a case in which you are drilling a 150 foot hole. The driller has just added the last five foot flite of auger and drilled it down flush with the surface. The cuttings at the surface at that point look "clean" and so you pull out and back fill the hole, reporting that there is no contamination down to 150 feet. Since it may take several minutes for cuttings from the tip of the bit to travel that distance, you really haven't seen a sample of the formation at 150 feet to know if there is any contamination there or not. One should always continue to rotate the augers in place for awhile once the zone of interest has been reached in order to allow time for the cuttings from that interval to reach the surface. In some cases, for example in clayey soils, pieces of the formation material may still be stuck to the drill bit when the augers are removed from the boring, thereby providing additional clues to the bottom hole lithology.

5.5 Apparent Thickness vs True Thickness

The contaminated section of the core represents a thickness greater than the actual mobile hydrocarbon layer. An air/hydrocarbon capillary zone will form above the mobile hydrocarbon layer much as a air/water capillary zone forms above the water table. Since at least the lower part of the air/hydrocarbon capillary zone may be 100% saturated with hydrocarbon, it will be impossible to distinguish between this capillary zone and the mobile hydrocarbon layer just by looking at the core. The apparent contaminated zone will, therefore, be a combination of the two. Over time, the elevation of the water table and capillary zone can change in response to fluctuations in regional water levels. Pumping and injection activities that we initiate in our clean up efforts also influence water levels. The hydrocarbon saturated layer, which is supported by the capillary zone, drifts up or down along with the fluctuating potentiometric surface, potentially smearing the hydrocarbon over a large interval. This phenomenon is shown in Figure 5-1. The smeared zone can further confuse efforts to pick the true thickness of the mobile hydrocarbon layer in the formation. Table 5-1 shows the results from several cores cut recently at the refinery. Note the fairly wide range in difference between the gauged thickness and the thickness of the visibly contaminated zone in the core. In one case (Row - 175), the gauged and core thicknesses are virtually identical. In another, (Row-189), however, the thicknesses are off by a factor of 6.

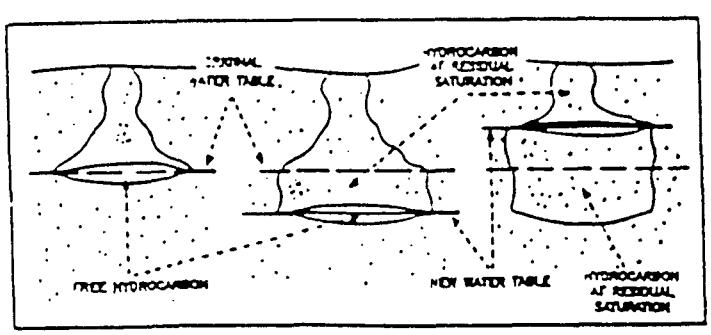


FIGURE 5-1 CONTAMINATING EFFECT ON SOIL CAUSED BY FLUCTUATING WATER TABLE (AFTER CONCAWE, 1979, FIG. 13).

Table 5-1

Comparison of the Gauged Hydrocarbon Thickness with the Hydrocarbon Thickness Seen in Cores

Well	Gauged Product Thickness (feet)	Thickness of the Contaminated Zone in the Core (feet)
Row-133	17.72	13.00
Row-175	5.22	5.32
Row-188	12.75	4.30
Row -189	12.75	2.25

Simply using the thickness of the contaminated zone in a core will result in over estimating the true thickness of the mobile hydrocarbon layer in the formation. In all cases, though, the contaminated thickness in the core is greater than the true thickness of mobile hydrocarbon in the formation. Consequently the core thickness could be considered a conservative upper limit to the thickness of the mobile hydrocarbon layer. Note also, that in spite of the fact that the core thickness is greater than the true thickness, it is probably still closer to the actual thickness than is the thickness of hydrocarbon that you gauge in the well.

5.6 The Use of UV Fluorescence to Detect Light Products in Cores

Visual detection of hydrocarbon in cores can sometimes be tricky. If the hydrocarbon is dark brown and the core is a light tan sand, the task of identifying the contaminated zone is fairly straightforward. However, if the hydrocarbon is clear or a light golden yellow (i.e. jet fuel or typical service station products), then the hydrocarbon saturated sands may be virtually indistinguishable from the water saturated sands. On holes where respirators are being worn, odor can not be used as a method to identify hydrocarbon contaminated sands. In this situation, it is easy for the presence of hydrocarbon to be missed during field inspection of the cores. It may not be until later lab tests on the samples that the hydrocarbon is detected, perhaps leading to some false preliminary reports of "clean" sands. During the early site assessment work at the refinery we encountered this kind of problem. In comparing field descriptions of samples and later lab test results on these same samples, reports for that period occasionally contain comments along the lines of ".....elevated oil and grease levels could not generally be correlated with visible liquid hydrocarbon in the soils". In the instances when this lack of correlation occurred, later fingerprinting of the liquid hydrocarbon present in the cores generally revealed hydrocarbon in the light distillate (gasoline) and jet fuel range. In the cases where visual and lab detection of hydrocarbon correlated well, fingerprinting generally indicated hydrocarbon in the heavier range (i.e. fuel oil and gas oil). Because of this problem, we borrowed a technique that has

long been used by oilfield geologists, the detection of liquid hydrocarbon in cores by means of ultra-violet (UV) fluorescence.

When certain substances are exposed to a UV light source, their electrons absorb the UV energy and are "kicked" into a higher or "excited" electronic level. Almost immediately, however, these "excited" electrons drop back down to their original or ground state. In the process of dropping to the lower energy level, they emit a burst of light, that we call fluorescence. Since most hydrocarbons fluoresce, including the light colored gasolines and jet fuels, we can use a UV light to detect their presence even if we can't identify them under normal (white) light. Small samples can be gathered at regular intervals along the core and placed under a UV light in a darkened room. [Special cabinets, designed to eliminate external light interference, may be purchased for use in the field.] Those samples with air or water filling the pore spaces will remain dark. Samples with hydrocarbon filling the pores will glow. All other things being equal, the 100% hydrocarbon saturated samples will glow the brightest. Lower percents of hydrocarbon saturation (i.e. above the air/hydrocarbon capillary zone and the dissolved hydrocarbon phase in water) will be identifiable but will show a duller fluorescence. A UV light, however, is not a quantitative tool. It will not tell you how much hydrocarbon is present. Rather, it is a qualitative tool - it will tell you whether or not fluorescent hydrocarbon is present. Fluorescence can be used as a "real time" screening tool to detect the presence of hydrocarbon's that might otherwise be missed by simple visual examination of the core.

5.7 Summary

Continuous coring can be a useful tool in evaluating the extent of contamination at a site. It's main drawback is probably cost, since cutting cores will take longer than simply drilling, and the fact that cores provide only a "snapshot in time" of the contamination. In other words, cores, unlike recharge tests, are not easily repeatable. If you want to see how the contaminated zone changes over time, you would have to drill a brand new hole. Continuous cores, however, provide a number of advantages over conventional drill cuttings. Because the samples are depth discreet (i.e. uncontaminated by the formation above), they provide a more accurate log of both the lithology and degree of contamination. They also provide a much better view of what the contaminated zone really looks like. The core provides a close up look at the contact between the hydrocarbon and water saturated sands. Any lithologic controls on hydrocarbon contamination (i.e. a preference for coarse sands or gravels as opposed to silts or clays) will be more easy to recognize in continuous cores. The thickness of the contaminated section indicated by the core is always greater than the "true" thickness of the mobile hydrocarbon layer in the formation. When large exaggerations exist in the hydrocarbon thicknesses gauged monitoring wells, however, the core data is often much closer to the true thickness than what the well gauging data indicates. In any case, the core data will delineate the thickness of the contaminated zone which must ultimately be dealt with during clean up - whether by pumping (for the mobile hydrocarbon layer) or by some additional technique like bioremediation.

6.0 SUMMARY

The quest to be able to measure the true thickness of the mobile hydrocarbon layer in the formation, although partly of academic interest, is really driven by some important practical considerations. Only by understanding the true thickness can we efficiently locate recovery wells, estimate volumes of hydrocarbon beneath the site and

accurately track the success of our recovery efforts over time. The authors hope that the well test and coring techniques described in this paper, can be used as tools in that effort.

REFERENCES

Blake, S. B. and R.A. Hall, 1984. "Monitoring Petroleum Spills with Wells: Some Problems and Solutions". Fourth National Symposium and Exposition on Aquifer Restoration and Ground Water Monitoring, NWWA, Columbus, Ohio.

CONCAWE, 1979. Protection of Ground Water from Oil Pollution. CONCAWE Report No. 3/79, The Hague.

Gruszczenski, T.S., 1987. "Determination of a Realistic Estimate of the Actual Formation Product Thickness Using Monitoring Wells: A Field Bailout Test". Proceedings of the NWWA/API Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water - Prevention, Detection and Restoration.

Hall, R.A., S.B. Blake and S.C. Champlin Jr., 1984. "Determination of Hydrocarbon Thickness in Sediments Using Borehole Data". Fourth National Symposium on Aquifer Restoration and Groundwater Monitoring, NWWA, Columbus, Ohio.

Biographical Sketches

Pat Hughes received his BS degree (Engineering) from West Point in 1971 and, after a tour in the service, his MS degree (Geology) from San Diego State University. He worked for three years as a geologist with the County of San Diego's environmental group. He then joined Chevron in 1981 and worked as a corporate hydrogeologist on numerous ground water studies across the U.S.. For the last 3 years he has been the project hydrogeologist at a large petroleum refinery involved in a site assessment and hydrocarbon recovery program. Mr. Hughes is a Registered Geologist in California.

Clay R. Sullivan is currently a Project Geologist with Riedel Environmental Services in Los Angeles, California and is involved in a hydrocarbon recovery effort at a petroleum refining facility. Mr. Sullivan is a Registered Geologist in the State of California. He received a BS degree in Geology from the University of New Mexico in 1979 and a MS degree in Geology from the Colorado School of Mines in 1984.

Ronald E. Zinner is currently the Lead Project Hydrogeologist for Riedel Environmental Services in Los Angeles, California. He received his B.S. degree in Geology from UCLA in 1980, and his M.S. degree in Geological Engineering from the University of Nevada-Reno in 1983. Mr. Zinner is a Registered Geologist in the State of California. For the last four years his work has focused on groundwater hydraulics with emphasis on liquid hydrocarbon recovery.

G

300454

APPENDIX G

REGION II LOW STRESS (LOW FLOW) GROUND WATER SAMPLING PROCEDURE

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION II

GROUND WATER SAMPLING PROCEDURE
LOW STRESS (Low Flow) PURGING AND SAMPLING

I. SCOPE & APPLICATION

This Low Stress (or Low-Flow) Purging and Sampling Procedure is the EPA Region II standard method for collecting low stress (low flow) ground water samples from monitoring wells. Low Stress Purging and Sampling results in collection of ground water samples from monitoring wells that are representative of ground water conditions in the geological formation. This is accomplished by minimizing stress on the geological formation and minimizing disturbance of sediment that has collected in the well. The procedure applies to monitoring wells that have an inner casing with a diameter of 2.0 inches or greater, and maximum screened intervals of ten feet unless multiple intervals are sampled. The procedure is appropriate for collection of ground water samples that will be analyzed for volatile and semi-volatile organic compounds (VOCs and SVOCs), pesticides, polychlorinated biphenyls (PCBs), metals, and microbiological and other contaminants in association with all EPA programs.

This procedure does not address the collection of light or dense non-aqueous phase liquids (LNAPL or DNAPL) samples, and should be used for aqueous samples only. For sampling NAPLs, the reader is referred to the following EPA publications: DNAPL Site Evaluation (Cohen & Mercer, 1993) and the RCRA Ground-Water Monitoring: Draft Technical Guidance (EPA/530-R-93-001), and references therein.

II. METHOD SUMMARY

The purpose of the low stress purging and sampling procedure is to collect ground water samples from monitoring wells that are representative of ground water conditions in the geological formation. This is accomplished by setting the intake velocity of the sampling pump to a flow rate that limits drawdown inside the well casing.

Sampling at the prescribed (low) flow rate has three primary benefits. First, it minimizes disturbance of sediment in the bottom of the well, thereby producing a sample with low turbidity (i.e., low concentration of suspended particles). Typically, this saves time and analytical costs by eliminating the need for collecting and analyzing an additional filtered sample from the same well. Second, this procedure minimizes aeration of the ground water during sample collection, which improves the sample quality for VOC analysis. Third, in most cases the procedure significantly reduces the volume of ground water purged from a well and the costs associated with its proper treatment and disposal.

III. ADDRESSING POTENTIAL PROBLEMS

Problems that may be encountered using this technique include a) difficulty in sampling wells with insufficient yield; b) failure of one or more key indicator parameters to stabilize; c) cascading of water and/or formation of air bubbles in the tubing; and d) cross-contamination between wells.

Insufficient Yield

Wells with insufficient yield (i.e., low recharge rate of the well) may dewater during purging. Care should be taken to avoid loss of pressure in the tubing line due to dewatering of the well below the level of the pump's intake. Purging should be interrupted before the water level in the well drops below the top of the pump, as this may induce cascading of the sand pack. Pumping the well dry should therefore be avoided to the extent possible in all cases. Sampling should commence as soon as the volume in the well has recovered sufficiently to allow collection of samples. Alternatively, ground water samples may be obtained with techniques designed for the unsaturated zone, such as lysimeters.

Failure to Stabilize Key Indicator Parameters

If one or more key indicator parameters fails to stabilize after 4 hours, one of four options should be considered: a) continue purging in an attempt to achieve stabilization; b) discontinue purging, do not collect samples, and document attempts to reach stabilization in the

log book; c) discontinue purging, collect samples, and document attempts to reach stabilization in the log book; or d) Secure the well, purge and collect samples the next day (preferred). The key indicator parameter for samples to be analyzed for VOCs is dissolved oxygen. The key indicator parameter for all other samples is turbidity.

Cascading

To prevent cascading and/or air bubble formation in the tubing, care should be taken to ensure that the flow rate is sufficient to maintain pump suction. Minimize the length and diameter of tubing (i.e., 1/4 or 3/8 inch ID) to ensure that the tubing remains filled with ground water during sampling.

Cross-Contamination

To prevent cross-contamination between wells, it is strongly recommended that dedicated, in-place pumps be used. As an alternative, the potential for cross-contamination can be reduced by performing the more thorough "daily" decontamination procedures between sampling of each well in addition to the start of each sampling day (see Section VII, below).

Equipment Failure

Adequate equipment should be on-hand so that equipment failures do not adversely impact sampling activities.

IV. PLANNING DOCUMENTATION AND EQUIPMENT

- Approved site-specific Field Sampling Plan/Quality Assurance Project Plan (QAPP). This plan must specify the type of pump and other equipment to be used. The QAPP must also specify the depth to which the pump intake should be lowered in each well. Generally, the target depth will correspond to the mid-point of the most permeable zone in the screened interval. Borehole geologic and geophysical logs can be used to help select the most permeable zone. However, in some cases, other criteria may be used to select the target depth for the pump intake. In all cases, the target depth must be approved by the EPA hydrogeologist or EPA project scientist.

- Well construction data, location map, field data from last sampling event.
- Polyethylene sheeting.
- Flame Ionization Detector (FID) and Photo Ionization Detector (PID).
- Adjustable rate, positive displacement ground water sampling pump (e.g., centrifugal or bladder pumps constructed of stainless steel or Teflon). A peristaltic pump may only be used for inorganic sample collection.
- Interface probe or equivalent device for determining the presence or absence of NAPL.
- Teflon or Teflon-lined polyethylene tubing to collect samples for organic analysis. Teflon or Teflon-lined polyethylene, PVC, Tygon or polyethylene tubing to collect samples for inorganic analysis. Sufficient tubing of the appropriate material must be available so that each well has dedicated tubing.
- Water level measuring device, minimum 0.01 foot accuracy, (electronic preferred for tracking water level drawdown during all pumping operations).
- Flow measurement supplies (e.g., graduated cylinder and stop watch or in-line flow meter).
- Power source (generator, nitrogen tank, etc.).
- Monitoring instruments for indicator parameters. Eh and dissolved oxygen must be monitored in-line using an instrument with a continuous readout display. Specific conductance, pH, and temperature may be monitored either in-line or using separate probes. A nephalometer is used to measure turbidity.
- Decontamination supplies (see Section VII, below).
- Logbook (see Section VIII, below).

- Sample bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags or labels, chain of custody.

V. SAMPLING PROCEDURES

Pre-Sampling Activities

1. Start at the well known or believed to have the least contaminated ground water and proceed systematically to the well with the most contaminated ground water. Check the well, the lock, and the locking cap for damage or evidence of tampering. Record observations.

2. Lay out sheet of polyethylene for placement of monitoring and sampling equipment.

3. Measure VOCs at the rim of the unopened well with a PID and FID instrument and record the reading in the field log book.

4. Remove well cap.

5. Measure VOCs at the rim of the opened well with a PID and an FID instrument and record the reading in the field log book.

6. If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Note that the reference point should be surveyed for correction of ground water elevations to the mean geodesic datum (MSL).

7. Measure and record the depth to water (to 0.01 ft) in all wells to be sampled prior to purging. Care should be taken to minimize disturbance in the water column and dislodging of any particulate matter attached to the sides or settled at the bottom of the well.

8. If desired, measure and record the depth of any NAPLs using an interface probe. Care should be taken to minimize disturbance of

any sediment that has accumulated at the bottom of the well. Record the observations in the log book. If LNAPLs and/or DNAPLs are detected, install the pump at this time, as described in step 9, below. Allow the well to sit for several days between the measurement or sampling of any DNAPLs and the low-stress purging and sampling of the ground water.

Sampling Procedures

9. Install Pump: Slowly lower the pump, safety cable, tubing and electrical lines into the well to the depth specified for that well in the EPA-approved QAPP or a depth otherwise approved by the EPA hydrogeologist or EPA project scientist. The pump intake must be kept at least two (2) feet above the bottom of the well to prevent disturbance and resuspension of any sediment or NAPL present in the bottom of the well. Record the depth to which the pump is lowered.

10. Measure Water Level: Before starting the pump, measure the water level again with the pump in the well. Leave the water level measuring device in the well.

11. Purge Well: Start pumping the well at 200 to 500 milliliters per minute (ml/min). The water level should be monitored approximately every five minutes. Ideally, a steady flow rate should be maintained that results in a stabilized water level (drawdown of 0.3 ft or less). Pumping rates should, if needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. As noted above, care should be taken to maintain pump suction and to avoid entrainment of air in the tubing. Record each adjustment made to the pumping rate and the water level measured immediately after each adjustment.

12. Monitor Indicator Parameters: During purging of the well, monitor and record the field indicator parameters (turbidity, temperature, specific conductance, pH, Eh, and DO) approximately every five minutes. The well is considered stabilized and ready for sample collection when the indicator parameters have stabilized for three consecutive readings as follows (Puls and Barcelona, 1996):

±0.1 for pH
±3% for specific conductance (conductivity)
±10 mv for redox potential
±10% for DO and turbidity

Dissolved oxygen and turbidity usually require the longest time to achieve stabilization. The pump must not be removed from the well between purging and sampling.

13. Collect Samples: Collect samples at a flow rate between 100 and 250 ml/min and such that drawdown of the water level within the well does not exceed the maximum allowable drawdown of 0.3 ft. VOC samples must be collected first and directly into sample containers. All sample containers should be filled with minimal turbulence by allowing the ground water to flow from the tubing gently down the inside of the container.

    Ground water samples to be analyzed for volatile organic compounds (VOCs) require pH adjustment. The appropriate EPA Program Guidance should be consulted to determine whether pH adjustment is necessary. If pH adjustment is necessary for VOC sample preservation, the amount of acid to be added to each sample vial prior to sampling should be determined, drop by drop, on a separate and equal volume of water (e.g., 40 ml). Ground water purged from the well prior to sampling can be used for this purpose.

14. Remove Pump and Tubing: After collection of the samples, the tubing, unless permanently installed, must be properly discarded or dedicated to the well for resampling by hanging the tubing inside the well.

15. Measure and record well depth.

16. Close and lock the well.

VI. FIELD QUALITY CONTROL SAMPLES

Quality control samples must be collected to determine if sample collection and handling procedures have adversely affected the quality of the ground water samples. The appropriate EPA Program Guidance

should be consulted in preparing the field QC sample requirements of the site-specific QAPP.

All field quality control samples must be prepared exactly as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples should be collected during the sampling event:

- Field duplicates
- Trip blanks for VOCs only
- Equipment blank (not necessary if equipment is dedicated to the well)

As noted above, ground water samples should be collected systematically from wells with the lowest level of contamination' through to wells with highest level of contamination. The equipment blank should be collected after sampling from the most contaminated well.

VII. DECONTAMINATION

Non-disposable sampling equipment, including the pump and support cable and electrical wires which contact the sample, must be decontaminated thoroughly each day before use ("daily decon") and after each well is sampled ("between-well decon"). Dedicated, in-place pumps and tubing must be thoroughly decontaminated using "daily decon" procedures (see #17, below) prior to their initial use. For centrifugal pumps, it is strongly recommended that non-disposable sampling equipment, including the pump and support cable and electrical wires in contact with the sample, be decontaminated thoroughly each day before use ("daily decon").

EPA's field experience indicates that the life of centrifugal pumps may be extended by removing entrained grit. This also permits inspection and replacement of the cooling water in centrifugal pumps. All non-dedicated sampling equipment (pumps, tubing, etc.) must be decontaminated after each well is sampled ("between-well decon," see #18 below).

17. Daily Decon

A) Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

B) Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Alconox, for 5 minutes and flush other equipment with fresh detergent solution for 5 minutes. Use the detergent sparingly.

C) Rinse: Operate pump in a deep basin of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

D) Disassemble pump.

E) Wash pump parts: Place the disassembled parts of the pump into a deep basin containing 8 to 10 gallons of non-phosphate detergent solution. Scrub all pump parts with a test tube brush.

F) Rinse pump parts with potable water.

G) Rinse the following pump parts with distilled/ deionized water: inlet screen, the shaft, the suction interconnector, the motor lead assembly, and the stator housing.

H) Place impeller assembly in a large glass beaker and rinse with 1% nitric acid (HNO_3).

I) Rinse impeller assembly with potable water.

J) Place impeller assembly in a large glass bleaker and rinse with isopropanol.

K) Rinse impeller assembly with distilled/deionized water.

18. <u>Between-Well Decon</u>

A) Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

B) Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Alconox, for 5 minutes and flush other equipment with fresh detergent solution for 5 minutes. Use the detergent sparingly.

C) Rinse: Operate pump in a deep basin of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

D) Final Rinse: Operate pump in a deep basin of distilled/deionized water to pump out 1 to 2 gallons of this final rinse water.

VIII. FIELD LOG BOOK

A field log book must be kept each time ground water monitoring activities are conducted in the field. The field log book should document the following:

- Well identification number and physical condition.
- Well depth, and measurement technique.
- Static water level depth, date, time, and measurement technique.
- Presence and thickness of immiscible liquid layers and detection method.
- Collection method for immiscible liquid layers.
- Pumping rate, drawdown, indicator parameters values, and clock time, at three to five minute intervals; calculate or measure total volume pumped.
- Well sampling sequence and time of sample collection.
- Types of sample bottles used and sample identification numbers.
- Preservatives used.
- Parameters requested for analysis.
- Field observations of sampling event.
- Name of sample collector(s).
- Weather conditions.
- QA/QC data for field instruments.

IX. REFERENCES

Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation, C.K. Smoley Press, Boca Raton, Florida.

Puls, R.W. and M.J. Barcelona, 1996, Low-Flow (Minimal Drawdown) Ground-water Sampling Procedures, EPA/540/S-95/504.

U.S. EPA, 1993, RCRA Ground-Water Monitoring: Draft Technical Guidance, EPA/530-R-93-001.

U.S. EPA Region II, 1989, CERCLA Quality Assurance Manual.

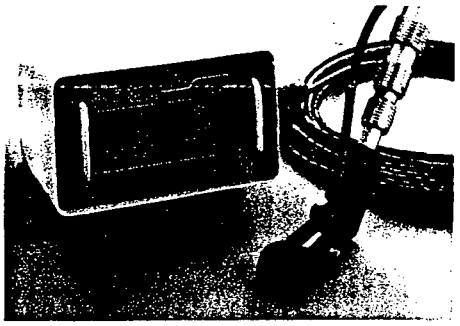
H

300467

APPENDIX H

SURFACE WATER FLOW METER DESCRIPTION

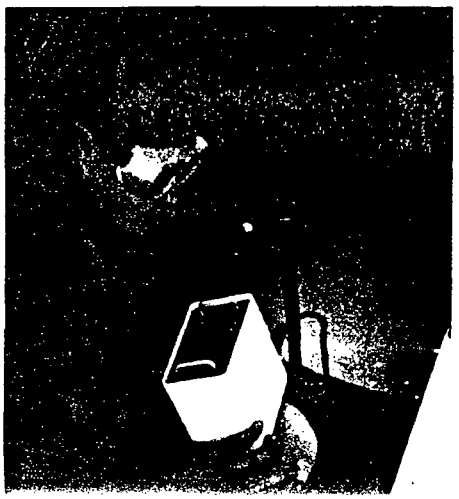
Sigma PVM



The PVM is housed in a rugged water resistant case. The unit weighs only 3 lbs.

▲ *The PVM provides an instantaneous read-out of velocity or flow in sewers, streams and other open channels.*

▼ *The PVM does not require calibration... it's ready to go when you are.*



Sigma PVM Portable Flow Velocity Meter

The Sigma PVM is a portable point velocity meter ideal for checking and calibrating primary devices, flow meters, and for spot measurements in sewers, streams, and irrigation channels. This rugged, simple-to-operate unit quickly determines fluid point velocity or time average velocity using a Doppler ultrasonic sensor. Velocity information is then processed for computing flow and controlling analog and display outputs.

The Sigma PVM is engineered for reliable performance under the most challenging conditions. Both forward and reverse flow can be computed in round or rectangular channels. You simply input the depth and channel configuration in common engineering units.

The portable battery-operated device achieves accuracies of ±1% of full scale. It features TRUE TIME AVERAGING for higher accuracy in turbulent flows. Average velocity is indicated on a 4-line x 20-character liquid crystal display.

- Doppler technology for fluid point velocity or time average velocity.
- Digital circuitry samples velocity measurements 15 times per second.
- Computation of forward and reverse flows.
- 12 hour battery life.

SIGMA

Innovation in water monitoring

300469

Sigma PVM Design Specifications

- **Included:** Portable velocity meter, velocity probe with 25 ft. (7.6 m) cable, nylon shoulder strap, battery charger, rechargeable nickel cadmium battery, swivel head probe holder, 2 extension rods, carrying case.
- **Velocity Sensor:** Ultrasonic Doppler.
- **Velocity Ranges:** 0.05 to ±10 ft./sec. (0.015 to ±3 m/s): bi-directional measurement.
- **Velocity Accuracy:** ±1% of full scale.
- **Resolution:** .01 ft./sec. (.003 m/s).
- **Minimum Depth:** 1.0" (25 mm).
- **Minimum Particulate Level:** 100 micron @ 100 PPM.
- **Display:** 4 line x 20 character LCD with contrast adjustment.
- **Recorder Output:** -2 to +2 VDC corresponding to -10 to +10 ft./sec. (-3 m/s to +3 m/s) (optional).
- **Power Source:** Rechargeable 6-cell 1500 mA-H Ni-Cad pack (internal to PVM).
- **RechargeTime:** 10 hours.
- **Charger Power Requirements:** 115 VAC for AC to 12 VDC converter. 10 - 15 VDC from automobile lighter socket.
- **OperatingTime:** Normal use: 4 weeks. Continuous use: 12 hours.
- **Operating Temperature:** 32°F to 122°F. (0°C to 50°C).
- **Sensor Cable Length:** 25 ft. (7.6 m) standard. Up to 125 ft. (38 m) optional.
- **Dimensions:** 4.5" H (11.4 cm) x 7" W (17.8 cm) x 6" D (15.2 cm).
- **Weight:** 3 lbs. (1.4 kg) without carrying case.
- **Probe Dimensions:** 1.0" H (25 mm) x 1.5" W (38 mm) x 1.5" D (38 mm).
- **Probe Materials:** Urethane and epoxy polymers; stainless steel.
- **Extension Rod:** Telescopic from 1.5 to 6 ft. (.5 m to 1.8m).

SIGMA
Innovation in water monitoring

AMERICAN SIGMA 11601 MAPLE RIDGE ROAD • P.O. BOX 820 • MEDINA, NEW YORK 14103-0820 USA
IN U.S. AND CANADA CALL 1-800-635-4567 • FAX: 716-798-5599 • http://www.americansigma.com

SALES ASSISTANCE **1-800-635-4567**
24 HOUR HELP LINE **1-800-635-1230**
email: sigma@americansigma.com

CE

© COPYRIGHT 1996 AMERICAN SIGMA INC. • GIV • TP • 10M • 5548 • 5/97 • PRINTED IN U.S.A.

APPENDIX I

BENTONITE AND DYE SPECIFICATIONS

DRILLERS SERVICE INC.

COMPLETE SERVICE TO THE GROUND WATER INDUSTRY SINCE 1954

AQUAGEL® GOLD SEAL®

Premium Untreated Bentonite for Geotechnical Drilling

AQUAGEL® GOLD SEAL® premium high-yield bentonite is mined from deposits located in Wyoming. AQUAGEL GOLD SEAL bentonite contains no polymer additives or chemical treatments of any kind. Only the highest quality bentonite is used for the product AQUAGEL GOLD SEAL. Wyoming bentonite is composed predominantly of soldium montmorillonite (a layered alumino-silicate) and is a completely naturally occurring clay.

AQUAGEL GOLD SEAL bentonite acts as a viscosifier and filtrate reducer for drilling fluids. The clay particles through positive and negative charged surfaces form gel structures and develop viscosity. The clay is structured in flat plate-like layers which overlap and form a thin impermeable filter cake on the face of a borehole.

AQUAGEL GOLD SEAL bentonite is a dry powdered clay and can be added directly to fresh water or freshwater drilling fluids. For use in salty or brackish water (less than 8000 ppm chloride), AQUAGEL GOLD SEAL is first hydrated in fresh water and then added to the salty or brackish water.

AQUAGEL GOLD SEAL bentonite when used in the treatment levels and manner recommended is an environmentally safe product.

Recommended Users

- Improving hole-cleaning capacity of fluid
- Reducing water seepage or filtration into permeable formations
- Rapidly forming a thin filter cake with low permeability
- Promoting hole stability in poorly consolidated formations
- Preventing loss of fluids to lost circulation zones

Major Advantages

- No polymer or chemical additives
- All naturally occurring clay material
- Quality controlled and manufactured to exceed API standards
- Environmentally acceptable product

DMD 76
Printed in U.S.A.

*AQUAGEL, GOLD SEAL and QUIK-GEL are registered trademarks of NL Industries, Inc.

NL Baroid P.O. Box, Houston, Texas 77251

Typical Properties

Dry Screen Analysis (Ground Material)
80% through 200 mesh (74 microns)

X-Ray Analysis (Typical Wyoming Bentonite)
85% Montmorillonite
5% Quartz
5% Feldspars
2% Cristobalite
2% Illite
1% Calcite and Gypsum

Chemical Analysis
(All Elements Reported as Oxide Form)

SiO_2	55.44%
Al_2O_3	20.14%
Fe_2O_3	3.67%
CaO	0.49%
MgO	2.49%
Na_2O	2.76%
K_2O	0.60%
Bound water	5.50%
Moisture (220° F)	8.00%
TOTAL	99.09%

Packaging

AQUAGEL® GOLD SEAL® premium bentonite is packaged in multiwall, water resistant paper bags containing 50 pounds (22.7 kg) or 40 kg (for Canada), or 100 pounds (55.4 kg).

Availability

AQUAGEL® GOLD SEAL® premium bentonite can be purchased through any QUIK-GEL® retailer, NL Baroid Service Center, or from the Houston plant.

Recommended Treatment

Approximate amount of AQUAGEL GOLD SEAL Premium Bentonite Added to Fresh Water or to Freshwater Drilling Fluid

	lb/100 gal	lb/bbl*	kg/m³
Added to Fresh Water:			
Under normal drilling conditions	30-50	13-22	35-60
To stabilize caving formations	60-80	25-35	70-100
To stop circulation loss	70-95	30-40	85-110
Added to Freshwater Mud:			
Under normal drilling conditions	10-25	4-10	11-28
To stabilize caving formations	20-45	9-18	25-50
To stop circulation loss	25-50	10-20	28-56

Method of addition: mix slowly through a jet mixer or sift slowly into the vortex of a high-speed stirrer.

*1 bbl = 42 U.S. Gallons

Because the conditions of use of this product are beyond seller's control, the product is sold without warranty either express or implied and upon condition that purchaser make its own tests to determine the suitability for purchaser's application. Purchaser assumes all risk of use and handling of this product.

This product will be replaced if defective in manufacture or packaging or if damaged. Except for such replacement, seller is not liable for any damages caused by this product or its use.

The statements and recommendations made herein are believed to be accurate. No guarantee of their accuracy is made, however.

CROMPTON & KNOWLES -- INTRACID RHODAMINE WT LIQUID
MATERIAL SAFETY DATA SHEET
NSN: 681000N018097
Manufacturer's CAGE: 69389
Part No. Indicator: B
Part Number/Trade Name: INTRACID RHODAMINE WT LIQUID

General Information

Company's Name: CROMPTON & KNOWLES CORP
Company's P. O. Box: 341
Company's City: READING
Company's State: PA
Company's Country: US
Company's Zip Code: 19603
Company's Emerg Ph #: 215-582-8765
Company's Info Ph #: 215-582-8765
Record No. For Safety Entry: 002
Tot Safety Entries This Stk#: 002
Status: SMJ
Date MSDS Prepared: 06MAR92
Safety Data Review Date: 08FEB96
MSDS Serial Number: CBVRX

Ingredients/Identity Information

Proprietary: YES
Ingredient: PROPRIETARY
Ingredient Sequence Number: 01

Proprietary: YES
Ingredient: PROPRIETARY
Ingredient Sequence Number: 02

Proprietary: YES
Ingredient: PROPRIETARY
Ingredient Sequence Number: 03

Proprietary: YES
Ingredient: PROPRIETARY
Ingredient Sequence Number: 04

Proprietary: YES
Ingredient: PROPRIETARY
Ingredient Sequence Number: 05

Physical/Chemical Characteristics

Appearance And Odor: DARK RED LIQUID. NO ODOR.
Boiling Point: 212F,100C
Melting Point: 14F,-10C
Specific Gravity: 1.13 +/- 0.02
Solubility In Water: SOLUBLE
pH: SUPDAT

Fire and Explosion Hazard Data

Flash Point: N/A(AQUEOUS)
Lower Explosive Limit: N/A
Upper Explosive Limit: N/A
Extinguishing Media: WATER, DRY CHEMICAL, CO*2.
Special Fire Fighting Proc: WEAR NIOSH/MSHA APPROVED SCBA & FULL PROTECTIVE EQUIPMENT(FP N).

Unusual Fire And Expl Hazrds: NONE EXPECTED.

Reactivity Data

Stability: YES
Cond To Avoid (Stability): DO NOT MIX WITH ACIDS.
Materials To Avoid: NONE KNOWN.
Hazardous Decomp Products: BURNING WILL PRODUCE OXIDES OF CARBON & NITROGEN.
Hazardous Poly Occur: NO
Conditions To Avoid (Poly): NOT RELEVANT.

Health Hazard Data

LD50-LC50 Mixture: NONE SPECIFIED BY MANUFACTURER.
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: YES
Route Of Entry - Ingestion: NO
Health Haz Acute And Chronic: CNTNS TRIMELITIC ACID, MAY CAUSE EYE & SKIN IRRITATION. INTRACID RHODAMINE WT LIQUID WAS TESTED IN BATTERY OF IN VITRO & IN VIVO MAMMALIAN ASSAYS RESULTING IN NEGLIGIBLE OR LOW LEVELS OF GENOTOXIC ACTIVITY EVEN AT VERY HIGH CONCS. (G.R.DOUGLAS ET AL, "COMPARATIVE MAMMALIAN IN VITRO AND IN VIVO STUDIES(EFTS OF OVEREXP)
Carcinogenicity - NTP: NO
Carcinogenicity - IARC: NO
Carcinogenicity - OSHA: NO
Explanation Carcinogenicity: NOT RELEVANT.
Signs/Symptoms Of Overexp: HLTH HAZ: ON THE MUTAGENIC ACTIVITY OF RHODAMINE WT", MUTATION RESEARCH, 118, 1983, 117-125). INTRACID RHODAMINE WT WAS POSITIVE IN A SALMONELLA/MAMMALIAN MICROSOME ASSAY(NESTMANN & KOWBEL, 1979). G.DOUGLAS AS REFERENCED, STATED THAT IMPURITIES IN DYE MAY HAVE CAUSED MUTAGENIC EFFECTS SEEN/(SUPDAT)
Med Cond Aggravated By Exp: NOT KNOWN.
Emergency/First Aid Proc: INHAL:MOVE TO FRESH AIR. IF BRTHG IS DFCLT, GIVE O*2 & GET MD ATTN RIGHT AWAY. EYE:FLUSH W/FLOWING H*2O FOR @ LEAST 15 MINS, HOLD EYELIDS APART TO IRRIGATE THORO, GET MD ATTN RIGHT AWAY. SKIN: WASH AFFECTED AREAS THORO W/SOAP & H*20. IF IRRIT DEVELS, CONSULT MD. INGEST:DILUTE W/WATER & INDUCE VOMIT. GET IMMED MD ATTN. NEVER GIVE FLUIDS/ INDUCE VOMIT IF PATIENT IS UNCON/HAS CONVULSIONS.

Precautions for Safe Handling and Use

Steps If Matl Released/Spill: WEAR APPROP SAFETY EQUIP. CNTN & CLEAN UP SPILL IMMED PVNT FROM ENTERING FLOOR DRAINS. CONTAIN LIQUIDS USING ABSORBANTS, SWEEP PWDRS CAREFULLY MINIMIZING DUSTING. SHOVEL ALL SPILL MATLS INTO DISP DRUM, FOLLOW DISP INSTRUCTIONS. SCRUB SPILL(ING 5)
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.
Waste Disposal Method: BURY OR INCINERATE ACCORDING TO FEDERAL, STATE & LOCAL REGULATIONS. CONTAINERS SHOULD BE TRIPLE RINSED ACCORDING TO FEDERAL, REGULATIONS AND/OR GOOD WASTE MANAGEMENT PRACTICE.
Precautions-Handling/Storing: NONE SPECIFIED BY MANUFACTURER.
Other Precautions: NONE SPECIFIED BY MANUFACTURER.

Control Measures

Respiratory Protection: NONE REQUIRED UNDER NORMAL CONDITIONS. USE NIOSH/ MSHA APPROVED RESPIRATOR APPROPRIATE FOR EXPOSURE OF CONCERN(FP N).
Ventilation: LOCAL EXHAUST.
Protective Gloves: RUBBER GLOVES.
Eye Protection: ANSI APPRVD CHEM WORKERS GOGGS(FP N).
Other Protective Equipment: ANSI APPROVED EMER EYEWASH & DELUGE SHOWER(FP N). APRON, COVERALL TO MINIMIZE SKIN CONTACT.
Work Hygienic Practices: IN ACCORDANCE W/GOOD INDUSTRIAL PRACTICE, HANDLE THIS PRODUCT W/CARE & AVOID PERSONAL CONTACT.

Suppl. Safety & Health Data: USERS OF THE "L" VERSION OF HMIS TO CONSULT THE "LR" VERSION OF HMIS(FP N). EFTS OF OVEREXP: ALTERNATIVELY THE DYE MAY BE POINT MUTAGEN. DOUGLAS FURTHER REPORTED THAT TAKING DATA ALTOGETHER FROM HIS STUDY, "...RHODAMINE WT APPEARS NOT TO REPRESENT A MAJOR GENOTOXIC HAZARD." PH: 10.5-10.8.

==========

Transportation Data

==========

==========

Disposal Data

==========

==========

Label Data

==========

Label Required: YES
Technical Review Date: 09FEB96
Label Date: 09FEB96
Label Status: G
Common Name: INTRACID RHODAMINE WT LIQUID
Chronic Hazard: NO
Signal Word: CAUTION!
Acute Health Hazard-None: X
Contact Hazard-Slight: X
Fire Hazard-None: X
Reactivity Hazard-None: X
Special Hazard Precautions: ACUTE: MAY CAUSE EYE AND SKIN IRRITATION. CHRONIC: NONE LISTED BY MANUFACTURER.
Protect Eye: Y
Protect Skin: Y
Protect Respiratory: Y
Label Name: CROMPTON & KNOWLES CORP
Label P.O. Box: 341
Label City: READING
Label State: PA
Label Zip Code: 19603
Label Country: US
Label Emergency Number: 215-582-8765

300478

APPENDIX J

ASTM METHOD D 5613-94

Designation: D 5613 – 94

Standard Test Method for Open-Channel Measurement of Time of Travel Using Dye Tracers[1]

This standard is issued under the fixed designation D 5613; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers a means of measuring the time-of-travel of water and waterborne solutes by the use of dye tracers and tracing techniques. This test method is similar to methods developed by the U.S. Geological Survey and described in other referenced documents.

1.2 This test method describes the dye tracers, measuring equipment used, and field and laboratory procedures customarily used.

1.3 This test method describes the methods of tracer study analysis and data presentation.

1.4 The user of this test method should address the following concerns regarding the use of tracers in water bodies:

1.4.1 Determine whether the chemical has clearance or approval or has potential or preceived impacts relating to potable, industrial, irrigation, or fish and wildlife use.

1.4.2 Determine whether approvals are required by involved agencies.

1.4.3 Document contacts regarding notification.

1.5 The values stated in inch-pound units except for chemical concentrations and liquid volumes for step dilutions, which are stated in SI units, are to be regarded as the standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazards statements, see Section 9.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1192 Specification for Equipment for Sampling Water and Steam in Closed Conduits[2]

D 2777 Practice for Determination of Precision and Bias of Applicable Methods of Committee D-19 on Water[2]

D 3370 Practices for Sampling Water from Closed Conduits[2]

D 3858 Practice for Open-Channel Flow Measurement of Water by Velocity-Area Method[2]

D 4411 Guide for Sampling Fluvial Sediment in Motion[3]

2.2 *ISO Standard:*

ISO 555/2-1974 Liquid Flow Measurement in Open Channels—Dilution Methods for Measurement of Steady Flow, Part 2: Integration (Sudden Injection) Method.[4]

3. Terminology

3.1 *Descriptions of Terms Specific to This Standard:*

3.1.1 *automatic programmable sampler*—a portable device designed to collect sequential, discrete water samples representative of the water mixture moving in the river in the vicinity of the sampler at a single point in a cross section. Depending on the make and model of the device, water samples can be collected at equal or variable time intervals.

3.1.2 *centroid*—the center of mass of the dye response curve calculated as outlined by Parker and Hunt (**1**).[5]

3.1.3 *depth-integrated sample*—a water sample collected in such a manner as to be representative of the water mixture moving in the river in the vicinity of the sampler at a single vertical in a cross section.

3.1.4 *dispersion*—the three-dimensional process of disseminating the dye within a river's waters.

3.1.5 *flow duration*—the percentage of time during which a specific discharge is equalled or exceeded.

3.1.6 *fluorometer*—an instrument that measures the luminescence of a fluorescent substance when subjected to a light source of a given wave length.

3.1.7 *injection site*—a study site where the tracer is to be introduced into a parcel of river water. This study site is usually a sufficient distance upstream of the study reach such that complete vertical and lateral mixing of the tracer in a parcel of river water has occurred before the water parcel's entry into the study reach.

3.1.8 *lateral dispersion*—the process of disseminating the dye within a river water's horizontal axis perpendicular to its longitudinal axis. The completion of this process is dependent on the width of the river and velocity variations.

3.1.9 *leading edge*—the first detectable dye concentration observed at a sampling site.

3.1.10 *longitudinal dispersion*—the process of disseminating the dye within a river's waters along its upstream-downstream axis. This component of the dispersion process continues downstream indefinitely.

3.1.11 *mixing*—the blending of two or more substances into one uniform mass.

[1] This test method is under the jurisdiction of ASTM Committee D-19 on Water and is the direct responsibility of Subcommittee D19.07 on Sediments, Geomorphology, and Open-Channel Flow.

Current edition approved Sept. 15, 1994. Published November 1994.

[2] *Annual Book of ASTM Standards*, Vol 11.01.

[3] *Annual Book of ASTM Standards*, Vol 11.02.

[4] Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.

[5] The boldface numbers in parentheses refer to the list of references at the end of this test method.

3.1.12 *peak*—the maximum dye concentration observed at a sampling site.

3.1.13 *point sample*—a water sample collected in such a manner as to be representative of the water mixture moving in the river in the vicinity of the sampler at a single point in a cross section.

3.1.14 *sample site*—a study site where water samples are collected for determination of the tracer-concentration response curve.

3.1.15 *standard integrated depth sampler*—a device designed to accumulate a water sample from a stream vertical at such a rate that the velocity in the nozzle at the point of intake is always as nearly as possible identical with the immediate stream velocity.

3.1.16 *study reach*—the section of a river's length that is to be studied.

3.1.17 *study site*—sections of a river where data are to be determined, monitored, measured, and where tracer is to be introduced into the river.

3.1.18 *tracer response curve*—at each sampling site, the plots of tracer concentration versus time after the tracer injection.

3.1.19 *trailing edge*—the point of the falling limb of the dye response curve that is equal to approximately 2 % of the peak concentration observed at a sampling site.

3.1.20 *vertical dispersion*—the process of disseminating the dye within a river's water's vertical axis perpendicular to its upstream-downstream axis. This dispersion process is usually completed first.

4. Summary of Test Method

4.1 Dye tracers injected into a stream are assumed to behave in the same manner as the water molecules themselves. A measure of the longitudinal movement of a tracer along a given streamline will be a measure of the movement of an element of fluid in the stream and of its dispersion characteristics for that streamline.

4.2 The initial planning of a dye tracer time-of-travel study involves the estimation of stream velocities and the required tracer injection volume. The information necessary for these estimations is obtained by reviewing historical flow data and topographic maps and by making a reconnaissance of the proposed study reach.

4.3 The time-of-travel for a given flow is determined by observing the passage of a slug-injected dye tracer cloud at previously identified locations along the study reach. The dye cloud response curve is defined at each reach location (study site) by measuring the dye concentration in collected water samples and noting the time that each sample was collected since the tracer injection.

4.4 After tracer studies have been conducted at two or more flow durations on the study reach, estimation of the time-of-travel and dispersion of a solute can be made at any flow between those studied. Tracer studies are typically performed at 40 to 90 % flow duration ranges.

5. Significance and Use

5.1 *Purpose:*

5.1.1 This test method covers the use of fluorescent dye tracers in streams to determine the rate that a solute moves along a streamline for a given river reach and the rate at which a solute disperses as it moves downstream.

5.1.2 Accurate measurements of a stream's velocity and dispersion coefficient that can be determined by a tracer study are important parameters for water-quality models.

5.1.3 Determined in advance to potential spilled or released noxious substances, velocity and dispersion rates are used to predict the time of arrival, passage time, and maximum concentration. Public health officials need this information to decide whether, when, and how long to suspend operations of public water-supply intakes in the reach downstream of a spill.

5.2 *Assumptions:*

5.2.1 This test method assumes that the dye tracer behaves in the same manner as the water in which it is injected. Dispersion and mixing of the tracer in the receiving river occur in all three dimensions of the channel. Longitudinal mixing is unending since boundaries do not exist in this direction.

5.2.2 The tracer response curve at a point downstream from the point of tracer injection can be represented by plotting the tracer concentration against elapsed time since the injection (Fig. 1).

5.2.3 A tracer response curve has four important characteristics: the elapsed time to the response curve's leading edge; elapsed time to the response curve's peak concentration; elapsed time to the response curve's centroid; and elapsed time to response curve trailing edge at 2 % of the peak concentration.

5.2.4 Between two monitoring locations separated by a long stream length, the time-of-travel for individual response curve characteristics is the difference in the elapsed times since injection for that characteristic at the two locations.

5.2.5 The duration or time of passage of a tracer response curve at a particular river location is the difference between the slowest trailing edge elapsed time since injection and the earliest leading edge elapsed time since injection determined in the cross section.

5.3 *Tracers:*

5.3.1 Conservative tracers used to investigate fluid motion are generally extrinsic, artificial, and chemical substances and are usually classified according to the methods of detection used and chemical composition.

5.3.2 Properties to be considered when selecting a tracer for a study include detectability, toxicity, solubility, cost, natural background concentration, and sorption characteristics.

5.3.3 Fluorescent dye tracers such as Rhodamine WT, pontacyl pink, and acid yellow 7 are generally good chemical tracers. Rhodamine WT has the most numerous qualities preferred by many state and federal agencies for open-channel studies.

5.3.4 Other tracers can be used when water-quality or physical conditions are not suitable for the use of fluorescent dyes in a proposed study reach. These include salt-based chemical tracers such as sodium chloride, radioactive tracers such as tritium, and tracers determined with neutron activation analysis such as bromine and lithium (3).

5.3.5 These tracers are considered to be generally conservative and, in terms of this test method, differ primarily in the apparatus required to measure the concentrations in the study reach. Discussions in subsequent sections will be

300481

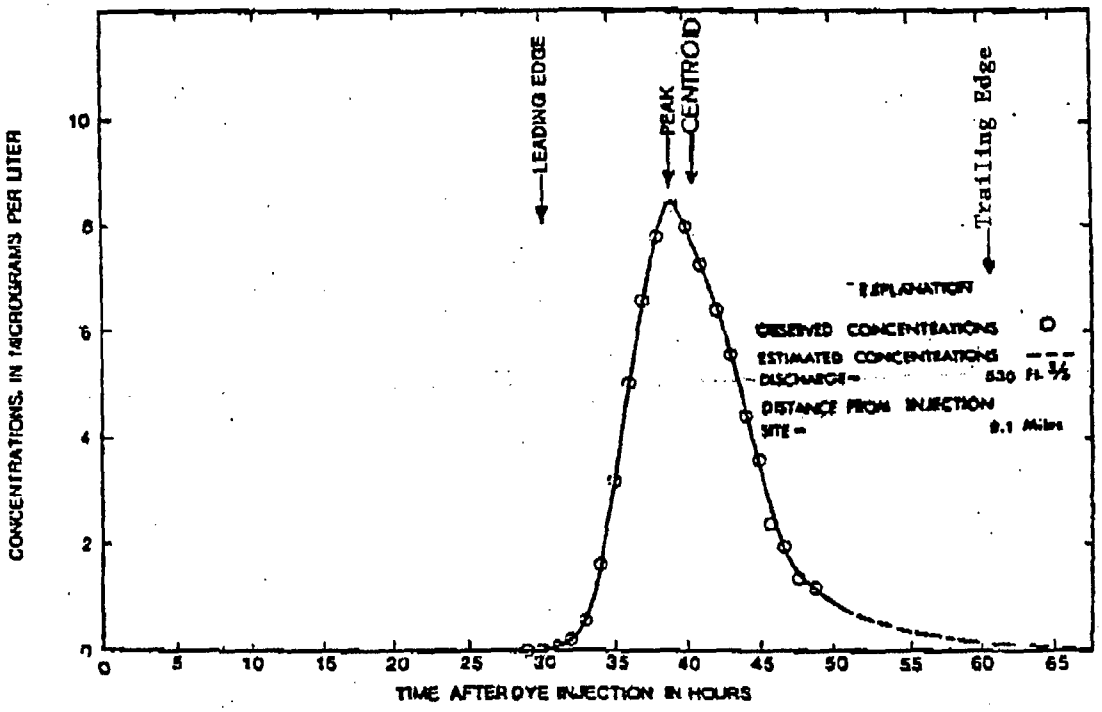


FIG. 1 Travel Time from Burnham Versus Concentration at Clinton, Maine, Sept. 18–20, 1979 (from Parker) (2)

limited to fluorescent dye because of the simplicity of fluorometric analysis.

5.3.6 Different tracers require varied levels of permits before being introduced into the environment. For example, radioactive tracers require permits from the Nuclear Regulatory Commission (NRC) and usually state and local permits. Fluorescent dye tracers do not usually require formal permits for use in a study.

6. Interferences

6.1 Natural water may exhibit background fluorescence that is not the result of a fluorescent dye tracer. This background fluorescence may result from scattered light, fluorescence of natural materials or pollutants, or other causes (4).

6.2 The fluorescence of Rhodamine WT is stable in solutions having a pH in the range from 5 to 10, which is within the range of most streams. Rhodamine WT fluorescent decreases when in solutions having a pH below 5 (5).

6.3 Dye tracer fluorescence may be quenched by the action of other chemicals in the streamwater. The quenching agent may cause any of the following to occur (6): absorption of exciting light, absorption of light emitted by the dye, degradation of the excited-state energy, and chemically changing the fluorescent compound of the dye tracer.

6.4 The permanent reduction of Rhodamine dye tracer fluorescence can be caused by photochemical decay as a result of exposure to sunlight (7). Sunlight degradation half-lives for the dye at the water surface to a depth of 0.03 ft ranged from 15 to 30 days at 30° North latitude, depending on the season of the year. The degradation half-lives ranged from 15 to 44 days at 40° North latitude, depending on the season of the year. The photochemical decay half-life increases with increased water depth and decreasing light intensity; it is therefore not a concern for most practical problems.

7. Apparatus

7.1 Dye is usually injected by pouring a measured amount as a slug into the center of the flow from a graduated laboratory cylinder. Graduated laboratory cylinders are convenient for measuring and injecting small volumes. Large-volume injections can be measured in terms of full dye containers. The measured volumes of tracer to be injected can be mixed with streamwater in a larger container that can also be used as an injection vessel.

7.1.1 Multiple-point injections across the channel are used on wide streams to shorten the effective length of river required for lateral mixing of the tracer to be completed. The volume of tracer to be injected is divided into several injection vessels that are poured in the stream simultaneously at several points along the cross section. A variation of this approach is to make a line injection by pouring the tracer continuously while crossing the stream. Such an injection should be limited to the center 75 % of the flow. This limitation of injection will optimize the reach length required for complete transverse mixing of the tracer.

7.2 Sample collection apparatuses range in sophistication from hand-held samplers to programmable automatic sample collection systems. The selection of sample collection devices depends on the size of the study, availability of personnel, and hydrologic conditions at each sample site. Any point sampling method may be used where complete mixing has occurred; however, a depth-integrated sample may be necessary where mixing may not have been achieved.

7.2.1 Glass bottles are preferred when long-term storage is

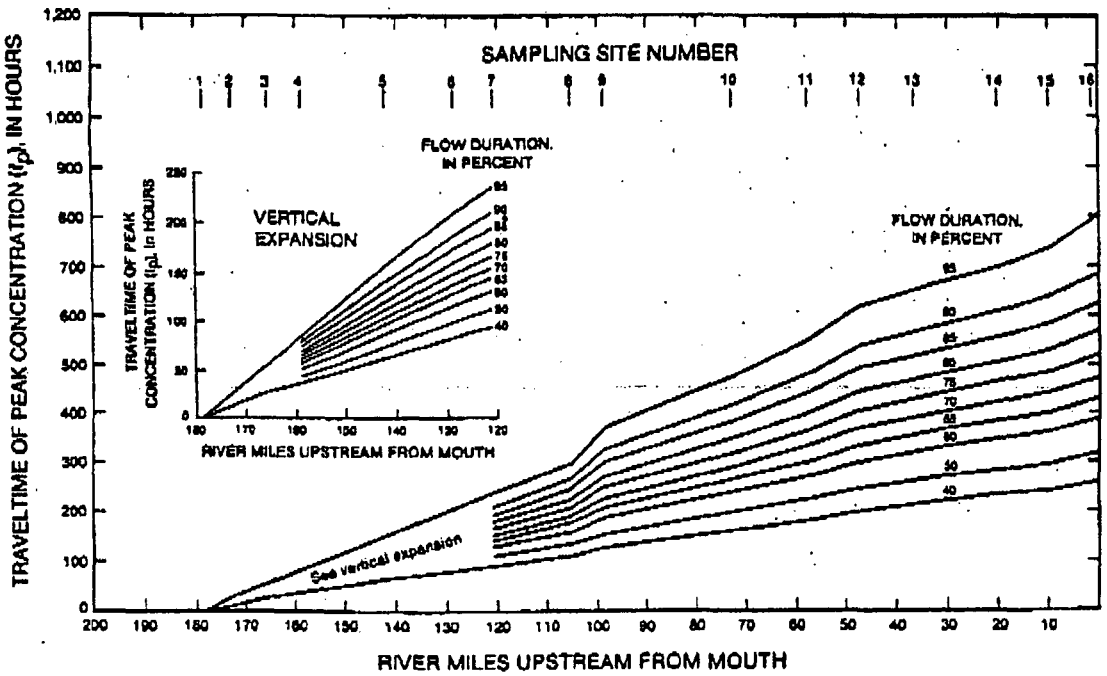


FIG. 15 Travel Time-Distance Relation for Peak Concentrations of a Solute at Selected Flow Durations, South Fork Shenandoah River from Waynesboro, Virginia, to Harpers Ferry, West Virginia (from Taylor, et al) (10)

REFERENCES

(1) Parker, G. W., and Hunt, G. S., "Initial Assessment of Time-of-Travel Through Gulf Island Pond and the Lower Androscoggin River, Maine," *U.S. Geological Survey Water-Resources Investigations Report 83-4020*, 1983.

(2) Parker, G. W., "Time-of-Travel Study in the Sebasticook River Basin, Maine," *U.S. Geological Survey Open-file Report 81-545*, 1981, p. 50.

(3) Gaspar, E., "Hydrological Tracers," *Modern Trends in Tracer Hydrology*, Vol I, 1987, pp. 1–48.

(4) Wilson, J. F., Jr., Cobb, E. D., and Kilpatrick, F. A., "Fluorometric Procedures for Dye Tracing," *Techniques of Water-Resources Investigations of the U.S. Geological Survey*, Book 3, Chapter A12, 1986, p. 34.

(5) Smart, P. L., and Laidlaw, I. M. S., "An Evaluation of Some Fluorescent Dyes for Water Tracing," *Water Resources Research*, Vol 13, No. 1, 1977, pp. 15–33.

(6) Williams, R. T., and Bridges, J. W., "Fluorescence of Solutions—A Review," *Journal of Clinical Pathology*, Vol 17, 1964, pp. 371–394.

(7) Tai, D. Y., and Rathbun, R. E., "Photolysis of Rhodamine-WT Dye," *Chemosphere*, Vol 17, No. 3, 1988, pp. 559–573.

(8) Edwards, T. K., and Glysson, G. D., "Field Measurement of Fluvial Sediment," *U.S. Geological Survey, Open-File Report 86-531*, 1988.

(9) Kilpatrick, F. A., "Automatic Sampler for Dye Tracer Studies," *Water Resources Research*, Vol 8, No. 3, 1972, pp. 737–742.

(10) Taylor, K. R., James, R. W., Jr., and Helinsky, B. M., "Traveltime and Dispersion in the Shenandoah River and its Tributaries, Waynesboro, Virginia, to Harpers Ferry, West Virginia," *U.S. Geological Survey, Water-Resources Investigations Report 86-4065*, 1986, p. 60.

(11) Yotsukura, Nobuhiro, and Cobb, E. D., "Transverse Diffusion of Solutes in Natural Streams," *U.S. Geological Survey Professional Paper 582-C*, 1972, p. 19.

(12) Fischer, H. B., et al, *Mixing in Inland and Coastal Waters*, Academic Press, New York, NY, 1979, p. 483.

(13) Kilpatrick, F. A., "Dosage Requirements for Slug Injections of Rhodamine BA and WT Dyes in Geological Survey Research," *U.S. Geological Survey Professional Paper 700-B*, 1970, pp. 250–253.

(14) Boning, C. W., "Generalization of Stream Travel Rates and Dispersion Characteristics from Time-of-Travel Measurements," *U.S. Geological Survey Journal of Research*, Vol 2, No. 4, 1974, pp. 495–499.

(15) Kilpatrick, F. A., and Taylor, K. R., "Applications of Dispersion Data," *Water Resources Bulletin*, American Water Resources Association, Vol 22, No. 4, 1986, pp. 537–548.

(16) Jack, A. R., "Traveltime and Dispersion of a Soluble Dye in the South Branch Potomac River, Petersburg to Green Spring, West Virginia," *U.S. Geological Survey Water-Resources Investigations Report 84-4167*, 1986, p. 14.