

**Work Plan**  
for  
**On-Shore Site Assessment**  
**Screening Evaluation**

**Former Derecktor Shipyard**  
**Naval Education & Training Center**  
**Newport, Rhode Island**



**Northern Division**  
**Naval Facilities Engineering Command**  
**Contract Number N62472-90-D-1298**  
**Contract Task Order 0173**

**April 1996**



**Brown & Root Environmental**

A Division of Halliburton NUS Corporation

**WORK PLAN  
FOR ON-SHORE SITE ASSESSMENT  
SCREENING EVALUATION**

**FORMER DEREKTOR SHIPYARD  
NAVAL EDUCATION & TRAINING CENTER  
NEWPORT, RHODE ISLAND**

**COMPREHENSIVE LONG-TERM  
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT**

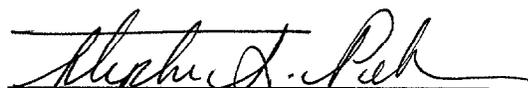
**Submitted to:  
U.S. Naval Facility Engineering Command  
Northern Division, Code 18  
Environmental Contracts Branch  
10 Industrial Highway, Mail Stop #82  
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**Contract No. N62472-90-D-1298  
Contract Task Order No. 0173**

**April 1996**

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## **1.0 INTRODUCTION**

This Work Plan has been prepared under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Task Order (CTO) 0173 dated March 30, 1994. The statement of work requires Brown & Root Environmental (B&R Environmental), formerly known as Halliburton NUS Corporation (HNUS), to provide a Work Plan for a Site Assessment Screening Evaluation (SASE) at the former Derecktor Shipyard, which is a part of the Naval Education & Training Center (NETC) in Newport, Rhode Island.

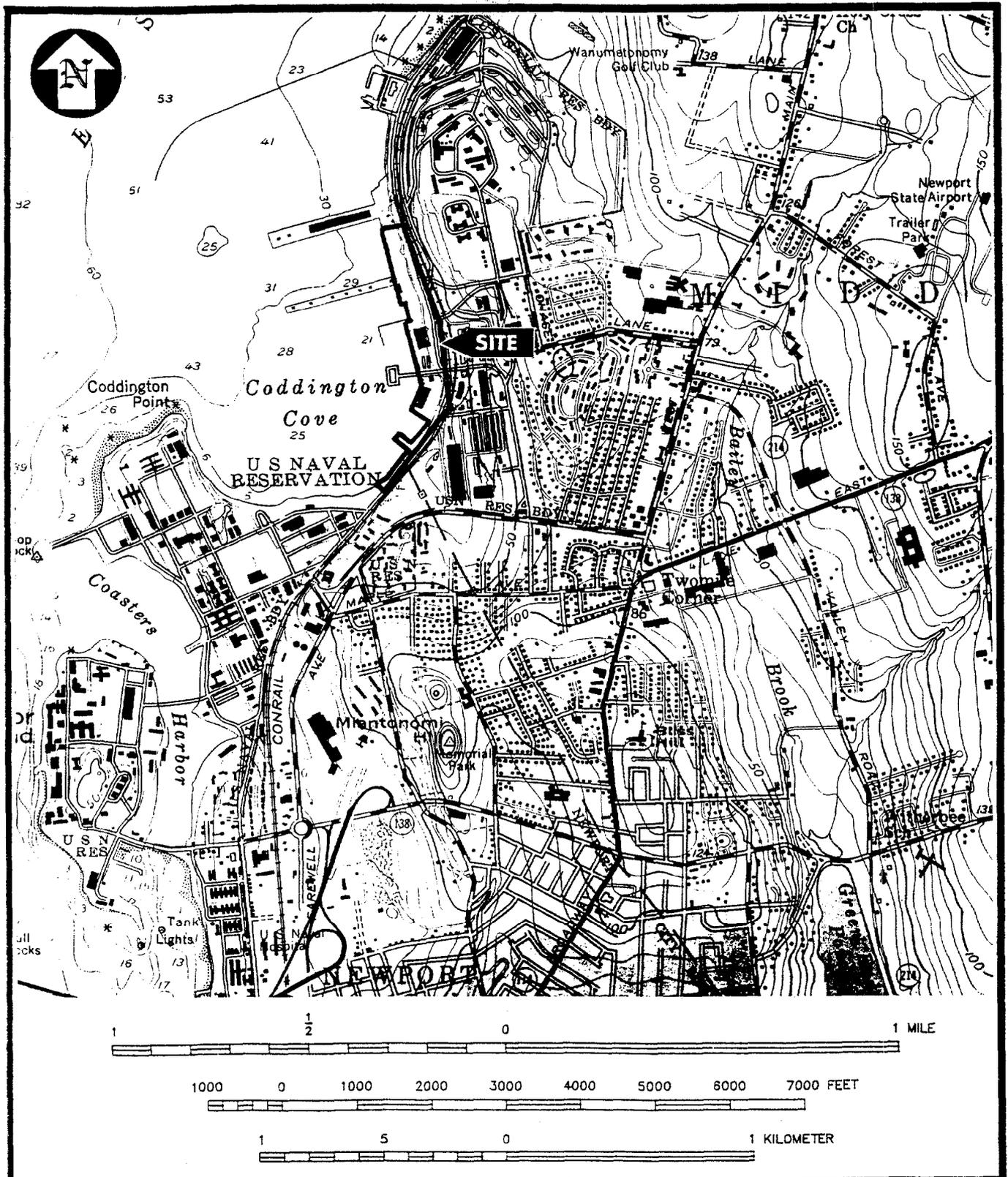
The Derecktor Shipyard was a privately operated ship maintenance and construction yard from 1979 to 1992. The property was leased to Robert E. Derecktor but owned by the U. S. Navy. The Navy had also used the site for shipbuilding activities from 1962 to 1978. The site location is shown on Figure 1-1.

### **1.1 PROJECT OBJECTIVES**

The objective of the SASE for Derecktor Shipyard is to identify and evaluate contaminants that may exist in the buildings, fill, soil, and groundwater due to past operations at the site.

The SASE will target known areas of contaminant discharge for sample collection and analysis. Intrusive investigations will concentrate on identifying chemical contaminants in the subsurface materials and the transport mechanisms that are available to them. The contaminants found will be evaluated with respect to their opportunity to affect people on and around the site.

This information will be used to produce a preliminary human health risk assessment providing a qualitative evaluation of the potential effects of exposure to those contaminants. In addition, this information will be used to prepare a conceptual model for an "on shore" ecological risk assessment. This model will support another conceptual model and risk assessment currently under development for the marine environment adjacent to the site. These evaluations and models will be used to determine the need to conduct a Remedial Investigation.



SITE LOCATION MAP  
 DEREKTOR SHIPYARD  
 NEWPORT, RHODE ISLAND



Halliburton NUS  
 CORPORATION

FIGURE 1-1

A Preliminary Site Assessment Report (PA) was prepared by ENSR Consultants and Engineers of Acton, Massachusetts, in May 1993. The PA identified several areas of concern where additional investigations were merited. These areas were identified by visual observations and review of historical records for the shipyard.

The scope of work for this project specifies tasks to implement the recommendations made in the Preliminary Assessment report. These tasks include sampling soil and groundwater, evaluating sandblast material used on site as fill, evaluating building and storm drainage systems, and evaluating certain areas of the buildings where hazardous materials were stored or used.

These areas were defined as follows:

- Areas in and around Building 6
- Areas in and around Building 40
- Areas in and around Building 42
- Areas in and around Building 234
- The Waterfront area south of the present fence line at Pier 2, and north of the Autoport gasoline station (located south of Building 234)

These areas of the shipyard were inspected in April 1994 by B&R Environmental personnel, facility representatives, and the NAVFAC Remedial Project Manager (RPM) for this CTO. At that time, the shipyard was divided into four sub-areas for the completion of the SASE:

- North Waterfront: bounded on the north by the existing fence south of Pier 2, on the east by the Penn Central right of way, on the south by the area surrounding Buildings 6 and 42, and on the west by Narragansett Bay.
- Central Shipyard: bounded on the north by unmarked points approximately 100 feet north of Buildings 42 and 6, on the east by the Penn Central right of way, on the south by the southern edge of Simonpietri Drive, and on the west by Narragansett Bay.
- Building 234 Area: bounded on the north by the southern edge of Simonpietri Drive, on the east by the Penn Central right of way, on the south by unmarked points approximately 25 feet south of the foundation for the former Building 234, and on the west by Narragansett Bay.

- South Waterfront: bounded on the north by unmarked points approximately 25 feet south of the foundation for the former Building 234, on the east by the approximate location of the above ground steam line on the west side of Defense Highway, on the south by the Autoport gas station, and on the west by Narragansett Bay.

Figure 1-2 is a base map that presents the boundaries of the study area, its four sub-areas, and the major features within these sub-areas.

The Preliminary Assessment report also recommends investigations in the Coddington Cove area of Narragansett Bay to determine if the marine ecosystem has been impacted by the on-shore activities. To direct an off-shore investigation and prepare an ecological risk assessment for this area, a separate Work Plan has been prepared, and this project is currently under way. A draft report is scheduled to be published in June 1996.

## **1.2 PROJECT ORGANIZATION AND RESPONSIBILITIES**

The B&R Environmental team will be responsible for managing and performing the field investigation activities presented in this Work Plan. Figure 1-3 presents the proposed staff organization with names of key personnel.

NAVFAC personnel will be responsible for administrative and technical oversight of the program and project management and coordination between state or federal regulatory agencies, while the NETC on-site representative will be responsible for on-site coordination with B&R Environmental.

Key Navy personnel supporting this project are as follows:

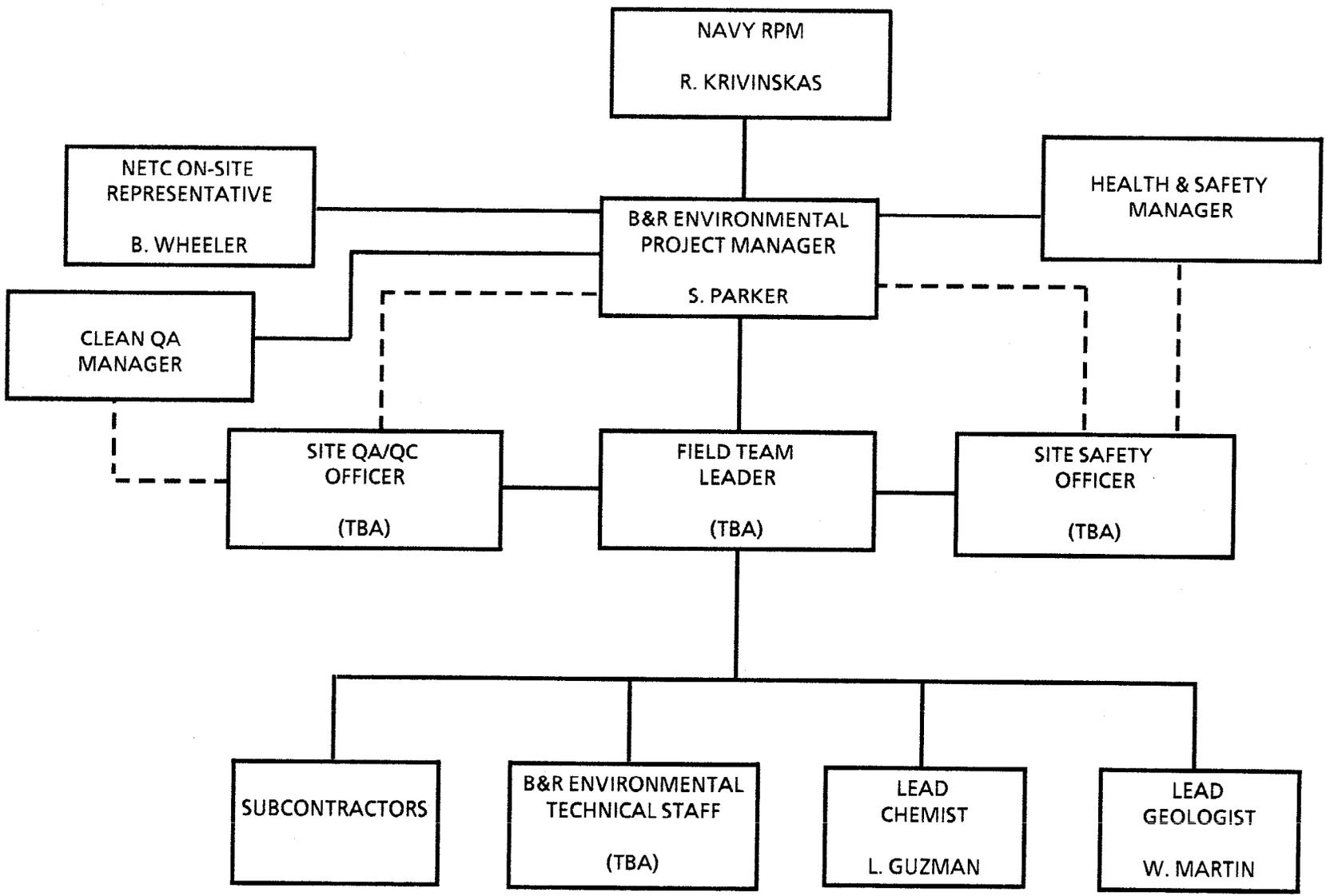
Robert Krivinskas, RPM  
Naval Facilities Engineering Command, Northern Division

Brad Wheeler, Facility Contact  
NETC Newport

**FIGURE 1-3  
 STAFF ORGANIZATION  
 FORMER DERECKTOR SHIPYARD, CTO 173,  
 ON-SHORE SITE ASSESSMENT SCREENING EVALUATION  
 NETC, NEWPORT, RHODE ISLAND**

WS295091F

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Key B&R Environmental personnel supporting this project are as follows:

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Project Manager

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The B&R Environmental Project Manager (PM) will have the primary responsibility for implementing and managing the SASE. The B&R Environmental Project Manager will also be responsible for notifying regulatory agencies of field activities or schedule modifications. The Field Team Leader (FTL) and lead technical staff will support the PM.

The CLEAN Health and Safety Manager is responsible for reviewing health and safety plans for all CLEAN operations, and performs site audits to ensure compliance with site health and safety requirements.

The Quality Assurance Manager is responsible for QA/QC requirements for the B&R Environmental CLEAN program. This individual reviews data and deliverable documents, and performs system audits to ensure contract QA/QC goals are met.

The Lead Chemist will direct the on-site sample analytical (screening) efforts. The Lead Chemist will advise the PM on technical requirements of the data and sample collection efforts. This individual will also coordinate the efforts of the field analysts with the FTL and sampling staff to guarantee that the goals of the screening program are met. The Lead Chemist will assume a second role as site QA/QC officer.

The Lead Geologist will direct technical work relating to the geologic and hydrogeologic investigations. The Lead Geologist will advise the PM on technical requirements relating to these tasks. Direction of certain subcontractors may be delegated from the FTL to the Lead Geologist, (i.e., drilling). This individual will also coordinate the efforts of the field geologists with the FTL and the Project Manager to ensure the goals of the task are met.

The FTL will be responsible for directing on-site field activities and will report directly to the PM. The FTL will coordinate efforts of the field sampling staff, the subcontractors, and the lead technical staff. The FTL will be responsible for identifying problem areas and bringing them to the attention of the PM for resolution.

The Site Safety Officer (SSO) and Site QA/QC Officer (SQO) are field team members to be selected for this project. The SSO and SQO report to the B&R Environmental PM.

In addition to the above personnel, Brown & Root Environmental program personnel will provide overall support in subcontracting, cost tracking, progress reporting, and supervising the project manager. The program personnel include the following:

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Program Manager

Michael Turco, P.E.  
Deputy Program Manager

Brown & Root Environmental, Wayne, PA  
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### **1.3 PROJECT DELIVERABLES**

Project deliverables submitted during this project will include:

- A SASE Report, including:
  - a summary of site background information,
  - a description of field investigation activities,

- a summary of geologic and hydrogeologic conditions found during investigation activities,
  - a summary and interpretation of chemical data,
  - a presentation and evaluation of field measurements,
  - conclusions and recommendations for additional investigation and remedial actions (as required).
- A preliminary human health risk assessment, including:
    - an exposure assessment describing concentrations of contaminants found and potential routes of exposure,
    - a preliminary selection of contaminants of concern,
    - a toxicity assessment for the contaminants of concern,
    - a preliminary risk characterization.
- A conceptual model for ecological risk assessment, describing:
    - a list of potential receptors and habitats,
    - an assessment of possible exposure pathways
    - the relationship between the assessment and measurement endpoints pertaining to the site related contaminants.
- Supporting documentation, including:
    - maps depicting surveyed monitoring wells, underground drain lines, other sampling points, and other significant features,
    - results from field screening and laboratory analysis of samples,
    - boring logs and well installation logs.

A more detailed description of the SASE Report is presented in Section 5.0 of this Work Plan.

## **1.4 WORK PLAN ORGANIZATION**

Section 2.0 of this Work Plan describes the history of the site and some of the findings of previous investigations on and around the site. In particular, the findings and recommendations of the Preliminary Assessment (PA) report prepared for Derecktor Shipyard are summarized. The recommendations made in the PA are reviewed with respect to the work area boundaries presented in Section 1.2.

Section 3.0 presents the field work required for this investigation. Tasks are listed in chronological order of execution. Sample collection procedures and analytical parameters are also described in Section 3.0.

Section 4.0 presents the Quality Assurance Plan for the SASE. This plan describes the QA/QC sample collection procedures and frequencies, data quality protocols, and analytical data validation requirements.

Section 5.0 presents a general outline of the SASE Report and preliminary human health risk assessment that will be prepared following completion of all the field work described in Section 3.0.

A Site Specific Health and Safety Plan is attached as Appendix A. Appendix B presents Standard Operating Procedures (SOPs) for the field investigation work. Appendix C presents the protocol to be used for field GC screening of soil and water samples, described in Sections 3.0 and 4.0. Appendix D presents the protocol to be used for field XRF screening of soil, described in Sections 3.0 and 4.0. Appendix E contains examples of forms to be used for documentation during this investigation.

## **1.5 CHANGES TO THE WORK PLAN**

If, during the investigation, the plan for collection of data needs to be altered, the work plan may be amended through the use of a Request for Field Modification. This form will be prepared by the Brown and Root Environmental Field Team Leader, forwarded to the B&R Project Manager. The B&R Project Manager makes a recommendation to the Navy RPM, who if necessary, will forward it to the regulatory oversight RPMs. Time limits on acceptance of or comment to the field modification requests will be stated. An example of this form is presented in Appendix E.

## 1.6

### SCHEDULE AND REGULATORY OVERSIGHT

A schedule for field investigations has not been prepared at this time. However, several activities require regulatory oversight, and interim deliverables will be provided for regulatory review. Therefore, a schedule will be prepared and submitted to the U.S. EPA and RIDEM upon development of a cost/schedule proposal to perform the field work. This schedule will be updated as necessary to inform oversight personnel when different tasks and activities will take place such that they can plan accordingly.

## **2.0 BACKGROUND**

The information provided in this section has been adapted from the Preliminary Assessment (PA) report for Derecktor Shipyard (ENSR, June 1993).

The Robert E. Derecktor of Rhode Island (Derecktor) Shipyard consists of 41.35 acres of land and improvements that was leased by the Rhode Island Port Authority and Economic Development Corporation (RIPAEDC) to Derecktor. RIPAEDC, in turn, leased this parcel from the U.S. Navy. The RIPAEDC lease commenced on January 1, 1979; Derecktor's sublease ran concurrently.

The area leased by Derecktor is surrounded on the northern, eastern, and southern property boundaries by Naval Education & Training Center (NETC). The western boundary of the parcel opens onto Coddington Cove, an inlet of Narragansett Bay.

### **2.1 ACTIVITY HISTORY**

The history of government involvement with lands in the Newport, Rhode Island, area dates back to the mid-1600s when property was first purchased from the Aquidneck Indians. Throughout the 1700s and 1800s, the presence of the U.S. Navy grew in the Newport area with the development of naval training facilities and the establishment of the Naval War College. Military activities increased sharply at the outbreak of World War I and again at the start of World War II.

Coddington Cove was acquired in 1940 for use as a supply station. Prior to this time, the Coddington Cove area was farm land with few buildings. During World War II, the Coddington Cove area experienced major development including construction of barracks, warehouse space, and hundreds of quonset huts. Although naval activity diminished following the end of World War II, some construction at Coddington Cove continued. In 1955, Pier 1 was completed to replace pier space lost in 1954 to Hurricane Carol. The adjacent Pier 2 was added in 1957.

In 1962, Newport became headquarters to the Commander Cruiser-Destroyer Force Atlantic. Dozens of naval warships and auxiliary support ships were home-ported at Newport. A 1962 aerial photograph of the Coddington Cove area shows 18 naval warships moored at Pier 1.

This use of the Coddington Cove area continued until the April 17, 1973, announcement of the Navy's Shore Establishment Realignment (SER) Program. The SER resulted in a reorganization of naval forces at Newport and the transfer of ships and activities to other Naval stations. The SER also directed transferring or excessing non-essential land and facilities. The 41 acres of land leased to RIPAEDC and subleased to Derecktor Shipyard was included in this excessing. The Derecktor Shipyard operated from 1979 until January 1992, when Derecktor filed for Chapter 11 bankruptcy.

The site was used by Derecktor to repair, maintain, and construct private and military ships. Repair and maintenance operations were concentrated around Pier 1. These operations consisted of sand blasting and painting, hull inspections, and other on-board ship repairs. Dry docks were moored at Pier 1. A large ferry known as the Greenport Ferry was moored between Buildings A18 and 234.

Derecktor also constructed new ships under contract to the U.S. Coast Guard and the U.S. Army. These ships were steel-structured, such as cutters and tugboats, built from the keel up, and outfitted for initial sea trials. Construction included cutting and welding steel, sand blasting, priming and painting the structure, and assembling the ship. Ship assembly was primarily conducted in Building 234. Supporting the ship maintenance and construction operations was an engineering department, a machine shop, an electrical shop, a pipe shop, and a vehicle maintenance shop.

## **2.2 SURROUNDING LAND USE**

The former Derecktor Shipyard area is surrounded entirely by U.S. Naval facilities. NETC facilities are generally situated at a higher elevation than the Derecktor Shipyard. The majority of the NETC buildings surrounding the site are used for administration, training, or naval research.

Abutting the site to the south is a NETC public works garage and vehicle maintenance building, and an oil-fired heating plant. The public works transportation shop and heating plant directly abut the Derecktor property and are immediately south of Buildings 3 and 5, respectively.

Further south of the site (approximately 500 yards) is a military housing development (Range Road). Additional housing (Simonpietri Drive) is present 150 yards east of the site (upgradient). Commercial fishermen use Coddington Cove for lobster fishing. There are no restrictions on access to the shipyard by water.

No natural fresh water bodies were observed within the Derecktor Shipyard. Approximately 80 percent of the shipyard is covered by buildings or pavement. Because precipitation cannot readily percolate through paved surfaces, water will tend to accumulate on the ground surface, which, in this case, consists of depressions in the pavement.

### **2.3 GEOLOGY/HYDROGEOLOGY**

The regional geology/hydrogeology for the site is presented below. Much of this information was extracted from a March 1993 Remedial Investigation/Feasibility Study (RI/FS) Work Plan conducted by TRC Environmental Corporation (TRC) for the NETC.

NETC is located at the southeastern end of the Narragansett Basin. This basin is a complex synclinal mass of Pennsylvanian aged sedimentary rocks that is the most prominent geologic feature in eastern Rhode Island and adjacent Massachusetts. Narragansett Basin is an ancient north to south trending structural basin originating near Hanover, Massachusetts. The basin is approximately 55 miles long and varies from 15 to 25 miles wide. The western margin of the basin is in the western portion of Providence, Rhode Island, and the eastern margin runs through Fall River, Massachusetts. Exposures of older rocks on Conanicut Island and in the vicinity of Newport suggest that the southern extent of the basin is near the mouth of Narragansett Bay.

The bedrock of the Narragansett Basin has been divided into the following five units: the Rhode Island Formation, Dighton Conglomerate, Wansulta Formation, Pondville Conglomerate, and Felsite at Diamond Hill. At NETC and most of the surrounding area, the bedrock is composed entirely of the Rhode Island Formation. The Rhode Island Formation is the most extensive and thickest of the Pennsylvania formations in Rhode Island.

Included within the Rhode Island Formation are fine to coarse conglomerate, sandstone, lithic graywacke, arkose, shale, and a small amount of meta-anthracite and anthracite. Most of the rock is gray, dark gray, and greenish, but the shale and anthracite are often black. Crossbedding and irregular, discontinuous bedding is characteristic of the formation. Rock in the southern portion of the basin, where the NETC is located, is metamorphosed, and contains quartz-mica schist, feldspathic quartzite, garnet-staurolite schist, and some quartz-mica-sillimanite schist. The beds of meta-anthracite and anthracite are mostly thin, but many areas within basin have been mined. Vein quartz, fibrous quartz, and pyrite are commonly associated with these coal layers, and the ash content is high.

Many areas on Aquidneck Island, on which NETC is located, obtain their water supply from wells. Areas relying on groundwater are mostly north of the Middletown area, but wells exist throughout the island. Most groundwater is used for domestic needs, although some is used by small industries and businesses.

Groundwater on Aquidneck Island is obtained from the unconsolidated glacial deposits of till and outwash and from the underlying Pennsylvanian bedrock. Throughout the area, depth to groundwater ranges from less than one foot to about 30 feet, depending upon the topographic location, time of year, and character of subsurface deposits. The average depth to the groundwater is approximately 14 feet on Aquidneck Island and moves from areas of high elevations to Narragansett Bay or the Sakonnet River.

Seasonal water level fluctuations are common in the area. These fluctuations range from less than 5 feet to as much as 20 feet on the hills. In the valleys and lowland areas, the fluctuations are generally less than 5 feet. During the late spring and summer, the water table usually declines as a result of evaporation and the uptake of water by the plants, and rises during autumn and following winter thaws.

The chemical characteristics of the groundwater are similar throughout the area; water is generally satisfactory for most ordinary uses. Most groundwater in the area is soft or only moderately hard; groundwater from till generally contains less mineral material and is softer than groundwater from bedrock. Locations where groundwater has a high iron content are scattered, but are most numerous around Newport and Middletown and the northern part of Portsmouth. Wells that have a high iron content usually penetrate only rocks of Pennsylvanian age.

The groundwater at NETC is shallow (less than 10 feet below the surface in most areas). This shallow depth makes groundwater contamination at NETC highly probable. Pollutants that do migrate into groundwater would flow to the west and discharge into Narragansett Bay. NETC extends along the western shoreline at Aquidneck Island, so the groundwater only has to migrate a short distance before discharging into Narragansett Bay.

The soils occurring at NETC have permeabilities that are moderate to moderately rapid, so they do not restrict the vertical movement of water. The glacial till, from which these soils were derived, is generally less permeable than the overlying soils but does not represent a barrier to the vertical migration of water. Therefore, it is possible that any contaminant transported in this water could contaminate the groundwater. Isolated areas also exist where the bedrock occurs at the surface.

Contamination is possible at these outcrops through the cracks and fissures that commonly occur in the bedrock.

The Rhode Island Department of Environmental Management (RIDEM) has established a state and groundwater classification system to protect its groundwater resources. The groundwater at Derecktor Shipyard is classified as GB. Groundwater classified as GB may not be suitable for drinking water without treatment due to known or presumed degradation. Groundwater classified as GB is typically located at highly urbanized areas or is located in the vicinity of disposal sites for solid waste, hazardous waste, or sewerage sludge.

## **2.4 FINDINGS OF THE PRELIMINARY SITE ASSESSMENT**

Based the information reviewed and the observations made during the PA, a number of conclusions regarding the Derecktor Shipyard were made. The following conclusions are those that apply to the study area, as described in Section 1.0 of this Work Plan.

- The Derecktor operations generated large quantities of hazardous wastes. These wastes included waste oil, paints, solvents, thinner, sodium hydroxide, and other waste solids and liquids.
- Housekeeping and hazardous material handling practices at the facility were poor. General debris and scrap materials were widely scattered around the facility.
- Waste materials were known to be disposed of on the property, including spent sand blast grit, oily liquids, and bilgewater from the dry dock. These liquids were reportedly placed in a small pit on the northern side of Building 42.
- Releases of hazardous material to the ground in the hazardous waste storage area (North Waterfront) and the pipe shop (Building 6) are suspected but have not been confirmed.
- Interior areas of some buildings, most notably Buildings 42, 234, and 6, have been significantly impacted by Derecktor operations. Depending on the intended reuse of these buildings, significant cleaning or floor and wall restoration may be necessary.

- The presence of asbestos-containing materials (ACM) is suspected in most of the buildings. If renovation or demolition of the buildings is intended, the presence of ACM would need to be confirmed.
- The primary pathways for contaminants to migrate from the site would be through the storm drain system and groundwater flow. Coddington Cove would be the primary receptor of contaminants through these pathways.

## **2.5 RECENT ACTIVITY**

Since the PA was issued, the site has undergone several major changes. Derecktor's oversized Building 234 was removed, leaving the original Building 234 in place, with the north and south walls demolished. All the material, machinery, and equipment in this building has been removed. Buildings 40 and 41 and Huts 3 and 4 were removed. The dry docks were removed, and the Greenport Ferry, once tied at the base of the pier to Building A18, was removed.

After bankruptcy proceedings, and during the shutdown and auction of the saleable materials, debris from building demolition and unwanted material was scattered throughout the site. NETC Newport has performed a surface cleaning at the site, that consisted of removing remaining debris, surface cleaning grossly contaminated concrete, and closing and removing underground storage tanks (USTs).

The PA did not include the area designated as the South Waterfront as a part of the study area. NETC representatives have indicated that this area has had fill materials placed on it by Robert E. Derecktor Inc. and should be evaluated as a part of this study. Therefore, this area was added to the site study area covered under this Work Plan.

## **2.6 RECOMMENDATIONS OF THE PRELIMINARY ASSESSMENT REPORT**

To confirm observations and conclusions made regarding environmental impacts at the Derecktor Shipyard, the PA recommended a limited investigative program with two objectives. The first would be to collect data to confirm presence or absence of the suspected contamination. The second would be to resolve issues such as the presence of USTs at Buildings 62 and 234 and the outlets of storm drains that could not be determined in the Preliminary Site Assessment. The complete nature and extent of contamination would not be defined.

The PA report recommendations are restated below, followed by the Navy's approach to address each recommendation. Since the issuance of the PA report, some of the recommended efforts have been instituted and others will be addressed by the SASE, as stated below.

1. Soil Sampling - Samples of soil would be collected and analyzed for target analyte list metals plus cyanide (TAL inorganics) volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and total petroleum hydrocarbons (TPHs). Samples would be collected at both the surface and at depth. Samples would be collected from the following areas where stained soil was observed or disposal activities were reported:

- Hazardous waste storage area (Waterfront Area)
- 20,000 gallon fuel tank by Building 40
- Building 234 southeast corner
- Building 234 north side
- Building 42 north and east sides
- Building 6 loading dock area by pipe shop

The effort described above will be somewhat modified and performed as a part of the SASE. This effort is detailed in Section 3.3 of this Work Plan.

2. Groundwater Monitoring - Shallow water table groundwater monitoring wells are recommended for areas where liquids are suspected or known to have been released to the ground surface. The wells would be 2-inch PVC installed with a hollow-stem auger drill rig. Following development of the wells, samples would be collected for laboratory analysis of VOC, SVOC and TAL inorganics. Wells would be located as follows:

- Hazardous waste storage area (North platform)
- Building 6 loading dock by pipe shop
- Building 42 northeast corner
- Building 40 west of fuel oil tank

The effort described above will be performed as a part of the SASE. This effort is described in detail in Section 3 of this Work Plan.

3. Marine Sediment Sampling - Sampling of marine sediments is recommended to confirm previous results and to determine if other areas of Coddington Cove have been impacted by the shipyard. Samples of marine sediments would be collected with both a dredge for surface

samples and with a corer to determine concentrations with depth. Samples would be collected in the following areas:

- North and south sides of Pier 1
- Along the waterfront at storm drain outfalls
- On the east and west sides of the Greenport Ferry including the storm drain outfall at the northwest corner of Building 234
- At the storm drain outfall west of Building 42
- South of Building 234 at the storm drain outfall
- A background location within Coddington Cove away from shipyard or Navy activities

The effort described above is currently in progress as a part of a separate project. This effort is described in the Final Work/Quality Assurance Project Plan for Narragansett Bay Ecorisk and Monitoring for Navy Sites, Addendum B: Derecktor Shipyard.

#### 4. Other Investigations

- Hazard Categorization - Categorization of drums and containers abandoned on the Activity is recommended. This process would allow materials to be properly classified and would identify hazardous wastes for disposal.

This effort has been performed by the NETC Newport. All chemical containers have been removed from the site.

- Blasting Grit - The used sand blast grit (black beauty) and rotoblast should be analyzed for total metal content and by the toxicity characteristic leaching procedure (TCLP) for hazardous waste determination.

This effort has been partially undertaken by the NETC Newport and the U.S. Navy Northern Division. Preliminary sampling and analysis performed by NETC personnel with XRF screening devices indicate that the sandblast material on the ground surface contains low concentrations of metals. Additional sampling was performed by TRC Environmental Corporation (TRC) and presented in an Environmental Assessment Report dated December 1994. The report indicates that this material has elevated levels of chromium, copper, lead, nickel, and zinc but that these metals do not appear to leach based on previous EP leaching tests performed by NETC.

The SASE investigation will confirm the results of this action, and also include TCLP metals tests on all samples of sandblast material collected. The Navy has initiated a limited removal of sandblast material in the area of Building 42. The data collected from the removal efforts and the SASE will provide a general estimate of the quantity of sandblast material remaining and a complete assessment of the metal's potential to leach into the soil and groundwater will be made.

- Asbestos Survey - Representative samples of suspected ACM should be collected from the suspected areas in the buildings and analyzed to determine if asbestos is present in pipe insulation and floor or ceiling tiles.

This effort has been performed by NETC Newport. Asbestos-containing building materials have been identified in the forms of pipe insulation, floor tile, and other insulation materials in several buildings at the site, including Building 42, and Building A-18. A copy of the report is available through the NETC.

- Underground Storage Tanks - The one UST at Building 5 and reportedly two USTs at Building 234 should be leak tested if the Navy desires to continue using these tanks. If the tanks fail a tightness test, soil borings around the tanks would be recommended to determine if petroleum products have been released. The 2,500 gallon UST at Building 234 should be located either through additional record search or a metal detection survey. A metal detection survey is recommended for Building 62 to confirm that all USTs in this area were removed. Soil borings with collection and analysis of samples with depth should be conducted to determine if petroleum products were released by the tanks that were removed.

The UST issues have been resolved by removal of the present USTs. The NETC performed this effort and copies of the tank closure reports are on file with the RIDEM UST Section and the NETC Newport.

The Navy has eliminated the area around Building 62 from the study area because its only association with the shipyard was as parking. One UST was located and removed from the southern end of Building 5 under RIDEM UST closure regulations. Similarly, one UST was located and removed from the northeastern corner of the Building 234 area. Excavations were performed in this area to attempt to locate a second suspected UST but none was found. Corrective action plans were prepared and executed for the USTs removed from Buildings 5 and 234. Reports for these actions are on file with the RIDEM UST Section, and the NETC.

- Above-ground Storage Tanks - An inventory of above-ground storage tanks should be conducted to determine their condition and contents if any. This inventory would enable proper disposal of tank contents and proper management of the tanks themselves.

All above-ground storage tanks have been removed by Derecktor as a part of the bankruptcy proceedings and subsequent auctions.

- Storm Drain System Evaluation - The storm drain system should be evaluated to determine the condition of catch basins and the degree of siltation or clogging. Many catch basins were observed to be blocked with debris or silted in with sand blast grit. Cleaning the storm drain system may be necessary to remove continuing sources of pollutants and to restore proper flow.

The NETC has performed a basewide investigation to describe the known locations of the storm drain systems, which included Derecktor Shipyard. This effort was performed by Sigmund and Associates, Inc. for the Department of the Navy. These findings will be augmented by the SASE investigation, as described in Section 3.0 of this Work Plan.

- Building Interior Sampling - Buildings where heavy staining on the concrete floor was observed should be sampled prior to reuse to determine the extent of contamination. This sampling would consist of wipe samples or, if deep staining is present, concrete chip or core samples. The floors should also be visibly inspected for cracks or holes where liquids may have seeped. If buildings will be occupied by personnel, then interior air sampling is recommended. The areas where sampling is recommended are Rooms A, B, and C and the hallways in Building 42, the burning room in Building 234, the tool crib in Building 4, and the pipe shop in Building 6.

The areas of the buildings described have undergone industrial cleaning to ensure safe working conditions, and wipe samples are no longer appropriate. Building 234 has been removed, and others will be investigated as a part of the SASE, as described in Section 3.2 of this Work Plan.

## **3.0 FIELD INVESTIGATION AND SAMPLING PLAN**

This section provides a detailed description of field work recommended in the PA and revised, as described in Section 2.6 of this Work Plan. The data collected during the field investigation will be used to prepare an SASE report and a preliminary (qualitative) human health risk assessment.

### **3.1 OBJECTIVES**

The objective of the Field Sampling Plan is to obtain adequate data to support the SASE report and preliminary risk assessment. The data acquired may also be used in a baseline risk assessment if a remedial investigation is warranted.

After these investigations are completed, a SASE report including a preliminary human health risk assessment will be prepared. The data collected during these investigations must be capable of supporting that risk assessment. The content of the report and risk assessment is described in Section 5 of this Work Plan.

The Field Sampling Plan is organized by the following chronological tasks:

- Task 1: Mechanical Pits and Trenches Inspection
- Task 2: Underground Drainage Systems Clearing and Tracking
- Task 3: Test Pit Excavation and Sample Collection
- Task 4: Geologic/Hydrogeologic Investigation
- Task 5: Catch Basin and Sump Sampling
- Task 6: Floor Drain Discharge Area Sampling
- Task 7: Location Survey
- Task 8: Evaluation of Cultural and Ecological Settings

These tasks have been separated into two sets: visual and instrument inspections (Tasks 1 and 2) and intrusive investigations (Tasks 3 through 8). The following sections describe the technical approach and expected procedures for these tasks.

## **3.2 VISUAL AND INSTRUMENT INSPECTIONS**

Tasks 1 and 2 are planned to clear debris and complete visual and instrument inspections to facilitate targeting investigation activities. Underground structures (drain lines, mechanical pits, etc.) will be cleared and inspected to identify potential discharge areas. These actions are described in the following subsections.

### **3.2.1 Task 1: Mechanical Pits and Trenches Inspection**

Numerous pits and trenches that are flush with the floor remain in the original Building 234. One such pit exists in Building 42. Debris floating in the pits disguises their presence and creates a hazard for personnel working in this area. Many of these pits are probably mechanical trenches and vaults for sub-floor hydraulic equipment that was used during shipyard operations.

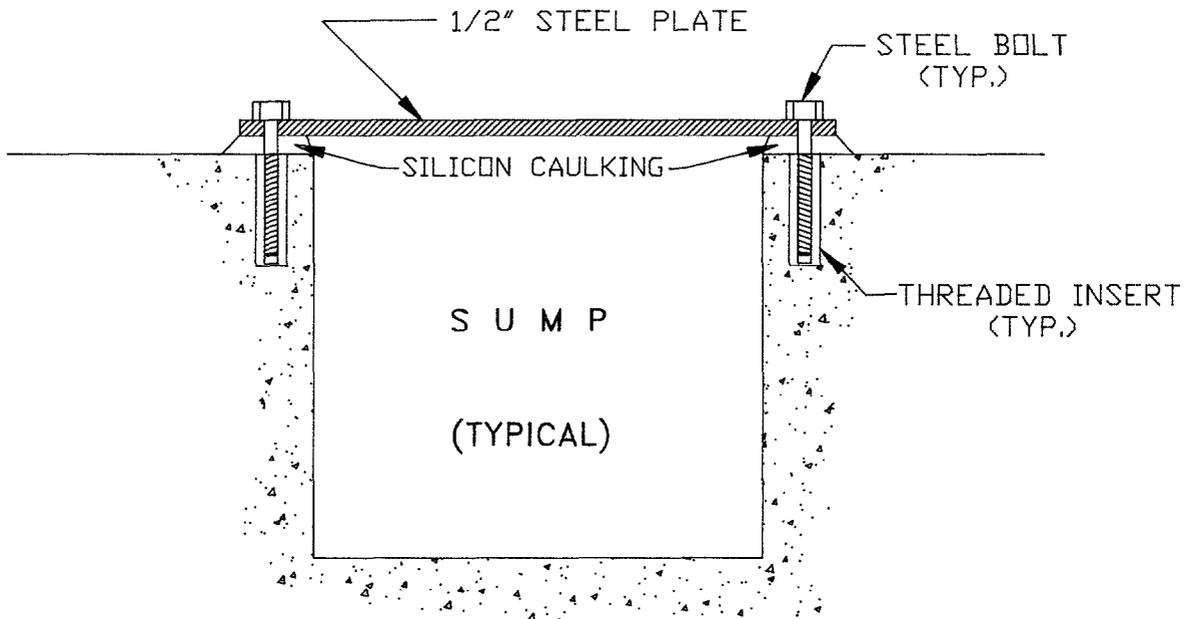
The fluids in these pits and trenches will be pumped out and containerized for waste characterization. The interior walls of the pits will be inspected for staining, cracks, holes, fractures, and connecting piping; if piping is found, it will be traced with utility tracing equipment.

Equipment used to track piping and outfalls may include ground-penetrating radar, magnetometer devices, utility tracing devices, metal detectors, video recording devices, smoke, and dye tracers. This effort will be performed by a subcontractor with proven experience in this type of activity. B&R Environmental will provide supervision and oversight support to the subcontractor. If outfalls or connections are identified, they will be marked and the locations will be surveyed for future sampling, as a part of Tasks 5 and 6.

Pits and trenches that have outlets but no identifiable outfall will be assumed to discharge to the ground subsurface. The expected areas of the discharge will be identified with a magnetometer or other utility tracing equipment and marked for future sampling. Sample collection in these discharge areas is to be performed as a part of Task 6.

Pits found to have unconsolidated bottoms will be numbered, photodocumented, and surveyed for sampling, as a part of Task 5.

Surveys of the pits and expected discharge locations will be performed as described in Section 3.5 of this Work Plan.



NOTE:  
 1. PLAN NOI TO BE USED FOR DESIGN.

DETAIL OF PROTECTIVE COVER FOR CLEANED SUMP		FIGURE 3-1	
FORMER DEREKTOR SHIPYARD		 <b>Brown &amp; Root Environmental</b> A Division of Halliburton NUS Corporation	
NETC - NEWPORT, RI			
DRAWN BY:	R.G. DEWSNAP	REV.:	0
CHECKED BY:	J. HOLDEN	DATE:	29 MAR 96
SCALE:	NONE	CONTRACT NO.:	N62472-90-D-1298
		55 Jonspin Road Wilmington, MA 01887 (508)658-7899	

After inspections, all pits and trenches will be numbered, photo documented to clearly show condition of their interiors, securely covered with steel plates, and sealed with silicone caulking (Figure 3-1).

The pumping operations will be performed by subcontractors to B&R Environmental operating under their own health and safety plan, and supervised by B&R Environmental technical staff. Solid and liquid waste from each pit or sump will be managed as a separate source, with separate samples for disposal parameter analysis. If results indicate similar constituents, the material from separate sources may be combined and shipped for bulk disposal. Fluid and sludge pumped from these pits and trenches will be managed as described in Section 3.4 of this Work Plan. Solid wastes will be containerized on site prior to removal/disposal.

Concrete core samples may be collected from selected pits and sumps if it is determined that these pits or sumps were a part of a contaminant source or release flowpath. This determination will be made based on the findings of the inspections, and results from any follow-up soil sample collections performed as a part of Tasks 5 and 6 (Section 3.3.3 of this Work Plan).

### **3.2.2            Task 2: Underground Drainage Systems Tracking and Clearing**

Storm drains and building floor drains were described in the PA report as a potential contaminant migration route to Coddington Cove. Storm drains were described as clogged with sandblast grit and other material. Photographs previously published in the PA report showed evidence of oil and other chemical disposal in many of these drains.

The PA report describes known routes of storm water drainage systems. These outfalls and catch basins are shown on the base map. However, additional catch basins, floor drains, sumps, and outfalls exist that do not have identified connections.

The Stormwater Pollution Prevention Plan prepared by Sigmund and Associates, Inc. (September 1994) will be reviewed and used as a baseline for collecting additional information. A comprehensive records search will be performed to identify existing drain lines and underground utilities. This search will be made using as-built drawings of the buildings constructed by the Navy and alterations made by Derektor. B&R Environmental recognizes that a record search was performed by ENSR as a part of the PA, but this exercise should be extended to include all records, including NAVFAC records in Philadelphia.

Culverts and storm drains not identified by the records search will be tracked, and cleared for inspection to determine contaminant discharge areas. Floor drains in the buildings that are not

identified by the records search will also be tracked, cleared, and inspected to identify potential discharge areas. These activities will apply to the following areas:

- Central Shipyard area (including Building 42)
- Building 234 area
- North Waterfront

If possible, the crawl space under Building 42 will be inspected to facilitate investigation of any suspect floor drains, the sump, and or other discharge points in and under the building.

The information collected during this task will be used to prepare a comprehensive map of underground drainage systems. This map and back-up information will be presented in the SASE report, as described in Section 5 of this Work Plan.

Equipment used to track piping and outfalls may include ground-penetrating radar, magnetometer devices, utility tracking devices, metal detectors, video recording devices, smoke, and dye. The clearing operations will be performed by subcontractors to B&R Environmental operating under their own health and safety plans, and supervised by B&R Environmental technical staff.

#### **3.2.2.1 Storm Drains/Catch Basins**

All the catch basins will be cleared by removing or excavating any blockage with dredges, augers, or high-powered suction equipment. If inflow/outflow pipes are identified, they will be tracked with utility tracking equipment. If the pipes appear to be open, smoke will be used to identify discharge locations. If no inlet/outlet pipes are identified in a catch basin, the catch basin will be numbered for sample collection. Locations of catch basins and discharge areas to be sampled will be surveyed by a subcontractor to B&R Environmental. Survey operations are described in Section 3.5 of this Work Plan.

Catch basins will be cleared by excavating silt and other foreign material and containerizing this material. Inflow/outflow pipes will then be cleared with medium pressure water sprays. Prior to the introduction of any water to the drainage systems, temporary containment will be installed at the outfalls identified by the tracking equipment. If possible, water collected in these temporary containment tanks will be recirculated to the cleaning system to reduce the volume of investigation-derived waste (IDW).

Silt and sediment collected will be removed and containerized on site for waste characterization. Solid waste from each catch basin will be managed as a separate source, with separate samples for disposal parameter analysis. If results indicate similar constituents, the material from separate sources may be combined and shipped for bulk disposal. Catch basins that are found to have unconsolidated bottoms will be marked for future sampling.

Samples from catch basins and suspected discharge areas will be collected as a part of Task 5, described in Section 3.3.3.1 of this Work Plan.

#### **3.2.2.2 Floor Drains**

Numerous floor drains were noted in Building 42, in the slab for the former Building 234, and in Huts 1 and 2. In addition, there are reportedly two sumps in Building 42, although only one has been confirmed by B&R Environmental.

The sump(s) will be pumped out and this fluid and any solid material present will be removed and containerized for waste characterization. Liquid waste from each pit or sump will be managed as a separate source, with separate samples for disposal parameter analysis. If results indicate similar constituents, the material from separate sources may be combined and shipped for bulk disposal. The walls and floors of these sumps will be inspected for connecting piping. If piping is found, it will be traced with utility tracing equipment. Once outfalls or connections are identified, these areas will be marked for sampling as a part of Task 6.

If no outlet is identified in the sumps, they will be securely covered with steel plates and sealed with silicon caulking (Figure 3-1).

Floor drains will be cleared if necessary, and tracked with utility tracing equipment to determine possible connections and discharge locations.

Floor drains that have no identifiable outfalls will be assumed to discharge to the subsurface soils. The expected areas of the discharge will be marked, numbered, and surveyed for future sampling as a part of Task 6. Survey operations are described in Section 3.5 of this Work Plan.

### **3.3 INTRUSIVE INVESTIGATIONS**

The primary objective of the intrusive investigations is to identify the contaminants present in the fill, the soils, and the groundwater at the site.

Once the nature of the subsurface contamination at the site has been characterized, then additional information will be used to identify possible mechanisms of contaminant transport and potential exposure pathways to human receptors and the marine environment near the shipyard. Such additional information is likely to include the following: published information on the environmental fate and transport of the contaminants detected, published exposure data on human and ecological receptors; and characterization of the site (physical environment, areas of potential contaminant exposure, plausible contaminant migration routes, and potentially impacted human and/or ecological receptors). In addition, comparisons between the on shore and off shore analytical databases will be conducted to identify contaminants common to both databases and, thus, those most likely to be associated with direct migration routes from the site into the marine environment.

Therefore, the information generated by the intrusive investigations and associated tasks will constitute a basis for the preparation of the reports described in section 5 of this work plan as well as support the investigations and ecological risk assessment for the off-shore environment.

### **3.3.1 Task 3: Test Pit Excavation and Sample Collection**

A large volume of spent sandblast material was used as fill in the study area. Large mounds of soil and possibly other debris exist in the South Waterfront Area. Facility representatives have reason to believe that these soil piles may contain some of this sandblast material. Therefore, test pits will be excavated in the South Waterfront soil piles and other areas of the site to determine presence of spent sand blast grit and other debris.

Test pit excavation was selected to acquire shallow soil samples because it is more cost effective than using a drill rig. Direct push sampling tools are not effective in loose sandy material because the entire device is withdrawn after a four-foot penetration. After withdrawal, the open hole tends to collapse, making it impossible to acquire additional intervals in their entirety. Furthermore, direct push sampling compacts the sample, and sample representativeness is severely compromised. Stones or other material hinder recovery in direct push sampling tools more than any other sample collection method.

Test pits will be excavated to identify the presence and extent of sandblast material and other debris and to collect samples for screening and laboratory analysis. Test pits will be excavated by a subcontractor to B&R Environmental, operating under the B&R Environmental Health and Safety Plan, and supervised by a B&R Environmental representative. Proposed locations are depicted on Figure 3-2.

Because some of the test pit activities are proximal to the shoreline in the south waterfront, these activities may fall under the Rhode Island Coastal Resources Management Council (CRMC) jurisdiction.

The CRMC must be notified of the work to be performed, and their concerns will be addressed prior to initiation of this work.

### **3.3.1.1 Test Pit Excavation**

A total of 24 test pits will be excavated in the following areas:

- Central Shipyard Area, particularly the north and east sides of Buildings 42 and 6
- The south and east sides of the former Building 234
- All of the North Waterfront Area
- All of the South Waterfront Area

Excavated material will be returned to the pits as backfill. Obvious forms of contamination (drums, sludges, etc.) will be separated out and disposed of appropriately.

The test pits will be excavated no further than the former elevation of the natural soils ground surface. Because the fill consists of mounds placed on beach and near-beach soils, these natural soils should be easily identified. If not, the excavations will be halted at the top of the water table, which will be below the level of the natural soils.

Six test pits will be excavated in the South Waterfront Area. Prior to excavation, this area will be inspected to attempt to identify areas of stressed vegetation. If areas of stressed vegetation are identified, test pits will be stationed at these areas. If no stressed vegetation is identified the initial inspection, the six test pits will be spaced at even intervals along the waterfront, and alternate between the western and eastern sides of the soil piles. Care will be taken to avoid damage to the intertidal area near these locations.

Two test pits will be excavated on the southern side of the former oversized Building 234. Two test pits will be excavated on the eastern side of the roadway designated as Defense Highway.

Three test pits will be excavated on the eastern side of Building 42, and one test pit will be excavated on the southern side of Building 42.

One test pit will be excavated on the southern side of Huts 1 and 2, in the reported vicinity of an underground vault.

Two test pits will be excavated on the northern side of Building 6. These test pits will be spaced alternately with those excavated east of Building 42.

Seven test pits will be excavated on the North Waterfront Area, at least 20 feet from the chain link fence. These test pits will not undermine the roadway or building foundations that may be nearby. An additional four test pits may be installed, if warranted by preliminary findings of the investigations.

All test pits will be photo documented, backfilled, and marked with stakes following completion. These stakes will be surveyed, as described in Section 3.5 of this Work Plan.

### **3.3.1.2 Sample Collection**

A minimum of three samples will be collected from each test pit. Samples will be collected from the ground surface (0-1 feet below ground surface), middle of fill, and bottom of fill directly above natural soils, as identified by visual observation. The samples will be collected after the excavation has been completed. Soil samples from test pit operations will be collected such that each sample will be a composite from each wall of the pit. The samples from the bottom of the pit will similarly be a composite from each wall and the bottom of the pit. Additional samples may be collected based on field observations. Soils will be collected from the center of the backhoe bucket using a scoop, and placed in a stainless steel bowl. Except for VOC samples, which will be collected directly from the bucket into the soil jar, all soil samples will be homogenized in the bowl prior to splitting for analyses. Analytes are described in Table 3-1.

At locations where concrete or asphalt cover is present on the ground surface, the 0-1 foot interval will begin at the bottom of this cover material. If asphalt is in contact with the surface soils, the upper four inches of the soil will be extruded from the sample to minimize interference of PAH compounds from the asphalt in the soil sample. As a result, the test pit log will show the ground surface as the bottom of the asphalt layer, but overlying materials will all be described in detail on the log as positive distances *above* the ground surface. The field geologist/engineer evaluating the samples will determine the presence and thickness of asphalt in the sample, and proceed with the sample collection accordingly.

All samples will be screened for metals on site with an X-ray fluorescence (XRF) detector, as described in Section 4.5 of this Work Plan. Based on the results from the XRF screening, approximately 20 percent of the subsurface samples will be selected for laboratory analysis. Selection will be based on the highest metal screening concentrations reported. All the surface soil samples collected will

**TABLE 3-1  
FIELD SAMPLES TO BE COLLECTED  
ON-SHORE SITE ASSESSMENT SCREENING EVALUATION  
FORMER DERECTOR SHIPYARD, CTO 173  
NETC, NEWPORT, RHODE ISLAND**

ACTIVITY	MEDIA	NUMBER OF SAMPLES							
		SCREENING <sup>(1)</sup>		LABORATORY					
		TARGET METALS	TARGET ORGANICS	TCL VOCs	TCL SVOCs <sup>(2)</sup>	TPH	TOTAL TAL INORGANICS	TCLP METALS	BUTYL-TINS
Test Pit Excavation Task 3 <sup>(3)</sup>	Surface Soil	24	0	24	24	24	24	24	24
	Subsurface Soil	48	0	10	10	10	10	10	10
Geologic/Hydrogeologic Investigation Task 4 <sup>(4)</sup>	Surface Soil	12	12	12	12	12	12	12	12
	Subsurface Soil	156	156	31	31	31	31	31	31
	Groundwater	0	0	13	13	13	13	0	13
Sumps and Catch Basins Task 5 <sup>(5)</sup>	Soil	0	0	15	15	15	15	15	15
Sump and Drain Discharge Areas Task 6 <sup>(6)</sup>	Shallow Soil Borings	42	42	9	9	9	9	9	9
	Total Aqueous	0	0	13	13	13	13	0	13
	Total Soils	283	211	115	115	115	115	115	115

**TABLE 3-1  
FIELD SAMPLES TO BE COLLECTED  
ON-SHORE SITE ASSESSMENT SCREENING EVALUATION  
FORMER DERECTOR SHIPYARD, CTO 173  
NETC, NEWPORT, RHODE ISLAND  
PAGE 2 of 2**

- (1) Target Metals include copper, lead, nickel, and zinc. Target Organic Compounds include trichlorethene, tetrachloroethene, ethylbenzene, and xylene. Refer to Section 4.5.2. Total VOCs will be determined by calculation.
- (2) SVOC Parameters include TCL base, neutral and acid extractable compounds, and pesticides and PCBs
- (3) Twenty-four pits proposed, 3 samples collected from each pit for screening, 20% subsurface samples for laboratory analysis, 100% surface samples for laboratory analysis.
- (4) Twelve borings proposed with continuous sampling through 25 feet of overburden (assumed). 20% subsurface samples for laboratory analysis, 100% surface samples for laboratory analysis. See text for analytical scheme.
- (5) Five sumps or catch basins assumed, all samples shipped for laboratory analysis
- (6) Seven drain discharge areas assumed, 3 borings with 3 screening samples collected from each, 20% split for laboratory analysis

undergo off-site laboratory analysis. In addition, all samples collected will be screened on site with a PID/FID for total VOCs using standard jar headspace analysis.

Laboratory samples will be analyzed for TCLP metals, total TAL inorganics, butyltin compounds, and volatile and semivolatile organic compounds (including BNA extractable compounds, pesticides, and PCB compounds).

If conditions indicate the need (i.e. if odors are present, visual evidence of oils or other organic contaminants are present, or PID/FID screening indicates the presence of organic vapors), VOC screening by field GC will be performed on aliquots of the samples collected for metals screening by XRF.

A summary of the number of field samples to be collected is presented in Table 3-1 of this Work Plan.

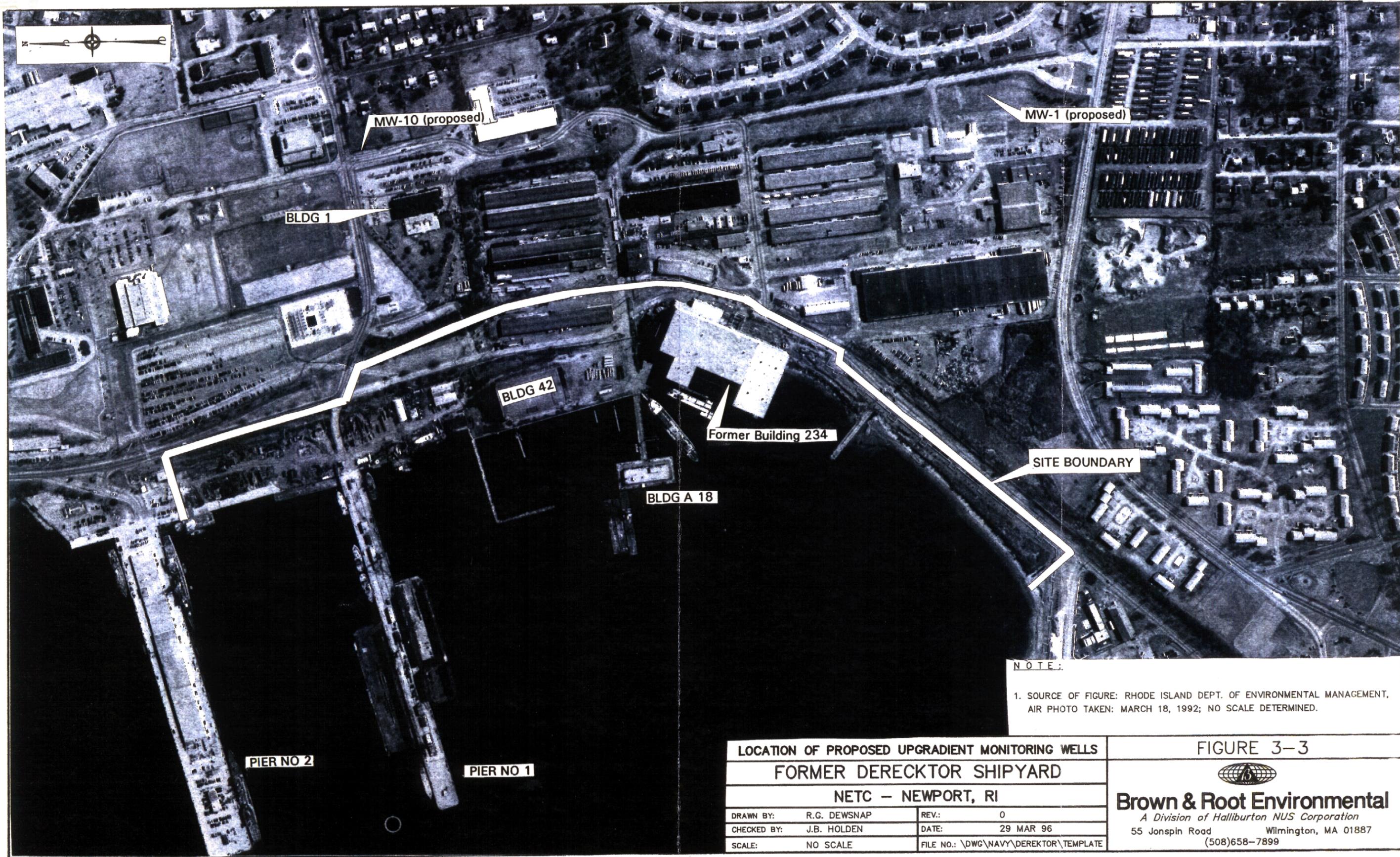
### **3.3.2 Task 4: Geologic/Hydrogeologic Investigation**

The geologic/hydrogeologic investigation will be performed for the entire site study area, except for Building A18.

The objective of this task is to evaluate the presence of soil and groundwater contamination resulting from historical activities at the site. Chemical data will be collected to assist in making preliminary determinations on the presence of contaminants in different media. These data will be used to prepare the preliminary risk assessment and to develop the scope of the RI/FS, if required. Data quality will be adequate for possible use later in a baseline risk assessment, if performed.

The scope of work for the geologic/hydrogeologic investigation includes the following specific components: characterization of the water table aquifer; determination of the leachability of inorganic and organic site contaminants in soils; initial characterization of bedrock; collection and evaluation of groundwater quality data at background locations; assessment of the nature and distribution of groundwater contamination on the site; and additional clarification of contaminant pathways including stormwater culverts, surface water runoff features, and permeable soils.

The subsurface exploration program will focus on areas of concern identified during the PA, but will be expanded to adequately characterize the entire site. Background borings and wells will also be installed as a part of this investigation. Proposed boring/well locations are presented on Figures 3-2 and 3-3 of this Work Plan. Figure 3-2 presents proposed boring/well locations within the site boundaries; Figure 3-3 presents proposed upgradient boring/well locations.



**NOTE:**  
 1. SOURCE OF FIGURE: RHODE ISLAND DEPT. OF ENVIRONMENTAL MANAGEMENT, AIR PHOTO TAKEN: MARCH 18, 1992; NO SCALE DETERMINED.

LOCATION OF PROPOSED UPGRADIENT MONITORING WELLS	
FORMER DEREKTOR SHIPYARD	
NETC — NEWPORT, RI	
DRAWN BY: R.G. DEWSNAP	REV.: 0
CHECKED BY: J.B. HOLDEN	DATE: 29 MAR 96
SCALE: NO SCALE	FILE NO.: \DWG\NAVY\DEREKTOR\TEMPLATE

FIGURE 3-3

  
**Brown & Root Environmental**  
 A Division of Halliburton NUS Corporation  
 55 Jonspin Road      Wilmington, MA 01887  
 (508)658-7899

00232601Y

Borings advanced during this activity will be labeled as MW## reflecting the number of the monitoring well that will be installed at that location. Table 3-2 describes the location, the expected screened interval, and the purpose of each of the 12 wells to be installed.

### **3.3.2.1 Investigation Target Areas**

As part of this task, 13 target areas have been identified for investigation. These areas consist of six areas of concern identified by the PA as potential discharge areas, four secondary areas of the site where extensive activity had occurred but which were not identified by the PA as areas of concern, and three background areas. The geologic/hydrogeologic investigation will target these areas, as described in the following paragraphs.

#### Areas of Concern Identified by the PA

The six areas of concern identified in the PA are:

- Loading dock area in the northeast corner of Building 6 (suspected chemical discharge area)
- North side of Building 42 (former location of the "bilgewater disposal pit")
- South side of Building 42 (former material storage area, and former location of Building 40)
- The former outdoor hazardous waste storage area on the North Waterfront Area
- North side of the exterior of the former Building 234 (suspected chemical discharge area)
- Southeast corner of the exterior of the former Building 234 (suspected chemical discharge area)

One boring will be advanced in each target area. This boring will be advanced through the overburden to the top of bedrock. Continuous samples will be collected during the boring advancement. The boring will then be backfilled to an appropriate depth for the well installation. Depth of well installations will be determined after review of the screening data. In general, the saturated zone that exhibits the highest concentrations of contaminants based on screening analysis will be targeted for the well screen interval, but alterations may be made due to other conditions noted in the field. These other conditions may include: vertical zones that are more or less permeable to water than others, depth to water, depth to bedrock, soil types present, visual evidence of contamination (and an absence of instrument responses to samples collected for screening), and the presence of multiple horizons of contaminants.

**TABLE 3-2  
BORINGS/WELL INSTALLATIONS  
FORMER DERECKTOR SHIPYARD, CTO 173  
ON-SHORE SITE ASSESSMENT SCREENING EVALUATION  
NETC, NEWPORT, RHODE ISLAND**

BORING/WELL NUMBER	LOCATION	WELL SCREEN INTERVAL	PURPOSE OF WELL
MW01 (upgradient location)	Southeast of site in grassy area north of Gate 10 (Refer to Figure 3-3)	Unconsolidated overburden based on field screening and soil conditions	Establish background soil and groundwater quality.
MW02	West of former oil discharge area	Unconsolidated overburden, based on field screening	Assess impacts of former oil discharges to soil and groundwater.
MW03	Hazardous Waste Storage Area	Deep unconsolidated overburden - based on field screening	Assess impacts of hazardous waste storage area on deep portions of soil and groundwater.
MW04	Northwest of Huts 1 and 2 in vicinity of vehicle maintenance facility and truck parking area	Deep unconsolidated overburden - based on field screening	Assess impacts of vehicle maintenance activities on soil and groundwater.
MW05	North of Building 42 within historical disposal area	Shallow bedrock	Assess impacts of bilgewater disposal in former pit on soil and shallow bedrock aquifer.
MW06	East of Building 6 in area of potential chemical disposal	Unconsolidated overburden - based on field screening	Assess impacts of reported disposal on soil and overburden aquifer.
MW07	South of Building 42 in former location of Building 40, former drummed hazardous waste storage area, and former fuel storage area	Unconsolidated overburden - based on field screening	Assess impacts of former waste and fuel storage on soil and overburden aquifer.

**TABLE 3-2  
BORINGS/WELL INSTALLATIONS  
FORMER DEREKTOR SHIPYARD, CTO 173  
ON-SHORE SITE ASSESSMENT SCREENING EVALUATION  
NETC, NEWPORT, RHODE ISLAND  
PAGE TWO**

BORING/WELL NUMBER	LOCATION	WELL SCREEN INTERVAL	PURPOSE OF WELL
MW08	Northeast of Building 234 in area of former USTs and former machine shop	Unconsolidated overburden - based on field screening	Assess impacts of USTs and former machine shop to soil and overburden aquifer.
MW09	Southeast of Building 234 in area of suspected liquid/solid waste disposal	Unconsolidated overburden - based on field screening	Assess impacts of disposal activities on soil and overburden aquifer, characterize upper bedrock.
MW10 (upgradient location)	Immediately east of Gate 11 and Building 1 (Refer to Figure 3-3)	Unconsolidated overburden - based on field screening	Establish background soil and groundwater quality.
MW11	Between Pier 2 and the Former Hazardous Waste Storage area (former bulk storage area)	Unconsolidated overburden - based on field screening	Assess impacts of former storage areas and other disposal on deep portions of overburden aquifer.
MW12	Between Pier 1 and the Former Hazardous Waste Storage area (former bulk storage area)	Unconsolidated deep overburden based on field screening	Assess impacts of former storage areas and other disposal on deep portions of overburden aquifer.
Optional Well (1)	South Waterfront, adjacent to soil piles placed as fill	Unconsolidated overburden - based on field screening	Assess affects of contaminants in fill/soil piles on the shallow overburden aquifer.

(1) The location of this well has not been determined, and thus does not appear on Figures 3-2 or 3-3.

### Secondary Target Areas

Four target subsurface investigation areas that the PA did not identify as areas of concern are:

- Area north of Huts 1 and 2
- Area west of Huts 1 and 2
- North end of the North Waterfront Area (former bulk storage area)
- Base of Pier 1 (former oil transfer point)

One boring will be installed in each target area. This boring will be advanced through the overburden to the top of bedrock. Continuous samples will be collected during the boring advancement. The boring will then be backfilled to an appropriate depth for the well installation. Depth of well installations will be determined after review of the screening data. In general, the saturated zone that exhibits the highest concentrations of contaminants based on screening analysis will be targeted for the well screen interval, but alterations may be made due to other conditions noted in the field. These other conditions may include: vertical zones that are more or less permeable to water than others, depth to water, depth to bedrock, soil types present, visual evidence of contamination (and an absence of instrument responses to samples collected for screening), and the presence of multiple horizons of contaminants.

### Background Target Areas

Three background target areas identified at the site are:

- 300 feet north of Gate 10, 1400 feet to the southeast of the original Building 234, in a small grassy area which has remained undeveloped, based on air photos from 1952 to 1992.
- Upgradient of Building 1 (approximately 1500 feet east of Pier 1), on the east side (upgradient) of Gate 11.
- West of steam plant, upgradient of former Building 234

One boring will be installed in two of the three target areas. The target area west of the steam plant upgradient of Building 234 will be excluded from the boring program because three wells currently exist in the vicinity: MW-101, MW-102, and MW-103. These wells were installed in 1993 by D. L. Maher for GZA as part of UST investigations at the steam plant.

Borings will be installed at the other two target areas which are believed to be unimpacted areas. These borings will be advanced through the overburden to the top of bedrock. Continuous samples will be collected during the boring advancement. The boring will then be backfilled to an appropriate depth for the well installation. Depth of well installations will be determined after review of the screening data and soil conditions. If contaminants are detected, the saturated zone that exhibits the highest concentrations of contaminants based on screening analysis will be targeted for the well screen interval.

### Contingency Target Areas

One additional target area was identified by the Technical Review Committee reviewing the draft versions of this work plan. The concern focused on the fill placed at the south waterfront. Since this material is piled fill, placed on beach, it was initially determined that the most cost-effective approach to determine the nature of the fill and presence of contaminants within it was to perform test pits (refer to Section 3.3.1).

If the findings of the test pit excavations indicate the presence of high concentrations of contaminants which may be leaching into the groundwater at the south waterfront, or if drums or other evidence of gross contamination is discovered, an additional well or wells may be placed in the south waterfront area to determine impact on the shallow overburden aquifer.

If such a change is warranted, the regulatory parties shall be notified using a Request for Field Modification as described in section 1.5 of this work plan.

### **3.3.2.2 Advancement of Borings**

A total of 12 borings will be advanced with drilling apparatus using hollow-stem augers, spin casing, or drive and wash drilling systems. The specific method will be determined based on field conditions and the expected use of the borehole.

Continuous standard penetration tests will be conducted during advancement of each boring. Soils will be described according to the Unified Soil Classification System, and logged to provide a complete lithologic record of the subsurface materials. As each split-spoon is opened, the soils will be monitored for organic vapors using a FID. The borehole itself will be periodically monitored for organic vapors, in accordance with the Health and Safety Plan (Appendix A).

Borings will be continued to bedrock as determined by the rig geologist. If evidence of contamination exists at the bedrock overburden interface, the Navy will review the need for additional bedrock borings/wells than are currently scoped.

A log of each borehole will be maintained by the field geologist to describe lithologies encountered, depth of geologic contacts, water levels, sample depths, bedrock characteristics, and any other pertinent observations made during drilling. Boring logs will also include information on sample number, type, and depth; sample interval and recovery; and data from Standard Penetration Tests. An example boring log is included in Appendix E of this Work Plan.

Two borings will be continued into bedrock by coring (MW05 and MW09). One boring (MW05) will be cored into bedrock a minimum of ten feet and will be finished as a bedrock monitoring well to provide bedrock aquifer water quality information. MW09 will be cored into rock a minimum of 5 feet to further characterize upper bedrock. The bedrock boring will be backfilled with bentonite chips and sand prior to overburden well construction. No well will be installed across the overburden/bedrock contact. Bedrock cores will provide an initial characterization of the nature of bedrock fracturing and potential contaminant transport in the bedrock. Rock coring will be performed with standard NX double-wall core barrels that will provide a nominal two-inch core and a three-inch diameter borehole. Bedrock coring will commence only after securely seating the drilling casing into the top of the rock to isolate the bedrock aquifer from the overburden aquifer. The bedrock cores will be logged by the rig geologist at the completion of each core run. Bedrock cores will be described using standard rock description methods. Where applicable, features such as grain size, color, hardness, sedimentary structures, and degree of cementation will be recorded. Planar features including fractures, joints, bedding planes, and other lithologic contacts will be recorded. Rock Quality Designation (RQD) will be calculated.

Drill cuttings will be containerized and sampled for waste characterization, as described in Section 3.4. Decontamination of sampling equipment and drilling apparatus will be performed as described in Section 3.6.

Drilling fluids will be changed after reaching bedrock, to eliminate the potential for cross contamination of aquifers.

#### **3.3.2.3 Soil Samples Collected From Borings**

Soil samples will be collected from the interval 0 to 1 feet at all boring locations, and all of these samples will be sent for off-site laboratory analyses, as shown in Table 3-1.

At locations where concrete or asphalt cover is present on the ground surface, the 0-1 foot interval will begin at the bottom of this cover material. If asphalt is in contact with the surface soils, the upper four inches of the soil cover will be extruded from the sample to minimize interference of PAH compounds from the asphalt in the soil sample. As a result, the boring log will show the ground surface as the bottom of the asphalt layer, but overlying materials will all be described in detail on the boring log as positive distances above the ground surface. The field geologist/engineer evaluating the split spoon samples will determine the presence and thickness of asphalt in the sample, and proceed with the sample collection accordingly.

Samples collected from below the one-foot interval will be screened with an on-site portable gas chromatograph (Photovac 10S50 or equivalent), calibrated to identify typical chlorinated volatile organic compounds and fuel oil components. Aliquots of all samples will also be screened for target metals by XRF. Aliquots from 20 percent of these samples will be shipped to laboratories for analysis of TCL volatile organic compounds (VOCs), total petroleum hydrocarbons, TCLP metals, total TAL inorganics, butyltin compounds, and TCL semivolatile organic compounds (including BNA extractable compounds, pesticides, and PCB compounds). Samples will be selected for laboratory analysis based on highest concentrations of organics and/or metals detected by the field GC and XRF. A 20 percent sample frequency will allow approximately two samples per borehole to be shipped for laboratory analysis, based on an expected 20 to 30 feet of overburden.

The analytical hierarchy will be based on the type of disposal area, as described in Table 3-2. For suspected chemical disposal areas TCL VOCs, TPH, and TCL SVOCs will be the primary concern. Total TAL inorganics, TCLP metals, and butyltins are the primary concern for areas of sand blast grit disposal.

The sample for each interval will be treated as a separate sample, and placed into a decontaminated stainless steel bowl. Aliquots of the material will first be removed and containerized for VOCs analysis; the remaining material will be homogenized with a decontaminated stainless steel "Scoopula" or similar device. After mixing to homogenize the sample, aliquots will be removed for each analyte described in Table 3-1.

Samples will be designated as the well designation (MW##), and depth intervals will be expressed in feet: Sample DSY-A-MW05-0204 indicates a sample from the boring for MW05, 2 feet to 4 feet below ground surface. Details of sample designations are presented in Section 4.3 of this Work Plan.

#### **3.3.2.4 Groundwater Monitoring Well Installation**

As part of the assessment of the nature and distribution of contaminants in groundwater, a monitoring well installation and sampling program will be conducted. This program includes installing 12 groundwater monitoring wells in borings advanced as described above. The location of each well is presented on Figure 3-2. The purpose of each installation is presented in Table 3-2.

Six wells will be installed in target areas of concern identified in the PA. These areas have been selected based on reports of past activities. Each well will be screened at an elevation selected after review of field GC and XRF screening results. Four other single well installations will be screened to provide groundwater quality samples in secondary target areas of the site.

Two additional wells will be installed on NETC property in locations hydraulically upgradient of the shipyard to establish background groundwater quality conditions in the overburden aquifer. Field GC and XRF screening results of soil samples collected during advancement of borings will determine the location of the well screens. One existing well, located upgradient of the building 234 area will be evaluated and sampled as a part of this task.

Both types of screening results will be weighted equally in selection of vertical placement of well screens. However, the approach of only one well per location, which is to be used for this study, may result in the need for some choices to be made at some locations as to whether to target the VOC contamination or the metals contamination. In areas of sandblast grit disposal, metals will be the primary concern; in chemical discharge areas, the VOCs will be the primary concern. If both intervals can be spanned with a ten-foot screen, the well will be installed to capture both sets of contaminants. Types of disposal areas are identified in Table 3-2.

Well screens and sandpacks used for overburden well installations will be sized in accordance with the geologic formation at each boring location. Well screens with slot sizes of 0.010 (0.25 mm) and 0.020 (0.5mm) will be available at the site. Filter pack sizes of 20-40 (0.85 mm - 0.425 mm) and 10-20 (2.0mm - 0.85 mm) sieve size sand will be available for installation with each respective screen aperture.

Screen aperture size and filter pack will be selected based on a visual inspection of the split barrel soil samples collected from the screened interval. The field geologist/engineer will classify the soil sample, and visually estimate the quantity of the coarse sand fraction present in the interval to be screened. If coarse sand (defined in ASTM D 2487-92 as ranging in size from 2 mm to 4.75 mm diameter) represents a minimum of 70% by weight of the mass, a 0.020 slot screen and 10-20 sieve size filter

pack will be installed. If coarse sand represents less than 70% of the screened interval, a 0.010 slot screen and 20-40 sieve size filter pack will be installed.

However, if the screen interval is highly stratified, containing lenses of silty soils, a 0.010 slot screen and 20-40 sieve size filter pack will be installed to minimize siltation of the well.

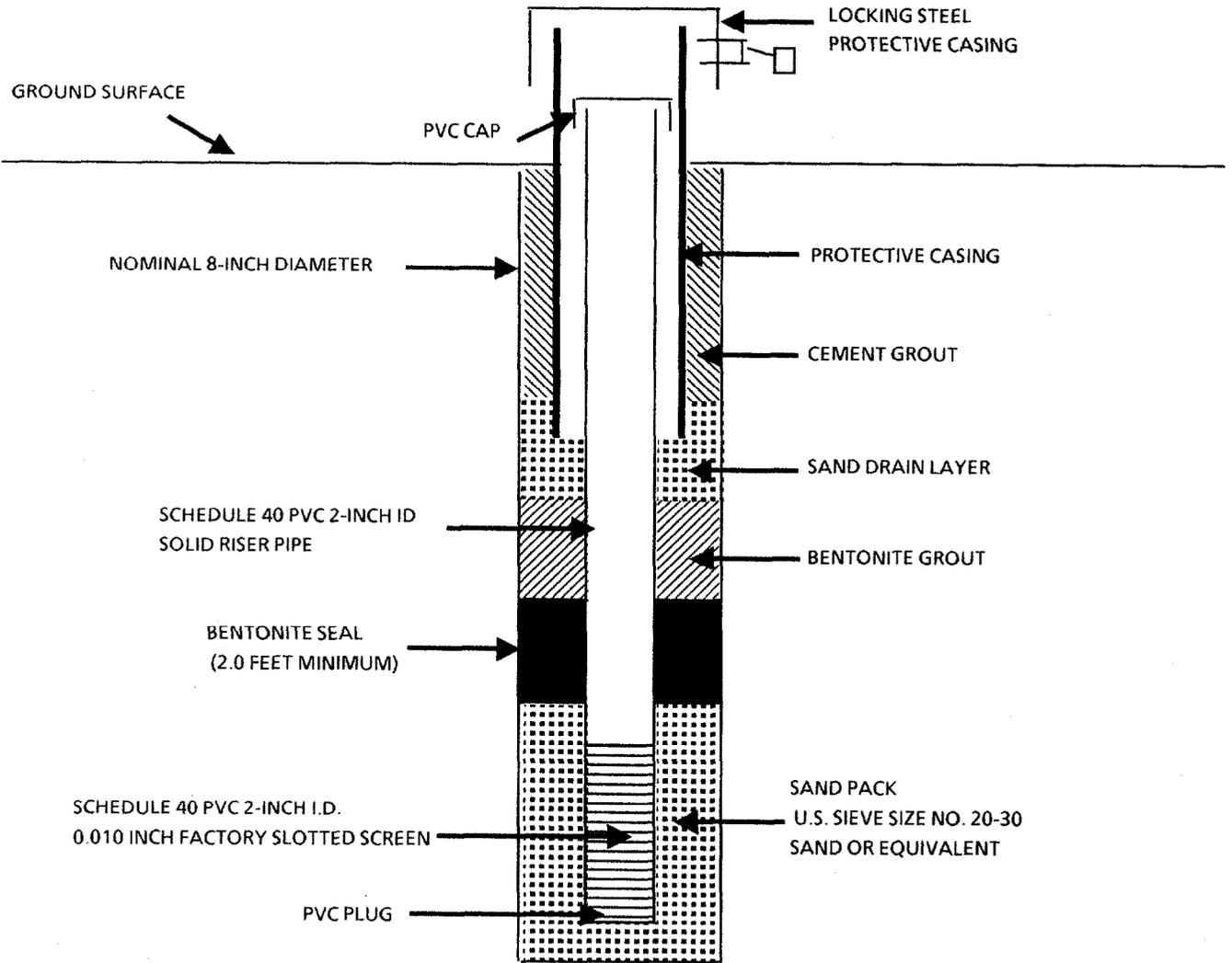
The well screens will be installed in the saturated zones, if possible, across the interval that shows the highest level of contamination. However, if conditions warrant it (i.e., if contaminants detected by screening indicate the presence of a light non-aqueous phase liquid [LNAPL]), screens may be placed across the water table to sample the LNAPL. Such changes to the work plan will be documented to the regulatory parties in Requests for Field Modifications as described in Section 1.5 of this work plan. Figures 3-4 and 3-5 present well construction details.

Overburden aquifer wells will be installed according to the following protocol: clean silica sand of uniform grain size will be carefully placed in the annular space between the well screen and casing, to a minimum of 1 foot above the top of the screen. A bentonite pellet seal with a minimum thickness of 2 feet will then be installed immediately above the silica sand backfill. The remainder of the borehole will be backfilled with a bentonite grout to a depth of 4 feet below ground surface. A one-foot thick layer of clean silica sand (such as that used for the sand pack) will be added to serve as a drainage layer beneath the protective casing. This minimizes the possibility of water collecting in the annular space between the casing and the riser. During the winter weather, water collecting in this annular space can freeze, resulting in binding the protective casing to the riser. Subsequent frost heaving of the installation can damage the well that has frozen to the casing. The hole will be finished with a cement grout seal and a protective steel casing or flush-mounted roadway box, where appropriate.

The bedrock core holes will be backfilled with bentonite and sand to the depth of the well screen, if one is to be installed. The screen will be set and held in place with stainless steel centralizers and the annular space will be backfilled with Ottawa sand. The area around the remaining riser will be backfilled with a bentonite grout. Bedrock core holes that will not contain a well screen will be abandoned by backfill with bentonite and sand.

During the well installation process, the depths of all backfill materials will be continually monitored with a weighted tape. Wells will be completed at the ground surface using flush-mounted road boxes or protective guard pipes. Wells located within paved areas will be finished with concrete grout to match the existing grade of the surrounding paved surfaces.

# OVERBURDEN WELL



(Not to Scale)

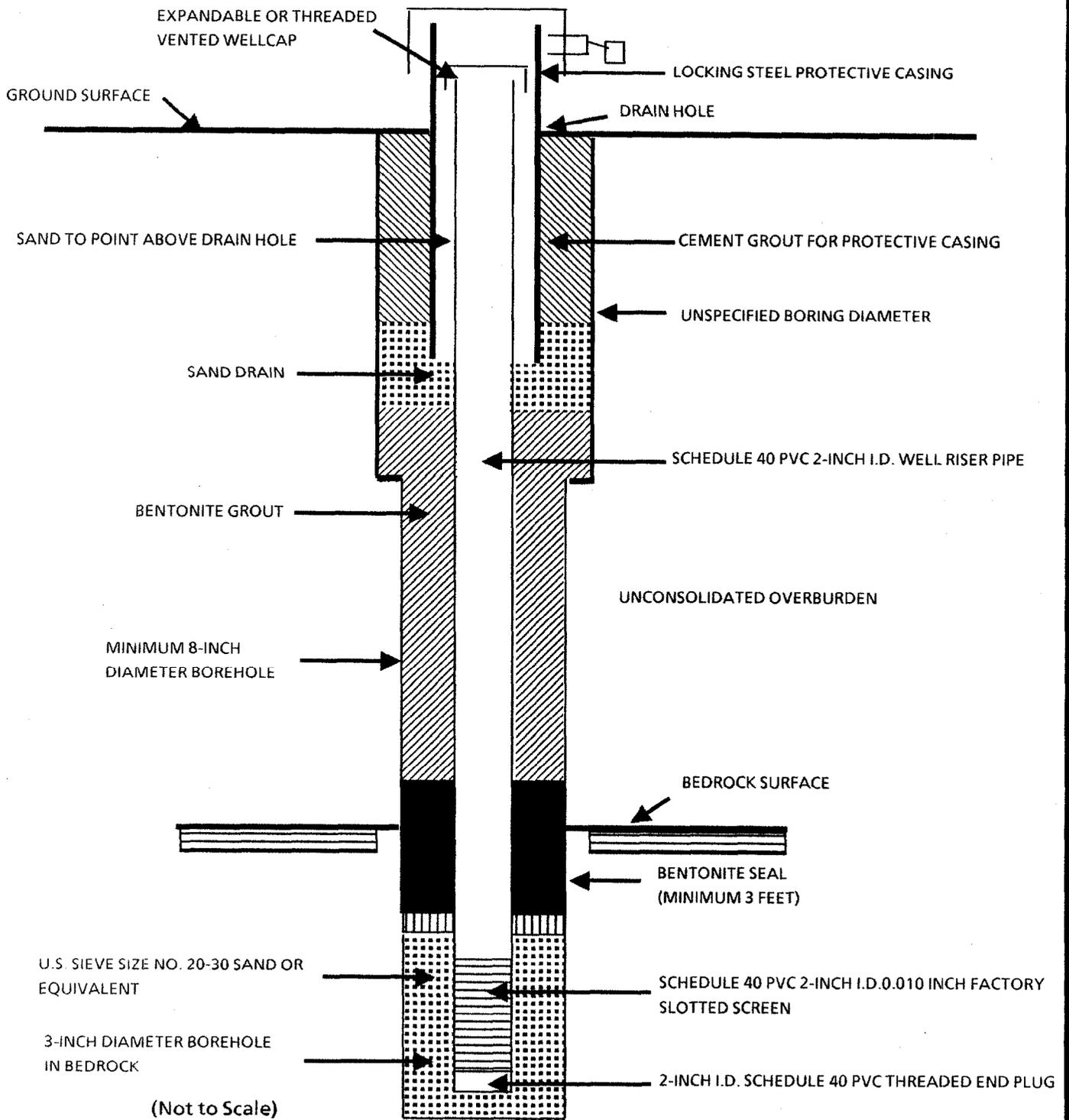
**OVERBURDEN WELL CONSTRUCTION DETAILS  
FORMER DERECKTOR SHIPYARD  
NAVAL EDUCATION AND TRAINING CENTER  
NEWPORT, RHODE ISLAND**



**Brown & Root Environmental**

**FIGURE 3-4**

# BEDROCK WELL



**BEDROCK WELL CONSTRUCTION DETAILS  
FORMER DEREKTOR SHIPYARD  
NAVAL EDUCATION TRAINING CENTER  
NEWPORT, RHODE ISLAND**



**Brown & Root Environmental**

**FIGURE 3-5**

Bentonite grout will be allowed to set for a minimum of one day prior to developing the well. Development will be conducted by bailing, or pumping and surging, to remove residual drill cuttings and fines from around the well screens.

The horizontal and vertical locations of the wells will be surveyed following the completion of well construction. A notch will be cut into the tops of the PVC well riser that will be used as a permanent reference point. The survey operations are described in detail in Section 3.5 of this Work Plan. Well purge water will be containerized in accordance with Section 3.4 of this Work Plan.

#### **3.3.2.5 Well Development**

Wells will be developed by bailing and/or surging and pumping, as determined by the field geologist. Fine-grained material around the well screen will be drawn into the well and removed by agitating the well water with a surge block and simultaneously pumping water from the well at a low discharge rate. A pump outfitted with ASTM drinking water grade polyethylene tubing will be used for removing the water from the well. To prevent cross contamination between the wells, the surge block will be decontaminated between use in each well. The surge block will be decontaminated with non-phosphate detergent and tap water, rinsed with tap water, rinsed with methanol, air dried, and rinsed with deionized water. The polyethylene tubing will also be replaced between each well. The dedicated new tubing will be rinsed with deionized water prior to its use. Water produced during well development will be containerized in 55-gallon drums (DOT Specification 17E), as described in Section 3.4 of this Work Plan.

Based on field conditions, should the use of the surge block and pumping technique be deemed inappropriate by the B&R Environmental field team, an alternative method will be used to develop the well. A suitable pumping device, e.g., submersible pump, Waterra™ pump, will instead be placed in the well and used for its development.

The volume of ground water extracted from each monitoring well during development will be monitored and water quality parameters will be determined every 15 minutes: pH, temperature, salinity, specific conductance, and turbidity. Development will continue until pH, temperature, and specific conductance have all stabilized and turbidity is equal to or less than 10 nephelometric turbidity units (NTUs). The well will be stable when consecutive readings differ less than 10 percent. If the NTU criteria is not achievable, the parties will determine if a turbidity standard of plus or minus 10 percent of successive well volumes is appropriate on a case-by-case basis.

If a well is not completely developed after 4 hours, the field geologist will notify the B&R Environmental PM for authorization to continue or to stop development.

#### **3.3.2.6 Groundwater Elevation Survey**

TRC conducted a tidal study as part of the Environmental Assessment Report for Building 42 in the central shipyard area in December 1994. The TRC report does not cover a large portion of the site, so a similar tidal study will be conducted on the 10 wells installed on site, as stated in this Work Plan.

Groundwater levels in all wells will be measured to a reference point, consisting of a notch cut at the top of the PVC well riser. Continuous recording pressure transducers will be installed in the 10 wells, and water levels will be recorded over a 24-hour period. Based on the results of the tidal study, the lag time between high and low tides and changes in groundwater heads in each well will be determined. Salinity will be determined at the corrected groundwater high and low periods.

#### **3.3.2.7 Hydraulic Conductivity Testing**

In-situ hydraulic conductivity testing will be conducted by performing variable-head slug tests in the ten on-site monitoring wells. The tests will be conducted in the overburden and bedrock aquifers and will be spatially distributed throughout the site. The information will be used to characterize the aquifer system and evaluate contaminant transport mechanisms. Testing will be conducted only after groundwater sampling and water level measurements have been collected.

Water levels will initially be determined manually. Falling and rising head tests will be conducted in wells with screens that are totally saturated. Rising head tests will be conducted in partially saturated well screens, if necessary. No falling head test will be conducted in partially saturated well screens. During the tests, water levels will be obtained using pressure transducers set for continuous readings and recording.

#### **3.3.2.8 Groundwater Sample Collection**

One round of groundwater sampling and analysis will be conducted. Due to concern noted by TRC regarding turbidity of groundwater samples collected during their 1994 study at Building 42, a low flow sample collection operation will be used for this task.

Samples will be collected from each of the newly installed monitoring wells and will include applicable field QA/QC samples (blanks and duplicates). One sample will be collected from one of the existing

wells (MW101 - MW103) west of the steam plant (Building 7). One of these wells will be selected after an inspection to determine condition and responsiveness. A summary of wells available for sampling in this area is presented in the Draft UST Remedial Investigation Report, Building 7 and Structure 84 (B&R Environmental, 2/96).

Groundwater samples will be analyzed for TCL volatile organic compounds, total TAL inorganics, butyltin compounds, and TCL semivolatile organic compounds (including BNA extractable compounds, pesticides, and PCB compounds). Table 3-1 presents a summary of field samples to be collected. Section 4.0 of this Work Plan describes analytical methodologies and QC requirements.

Work elements for this task include:

- Noting, measuring, and if possible, sampling of non-aqueous phase liquids (both LNAPL and DNAPL)
- Measuring water levels in wells prior to purging
- Purging wells using low-flow methodology
- Measuring pH, temperature, specific conductance, dissolved oxygen, salinity and turbidity periodically during the extraction of water from the well
- Collecting samples using low-flow methodology
- Documenting, packing, and shipping samples for analysis

#### Procedure

For each well to be sampled, the low flow sample collection procedures to be followed are summarized below. The U.S. EPA Region I SOP for low flow sample collection (SOP GW-001, 8/3/95) is presented in Appendix B4. This SOP is to be adhered to strictly during the collection of groundwater samples. RIDEM has provided a recommended approach for lowflow sample collection which differs slightly with the approach described in this work plan, and is also presented in Appendix B4. If the EPA method is unsuccessful in collection of a sample, the RIDEM method will be used. If the RIDEM method also proves unsuccessful, standard bailing techniques will be used.

1. The presence of floating product in the wells will be determined with the use of an ORS interface probe (or equivalent). The presence of product will be noted, and if appropriate, the thickness measured. The depth to water in the well will be measured and recorded to the nearest 0.01 feet.

2. The required length of tubing will be calculated and measured for attachment to either the submersible or the peristaltic pump, such that the intake (submersible pump, or tubing intake if peristaltic used) is placed at the midpoint of the saturated screened interval. Note that the tubing will be measured to allow a minimum distance between the well head and the discharge point (field testing equipment), to minimize temperature changes in the groundwater discharged from the well. Teflon or teflon-lined tubing will be used and disposed of after sampling is complete.
3. The pump and/or tubing will be slowly and smoothly lowered to the required depth to minimize the amount of mixing in the well. The pump cable and/or discharge tubing will be secured to the well casing (or PVC stick-up) to minimize movement.
4. The field testing equipment (and peristaltic pump head, if used) will be assembled, and placed as close as possible to the well head/discharge tubing. For the peristaltic pump, the discharge tubing will be connected to the pump head with a minimum length of pharmaceutical grade silicone tubing.
5. The pump will be connected to the power supply (generator or other power source) and the power supply turned on (without starting the pump).
6. The depth to water with the pump and/or tubing in the well will be re-measured and compared with the initial reading; if the readings vary by more than 0.05 feet, field personnel will wait for five minutes, remeasure the water, and begin pumping.
7. The pump will be started at the lowest flow setting. The pump start time will be recorded and the flow rate will be measured and recorded using a graduated measuring device and stopwatch. (Note that during the initial period of pumping, an estimated initial 5 to 10 minutes, the depth to water in the well should be measured frequently (at an estimated frequency of approximately once per minute), to enable timely pump flow adjustments to attempt to minimize significant drawdown in the well).
8. The initial groundwater sample discharged from the tubing will be collected, and the time and field parameters (pH, temperature, conductivity, turbidity, salinity, and dissolved oxygen) will be measured and recorded.
9. These field parameters (pH, temperature, conductivity, turbidity, salinity, and dissolved oxygen) and the depth to water in the well (using the M-scope or ORS probe) will be

measured at three to five-minute intervals (initially the water level will be measured more frequently, as discussed in step 7 above). The data and the associated time will be recorded on the low-flow sampling data sheet. Attempts will be made to maintain the drawdown in the well during pumping to 0.3 feet or less, by adjusting the pump flow rate. Drawdown for each well will vary depending on the recharge capacity of the well.

10. Following the stabilization of measured field parameters, groundwater samples will be collected. "Stabilization" of readings will be readings within plus or minus ten percent for three consecutive three to five-minute readings. Turbidity values are expected to be 10 NTUs or less at stabilization, however, the location of the well with respect to the contaminant source may result in turbidity readings that are "naturally" above 10 NTUs.

Following purging procedures, samples will be collected directly through the tubing into appropriate sample bottles. Samples will be preserved according to requirements described in Section 4.0. All non-disposable sampling equipment will be decontaminated prior to each use, as described in Section 3.6. All pertinent sampling data will be recorded on appropriate sample log sheets and in the site logbook.

If difficulties arise during the low flow sample collection procedures (i.e., minimum drawdown is not obtainable, or water chemistry readings do not show a stabilization pattern), affected wells will be sampled using standard bailing techniques. This change will constitute a request for field modification as described in Section 1.5 of this work plan.

Purge water from the wells will be containerized for waste characterization, as described in Section 3.4 of this Work Plan.

### **3.3.3 Tasks 5 and 6: Underground Drainage Systems Sampling**

During the investigation of drainage systems, described in Section 3.2.3, underground discharge areas may be identified. Catch basins and sumps with unconsolidated bottoms will be sampled under Task 5. Expected floor drain discharge areas will be sampled under Task 6.

This sampling effort will be performed by B&R Environmental personnel and subcontracted drilling personnel. Sampling procedures that will be used in each area are described in the following paragraphs.

### **3.3.3.1 Task 5: Catch Basin and Sump Sampling**

Catch basins, sumps, and pits with unconsolidated bottom materials that were identified as a part of Task 1 will be sampled as a part of this task.

Three samples will be collected from the bottom of each sump using a hand auger. Samples will be collected from 0.5 foot intervals to a maximum depth of 1.5 feet below the surface of the bottom materials. These areas will not be entered by sampling personnel. Extensions of the sampling tools will be used so that the samplers can operate from the ground surface. If necessary, platforms can be placed across the pits through which the samplers can operate.

All samples will be shipped to laboratories for analysis of VOCs, total petroleum hydrocarbons, TCLP metals, total TAL inorganics, butyltin compounds, and semivolatile organic compounds (including BNA extractable compounds, pesticides, and PCB compounds).

Decontaminated hand augers will be turned into the subsurface materials at 0.5 foot intervals. Each interval will be treated as a separate sample, and placed into a decontaminated stainless steel bowl. An aliquot of the material will first be removed and containerized for VOCs analysis; the remaining material will be homogenized with a decontaminated stainless steel "Scoopula" or similar device. After mixing to homogenize the sample, aliquots will be removed for each analyte described in Table 3-1.

Sample locations will be designated as Catch Basin (CB)#. Samples will be labeled as surface soils (S) and depth intervals will be expressed in tenths of feet: Sample DSY-S-CB2-SS-1015 indicates a surface soil sample from Catch basin No. 2, 1.0 feet to 1.5 feet below ground surface. Details of sample designations are presented in Section 4.3 of this Work Plan.

Because the borings are shallow, they will not be backfilled after sample collection, except that excess sample material will be replaced in the borehole within the catch basin, sump, or pit. Sampling equipment and drilling apparatus decontamination will be performed, as described in Section 3.6.

### **3.3.3.2 Task 6: Floor Drain Discharge Area Sampling**

Floor drains that were found to "dead end" into the ground and not connect to a storm drain or sewer line will be considered to be a potential contaminant source. The soils around the expected discharge area will be sampled as a part of this task.

Continuous samples will be collected from borings advanced in these areas at 2-foot intervals to a total depth of 6 feet below the expected point of discharge. A minimum of three such borings will be advanced at each expected discharge point to allow for error in locating the discharge point. These samples will be collected by a drilling rig using the drilling and sampling methods described in Section 3.3.2.2 of this Work Plan.

Samples will be screened with an on-site portable gas chromatograph (Photovac 10S50 or equivalent) calibrated to identify typical chlorinated organic compounds and fuel oil components. Aliquots of all samples will also be screened for target metals by XRF. Twenty percent of these samples will be shipped to laboratories for analysis of TCL VOCs, total petroleum hydrocarbons, TCLP metals, total TAL inorganics, butyltin compounds, and TCL semivolatile organic compounds (including BNA extractable compounds, pesticides, and PCB compounds). Samples will be selected for laboratory analysis, as described in Section 4.5 of this Work Plan.

The analytical hierarchy will depend on the type of disposal area, as described in Table 3-2. For chemical disposal areas, TCL VOCs, TPH and TCL SVOCs will be the primary concern. Total TAL inorganics, TCLP metals, and butyltins are the primary concern for areas of sand blast grit disposal.

Sampling tubes will be driven into the ground at 2-foot intervals. Aliquots of the material will first be removed and containerized for VOCs analysis; the remaining material will be homogenized with a decontaminated stainless steel "Scoopula" or similar device. After mixing to homogenize the sample, aliquots will be removed for each analyte described in Table 3-1.

Sample locations will be designated as Shallow Borings (SB)#, and depth intervals will be expressed in feet: Sample DSY-SB-23-0204 indicates a sample from Shallow Boring No. 23, 2 to 4 feet below ground surface. Details in sample designations are presented in Section 4.3 of this Work Plan.

Borings will be backfilled with bentonite and sand mix, as described in Section 3.3.2.2 of this Work Plan.

Shallow boring locations will be surveyed, as described in Section 3.5 of this Work Plan. Drill cuttings and excess sample material will be handled as described in Section 3.4. Decontamination of sampling equipment and drilling apparatus will be performed, as described in Section 3.6.

### **3.4 INVESTIGATION-DERIVED WASTE (IDW)**

Waste materials that will be generated during the field investigation may include drill cuttings and fluids, well purge and development water, decontamination fluids, wash water from steam cleaning and cleaning of pits and sumps, disposable sampling equipment, and used personal protective equipment (PPE).

B&R Environmental will be responsible for removing and disposing of all investigative waste materials (well purge water, soil cuttings, and PPE) following completion of the field investigation program. This waste disposal program will be conducted following each element of work described in the previous sections. In this manner, large quantities of wastes will not be stockpiled for disposal at the end of the investigation program.

Fluid wastes generated from cleaning tasks will be disposed of by the subcontractor performing the work. This material will include steam cleaning residue and sludge, and sediment from catch basins, sumps, pits, and floor drains.

Containers of IDW will be labeled as to their point of origin, and date collected. Samples of these materials will be labeled with the information on the containers. Containers of IDW that are found to be hazardous will be characterized and disposed of within 90 days.

#### **3.4.1 Solid Wastes**

Personal protective equipment (gloves, tyvek, and disposable boots) will be decontaminated, double bagged, and disposed of in an on-site industrial dumpster.

#### **3.4.2 Soil Wastes**

Excess drill cuttings, discarded sample material, and other soil wastes will be containerized. Soils from different target areas will not be mixed.

The screening results from sample collection will be used as the first step of segregating the wastes into groups, based on the level of contamination present.

Laboratory analysis of samples collected during the investigation program will be used to further characterize the materials, as required by state and federal disposal requirements. Additional samples for other parameters will also be required. Typical disposal parameters are listed below.

- TCLP Metals
- Volatile Organic Compounds
- PCB Pesticide Compounds
- Flash Point, Reactivity, Corrosivity
- Free Liquid

Analysis of representative samples of waste materials for disposal parameters will be the responsibility of an outside disposal subcontractor. All soil wastes will be shipped off site by this same subcontractor.

#### **3.4.3 Sandblast Material**

Sandblast material that is brought to the surface during drilling and sampling will, to the extent possible, be segregated from other soil wastes. This material will be containerized and stored for future disposal or treatment with the bulk of the fill/sandblast material.

Containers filled with sandblast material will be allowed to remain on site, until a remedial alternative for this material has been determined to be necessary. Containers will be staged on pallets and securely covered to protect labeling information.

Excavated sandblast material from test pit activities, described in Section 3.3.1 of this Work Plan, will be returned to the excavated pits. This approach will prevent mixing clean fill into sandblast material, and all sandblast material can be removed under a planned remedial action.

#### **3.4.4 Aqueous Wastes**

Decontamination fluids, well purge and development water, and drilling fluids will be initially contained in 55-gallon drums. This material will be combined at the conclusion of the project and shipped off site for disposal in accordance with RIDEM, USEPA, and DOT Regulations.

### **3.5 TASK 7: SURVEY**

Following the investigative work, a survey will be performed to identify horizontal locations of sample points, and other significant features identified during the investigation. Surveys will be performed by a subcontractor supervised by B&R Environmental working under B&R Environmental's Health and Safety Plan.

The base map presented in this Work Plan will be used; however, locations of existing buildings, and study area boundaries will be confirmed by survey.

The survey will be conducted to establish relative locations of sample points. Survey control will be maintained by tying into either the State of Rhode Island or USGS grid systems. Horizontal and vertical measurements will be made relative to existing wells or on-site control points.

All surveyed features will be horizontally located to within  $\pm 0.1$  foot. Tops of PVC well risers will be located to plus or minus 0.01 foot vertically.

It is expected that the following tasks will provide points that will require surveys. These tasks and the features that will be surveyed are described below:

- Task 1: Expected discharge points from pits and trenches, original Building 234
- Task 2: Expected discharge points from underground drainage systems, including catch basins, and underground discharge areas
- Task 3: Test pit locations
- Task 4: Boring locations and monitoring well elevations
- Tasks 5 & 6: Other sample locations

In addition, any sample collection points that are established during the investigation will be surveyed.

Surveyed points will be mapped with Autocad V12.0 or a compatible system. The survey subcontractor will provide hard-copy prints and disk versions of the survey information for each survey operation. Survey points for each task will be set on different "layers" of the Autocad data such that printouts of sample collection points can be made specific to each task or any group of tasks.

### **3.6 DECONTAMINATION PROCEDURES**

Decontamination procedures are summarized below:

#### Monitoring Equipment

All monitoring equipment will, to the extent possible, be wrapped and sealed in plastic with only the controls, readouts, and intake and exhaust ports open to the atmosphere. If monitoring equipment decontamination is required the following procedure will be utilized:

- remove gross contamination with potable water
- scrub with potable water/liquinox
- rinse lightly with potable water
- remove plastic covering
- wipe dry immediately with disposable towels

#### Drilling, Excavation, and Other Heavy Equipment

Drill rigs and excavation equipment will be decontaminated by steam cleaning following their arrival on site and prior to beginning work at each location.

Drilling casing, rods, and augers, as well as the affected portions of the drilling rigs, will be decontaminated before beginning each borehole. Excavation equipment used for test pit investigations will be decontaminated before operating at each location. Excavation equipment used to clean catch basins will be decontaminated between each location.

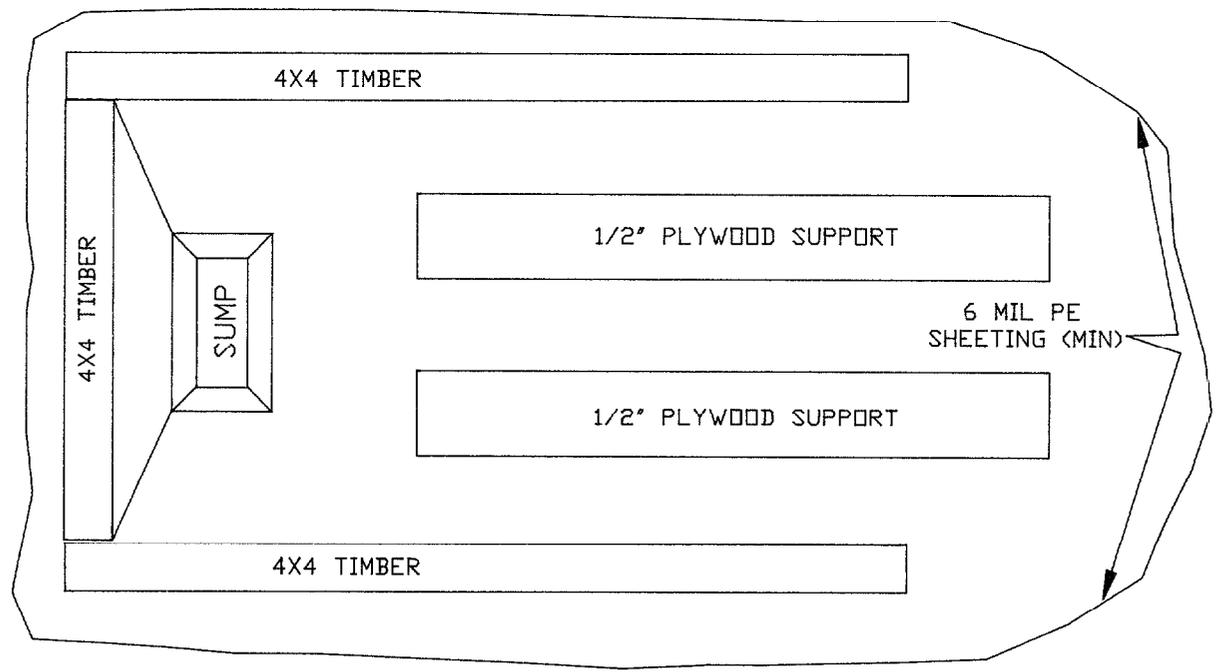
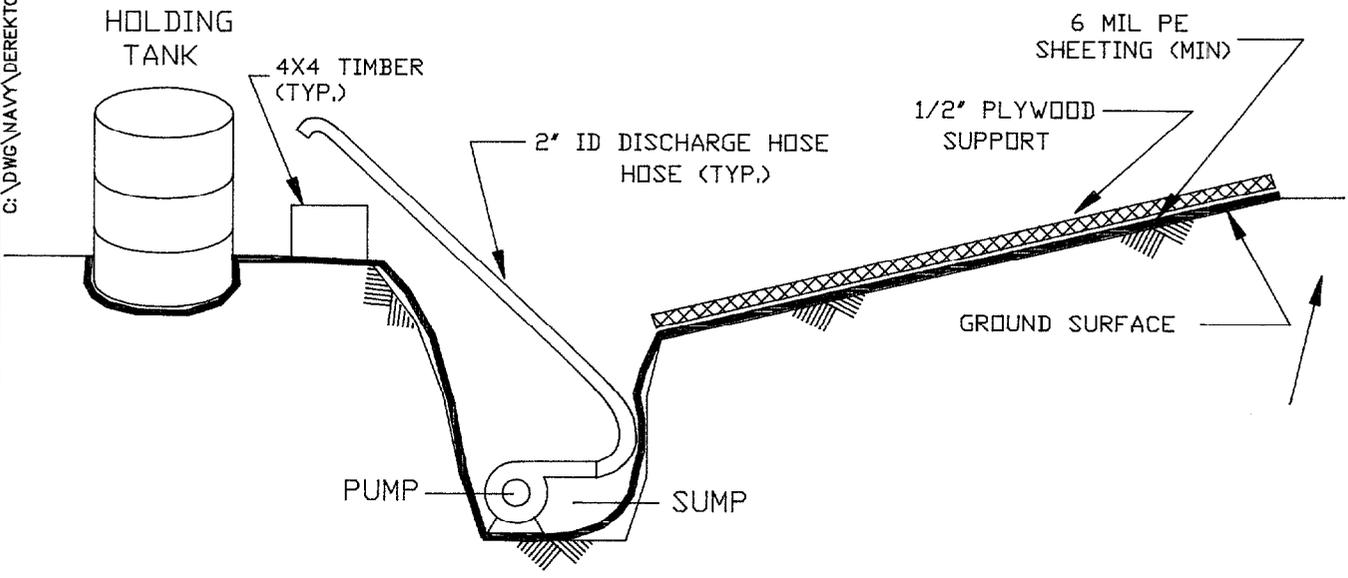
Heavy equipment decontamination will be performed at a temporary, centrally located decontamination pad constructed specifically for this purpose. Figure 3-6 presents a description of a typical temporary decontamination pad. The decontamination pad will be large enough to capture all wash water and channel it into a sump. The fluids in the sump will be containerized after each use.

#### Sampling Equipment

All non-disposable sampling equipment that comes in contact with the sample medium will be decontaminated to prevent cross contamination between sampling points. This includes equipment such as soil sampling spatulas, split spoons, and hand auger buckets, etc. The following decontamination sequence will be employed:

- remove gross contamination by scrubbing with potable water
- scrub with potable water/liquinox
- rinse with potable water
- rinse with 10 percent nitric acid
- rinse with methanol
- rinse with deionized water
- air dry on steel screens
- wrap with aluminum foil, dull side toward equipment.

C:\DWG\NAVY\DEREKTOR\DEC\_PAD.DWG



NOTE:  
 1. PLAN NOT TO BE USED FOR DESIGN.

<b>DETAIL OF TEMPORARY DECONTAMINATION PAD</b>		<b>FIGURE 3-6</b>	
<b>FORMER DEREKTOR SHIPYARD</b>		 <b>Brown &amp; Root Environmental</b> A Division of Halliburton NUS Corporation	
<b>NETC - NEWPORT, RI</b>			
DRAWN BY: R.G. DEWSNAP	REV.: 0	55 Jonspln Road Wilmington, MA 01887 (508)658-7899	
CHECKED BY: S. PARKER	DATE: 29 MAR 96		
SCALE: NONE	CONTRACT NO.: N62472-90-D-1298		

## Submersible Pump

The following decontamination sequence will be employed for submersible pumps (the electrical wires must be rinsed with the decontaminating solutions as well):

- upon removal of the pump from the well following sample collection, the pump will be submersed in a bucket containing a potable water and the exterior surface scrubbed. At least 1 to 2 gallons of water will be pumped through (start pump at a low flow rate, as in sampling, and increase to a high speed).
- Submerge pump in a bucket containing a potable water and detergent (Alconox or Liquinox) solution. At least 1 to 2 gallons of detergent will be pumped through (start pump at a low flow rate, as in sampling, and increase to a high speed).
- Remove the pump and rinse or spray with potable water to minimize transfer of soap to the rinse bucket.
- Submerge the pump in a bucket of a potable water rinse and pump least 1 to 2 gallons through (start pump at a low flow rate, as in sampling, and increase to a high speed).
- Submerge the pump in a bucket of a deionized/distilled water rinse and pump least 1 to 2 gallons through (start pump at a low flow rate, as in sampling, and increase to a high speed).
- Submerge the pump in a bucket of 10 percent nitric acid rinse and pump least 1 to 2 gallons through.
- Submerge the pump in a bucket of a deionized/distilled water rinse and pump least 1 to 2 gallons through (start pump at a low flow rate, as in sampling, and increase to a high speed).
- Submerge the pump in a bucket of isopropyl alcohol rinse and pump least 1 to 2 gallons through.
- Submerge the pump in a bucket of a deionized/distilled water rinse and pump least 1 to 2 gallons through (start pump at a low flow rate, as in sampling, and increase to a high speed).

- Air dry and wrap the pump in aluminum foil (dull side towards pump)

### **3.7 TASK 8: EVALUATION OF CULTURAL AND ECOLOGICAL SETTINGS**

One of the goals of the SASE is to provide a preliminary determination of the presence of risk to area receptors from the contaminants on site. As a part of that preliminary determination, the receptors must be identified.

The surrounding area was evaluated briefly as a part of the Preliminary Assessment. This evaluation will be expanded with an evaluation of the cultural setting and an evaluation of the terrestrial ecological setting.

#### **3.7.1 Cultural Setting**

The cultural setting of the site will be evaluated to determine the presence of contamination of environmental media with regard to the potential exposure of human receptors. Receptors may include persons living, working, or recreating within a one-half mile radius of the study area. The demographics of this area will be evaluated.

This evaluation will be based on the information presented in the Preliminary Assessment report for the site, and expanded to describe distances between the site and nearby water supply wells, residential housing (Navy and civilian), commercial and industrial facilities, and recreational facilities.

#### **3.7.2 Off-Shore Ecological Setting**

The ecology of the marine environment adjacent to the site is currently under evaluation as a part of the Off-Shore Ecological Risk Assessment for Derecktor Shipyard, and a draft report is expected in June 1996.

#### **3.7.3 On-Shore Ecological Setting**

An on-shore ecological screening characterization of the site will be performed, in part, through the performance of a site walkover by a qualified ecologist. This walkover will involve the following evaluations:

- identify the types and spatial extent of habitats that are present on and around the site;

- identify the species and biological communities on and adjacent to the site that may use these habitats and that may be potential receptors with regard to contaminants present in soils, sediments, and surface waters at the site;
- determine the presence of contamination of environmental media with regard to potential exposure of receptor species;
- identify on-site and adjacent wetlands, if appropriate, and their approximate boundaries; provide sketch maps of the wetland boundaries relative to the site;
- if feasible, determine the habitat(s) present at the site prior to shipyard operations (1979).

#### **3.7.3.1 Characterization of Habitats**

The objective of the habitat characterization is to identify the nature and composition of non-marine animal and plant communities in the vicinity of the site to provide a basis for identifying potential receptors. The marine ecosystems near the site will be characterized in a separate study.

To characterize the habitats at and in the vicinity of the site, biologists will provide: descriptions of the nature and composition of plant and animal communities at the site and the immediate vicinity of the site; descriptions emphasizing wildlife species, their habitat, and key food habits; a description of significant habitat; and, if applicable, information on federal-or state-threatened or endangered species.

These tasks will be accomplished by conducting a literature search, a review of threatened and endangered species, and a field assessment (a qualitative survey of the flora and fauna).

#### **3.7.3.2 Literature Review**

The purpose of the literature review is to provide background information on the habitats and species of plants and animals expected to occur on the site and in proximate areas; and the use of the general area by migrating or overwintering species. The review will include the RIDEM, US Fish and Wildlife Service (USFWS), and B&R Environmental data sources.

### **3.7.2.3 Review of Threatened And Endangered Species**

RIDEM and USFWS, Office of Endangered Species, lists will be reviewed by B&R Environmental to identify endangered, protected or threatened species that may inhabit or use the Newport area and the environments associated with the site. This information will be checked with RIDEM and the USFWS and maps will be provided at appropriate scales to show important habitat or nesting sites for these species. If appropriate, these maps will be presented at the same scale and on the same base map as the wetland delineations. The determination of potential effects on any endangered or threatened species identified as being present in the site area will receive special consideration.

### **3.7.3.4 Field Assessments**

The purpose of this task is to provide qualitative field verification of the types of habitat and wildlife on and near the site.

The goal of the wildlife assessment is to provide site-specific observations concerning the diversity (type) of species rather than data for assessment of population structure or community analyses. Since the objective is to provide an inventory of terrestrial fauna on site, the survey will be qualitative rather than quantitative. These data will be used to provide an informed site-specific basis for selection of potential ecological components (receptors).

The survey requires a walkover of the site. Positioning will be by "line of site" and will therefore be approximate. A field map will be used to guide the survey and for recording observations. The walkover path will be planned and modified as appropriate in the field. The path will be dictated by the types of environments encountered and their extent, as based upon visual observations. Obvious habitat features that may be of particular value to wildlife will be examined closely. The course of the walkover will be based on such observations as nesting sites, physical signs of wildlife, audible signs of birds, changes in vegetation patterns, obvious changes in hydrologic conditions, changes in slope, and physical accessibility.

During the survey, observations will be made on:

- major flora in habitat areas; and
- bird, amphibian, reptile, and mammal sightings or physical evidence of these, e.g., nesting sites, tracks.

Observations will be recorded in several ways:

- a base map will be used to mark the locations of major habitat types; and
- observations and notes will be recorded by the biologist in a field log book.

Lists of flora and fauna will be produced for inclusion in the report. These lists will be species-specific where possible. The method for species identification, i.e., visual sighting, identification by tracks or other physical evidence, and audible identification, will be included on the fauna list.

### **3.7.3.5 Data Products**

The data products from the habitat survey will include tables and maps that will facilitate a qualitative biological characterization of the site and proximate areas. These will be provided in a report that will include:

- narrative descriptions of the nature and composition of plant and animal communities in the immediate vicinity of the site referencing a combination of maps (for major vegetation and habitat types) and tables (for species composition of the communities) obtained;
- descriptions emphasizing wildlife species observed, and their habitat requirements described in available literature, and key food habits; important features of the biology of these species, such as migrations into and out of the area through pertinent literature sources;
- a description of significant habitat, wetlands, regulated streams, lakes, and other resources in the immediate vicinity of the site. As suggested by US EPA (1989) guidance, habitats that "are unique or unusual or necessary for continued propagation of key species" will be described. The USFWS and RIDEM are primary sources of this information; and
- information on federal- or state-threatened or endangered species.

These data products will be used to develop a conceptual model for the site, as described in Section 5.2 of this Work Plan.

## 4.0 QUALITY ASSURANCE/QUALITY CONTROL

This section provides technical guidelines and procedures for conducting the field work. This document references the B&R Environmental Standard Operating Procedures (SOPs) for specific protocols for procedures discussed in Section 3.0.

Pertinent SOPs are included in this Work Plan as Appendix B. These SOPs include, but are not limited to:

<u>SOP</u>	<u>DESCRIPTION</u>
GH-1.3	Soil and Rock Sampling
GH-1.4	Soil and Rock Drilling
GH-1.5	Borehole and Sample Logging
GH-1.7	Groundwater Monitoring Well Point Installation
GH-1.8	Excavation of Exploratory Test Pits and Trenches
GH-2.5	Water Level Measurement and Mapping
SA-1.1	Groundwater Sample Acquisition
SA-6.1	Sample Identification and Chain of Custody
SA-6.2	Sample Packaging and Shipping
SA-6.3	Site Logbook
SF-1.1	On-Site Water Quality Testing
ME-02	OVA 128 Organic Vapor Analyzer
SOP 9013	Wade et. al. - Quantitative Determination of Butyltins
RIDEM	Required Monitoring Well Construction Standards and Abandonment Procedures
EPA-GW-001	Low Flow Groundwater Sampling

### 4.1 QUALITY ASSURANCE OBJECTIVES

The objectives of the sampling are to provide sufficient data to make a preliminary identification of contaminants present at Derecktor Shipyard. This determination is necessary to support a preliminary and a baseline risk assessment, and to provide preliminary waste characterization data for disposing or treating sandblast fill materials. To accomplish these objectives, two types of samples will be collected:

- Field-screening samples for target VOCs and metals (soils and aqueous IDW)
- Laboratory-analyzed samples for TCL and TAL parameters, as well as total petroleum hydrocarbons (TPH) TCLP metals, and butyltin compounds (soil, sandblast fill, and groundwater)

Achieving these objectives requires that the data collected from the field conform to an appropriate level of quality. The quality of a data set is measured by certain characteristics of the data, namely the precision and accuracy, representativeness, completeness, and comparability (PARCC) parameters. Some of the parameters are expressed quantitatively, while others are expressed qualitatively. The PARCC goals for a particular project are determined by the intended use of the data, usually referred to as Data Quality Objectives (DQOs). DQOs are discussed in Section 4.1.1; the PARCC parameters are discussed in Section 4.1.2.

#### **4.1.1 Data Quality Objectives**

The intended use of the data resulting from a field investigation is a determining factor in defining the Data Quality Objective (DQO) for that data. As described by the Naval Energy and Environmental Support Activity (NEESA), in the guidance document entitled "Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program" (NEESA, June 1988), the Navy has adopted three analytical quality levels (C, D, and E) corresponding to EPA quality levels III, IV, and V, respectively, as described in the EPA document "Data Quality Objectives for Remedial Response Activities Development Process" (EPA/540/G-87/003, March 1987). The analytical data reports to be generated for those samples that undergo laboratory analysis will conform with NEESA data quality Level D requirements.

Two types of data will be generated as part of this study. Field screening data will be generated that will be consistent with EPA DQO level II. Laboratory analytical data will be prepared that will be consistent with EPA DQO level IV. The intended use of the analytical data is twofold: the screening data shall be used to target samples for laboratory analyses, and identify "hot spots" in the soils. Laboratory data will be used for preliminary indications of the nature and extent of contamination at the site.

#### **4.1.2 PARCC Parameters**

The precision and accuracy, representativeness, completeness, and comparability (PARCC) goals for the work covered by this quality assurance plan are discussed in the following sections.

#### **4.1.2.1 Precision and Accuracy**

Field and laboratory precision and accuracy performance can affect the attainment of project objectives, particularly when compliance with established criteria is based on laboratory analysis of environmental samples.

Analytical precision and accuracy will be evaluated upon receipt of the analytical (field screened and laboratory) data. Analytical precision will be measured as the relative percent difference from duplicate measurements and relative standard deviation from three or more replicates. Analytical accuracy measures the bias as the percent recovery from matrix spike and matrix spike duplicate samples. The samples will be analyzed using NEESA-approved laboratories and will be evaluated using NEESA guidelines.

Field sampling precision and accuracy are not easily measured. Field contamination, sample preservation, and sample handling will affect precision and accuracy. By following the appropriate B&R Environmental Standard Operating Procedures, precision and accuracy errors associated with field activities can be minimized. Field duplicates and blanks (field, trip, and rinsate) will be used to estimate field sampling precision and accuracy for soil samples submitted for laboratory analysis.

Field duplicate and field quality control blank analyses results will be used to review the laboratory-analyzed results and determine the useability of the data with respect to its intended use. In general, results that are rejected by the data review process will be disqualified from application to the intended use. Qualified data will be used to the greatest extent practicable.

#### **4.1.2.2 Representativeness**

Representativeness describes the degree to which analytical data accurately and precisely define the population being measured. Several elements of the sampling and sample handling process must be controlled to maximize the representativeness of the analytical data (appropriate number of samples collected, physical state of the samples, site-specific factors, sampling equipment, containers, sample preservation and storage, holding times, sample identity and chain of custody will be defined to ensure that the samples analyzed represent the population being measured). The sampling program is designed to provide analytical data that is representative of the existing contaminant levels.

On-site screening (GC and XRF) will be used to locate presence of VOCs and metals in soil, and relative amounts between one location or another. Screening analysis is described in Section 4.5.2. Screening

analysis will be used to evaluate the presence of these contaminants in soils during soil sample collection and test pit activities.

The sample collection for field screening and laboratory analysis will be the same. Every effort will be made to collect soil samples that represent the soil under investigation. The samples will be collected in VOC vials, maintained at 4 degrees C, and analyzed within the allowed holding time to insure representativeness.

The type and concentration of the contaminants in the samples screened on site depends on the type of contaminants present in the soil samples and their concentration. The volatile contaminants in the headspace represent the volatile contaminants of the soil in the container. The sample with the highest concentration of volatile contaminants of the soil will deliver the highest concentration of volatile contaminants to the headspace container.

Screening data (on site GC and XRF) will not be used to make determinations of true nature or extent of contamination. The screening data will be used to determine hot spots of contamination to target laboratory split samples. The laboratory split samples alone will support future laboratory analysis to determine nature and extent of contamination as part of a remedial investigation if one is warranted.

Representativeness of data is also affected by sampling techniques. Sampling techniques are described in Section 3.0 and in the B&R Environmental Standard Operating Procedures included in Appendix B.

#### **4.1.2.3        Completeness**

Completeness describes the amount of data generated that meets the objectives for precision, accuracy, and representativeness versus the amount of data expected to be obtained. For relatively clean, homogeneous matrices, 100 percent completeness is expected. However, as matrix complexity and heterogeneity increase, completeness may decrease. Where analysis is precluded or where data quality objectives are compromised, effects on the overall investigation must be considered. Whether or not any particular sample is critical to the investigation will be evaluated in terms of the sample location, the parameter in question, the intended data use, and the risk associated with the error.

The sampling and analysis program for the site is sufficiently broad in scope to prevent a single data point or parameter from jeopardizing attainment of the monitoring objectives. Each medium is critical to the assessment of contaminant migration. Consequently, there exists some critical data requirement below which the objectives of the monitoring program will be compromised.

Critical data points may not be evaluated until all the analytical results are evaluated. Additionally, several sampling points, in aggregate, may be considered to be critical either by location or by analysis. A subsequent sampling event may be necessary if it becomes apparent that the data for a specific medium are of insufficient quality, either with respect to the number of samples or an individual analysis.

For the purposes of this effort, 90 percent is established as the minimum acceptable level of completeness. A data point will be determined to contribute to the completeness of the data set if the information provided is meaningful, useful, and contributes to the project objectives.

#### **4.1.2.4           Comparability**

One of the objectives of the sampling effort is to provide analytical data that is characterized by a level of quality that is comparable between sampling points. By specifying the use of standard analytical procedures (as well as standardizing field sampling procedures by employing B&R Environmental and others SOPs), the potential for variables to affect the final data quality will be effectively minimized. Analytical methods for this work are shown in Table 4-1, and SOPs appear in Appendix B.

#### **4.1.3               Quality Control Samples**

QC samples to be collected during the sampling effort are identified below, and include field duplicates or replicates, laboratory duplicates or replicates, rinsate blanks, trip blanks, and field blanks. Each type of field quality control sample defined below will undergo the same preservation, holding times, etc., as the field samples. Table 4-2 presents a summary of these QC samples to be collected during this field sampling event.

##### **4.1.3.1           Field Duplicates**

Field duplicates will be submitted at the rate of one for every 10 samples per matrix, or at a rate greater than one per 10 samples if less than 10 are shipped to the laboratory on any given day. Field personnel will note on the sample summary form and in the logbook which samples are field duplicates. Duplicate samples will be shipped blind to the laboratories, and shipping paperwork will be completed accordingly.

Field personnel will note in the remarks block on the chain-of-custody form which of the samples is to be used for internal laboratory matrix spike/matrix spike duplicate analysis. Field duplicates and multiple sample aliquots are collected by mixing a double portion of the required volume of sample and

**TABLE 4-1**  
**SAMPLE CONTAINER, PRESERVATIVE, AND HOLDING TIME REQUIREMENTS**  
**ON-SHORE SITE ASSESSMENT SCREENING EVALUATION**  
**FORMER DERECKTOR SHIPYARD, CTO 173**  
**NETC NEWPORT, RHODE ISLAND**

SAMPLE MEDIUM	ANALYSIS	SAMPLE CONTAINER	PRESERVATIVE	HOLDING TIME
Soils	Target Metals Screening	4 oz PE Bag	None	None
	Target VOCs Screening	80 ml VOA vial	None	7 Days (Analysis)
	TCL VOCs (CLP SOW OLM03.0)	2 oz VOA vial	Cool to 4°C	14 Days (Analysis)
	TCL SVOCs (CLP SOW OLM03.0)	8 oz wide mouth jar	Cool to 4°C	7 Days (Extraction)
	TCL PCBs/Pesticides (CLP SOW OLM03.0)	8 oz wide mouth jar	Cool to 4°C	7 Days (Extraction)
	TPH by IR (EPA 418.1)	4 oz wide mouth jar	Cool to 4°C	28 Days (Analysis)
Groundwater	TAL Metals (CLP SOW ILM03.0)	4 oz wide mouth jar	Cool to 4°C	Mercury, 28 Days, Others, 6 months
	TCLP Metals (SW/1311 40 CFR Part 261)	20 oz amber wide mouth jar	Cool to 4°C	Mercury, 28 Days, Others, 6 months
	Butylin Compounds (Wade 1990)	4 oz wide mouth jar	Cool to 4°C	7 Days
	TCL VOCs (CLP SOW OLM03.0)	2 - 40 ml VOA vials	HCl to pH <2/Cool to 4°C	14 Days (Analysis)
Groundwater	TCL SVOCs (CLP SOW OLM03.0)	80 oz amber bottle	Cool to 4°C	7 Days (Extraction)
	TCL PCBs/Pesticides (CLP SOW OLM03.0)	80 oz amber bottle	Cool to 4°C	7 Days (Extraction)
	TPH by IR (EPA 418.1)	32 oz amber bottle	HCl to pH <2	28 Days (Analysis)
	TAL Metals (CLP SOW ILM02.1)	1 liter PE bottle	HNO <sub>3</sub> to pH <2	Mercury, 28 Days, Others, 6 months
	Specific Conductance (EPA 120.1)	Field Measurement	Not Applicable	Not Applicable
	pH (EPA 150.1)	Field Measurement	Not Applicable	Not Applicable
	Temperature (EPA 170.1)	Field Measurement	Not Applicable	Not Applicable
	Dissolved Oxygen (EPA 360.1)	Field Measurement	Not Applicable	Not Applicable
	Turbidity (EPA 180.1)	Field Measurement	Not Applicable	Not Applicable
	Salinity (Standard Methods)	Field Measurement	Not Applicable	Not Applicable

**TABLE 4-2**  
**FIELD QUALITY CONTROL SAMPLE SUMMARY**  
**ON-SHORE SITE ASSESSMENT SCREENING EVALUATION**  
**FORMER DERECKTOR SHIPYARD, CTO 173**  
**NETC, NEWPORT, RHODE ISLAND**

SAMPLE TYPE	MEDIA	ANALYSIS	FIELD SAMPLES <sup>(1)</sup>	FIELD DUPLICATES (1 PER 10 FIELD SAMPLES)	RINSATE BLANKS (1 PER DAY) <sup>(2)</sup>	FIELD BLANKS (1 PER WATER SOURCE PER EVENT)	TRIP BLANKS (1 PER 10, 1 PER SHIPMENT)	TOTAL QUANTITY <sup>(3)</sup>
Test Pit Excavation, Task 3	Soils	Target Metals Screening	72	0	0	0	0	72
		TCL VOCs	34	3	4	2	2	45
		TCL SVOCs	34	3	4	2	0	43
		TCL Pesticides/PCBs	34	3	4	2	0	43
		TPH	34	3	4	2	0	43
		TAL Metals	34	3	4	2	0	43
		TCLP Metals	34	3	0	0	0	37
		Butyltin Compounds	34	3	4	2	0	43
Geologic/Hydrogeologic Investigation, Task 4	Soils	Target Metals Screening	169	0	0	0	0	169
		Target VOCs Screening	169	0	0	0	0	169
		TCL VOCs	44	4	22	3	20	93
		TCL SVOCs	44	4	22	3	0	73
		Pesticides/PCBs	44	4	22	3	0	73
		TPH	44	4	22	3	0	73
		TAL Metals	44	4	22	3	0	73
		TCLP Metals	44	4	0	0	0	48
	Butyltin Compounds	44	4	22	3	0	73	
	Groundwater	TCL VOCs	13	2	4	1	4	24
		TCL SVOCs	13	2	4	1	0	20
		Pesticides/PCBs	13	2	4	1	0	20
		TPH	13	2	4	1	0	20
		TAL Metals	13	2	4	1	0	20
Butyltin Compounds		13	2	4	1	0	20	

**TABLE 4-2  
FIELD QUALITY CONTROL SAMPLE SUMMARY  
ON-SHORE SITE ASSESSMENT SCREENING EVALUATION  
FORMER DERECKTOR SHIPYARD, CTO 173  
NETC, NEWPORT, RHODE ISLAND  
PAGE TWO**

SAMPLE TYPE	MEDIA	ANALYSIS	FIELD SAMPLES <sup>(1)</sup>	FIELD DUPLICATES (1 PER 10 FIELD SAMPLES)	RINSATE BLANKS (1 PER DAY) <sup>(2)</sup>	FIELD BLANKS (1 PER WATER SOURCE PER EVENT)	TRIP BLANKS (1 PER 10, 1 PER SHIPMENT)	TOTAL QUANTITY <sup>(3)</sup>
Sump Bottoms and Catch Basins, Task 5	Soil Samples	TCL VOCs	15	2	3	1	2	23
		TCL SVOCs	15	2	3	1	0	21
		TCL Pesticides/PCBs	15	2	3	1	0	21
		TPH	15	2	3	1	0	21
		TAL Metals	15	2	3	1	0	21
		TCLP Metals	15	2	0	0	0	17
		Butyltin Compounds	15	2	3	1	0	21
Sump and Drain Discharge Areas, Task 6	Shallow Soil Borings	Target VOCs Screening	42	0	0	0	0	42
		Target Metals Screening	42	0	0	0	0	42
		TCL VOCs	9	1	5	2	5	20
		TCL SVOCs	9	1	5	2	0	15
		TCL Pesticides/PCBs	9	1	5	2	0	15
		TPH	9	1	5	2	0	15
		TAL Metals	9	1	5	2	0	15
		TCLP Metals	9	1	0	0	0	10
Butyltin Compounds	9	1	5	2	0	15		

- (1) Refer to Table 3-1 for number of field samples anticipated.
- (2) Per NEESA guidance, only rinsate blank samples obtained from every other day are analyzed unless significant contaminant detections are recorded. The field crew will denote on the associated chain-of-custody form which rinsate blanks are to be "held".
- (3) In order to accommodate laboratory quality control analyses (i.e., matrix spike, matrix spike duplicate, laboratory duplicate) the field crew will provide multiple aliquots of samples (as applicable) with a frequency of one per 20 samples of similar matrix.

dividing it into two sample containers. Aliquots for VOC analysis are always removed prior to homogenization. Field duplicates provide precision information regarding homogeneity, handling, shipping, storing, preparation, and analysis.

#### **4.1.3.2 Rinsate Blanks**

Rinsate blanks are obtained under representative field conditions by running analyte-free deionized water through sample collection equipment after decontamination, immediately before sampling and placing it in the appropriate sample containers for analysis. These samples are used to assess the effectiveness of decontamination procedures. Rinsate blanks will be prepared at the rate of one per day and will be analyzed for the same parameters as the related samples. All rinsate samples will be sent to the laboratory. However, only rinsate samples collected from every other day will be analyzed; the other rinsate samples will be marked "hold" on the chain-of-custody forms. "Hold" samples will not be analyzed unless significant contamination is noted in the preceding rinsate blank analyses.

#### **4.1.3.3 Field Blanks**

Field blanks will consist of the source water used in decontamination (includes analyte-free deionized water, potable water from each source, and other waters used in decontamination operations). Field blanks will be prepared at the rate of one per source of water per sampling event.

#### **4.1.3.4 Trip Blanks**

Trip blanks consist of aqueous VOC samples prepared by the laboratories. One sample will accompany each shipment of VOC samples to the laboratories. If more than ten VOC samples are in one shipment, one trip blank sample will be provided for each ten field samples. If less than ten VOC samples are in one shipment, one trip blank will be provided. If there are multiple sampling crews out at one time, trip blanks will accompany each sampling team. If the samples are "pooled" in a single cooler for shipment, then the trip blanks accompanying each respective sampling team will be submitted for VOC analysis.

#### **4.1.3.5 Matrix Spike/Matrix Spike Duplicates**

A matrix spike sample is will be identified by field teams at a frequency of one in 20 field samples collected. Samples for matrix spike analyses are collected in triplicate volume, such that there are three containers for each analyte group. One aliquot is analyzed as a field sample in a manner

consistent with the other field samples. The second aliquot is spiked and analyzed to determine spike recoveries. The third is spiked also and analyzed as a duplicate to the second aliquot.

#### **4.2 SAMPLING PROCEDURES**

Field sampling will be conducted in accordance with Section 3.0 of this document and the B&R Environmental SOPs presented in Appendix B. Allowable sample holding times and preservation requirements are shown in Table 4-1.

#### **4.3 SAMPLE DESIGNATION AND CUSTODY**

Samples collected will be tracked by sample number and date collected. The sample number will be the basis for maintaining chain of custody. These procedures are described below.

##### **4.3.1 Sample Numbering**

Samples will be labeled as soon as they are collected. Sample numbers will reflect the source, medium, and location. An alpha numeric numbering system will be used to describe this information. This system is detailed below:

AAA	-	A	-	AANN	-	NNNN
(Site Identifier)		(Medium)		(Sample Location)		(Depth)

The site identifier for Derecktor Shipyard is DSY. Medium indicates solids (S) or Aqueous (A). Sample locations will be noted as MW (groundwater and soil from borings for groundwater monitoring wells-Task 2B), SS (surface soils-Task 2C) or SB (shallow borings-Task 2D).

For example, a soil sample collected from 2-4 feet below ground surface from well MW1 will be identified as DSY-S-MW01-0204. The first groundwater sample collected from this well will be identified as DSY-A-MW01-01.

Blind duplicate samples will be designated such that the location designation will be replaced with a chronological number:

Duplicates:                   DSY-A-DUPL#

Field blanks will be designated such that they can clearly be identified as field blanks. The designation must be able to be referenced to the source using the field paperwork.

Field Blanks:                   DSY-A-HYD1-FB

Rinsate blanks will be identified using the code for the sample for which the tool was last used, the identifier (RB), and its chronological number.

Rinsate Blanks:               DSY-A-MW12-0204-RB#

Trip blanks will be designated so that they can clearly be identified as aqueous trip blanks using an identifier (TB) and its chronological number.

Trip Blanks:     DSY-A-TB#

Matrix spike samples are simply marked as such on the sample containers and on the Chain of Custody Record.

#### **4.3.2           Sample Chain of Custody**

Custody of samples must be maintained and documented at all times. To ensure the integrity of a sample from collection through analysis, an accurate written record is necessary to trace the possession and handling of the sample. This documentation is referred to as the "chain of custody". Chain of custody begins when samples are collected in the field, and is maintained by storing the samples in secure areas until custody can be passed on. All samples will be accompanied by a chain-of-custody form that will describe the analytical parameters, and the persons who are responsible for its integrity.

Samples will be placed on ice and attended by B&R Environmental personnel or placed in locked vehicles or designated storage areas until analysis or shipment to an off-site laboratory. Chain-of-custody procedures are described in further detail in the SOPs presented in Appendix B of this Work Plan.

#### **4.4 CALIBRATION PROCEDURES**

Field equipment normally requiring calibration will be calibrated and operated in accordance with the manufacturer's instructions and manuals. A log will be kept on site, documenting the periodic calibration results for each field instrument.

Calibration procedures for laboratory equipment used in the analysis of environmental samples will be performed in accordance with NEESA requirements, i.e., CLP requirements for NEESA Level D.

#### **4.5 ANALYTICAL PROCEDURES**

Samples collected will be analyzed for various parameters described in previous sections and Tables 3-1 and 4-1. The primary analytical tools will be on-site screening instruments that will be able to identify target analytes. To supplement this data, laboratory analysis will be performed on 20 percent of the samples collected during each task. Laboratory data will be used as a baseline for comparison to determine accuracy and precision of the screening data.

To ensure that comparisons can be made representing the entire range of concentrations of contaminants present, aliquots of samples for laboratory analysis will be taken at random from the total group of samples collected. This methodology prevents a continued selection of samples from certain vertical or lateral locations or samples that are found by screening to contain high or low concentrations of target compounds.

##### **4.5.1 Laboratory Analysis**

Those environmental samples collected for laboratory analysis during the field investigation will be analyzed by a laboratory previously approved by NEESA. The analytical procedures will conform to NEESA quality Level D, as described in Section 4.1.1. In general, standard EPA analytical procedures will be employed, as depicted in Table 4-1. Level D data validation will be conducted in accordance with NEESA guidance.

One non-standard analysis will be performed as a part of the laboratory analytical program. Samples will be analyzed for butyltin compounds using methods specified by Wade et. al. (1990). This method was successfully used by the University of Rhode Island Graduate School of Oceanography in their ongoing study of contaminants in the sediments in Coddington Cove. Butyltin compounds are particularly toxic materials used in anti-fouling paints. Therefore, these compounds are potential contaminants of concern at this site, particularly in the waste sandblast materials. The Wade method

is summarized in Quinn, et. al., "Chemical Contaminants in Marine Sediments from the former Derecktor Shipyard Site at Coddington Cove, Newport, Rhode Island".

#### 4.5.2 Field Screening

Soil samples collected for field screening will be analyzed in the field using two methods. Samples will be analyzed with a Spectrace XRF or equivalent x-ray fluorescence device for target metals and with a field gas chromatograph (Photovac 10S50 or equivalent) for target VOCs. The analytical method and QC requirements for metals samples will be in accordance with the method specified by the instrument manufacturer. The detection limits for the individual screening techniques are 10.0 ug/kg for VOCs and specific to each individual target metal. The analytical method and QC requirements for VOC samples will be in accordance with the method specified in Appendix C. The analytical method and QC requirements for XRF samples will be in accordance with the method specified in Appendix D.

Target metals have tentatively been identified: copper, lead, nickel, and zinc. These metals have been selected because they were detected in the sediments of Coddington Cove at concentrations that are thought to have negative effects on the marine environment (Quinn et al, 1993). Copper is a primary element in most anti-fouling paints used on ships since before the 1940s. Lead is also a primary component of many other types of paints. Nickel and zinc may have been produced as a product of sandblasting raw steel prior to painting. Detection limits for these metals in soil screening samples are as follows:

Copper	100 mg/kg
Lead	30 mg/kg
Nickel	100 mg/kg
Zinc	100 mg/kg

Target VOCs have also been tentatively identified: trichloroethene (TCE); tetrachloroethene (PCE); 1,2-dichloroethene; 1,1, 1-trichloroethane; ethylbenzene; and xylenes. Total VOCs will determined by calculation as described in Appendix C. TCE and PCE were selected because they are typical contaminants used in metals cutting and machining. The other chlorinated compounds have been selected because they are breakdown products of TCE and PCE. Ethylbenzene and xylenes have been selected because they are components of light fuel oils such as No. 2 fuel (diesel) and gasoline, which are known to have been handled on site in large quantities.

The organic and inorganic parameters selected for screening will be under review constantly during the sample collection effort.

Field GC and XRF screening will be performed in trailer or office, in a separate room isolated from foot traffic and normal entrance/exit. This area will be regulated between 20°C and 28°C via either heat or air conditioning.

VOC and metals screening results will be weighted equally to select laboratory samples. However, there will be a need for some choices to be made at some locations as to whether to target the VOC contamination or the metals contamination. In areas of sandblast grit disposal, metals will be the primary concern; in chemical discharge areas, the VOCs will be the primary concern. Table 3-2 describes area of grit disposal and chemical disposal.

The subsequent laboratory data (from analysis performed on 20 percent of the samples screened) will be reviewed as soon as it becomes available to determine if these target screening parameters represent contaminants found by the laboratory analysis.

#### **4.6 DATA REDUCTION, REVIEW, AND REPORTING**

Analytical data will be reviewed by qualified B&R Environmental technical staff. Laboratory data will undergo Level D data validation. Data validation memoranda will be prepared and submitted to the project manager as a part of that activity. Data validation procedures are described in Section 4.10.2 of this Work Plan.

100 percent of the field screening data will be review by the project chemist. This review will be performed to determine instrument calibration, blank contamination, and laboratory precision. The chemist will report to the project manager the findings of the review. Field screening data will be collected and reported weekly to the project manager by the on-site analysts.

#### **4.7 INTERNAL QUALITY CONTROL**

Section 4.1.3 discussed the types and frequency of quality control samples that will be prepared during the field investigation activities for those samples to undergo laboratory analysis. The quantities of the various types of the QC samples are shown in Table 4-2. Laboratory analysis will follow the QC criteria described in the EPA-approved procedures.

Quality control criteria for field GC screening, acceptance windows, and evaluation of data quality are described below.

**Initial Calibration:** Three level concentration standards and an air blank. The relative standard deviation of the calibration factor for all compounds should be equal to or less than 35 percent. If criteria is not met, check instrument, prepare, and reanalyze fresh standards.

**Continuing Calibration:** The relative percent difference between the average initial and continuing calibration factor should be equal to or less than 30 percent. If the criteria fails, a fresh standard must be prepared and a new initial calibration must be performed.

**Screening Duplicated:** The relative percent difference for the soil samples screened in duplicate should be equal to or less than 40 percent. If this criteria is not met, both samples should be reanalyzed.

Quality control criteria for XRF screening, acceptance windows, and evaluation of data quality are described below.

Initial calibration will be performed in accordance with the instrument manufacturers specification.

Continuing calibration will be performed by analyzing a certified standard after every 10 field samples analyzed.

Duplicate samples will be analyzed for every 10 field samples analyzed. Relative percent difference should be less than 50 percent.

#### **4.8 PERFORMANCE AND SYSTEM AUDITS**

System audits will be performed as appropriate to ensure that the work is being implemented in accordance with the approved project SOPs and in an overall satisfactory manner.

- The FTL and the project QA/QC officer will supervise and on a daily basis check to ensure that the equipment is thoroughly decontaminated, samples are collected and handled properly, and the field work is accurately and neatly documented.
- The data reviewer(s) will review the data and will check that the data was obtained through the approved methodology, and that the appropriate level of QC effort and reporting were conducted. The data validation effort will be supervised by the B&R Environmental CLEAN Quality Assurance Manager or designee.

- The PM will oversee the FTL and data reviewer, and check that management of the acquired data proceeds in an organized and expeditious manner.

#### **4.9 PREVENTATIVE MAINTENANCE**

B&R Environmental has established a field equipment maintenance program to ensure the availability of equipment in good working order when and where it is needed. This program consists of the following elements:

- The equipment manager maintains an inventory of the equipment by model and serial number, quantity, and condition. Each item of equipment is signed out when in use, and its operating condition and cleanliness is checked upon return.
- The equipment manager conducts routine checks on the status of equipment and is responsible for stocking spare parts and equipment readiness.
- The equipment manager maintains the equipment manual library and trains field personnel in the proper use and care of equipment.
- The FTL is responsible for working with the equipment manager to make sure that the equipment is tested, cleaned, charged, and calibrated in accordance with the manufacturer's instructions before being taken to the job site.
- While the equipment is in the field, the FTL takes responsibility for the equipment, maintains calibration records, and performs maintenance operations and checks.

#### **4.10 DATA ASSESSMENT PROCEDURES**

The following paragraphs describe the procedures used to evaluate data prior to inclusion and description in the deliverable reports described elsewhere in this work plan.

##### **4.10.1 Representativeness, Accuracy, and Precision**

All laboratory data generated in the investigation will be assessed for representativeness, accuracy, and precision, as described in Section 4.1.2. The completeness of the data will also be assessed by comparing the acquired data to the project objectives to see that these objectives are being addressed

and met. The specific information used to determine data precision, accuracy, and completeness will be provided in the laboratory data packages.

The PARCC parameter assessment will be conducted by qualified B&R Environmental personnel. The representativeness of the data will be assessed by determining if the data are consistent with known or anticipated chemical conditions and accepted principles.

Field measurements will be checked for completeness of procedures and documentation of procedures and results.

Precision and accuracy will be determined using replicate samples and blank and spiked samples, respectively. PARCC parameters are addressed in more detail in Section 4.1.2.

#### **4.10.2      Data Validation**

Samples will be analyzed for parameters described on Table 4-1 of this Work Plan. Results will be validated "Level D" using the "National Functional Guidelines for Organic/Inorganic Data Review" (U.S. EPA December 1990, revised February 1994 [organic] and February 1993 [inorganic]). Use of these validation protocols is in accordance with the Navy Installation Restoration Laboratory Quality Assurance Guide, Interim Document (revised February 1996), and the NEESA 20.2047B; June 1988 guidelines.

Field screening data will undergo a data review, which includes the tasks consistent with EPA "Tier II" data validation.

#### **4.10.3      Data Evaluation**

The evaluation of the data collected during the field investigation will include analysis of chemical concentrations in samples collected from the field. Comparisons of screening and laboratory analytical data will be made to determine the level of accuracy of the screening procedures. Further evaluation of the data will be performed in conjunction with the preparation of the SASE report and preliminary risk assessment.

### **4.11            CORRECTIVE ACTION**

The QA program will enable problems to be identified, controlled, and corrected. Potential problems may involve non-conformance with the SOPs and/or analytical procedures established for the project,

or other unforeseen difficulties. Any person identifying an unacceptable condition will notify the FTL and the PM. The PM, with the assistance of the Quality Assurance Manager and the project QA/QC officer, will be responsible for developing and initiating appropriate corrective action and verifying that the corrective action has been effective.

Corrective actions may include re-sampling and/or re-analysis of samples or modifying project procedures. If warranted by the severity of the problem (for example, if a change in the approved Work Plan is required), the Navy will be notified in writing and their approval will be obtained prior to implementing any change. Additional work that is dependent on a nonconforming activity will not be performed until the source of the problem has been addressed.

#### **4.12 QUALITY ASSURANCE REPORTS/DOCUMENTS**

A bound/weatherproof field logbook will be maintained by the FTL. The FTL or designee will record all information related to sampling or field activities. This information may include sampling time, weather conditions, unusual events, field measurements, description of photographs, etc. The site logbook maintained by the FTL will contain a summary of the day's activities and will reference the other field logbooks when applicable.

In addition, the following information will be maintained on a daily basis:

- field screening samples delivered to the site screening laboratory, and results of samples run in that laboratory
- health and safety concerns, incidents, PPE used, and instruments used to determine PPE levels
- site sign-in log
- copies of all COCs of samples collected

At the completion of field activities, the FTL will submit to the PM all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheets, etc. The PM will ensure that these materials are entered into the project file.

Changes in project operating procedures may be necessary as a result of changed field conditions or unanticipated events. A summary of the sequence of events associated with field changes is as follows:

- The FTL notifies the PM of the need for the change.
- If necessary, the PM will discuss the change with the pertinent individuals, e.g., Navy personnel, B&R Environmental Navy CLEAN Quality Assurance Manager, and will provide a verbal approval or denial to the FTL for the proposed change.
- The FTL will document the change on a Request for Field Modification and forward the form to the PM at the earliest convenient time (end of the workday).
- The PM will sign the form and distribute copies to the Program Manager, Quality Assurance Manager, FTL, and the project file. If necessary, the PM will submit the form to the Navy RPM for delivery to the regulatory oversight parties.
- A copy of the completed Request for Field Modification will also be attached to the field copy of the affected document, Work Plan/Field Sampling Plan.

## **5.0 REPORTING**

Following the completion of the field and analytical work described in Section 3, the results of the information collected will be described in the form of a Site Assessment Screening Evaluation (SASE) report.

The SASE report will contain seven major sections, to reflect the general outline of a Remedial Investigation report. This outline has been selected because much of the data collected during the SASE will be used to help support a future remedial investigation report, and a baseline human health risk assessment.

### **5.1 BACKGROUND AND FINDINGS OF THE INVESTIGATIONS**

Section 1.0 will describe the history of the site and the purpose of the SASE report. The site background sections will include information from the PA, which was prepared under CTO 100 (May, 1993). Additional background information discovered during this investigation and activities at the site since the publication of the PA will be described in detail and incorporated into the site background section.

Section 2.0 will describe the investigations performed at the site. This section will be based on Section 3.0 of this Work Plan and the modifications of the field work, if any are made, during the period of activity.

Section 3.0 will describe the physical characteristics of the study area as they are at the time of the investigation. These will include the standing surface features (buildings, pipelines, roadways, fences, etc). The subsurface features, including the geology and hydrogeology, will be described as determined by explorations performed. Figures will be prepared depicting aerial and/or cross sectional views of site features including: geology, maximum and minimum water table elevations, and depth to bedrock, etc.

Section 4.0 will describe the contaminants found. This section will also be based on Section 3.0 of the Work Plan and its modifications. Potential source areas have already been identified in the PA, and the field work is designed around these findings. During the field work, additional source areas may be identified or some of those targeted may be eliminated. All chemical analytical data collected during the field work will be presented in this section. Preliminary identification of primary site contaminants

will be made. The primary site contaminants will be selected based on frequency of detection, concentration, mobility, and persistence in the environment.

Background concentrations will be determined by sample collection and analysis. Background samples of surface soils will be collected from the boring locations described in Section 3.3.2.1 of this work plan. Arithmetic averages of contaminant concentrations in these samples will be calculated and used as references for comparison to RIDEM state average data and to contaminant concentrations in site samples. These comparisons will be made and presented at a meeting to be held after completion of the data assessment and prior to the preparation of the Draft SASE report. The exact approach for selection of data to be used as "background" will be determined at that time.

Summary tables will be included for all of the matrixes sampled. Concentrations of contaminants in these tables that exceed background concentrations, regulatory standards, and/or risk criteria will be delineated.

Figures may include aerial and/or cross-sectional views. As appropriate, pertinent information such as concentration of contaminants, location of samples, etc, will be included in the figures.

Section 5.0 will describe the expected transport mechanisms available to the primary site contaminants. The focus of the discussion will center around the leachability of metals from the used sandblast grit that was used as fill in different locations around the site. The possibility of the transport of these contaminants to groundwater and subsequently into the waters and sediment of Narragansett Bay will be discussed. In addition, the other contaminant pathways will be identified for organic compounds if they are identified.

Section 5.0 will also describe the persistence of the contaminants after release to the environment. This discussion will be used to add or delete contaminants from the list of primary site contaminants identified in Section 4.0.

## **5.2 PRELIMINARY HUMAN HEALTH RISK ASSESSMENT**

Section 6.0 of the SASE report will consist of a preliminary human health risk assessment. This assessment will provide a risk-based selection of contaminants of concern, which will be compared with the primary site contaminants identified in Sections 4.0 and 5.0.

A risk-based selection of contaminants will be made by use of a concentration-toxicity screening procedure. In this procedure, each contaminant detected is scored for each medium in which it was

detected based on its toxicity and concentration. The score for each contaminant is evaluated by its ratio to the sum of the total of all scores for that medium. The concentration-toxicity screening evaluation is described in the Risk Assessment Guidance for Superfund, Volume I, December, 1989.

The contaminants selected in this manner will be compared with those selected as primary site contaminants based on frequency of detection, mobility, and persistence. The contaminants that appear on both lists will be selected as preliminary contaminants of concern for the site.

This section will also include an qualitative exposure assessment, abbreviated toxicity assessment, and qualitative risk characterization. These evaluations will be made from the available literature, the findings of the field investigation, and the evaluation of the cultural and ecological settings (Section 3.7).

The preliminary risk assessment will be prepared in accordance with current U.S. EPA guidance. This guidance is contained in various documents that include, but are not limited to, the following:

- Risk Assessment Guidance for Superfund - Volume I - Human Health Evaluation Manual (Part A). December 1989. EPA/540/1-89/002.
- Risk Assessment Guidance for Superfund - Volume I - Human Health Evaluation Manual - Supplemental Guidance - "Standard Default Exposure Factors". March 25, 1991. OSWER Directive 9285.6-03.
- Guidance for Data Useability in Risk Assessment. October 1990. EPA/540/G-90/008.
- Supplemental Guidance to RAGS: Calculating the Concentration Term. May 1992. OSWER Publication 9285.7-081.
- Exposure Factors Handbook. May 1989. EPS/600/8-89/043.
- Development of Statistical Distributions or Ranges of Standard Factors Used in Exposure Assessments. August 1985. EPA/600/4-41/041.
- Superfund Exposure Assessment Manual. April 1988. EPA/540/1-88/001.
- Dermal Exposure Assessment: Principles and Applications. January 1992. EPA/600/8-91/011B.

- Risk Assessment Guidance for Superfund - Volume I - Human Health Evaluation Manual - Supplemental Guidance - "Dermal Risk Assessment". August 18, 1992.
- Draft Soil Screening Level Guidance. September 1993.
- Health Effects Assessment Summary Tables - FY-1994 Annual and Supplements. March 1994. EPA/540/R-94/058.
- "Integrated Risk Information System" on-line data base on toxicological data.
- Region I Supplemental Risk Assessment Guidance for the Superfund Program. June 1989.

### **5.3 ECOLOGICAL ASSESSMENT**

Section 7.0 of the SASE report will consist of a conceptual model for ecological risk to terrestrial receptors. An investigation and ecological risk assessment will be performed by the Navy for the marine ecosystem proximate to the site under a different work plan. A draft report for this marine ecological risk assessment is scheduled for completion in June 1996.

The on-shore ecological screening characterization of Derecktor Shipyard will determine the existence of ecological receptors and terrestrial habitats potentially impacted by the site. If such receptors exist or are potentially present at the site and/or the surrounding area, an on-shore ecological conceptual model will be prepared to ascertain if viable exposure scenarios exist by which site-related contaminants may pose a risk to terrestrial ecological receptors.

During the development of the on-shore ecological conceptual model, diverse types of information will be used to identify which of the possible ecological exposure pathways constitute complete pathways. This information will also identify those pathways that are more likely to represent a significant risk to ecological receptors.

Information to be considered in the conceptual model includes the following: analytical data for exposed surface soils (and other environmental media, if relevant); literature review of the characteristics of detected site-related contaminants (information on fate, transport, toxicity and ecological effects); ecological characterization of the site (physical environment, areas of potential contaminant exposure, contaminant migration routes, and potential ecological receptors); and literature review of potential ecological receptors (habitats, natural history and distribution). The conceptual

model will also consider the relationship of assessment and measurement endpoints determined based on the characteristics of the site-related contaminants, their potential toxic and ecological effects, and the ecological receptors potentially at risk.

If complete ecological exposure pathways associated with the site are identified, then the on-shore ecological conceptual model will determine additional data requirements and the appropriate approach for conducting a terrestrial ecological risk assessment.

The on-shore ecological conceptual model will be prepared in accordance with the framework for problem formulation of ecological risk assessments, as described in U.S. EPA guidance documents (U.S.EPA 1991; 1992a; 1992b) and in Wentsel et al. (1994). Other supporting references may include Bartell et al. (1992), Maughan (1993), Suter et al. (1993), and U.S. EPA (1989a; 1989b; 1989c). In addition, U.S. EPAs "Ecological Risk Assessment Guidance for Superfund: Process for designing and Conducting Ecological Risk Assessments" will be consulted if the final version of this document has been released.

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## REFERENCES

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**HEALTH AND SAFETY PLAN**

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**FORMS FOR FIELD INVESTIGATIONS**

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**HEALTH AND SAFETY PLAN**

**Appendix A**  
**Final Health and Safety Plan**  
**for**  
**On-Shore Site Assessment**  
**Screening Evaluation**

**Former Derecktor Shipyard**  
**Naval Education & Training Center**  
**Newport, Rhode Island**



**Northern Division**  
**Naval Facilities Engineering Command**  
**Contract Number N62472-90-D-1298**  
**Contract Task Order 0173**

**September 1995**

APPENDIX A  
FINAL HEALTH AND SAFETY PLAN  
FOR  
ON-SHORE SITE ASSESSMENT SCREENING EVALUATION

FORMER DERECKTOR SHIPYARD  
NAVAL EDUCATION & TRAINING CENTER  
NEWPORT, RHODE ISLAND

COMPREHENSIVE LONG-TERM  
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

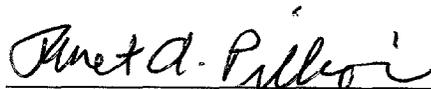
Submitted to:  
U.S. Naval Facility Engineering Command  
Northern Division, Code 18  
Environmental Contracts Branch  
10 Industrial Highway, Mail Stop #82  
Lester, Pennsylvania 19113-2090

Submitted by:  
Halliburton NUS Corporation  
993 Old Eagle School Road  
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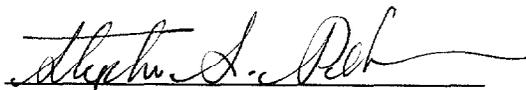
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Contract Task Order No. 0173

September 1995

SUBMITTED FOR HALLIBURTON NUS BY:

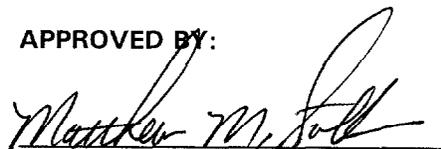


JANET A. PILLION  
HEALTH AND SAFETY OFFICER



STEPHEN S. PARKER  
PROJECT MANAGER  
HALLIBURTON NUS CORPORATION  
WILMINGTON, MASSACHUSETTS

APPROVED BY:



MATTHEW SOLTIS, CSP, CIH  
HEALTH AND SAFETY MANAGER

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## **1.0 INTRODUCTION**

This Health and Safety Plan (HASP) was prepared to provide safe procedures and practices for Halliburton NUS Corporation and subcontractor personnel engaged in Remedial Investigation field activities at the former Derecktor Shipyard, at the Naval Education and Training Center (NETC) located in Newport, Rhode Island.

This plan has been developed to conform to the requirements of 29 CFR OSHA Standard 1910.120 (Hazardous Waste Operations and Emergency Response) as well as guidance set forth in the CLEAN Health and Safety Management Plan (HSMP) developed by Halliburton NUS (dated August 1991), and is based on the available information concerning possible contaminants and physical hazards that exist, or may exist, on the site.

As more data concerning the nature and/or concentrations of contaminants becomes available, the Health and Safety Plan will be modified accordingly. Modifications will be determined by the Health and Safety Officer (HSO). They will be communicated via task specific health and safety plans obtained by field personnel prior to each new site visit.

All activities covered by this HASP must be conducted in complete compliance with this HASP and with all applicable federal, state, and local health and safety regulations.

Subcontractors performing work onsite will be required to comply with the minimum requirements of this plan. Each subcontractor employee performing work at the site must complete a copy of the HASP review form (Attachment A) indicating that the individual has read, understands, and will comply with the HASP.

### **1.1 KEY PERSONNEL/RESPONSIBILITIES**

The Halliburton NUS Project Manager (PM) is responsible for the overall direction and implementation of the project tasks and is therefore ultimately responsible for the implementation of this HASP. Specifically, the PM is responsible for collecting the training and medical documentation and HASP review form(s) from the Halliburton NUS Field Team and subcontractors and forwarding these documents to the HSO and CHSM.

The CLEAN Health and Safety Manager (CHSM) is responsible for oversight of health and safety issues in conjunction with this project. The CHSM must approve any modifications to this HASP after finalization.

On-site health and safety issues will be delegated to the Site Safety Officer (SSO). This individual will be responsible for day to day implementation of the HASP and its requirements. As a part of this role, the SSO is responsible for assisting the CHSM in ensuring compliance with the CLEAN Health and Safety guidelines and to provide technical expertise for this project. The SSO has the authority to stop all work where imminent danger is perceived and is responsible for initiating emergency response and coordinating site evacuation when necessary.

The Halliburton NUS Field Team Leader (FTL) is responsible for the day to day operations at the site, and shall support the SSO in implementation of this Health and Safety Plan.

An alternate SSO will be named at the commencement of field activities. The alternate SSO will assume the responsibilities of the SSO in his/her absence.

Any personnel performing work at the Site must be approved by the Halliburton NUS Project Manager and the CLEAN Health and Safety Manager (CHSM) prior to the commencement of field activities.

**Site Name:** Derecktor Shipyard  
**Address:** Simon Pietri Drive, Coddington Cove, Middletown, RI, 02840  
**Site Contact:** Brad Wheeler  
**Phone No.:** (401) 841-3735  
**Client Contact:** Debra Carlson  
**Phone No.:** (215) 595-0567 x 147  
**Purpose of Site Visit:** Remedial Investigation  
**Proposed Date of Work:** 1995

**PERSONNEL ASSIGNMENTS**

<u>Halliburton NUS Personnel</u>	<u>Assignment</u>
John Trepanowski	CLEAN Program Manager
Stephen S. Parker	Project Manager
TBA	Field Team Leader (FTL)
Matthew Soltis	CLEAN HSM
Janet Pillion	Health & Safety Officer
TBA	Tech. Staff/Site Safety Officer (SSO)

<u>Non-Halliburton NUS Personnel</u>	<u>Purpose</u>
TBA	Drilling Subcontractor
TBA	Geophysics Subcontractor
TBA	Response/Cleanup Subcontractor

Plan Reviewed and Approved by: Matthew M. Soltis (9/5/95)

Halliburton NUS Project Manager: Stephen S. Parker (9/6/95)

**MODIFICATION OF THIS HASP IN THE FIELD MUST BE APPROVED BY THE HEALTH AND SAFETY OFFICER (HSO)**

## 2.0 SITE BACKGROUND

The Robert E. Derecktor of Rhode Island (Derecktor) Shipyard consists of 41.35 acres of land and improvements. The property is surrounded on the north, east and south boundaries by the Naval Education and Training Center (NETC) and the Naval Underseas Warfare Center (NUWC). The western boundary opens onto a portion of Narragansett Bay called Coddington Cove.

The Derecktor Shipyard operated from 1979 until January 1992 when Derecktor filed for Chapter 11 bankruptcy. The property was used by Derecktor for the repair, maintenance, and construction of private and military ships and building of new ships. Repair and maintenance operations were concentrated around Pier 1. These operations consisted of sand blasting and painting, hull inspections and other on-board ship repairs. Dry docks were moored at Pier 1 and were utilized during these operations.

The Shipyard operations involved the generation of large quantities of hazardous wastes. These wastes included waste oil, paints, solvents, thinner, sodium hydroxide and other waste solids and liquids. Housekeeping and hazardous material handling practices at the facility were poor. General debris and scrap materials were widely scattered around the facility. Waste materials were known to be disposed of on the property. This includes spent sand blast grit and oily liquids from the dry dock. These liquids were reportedly placed in a small pit on the north side of building 42. Releases of hazardous material to the ground in the hazardous waste storage area (Waterfront) and the pipe shop (Building 6) are suspected but have not been confirmed. Interior areas of some buildings, most notably 42, 234, and 6 have been significantly impacted by Derecktor operations. The presence of (asbestos containing material) ACM is suspected in most of the buildings. If renovation or demolition of the buildings is intended, the presence of ACM would need to be confirmed.

For more detail regarding site background information, refer to the Work Plan and Field Sampling Plan documents.

### **3.0 SCOPE OF WORK**

The sections presented below are abbreviated descriptions of work to be performed as a part of the Remedial Investigation at the Derecktor Shipyard property in Newport, Rhode Island. For complete descriptions of the work to be performed, refer to the Field Sampling Plan (Section 3.0 of the Work Plan).

In general, the following tasks will be performed:

- Task 1 Mechanical Pits and Trenches Inspection
- Task 2 Underground Drainage Systems Tracking and Clearing
- Task 3 Test Pit Excavation and Sampling
- Task 4 Geologic and Hydrogeologic Investigation
- Task 5 Catchbasin and Sump Sampling
- Task 6 Floor Drain Discharge Area Sampling

Some of these tasks involve similar activities which may be performed as one task.

## 4.0 HAZARD ASSESSMENT

This section presents information regarding known and suspected chemical and physical hazards associated with the investigatory activities at the Site. Only those activities anticipated in this HASP are considered in this evaluation. Any additional activities must be communicated to the CHSM for inclusion into this plan. This evaluation is based solely on the currently available information. As new data comes available, this HASP may need to be modified accordingly.

The types and degree of potential hazards that may be presented to site personnel vary depending on factors such as the task to be performed, the location involved, climatic conditions, etc. The site tasks scheduled to take place in this project can generally be segregated into two categories: intrusive and nonintrusive. The types and degrees of risks recognized in this project are more significant in regard to the intrusive activities (i.e. excavating, drilling, soil sampling, etc.) rather than the nonintrusive operations (i.e. visual site inspections, surveying activities, GPR, etc.).

### 4.1 CHEMICAL HAZARDS

Hazards associated with this investigation include the potential for exposure to site contaminants via inhalation of toxic vapors and/or airborne particulates, dermal contact, and (to a much lesser extent) ingestion.

#### 4.1.1 Sandblast Grit

Large volumes of sandblast grit was generated during repair, maintenance, and construction of private and military ships, and is prevalent throughout the site as fill or in piles. The sandblast grit is a waste generated from Carborundum type abrasive materials used for cutting, grinding, and polishing painted or unpainted metal surfaces. The abrasive materials are typically silicon carbide, fused alumina and other materials.

Based on some area sediment sampling results, the grit waste probably contains high concentrations of lead, copper, nickel, and zinc; other metals at lower concentrations are also probably present. Personnel exposure to the sand blast grit is primarily a particulate inhalation concern. The potential exists for the grit to become an airborne particulate hazard if there are dry/dusty conditions on-site.

#### 4.1.2 Fuel Oils

Previous site activities and observations indicate the potential for fuel oil contamination, specifically #2 fuel oil, to be present on-site. Fuel oils are considered to be of moderate to low toxicity and are not considered to be carcinogenic by NTP, OSHA, or IARC. Potential route(s) of entry are inhalation and skin/dermal contact. Fuel oil health hazard data sheets present dermal exposure as the primary route of concern. Federal or recommended airborne exposure limits have not been established for fuel oil vapors; however, the following toxic and hazardous ingredients of petroleum hydrocarbons include: benzene, cyclohexane, heptane, methyl cyclohexane, toluene, octane, xylenes, nonane, and hexane. Permissible concentrations include naphtha (100 ppm), Stoddard Solvent (100 ppm), and benzene (1 ppm). Benzene is an OSHA regulated carcinogen. Effects of short-term (acute) overexposure may be indicated by symptoms such as headache, dizziness, blurred vision, drowsiness, dermatitis, difficulty in breathing, irritations of the eyes, nose and throat, and at extremely high concentrations death may occur. Chronic effects of overexposure include: hydrocarbons - nausea, headache, dry, cracked skin; benzene - irritation of nose, eye, respiratory system, nausea, lassitude. Effects of long-term (chronic) overexposure typically result in the development of chronic dermatitis.

Because of the very low vapor pressure of fuel oils, work being conducted in an outdoor environment, overexposure to their vapors is not expected to occur. It is not expected that fuel oils will be encountered during work in the buildings. Dusts from soils that are contaminated with fuel oils may be generated during subsurface activities. Dermal contact is the most likely route of exposure.

Material Safety Data Sheets (MSDS') state that no special respiratory protection is required when working with #2 fuel oil under normal conditions of use and with adequate ventilation. For skin protection, impervious gloves (i.e. viton, nitrile) or clothing is recommended when continuous exposure is expected to prevent repeated or prolonged skin contact.

#### **4.1.3 Waste Oils**

Previous site activities and observations indicate the potential for waste oil contamination to be present on-site. For the lack of specific constituent or source information regarding the waste oil onsite, hazard information will be presented for petroleum hydrocarbons.

Toxic and hazardous ingredients of petroleum hydrocarbons (listed with their permissible exposure limit) include: benzene (1 ppm), cyclohexane (300 ppm), heptane (400 ppm), methylcyclohexane (400 ppm), toluene (100 ppm), octane (300 ppm), xylenes (100 ppm), nonane, hexane (50 ppm), naphtha (100 ppm), and Stoddard Solvent (100 ppm). Chronic effects of overexposure include: hydrocarbons - nausea, headache, dry, cracked skin; benzene - irritation of nose, eye, respiratory system, nausea, lassitude. Benzene is an OSHA regulated carcinogen.

#### **4.1.4 Other Chemicals**

Material Safety Data Sheets (MSDS) for decontamination solutions that field crews will use during the investigation are presented as Attachment B. All containers of decon solutions will be properly labeled in accordance with OSHA's Hazard Communication Standard, 29 CFR 1910.1200 and 1926.59.

The most likely route of exposure for these chemicals is through dermal exposure, although ingestion and eye contact via a potential splash hazard exists.

#### **4.1.5 Chemical Hazard Evaluation of Each Site Task**

Although there are numerous tasks outlined in the Scope of Work, many utilize the same type of activities to complete them. Due to this fact, work activities will be grouped as appropriate and addressed in this section instead of each individual site task. A hazard evaluation for these work activities is as follows:

##### **Drilling/Excavations/Soil Sampling/Debris Removal/Underground Drainage Systems Sampling**

Drilling (geologic/hydrogeologic investigation) and excavation (test pitting) activities, and other soil-disturbing and sampling investigation activities present the highest exposure potentials of this investigation. Exposure concerns include inhalation of contaminant-laden dust and/or volatile organic emissions caused by soil or waste disturbance, and direct skin contact with contaminants. The physical hazards associated with these tasks are addressed in Section 4.2 of this HASP.

Exposure potentials could vary significantly depending on where the drilling, excavation, or sampling activities are taking place; activities in the sandblast grit or disturbances in other known waste sources or debris poses the greatest risk of worker exposure. Drillers, heavy equipment operators and other workers are especially at risk to exposure due to their work position proximity to the boreholes, soils, or other potentially contaminated material or media (VOCs & particulates), or during handling of potentially contaminated augers or removal/sampling of other waste and contaminated media (dermal contact).

## Groundwater Sampling

This task present a moderate to low exposure potential. The primary concern for these tasks is inhalation of volatile organic compounds while sampling potentially contaminated waters and dermal contact with contaminated water. These hazards will also vary depending on the sample locations. It is likely that the drilling operations will provide some data regarding the concentrations of contaminants in each well. This data can be used to help anticipate the levels of protection needed prior to groundwater work.

## Site Walkovers/Survey

These tasks present a low exposure potential due to the non-intrusive nature of the activity. It is not anticipated that an exposure to contaminant-laden particulates or volatile organic compounds would occur during these tasks. If information collected during site activities indicates the potential for exposure then these tasks will be reevaluated.

### **4.1.6 Control of Chemical Hazards**

Exposure to site contaminants will be controlled through the use of the following elements:

- Personal Protective Equipment (PPE) - PPE consisting of protective clothing, and respiratory protection, as necessary, to reduce/eliminate exposure to contaminants. For specific PPE requirements, refer Section 6.0.
- Air Monitoring - Work area monitoring will be performed with a flameionization detector (FID) (OVA 128 or equivalent) calibrated to respond to the compounds identified previously in this section. The readings detected on this instrument will be used to determine the need for respiratory protection during work at the site (refer to Sections 5.0 and 6.0 of this HASP).
- Decontamination Procedures - Personal and equipment decontamination procedures were established to reduce/eliminate personnel exposure to site contaminants and to control the migration of contamination from dirty to clean areas. Specific decontamination requirements are outlined in Section 8.0.
- Safe Work Practices - Safe work practices, such as those found in Section 7.2, will be followed to aid in the efforts to reduce exposure.

### **4.2 PHYSICAL HAZARDS**

Certain physical hazards may also be presented to site personnel involved with field activities. These may be intrinsic to the nature of the operation being performed, or the result of factors such as the work location or schedule. These potential risks include the following:

- Contact with subsurface/energized utilities during subsurface operations.
- Exposure to moving machinery - struck by/caught between hazards (e.g. rotating augers, point of operation areas, nip points, etc.).
- Noise in excess of 85 dBA.
- Uneven or unstable terrain - could cause slip/trip/fall type hazards.
- Strain or muscle pulls from manual lifting.

- Heat/Cold stress.
- Accidents associated with working in areas of vehicle traffic.
- Inclement weather.
- Natural hazards (e.g. snakes, ticks, mosquitos, poisonous plants, etc.).

#### 4.2.1 Control of Physical Hazards

Control efforts for these physical hazards include the following:

##### Contact with Subsurface Utilities/Energized Sources

One of the hazards associated with the execution of this scope of work is the potential for encountering energized sources (i.e. pressurized lines, water lines, telephone lines, and buried utilities such as gas or electric lines), primarily while engaged in drilling/subsurface activities. Due to the obvious ramifications associated with this hazard, extreme caution and strict adherence to procedures to detect, identify, and take evasive action shall be followed during the completion of the scope of work. Also, any areas targeted for subsurface activities shall first be investigated to determine the presence of underground utilities. Any such utilities identified shall be physically marked and avoided. Efforts will be made through local contacts, as-built drawings (where available) along with geophysical surveys to identify potential locations. Positive readings will require the relocation of a soil boring point. To further avoid hazards of this type, no drilling mast or any other such projecting items shall be permitted within a 20-foot radius of any energized source.

##### Exposure to Pinch/Compression Points

Personnel are to be advised of struck by/caught between type hazards related to hand/clothing contact with moving machinery. Protective gear must fit properly and be taped, when applicable, not only to control chemical exposure, but also to avoid contact with moving machinery. Additionally, equipment shall be shut down and locked out before maintenance functions are performed.

Drilling equipment must be inspected by an individual familiar with it's operation following it's arrival on site to determine that it is working properly and to instruct site personnel on emergency shut-down procedures.

##### Rotating Machinery

Geologic/Hydrogeologic Investigations will be accomplished using rotating equipment as proposed in the execution of the scope of work. The most predominant physical hazard associated with this type of work is entanglement of safety equipment or clothing into the rotating augers. To address this hazard, a thorough inspection of all equipment will be performed to remove or guard potential snag points. Also, efforts will be taken to ensure that emergency stop devices operate properly, and that all members of the field team know the location and operation of these devices. Persons working in close proximity to or in the operation of the drill rig be required to secure all loose clothing or protective equipment to avoid possible entanglement. All mechanized equipment brought on-site (including drilling equipment and excavation equipment) to complete this scope of work will be inspected initially prior to the commencement of on-site activities and then periodically thereafter. These inspections will be performed by the SSO and include the following:

- All safety guards are in place
- All safety-restraints (i.e. seatbelts) are in place and functioning properly as required by Federal regulations
- All mobile equipment is equipped with a backup alarm and emergency stop device

- All operators are qualified to do so. All drivers will be required to have their Commercial Drivers License
- Traffic control measures (routes and regulations) will be established and adherence required
- All maintenance performed on the equipment will employ manufacturers recommended parts and be inspected prior to returning to services by the SSO

#### Strain/Muscle Pulls

During any manual handling tasks, personnel are to lift with the force of the load supported by their legs and not by their backs. The correct number of personnel must be used to lift or handle heavy equipment. These procedures are to be employed to attempt to avoid back strain and/or other injuries.

#### Heat/Cold Stress

Worker overexposure to heat is a recognized potential hazard due to possible ambient temperatures combined with the use of personal protective equipment which can contribute to this threat. It will be the responsibility of the FTL, with assistance from the SSO, to determine the need to employ heat stress monitoring techniques and control measures based on observations of site conditions and personnel. Generally, consideration for these efforts are to commence if/when ambient weather conditions involve temperatures in excess of 70 degrees Fahrenheit. Additionally, cold stress is also a recognized potential hazard posed to workers. Refer to Attachment A for recognition, evaluation, and control of these potential hazards.

#### Buddy System

The activities conducted and equipment utilized during the site work demand competency, coordination, and concentration. To prevent accidents and injuries occurring on-site, and in order to provide rapid assistance to employees in the event of an emergency, implementing the "buddy system" or organizing employees to support "line-of-sight" is required.

The buddy system will be implemented in all work areas where there exists the potential for a significant chemical exposure and work areas proximal to vehicle traffic, heavy equipment and other machinery or equipment that poses a threat of serious injury to on-site workers. Line-of-site or a communication system can be via visual, voice, or regular radio contact and must be maintained at all times.

#### Confined Space Entry

Confined space entries are not anticipated during this remedial investigation and therefore will not be discussed in this HASP. If confined space entry becomes necessary for any reason, the project manager and the CHSM must modify this HASP prior to authorizing entry.

#### Natural Hazards

Natural hazards such as poisonous plant, bites from poisonous or disease carrying animals or insects (e.g. snakes, ticks, mosquitos) cannot be avoided in this type of environment. However, in an effort to offset the impact of this hazard, field personnel will have access to commercially available snake bite kits and insect repellents. Potential nesting areas in and about work areas shall be avoided to the greatest extent possible. Lastly, within recent years a marked increase in Lyme's Disease has been reported. Ticks have been shown to be the primary vector in the transmission of this disease. In an effort to control this hazard, close attention will be given during operations and decontamination with regard to personal hygiene to detect and remove any ticks from personnel.

### Overhead/Eye Hazards

Head protection (hard hats) will be required whenever and wherever potential overhead hazards are recognized, including when in the vicinity of any operating heavy machinery. Eye protection will be required wherever potential eye hazards are recognized.

### Inclement Weather

Incidents of inclement weather will be evaluated by the FTL, with input from the SSO, in regard to limiting or interrupting site operations. At a minimum, however, site operations will be interrupted in the event of electrical storms and other severe conditions (e.g. torrential rain, high wind, etc.).

### Test Pitting

- Entrance into a test pit is forbidden in all circumstances. If necessary, personnel must use remote samplers or collect samples from the backhoe bucket.
- Container sampling can occur during test pitting operations only with prior approval and written procedures from the HSO.
- Clean fill dirt must be located near all test pit locations prior to the beginning or start of the job. This soil is required to cover any ruptured drums, in order to reduce potential emissions.
- Personnel must not lean over test pits.
- All personnel must stand upwind of the test pits and away from the reach of the backhoe, tires, and outriggers.
- Personnel may not approach a test pit closer than 2 feet from the edge. Unstable pits must be sloped at the side to prevent cave-in.
- Open pits must be staffed by site personnel at all times.
- The backhoe operator must be instructed not to undermine the excavation.
- The SSO shall frequently inspect test pits for slide or cave-in potential.
- All work areas must be kept free of ground clutter.

### Noise Exposure

Elevated sound levels may be generated as a result of activities onsite which may cause hearing damage and/or be a hinderance to communication.

- Noise levels are not to exceed the 8-hour time-weighted average OSHA action level of 85 dBA without the use of hearing protection. As a general rule-of-thumb, hearing protection will be required if personnel standing approximately 2 feet apart cannot converse without raising their voices to be heard.

The use of hearing protection, either ear muffs or ear plugs, will be used during all noisy field activities (i.e. drilling, excavating) to effectively reduce noise levels.

## 5.0 AIR MONITORING

This section presents requirements for the use of real-time air monitoring instruments during site activities involving potential for exposure to site contaminants. It establishes the types of instruments to be used, the frequency of which they are to be used, techniques for their use, action levels for upgrading/downgrading levels of protection, and methods for instrument maintenance and calibration.

### 5.1 INSTRUMENTS AND USE

Air monitoring using a photoionization detector (PID) or a flame ionization detector (FID) will be conducted onsite in the breathing zone of high risk workers during subsurface explorations and during any other activity deemed necessary to determine the presence or absence of ionizable organic compounds.

The HNu-PI101, a PID, equipped with a 10.2 eV lamp, or the OVA Model 128 FID, will be used to detect the presence or absence of airborne ionizable chemical gases and vapors. The PID/FID will be calibrated and operated as outlined in the HNUS Standard Operating Procedures. The HNu does not detect methane. The OVA 128 does detect methane; if there are any sustained readings in the breathing zone using the OVA 128, the methane screening technique will be used to determine if there are other VOCs present. Respiratory protection upgrade need not occur if the readings are determined to be from methane and are less than 10% of the Lower Explosive Limit (LEL) reading.

A combustible gas (lower explosive limit (LEL) and oxygen (O<sub>2</sub>) alarm meter will be used to monitor levels of combustible gas and oxygen deficient atmospheres during subsurface activities. The LEL/O<sub>2</sub> meter will be calibrated using pentane (0.75 percent by volume in air) and operated as outlined in the HNUS Standard Operating Procedures. If airborne concentrations of flammable vapors exceed 10 percent or greater of the LEL, no work will take place until the source of the emission has been identified and control measures instituted or until vapor concentrations subside. Monitoring with the LEL/O<sub>2</sub> meter will only be necessary if there are sustained readings detected using the PID/FID air monitoring instrument.

In summary, the following air monitoring instruments will be utilized during the following tasks as specified above and in accordance with the action levels specified in Section 3.3:

- Site Walkovers/Survey - None
- Drilling/Excavations/Underground Drainage Systems Sampling - PID/FID monitor; LEL/O<sub>2</sub> monitor
- Soil & Groundwater Sampling/Debris Removal - PID/FID monitor.

**NOTE:** It should be realized that the sandblast grit and some of the other contaminants of concern are nondetectable using these types of screening instruments. Therefore, in addition to the use of these screening instruments, emphasis will also be given to visual observations, as these contaminants may present themselves as particulates (or may be bound to particulates). It is also the logic used in selecting respiratory protection as presented in Section 6.0.

### 5.2 MODIFICATION OF AIR MONITORING REQUIREMENTS

The air monitoring requirements presented in Section 5.1 are based upon the tasks presented in Section 1.3 and the assumption that the contaminants presented in Section 4.1 are the only contaminants which pose a reasonable health risk to site workers covered by this HASP. In the event that this assumption is found to be invalid, the requirements will be subject to change.

### 5.3 ACTION LEVELS

The following action levels will apply to this project:

#### PID/FID Monitor

0.0 ppm to 5 ppm	Level D*
5 ppm to 25 ppm	Level C*
Greater than 25 ppm	Level B
Less than 19.5% O <sub>2</sub>	Level B
Greater than 50 ppm	Stop work and contact CLEAN Health & Safety Manager

These action levels are based upon the assumption that volatile organic compounds typical of petroleum products will be the only air contaminants which pose a reasonable health risk to site workers. In the event that this assumption is suspected to be invalid, the action levels will be modified as appropriate.

\* These respiratory protection levels do not downgrade the respiratory protection requirements as presented in Section 6.0

### 5.4 INSTRUMENT MAINTENANCE AND CALIBRATION

Air monitoring instruments will be maintained and pre-field calibrated. Field calibration and operational checks will be conducted in accordance with the HNUS Standard Operating Procedures. Field maintenance will consist of daily cleaning of the instruments using a damp towel or rag to wipe off the instrument's outer casing and overnight battery recharging.

### 5.5 RECORDKEEPING

Instrument calibration notes and readings will be recorded in the respective instrument log. Instrument readings observed during site monitoring activities will be recorded in the field logbook. PID/FID readings above background in the breathing zone must be recorded in the field logbook. This should indicate the date, reading(s) observed, duration of readings, workers potentially affected, and actions taken to reduce exposures.

## 6.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

This section presents requirements for the use of personal protective equipment for each of the activities being conducted as defined in Section 3.0 and 4.1.5 of this HASP. This section includes anticipated levels of protection for each of the activities, the criteria used for selecting various levels of protection, and criteria for modifying levels of protection based on personal observations.

### 6.1 ANTICIPATED LEVELS OF PROTECTION

All work is anticipated to be performed in a Level C or D Protection, as defined in Appendix B of OSHA Standard 29 CFR 1910.120 - "Hazardous Waste Operations and Emergency Response." Where activities overlap, the more protective requirements will be applied.

#### 6.1.1 Mobilization/Demobilization/Site Walkover

Level D Respiratory Protection - (No respiratory protection).

Minimum requirements during these activities include steel-toe/shank work boots. Hardhat will be worn where the potential for overhead hazards may exist. Leather or cotton work gloves will be worn, as needed, to prevent cuts and abrasions when handling equipment.

#### 6.1.2 Drilling/Excavations/Soil Sampling/Underground Drainage Systems Sampling

Level C Respiratory Protection - full-face, air-purifying respirators, or powered air-purifying respirators (PAPRs), equipped with GMC-H or GCI-H filters. Respirators must be NIOSH-approved. Level C respiratory protection must be worn during these activities regardless of the modification criteria as presented in Section 4.3.

Minimum requirements during these activities include hard hat, steel-toe/shank work boots, Tyvek coveralls, disposable boot covers, nitrile, viton, or silvershield gloves over latex/nitrile inner gloves, eye protection, and hearing protection (to be worn when the potential for noise exposure exists). All ankle and wrist seams will be taped and all loose clothing will be secured. If activities present the potential for Tyvek to become saturated, PVC coveralls will be substituted.

#### 6.1.3 Well Development/Groundwater Sampling

Level D Respiratory Protection - (No respiratory protection)

Minimum requirements during these activities include steel-toe/shank work boots, Tyvek coveralls, disposable boot covers, and nitrile, viton, or silvershield gloves over latex or nitrile inner gloves, and eye protection/splash goggles. All ankle and wrist seams will be taped. If activities present the potential for Tyvek to become saturated, PVC coveralls will be substituted.

### 6.2 PPE SELECTION CRITERIA

Respiratory protection (Level C) was selected for use during intrusive activities due to the potential for exposure to sandblast grit/contaminant-laden particulates and potential volatile organic compounds that may cause adverse health effects. There is no analytical data collected for this site, therefore, a more conservative approach is necessary until the site is more completely characterized. Nitrile/Viton/Silvershield gloves were selected to provide protection against potential contamination that could be encountered and to help reduce dermal absorption and ingestion as a result of incidental hand to mouth contact. Hard hats, eye protection, and work boots were selected to provide protection against some of the physical hazards associated with heavy equipment and disposable boot covers

were selected to help minimize the spread of contamination. Tyvek coveralls were selected to minimize the potential for contamination of street clothes and PVC coveralls were selected for use in the event that drilling and/or sampling operations have the potential to result in the saturation of work clothes and dermal contact. Hearing protection was selected to protect against hearing loss due to working with or around drill rigs or other heavy equipment.

### **6.3 PPE MODIFICATION CRITERIA**

This section presents criteria for upgrading and downgrading chemical protective clothing (CPC) and/or respiratory protection. Where uncertainties arise, the more protective requirement will apply.

#### **6.3.1 CPC Modification Criteria**

Tyvek coveralls and boot covers must be worn anytime there is a reasonable potential for contamination of street clothes. Polyvinyl chloride (PVC) coveralls must be worn if there is a reasonable potential for saturation of work clothes.

Nitrile, viton, or silvershield gloves must be worn anytime there is a reasonable potential for contact with site contamination.

#### **6.3.2 Respiratory Protection Modification Criteria**

Level C respiratory protection consisting of full-face, air-purifying respirators, or powered air-purifying respirators, equipped with GMC-H or GMI-H filters must replace Level D respiratory protection if there are sustained readings in the breathing zone that are greater than 5 ppm and less than 25 ppm.

Level B respiratory protection (supplied-air) must be worn if there are sustained readings in the breathing zone that are greater than 25 ppm.

### **6.4 RESPIRATORY PROTECTION**

Due to the potential for exposure to possible human carcinogens and other harmful contaminants, respiratory protection is required for work at the site if monitoring instrument readings indicate the presence of volatile organic compounds in the breathing zones of the workers.

Respiratory protection will be modified, based on the following guidelines utilizing the most stringent guideline applicable. Monitoring instrument readings will be initiated at the source of potential emissions (e.g. borehole, excavations, well headspace, etc.) and then to the workers breathing zone (B.Z.) if readings are detected at the source.

Level D protection (no respiratory protection) with appropriate dermal protection will be adequate under the following conditions:

- No odors present, no source PID/FID readings above 5ppm, and no signs/symptoms of overexposure.
- Odors detected, but no source PID/FID readings detected above 5 ppm and no signs/symptoms of overexposure.
- Source PID/FID readings above background but no breathing zone FID readings above 5 ppm.

Level C protection consisting of full face, air-purifying respirators (APR) equipped with organic vapor cartridges along with appropriate dermal protection will be acceptable under the following conditions:

- Sustained readings above 5 ppm but less than 25 ppm at the source and in the

breathing zone.

Level B protection consisting of positive pressure, pressure demand supplied air respiratory equipment or SCBA and appropriate dermal protection will be required under the following conditions:

- Sustained FID readings in the breathing zone above 25 ppm
- Anytime any odor, irritation, or other discomfort is perceived while wearing an APR which would indicate cartridge failure or "breakthrough"

The respiratory protection action levels presented above are based on monitoring instrument sensitivities and warning properties of the anticipated site contaminants.

## **7.0 SITE CONTROL MEASURES**

Various site control measures are required to prevent accidental injury due to physical and chemical hazards presented by the work performed. These control measures are described in the following subsections.

### **7.1 WORK ZONES**

Various activities will be undertaken in each of the separate work areas. Each location will involve a separate site set-up. The exclusion zone will be designated as the specific sampling, drilling, or other such work location. During drilling work, this area will be designated by the use of ropes, flagging, or cones to control pedestrian traffic and the entrance of unauthorized personnel. Each work location will also contain a personnel decontamination station, as part of the Contamination Reduction Corridor (CRC)

The Support Zone, where the administrative, communications, and other support services will be based, will be in a controlled area spatially removed from site contamination.

### **7.2 SAFE WORKING PROCEDURES**

The following minimum safe working procedure must be complied with during the performance of work at the Site:

- Eating, drinking, chewing gum or tobacco, taking medication, and smoking are prohibited where the possibility for the transfer of contamination exists.
- Upon leaving the exclusion zone, hands and face must be thoroughly washed. Any protective outer clothing is to be removed and left at a designated area prior to entering the clean area.
- Contact with potentially contaminated substances must be avoided. Equipment must not be placed on potentially contaminated surfaces.
- All personnel and equipment must be thoroughly decontaminated prior to leaving the site.
- All personnel must review and understand the site-specific Health and Safety Plan prior to commencing work on site.
- All personnel must satisfy training requirements and medical monitoring procedures as specified by OSHA regulations referenced in 29 CFR 1910.120.
- No flames or open fires will be permitted on site.
- No drilling within 20 feet in any direction of overhead power lines will be permitted. Additionally, all underground utilities must be positively identified and marked prior to drilling or excavating.
- Personnel must develop hand signals with the driller.
- A copy of the attached OSHA Job Safety poster must be prominently posted at each work site.

## 8.0 DECONTAMINATION

All personnel and re-usable equipment which comes into contact with potentially contaminated materials must be decontaminated prior to removal from the site. These decontamination procedures are described in the following subsections.

### 8.1 PERSONNEL DECONTAMINATION REQUIREMENTS

Exclusion Zone Crew: Prior to leaving the exclusion zone, personnel will briefly remove gross contamination from external clothing using decontamination equipment on hand. These individuals may then return to the contamination reduction zone and a thorough decontamination will be performed.

Support Crew: The support personnel will first assist drilling and other personnel through decontamination. The support personnel will then move through similar decontamination steps.

The decontamination of personnel and their protective clothing shall be performed in three stages:

Stage 1 includes removing contamination from reusable protective clothing with a detergent/water solution and soft bristle scrub brushes.

Stage 2 shall include removal of disposable protective clothing and double bagging for disposal. (Contaminated clothing will be bagged and left onsite for disposal by Coast Guard personnel.)

Stage 3 shall consist of workers washing hands and face with potable water and soap each time they leave the exclusion zone.

### 8.2 EQUIPMENT DECONTAMINATION

#### Monitoring Equipment:

All monitoring equipment will, to the extent possible, be wrapped and sealed in plastic with only the controls, readouts, and intake and exhaust ports open to the atmosphere. If decontamination of monitoring equipment is required, the following procedure will be utilized:

- remove gross contamination with potable water
- potable water/liquinox light wash
- light rinse with potable water
- remove plastic covering
- wipe dry immediately with disposable towels

#### Drilling and Other Heavy Equipment

Drill rigs, augers, and excavation equipment will be decontaminated by steam cleaning following arrival on site, and after completion of each boring or excavation.

#### Sampling Equipment

All devices or implements which actually contact the samples collected for laboratory analysis will be decontaminated after each use in accordance with the following procedure:

- remove gross contamination with potable water
- potable water/liquinox scrub
- rinse with potable water

- rinse with methanol, air dry
- rinse with deionized water, air dry
- wrap with aluminum foil (dull side toward equipment)

## **9.0 MEDICAL SURVEILLANCE/TRAINING REQUIREMENTS**

### **9.1 REQUIREMENTS FOR HNUS PERSONNEL**

All HNUS personnel participating in project field activities will have had a physical examination meeting the requirements of HNUS' medical surveillance program and will be medically qualified to perform hazardous waste site work using respiratory protection.

Documentation for medical clearances can be obtained from the HNUS HSO.

### **9.2 REQUIREMENTS FOR SUBCONTRACTORS**

Subcontractors are required to obtain a certificate of their ability to perform hazardous waste site work and to wear respiratory protection. The "Subcontractor Medical Approval Form" (Figure 9-1) must be used to satisfy this requirement providing it is properly completed and signed by a licensed physician.

### **9.3 INTRODUCTORY AND REFRESHER TRAINING**

#### **9.3.1 Requirements for Halliburton NUS Personnel**

All HNUS personnel must complete 40 hours of introductory hazardous waste site training prior to performing work under this Derecock Shipyard Remedial Investigation (RI) in Newport, Rhode Island. Additionally, HNUS personnel who have had introductory training more than 12 months prior to site work must have completed 8 hours of refresher training within the past 12 months before being cleared for site work. Supervisory training is required of any onsite personnel directly responsible for, or who supervise, employees working onsite.

Documentation of HNUS introductory, refresher and supervisory training can be obtained through the HSO. Copies of certificates or other official documentation will be used to fulfill this requirement.

#### **9.3.2 Requirements for Subcontractors**

All HNUS subcontractor personnel must have completed introductory hazardous waste site training or equivalent work experience as defined in OSHA Standard 29 CFR 1910.120(e) and 8 hours of refresher training meeting the requirements of 29 CFR 1910.120(e)(8) prior to performing work under this Derecock Shipyard Remedial Investigation (RI) in Newport, Rhode Island. Additionally, supervisory training is required of any onsite personnel directly responsible for, or who supervise, employees working onsite. HNUS subcontractors must certify that each employee has had such training by sending HNUS a letter, on company letterhead, containing the information in the example letter provided as Figure 9-2. Copies of training certificates will not be accepted as a substitute for the official letter but may be provided as supporting documentation.

### **9.4 SITE-SPECIFIC TRAINING**

HNUS will provide site-specific training to all HNUS employees and subcontractor personnel who will perform work at this project. This training will only be provided once and personnel who do not attend will not be permitted to perform work at the Derecock Shipard RI work area. Site-specific training will include:

**FIGURE 9-1  
SUBCONTRACTOR MEDICAL APPROVAL FORM**

For employees of

\_\_\_\_\_ Company Name

Participant Name: \_\_\_\_\_

Date of Exam: \_\_\_\_\_

**Part A**

The above-named individual has:

1. Undergone a physical examination in accordance with OSHA Standard 29 CFR 1910.120, paragraph (f) and found to be medically -

- qualified to perform work at the **Derecktor Shipyard** work site
- not qualified to perform work at the **Derecktor Shipyard** work site

and,

2. Undergone a physical examination as per OSHA 29 CFR 1910.134(b)(10) and found to be medically -

- qualified to wear respiratory protection
- not qualified to wear respiratory protection

My evaluation has been based on the following information, as provided to me by the employer.

- A copy of OSHA Standard 29 CFR 1910.120 and appendices.
- A description of the employee's duties as they relate to the employee's exposures.
- A list of known/suspected contaminants and their concentrations (if known).
- A description of any personal protective equipment used or to be used.
- Information from previous medical examinations of the employee which is not readily available to the examining physician.

**Part B**

I, \_\_\_\_\_, have examined \_\_\_\_\_  
Physician's Name (print) Participant's Name (print)

and have determined the following information:

**FIGURE 9-1  
SUBCONTRACTOR MEDICAL APPROVAL FORM  
PAGE TWO**

1. Results of the medical examination and tests as they pertain to site work (excluding finding or diagnoses unrelated to occupational exposure):

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2. Any detected medical conditions which would place the employee at increased risk:

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3. Recommended limitations upon the employee's assigned work:

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I have informed this participant of the results of this medical examination and any medical conditions which require further examination or treatment.

Based on the information provided to me, and in view of the activities and hazard potentials involved at the **Derecktor Shipyard** work site, this participant

- may  
 may not

perform his/her assigned task.

**FIGURE 9-1  
SUBCONTRACTOR MEDICAL APPROVAL FORM  
PAGE THREE**

Physician's Signature \_\_\_\_\_

Address \_\_\_\_\_

Phone Number \_\_\_\_\_

NOTE: Copies of test results are maintained and available at:

\_\_\_\_\_

\_\_\_\_\_

Address

**FIGURE 9-2  
OSHA TRAINING CERTIFICATION**

The following statements must be typed on company letterhead and signed by an officer of the company:

LOGO  
XYZ CORPORATION  
555 E. 5th Street  
Nowheresville, Kansas 55555

Month, day, year

Mr. Stephen Parker  
Project Manager  
Halliburton NUS Corporation  
55 Jonspin Road  
Wilmington, MA 01887

Subject: Hazardous Waste Site Training

Dear Mr. Parker:

The employees listed below have had introductory hazardous waste site training or equivalent work experience as required by 29 CFR 1910.120(e) and those employees listed below who have received their introductory training more than 12 months ago have also received 8 hours of refresher training in accordance with 29 CFR 1910.120 (e)(8). In addition, supervisory training is required of any onsite personnel directly responsible for, or who supervise, employees working onsite.

**LIST FULL NAMES OF EMPLOYEES**

Should you have any questions, please contact me at (555) 555-5555.

Sincerely,

(Name of Company Officer)

- Names of personnel and alternates responsible for site safety and health
- Safety, health and other hazards present on-site
- Use of personal protective equipment
- Work practices to minimize risks from hazards
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- The contents of the health and safety plan, and addendums, if any.
- Review of relevant MSDSs

#### **9.4.1 Site-Specific Training Documentation**

HNUS and subcontractor personnel will be required to sign a statement indicating receipt of site-specific training and understanding of site hazards and control measures. Refer to Attachment A for the site-specific training document.

## **10.0 EMERGENCY RESPONSE PLAN**

This emergency response plan has been prepared to accommodate requirements presented in 29CFR 1910.120. A copy of this Emergency Response Plan must remain on site at all times when work is in progress.

### **10.1 ANTICIPATED SITE EMERGENCIES**

Compliance with this HASP can assist in the prevention of anticipated site emergencies. There are several emergencies which can reasonably be anticipated during the RI activities at the Site, to include:

- Personal Injury/Illness
- Incipient Stage, non-structural fires (Class A or B)
- Unwanted chemical releases/exposures

These emergency situations can easily be recognized by visual observations, worker complaints or monitoring instruments. A chemical release shall be considered an emergency when it is sufficient to affect unprotected personnel, including site workers and the public.

### **10.2 PERSONNEL ROLES AND LINES OF AUTHORITY**

The SSO or alternate is responsible for initiating and coordinating emergency response actions during emergencies.

The FTL or alternate is responsible for assisting the SSO in notifying the appropriate outside emergency assistance, as needed, in accordance with Figure 10-1. Figure 10-2 depicts directions to the local hospital.

### **10.3 SAFE DISTANCES AND EVACUATION ROUTES**

All support personnel will remain a minimum of 100 feet upwind of all work and sample locations. All approaches to the sampling crews will be made from the upwind direction. The SSO shall continuously monitor prevailing wind direction and advise support or response crews accordingly.

Safe distances for unprotected personnel are to be determined by the FTL/SSO on an emergency specific basis. Considerations shall include wind direction and site topography. The FTL shall post evacuation routes and meeting points, for each work area, at the site command post.

### **10.4 SITE SECURITY AND CONTROL**

All crews will maintain observation of the area where work is being undertaken to assure that no inadvertent exposure to unauthorized and untrained personnel will occur. The contamination reduction and exclusion zones will be clearly marked to exclude unauthorized and unprotected persons from these areas.

A daily visitors log will be maintained to assure that all workers are accounted for during emergency response actions.

### **10.5 RESPONSE PROCEDURES**

The information provided in this subsection is presented as a guideline to assist the FTL and SSO in safe and effective response to anticipated site emergencies. This information is in no way designed to take the place of reasonable decisions based on incident-specific information.

### First Priority

Prevent further injury or illness by:

- Protecting response personnel
- Isolating the scene to authorized personnel only
- Rescuing the injured parties
- Notifying Outside Emergency Assistance

### Second Priority

Provide first-aid to those persons with life threatening injuries or illnesses.

### Third Priority

Alleviate the immediate hazards by:

- Extinguishing incipient stage fires
- Reducing chemical releases

### Fourth Priority

Provide first-aid to those persons with non-life threatening injuries or illnesses and further efforts to alleviate the hazard.

### Last Priority

Complete an incident report, critique the response and prevent recurrence. All persons with known or suspected chemically related injuries or illnesses shall be immediately examined by a licensed physician. The examining physician may choose to consult with the Halliburton NUS medical consultant for additional expertise on occupational injury/illness.

## **10.6 EMERGENCY EQUIPMENT**

This section provides guidelines for maintaining and selecting the appropriate PPE and emergency equipment for response to anticipated site emergencies.

Incipient Stage, Non-structural Fires (Class A or B)

- Class A,B,C Fire Extinguisher.
- Approach from up-wind side.
- No special PPE required unless fire has moved out of its incipient stage to an uncontrolled burn or if upwind approach is not possible. In either of these cases, do not attempt to extinguish the flames.

Personal Injury or Illness

- First-aid kit, eyewash station

## **10.7 EMERGENCY REPORTING**

Emergency reporting functions shall be the responsibility of the FTL. The FTL will become thoroughly familiar with this plan prior to the initiation of any site work activities.

In the event that an emergency incident occurs and offsite response assistance is necessary, the FTL shall contact the appropriate agency(s) presented in Figure 10-1.

**FIGURE 10-1**

**EMERGENCY REFERENCE INFORMATION**

AMBULANCE	911
POLICE	911
FIRE DEPARTMENT	911
NEAREST PHONE	Cellular Phone (508) 989-3702
PROJECT MANAGER*	Stephen S. Parker (508) 658-7899
SSO*	Janet Pillion (508) 658-7899
ALTERNATE SSO	TBA

**EMERGENCY CONTACTS (Medical & Health)**

Halliburton NUS Consulting Physician:	Health Resources Office: (617) 935-8581
CLEAN Health & Safety Manager:	Matthew Soltis, CSP, CIH Office: (412) 921-8912
Director of Industrial Hygiene & Safety:	Tom Samson, CIH Office: (713) 575-4562

National Response Center (for Environmental Emergency Only): 1-800-424-8802  
Halliburton NUS Wilmington, MA Office: (508) 658-7899

**Directions to Hospital:**

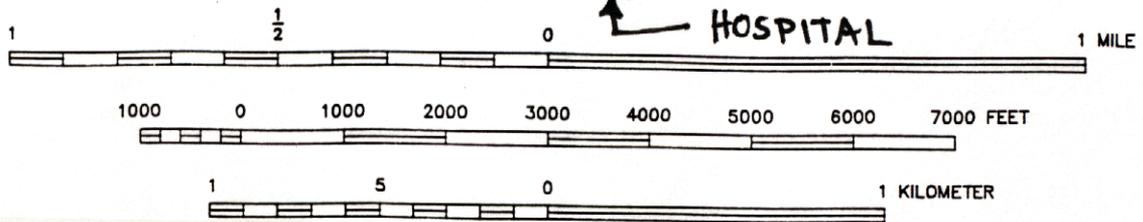
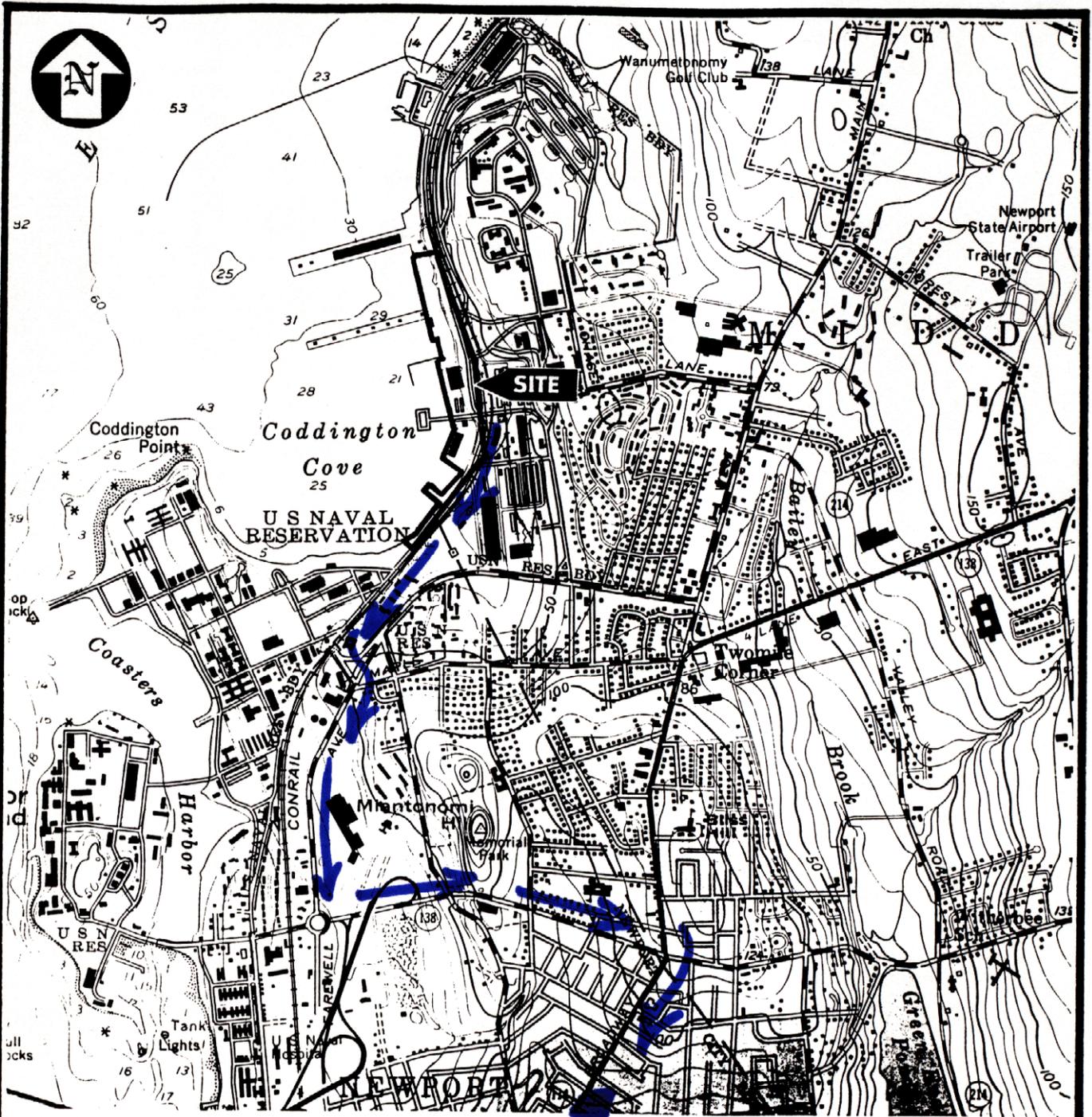
Take a right onto Defense Highway/Connell Memorial Road from the site.

Take a left onto Admiral Kalbius Road.

Take a right onto Route 114/138 (South).

The Newport Hospital will be on your left.

Note: Individuals must be contacted in all cases of accident, injury, or emergency.



**HOSPITAL MAP**  
**DERECKTOR SHIPYARD**  
**NEWPORT, RHODE ISLAND**



00232602Y

## 11.0 SPILL CONTAINMENT PROCEDURES

It is possible that decontamination solutions could spill during transport to/from the site and during use at the site. Containers will be stored in chemically compatible pans/trays for containment. All investigation derived waste (IDW) generated as a result of the investigation actions, including all the boring and well installations, decontamination, and inadvertent spills will be disposed of off site by HNUS unless otherwise directed by the Navy.

The procedures defined in this section comprise the spill containment program in place for HNUS activities at the site.

### 11.1 SPILL CONTROL

- Drums and containers used during site activities shall meet the appropriate DOT, OSHA, and EPA regulations for the wastes that they contain.
- Drums and containers shall be inspected and their integrity assured prior to being moved. Drums or containers that cannot be inspected before being moved because of storage conditions (i.e. buried, stacked behind other drums or several tiers high, etc.) shall be moved to an accessible location and inspected prior to further handling.
- Unlabeled drums and containers shall be considered to contain hazardous substances and handled accordingly until the contents are positively identified and labeled.
- Site operations shall be organized to minimize the amount of drum or container movement.
- Prior to movement of the drums or containers, all employees involved shall be warned of the potential associated hazards.
- Where spills, leaks, or ruptures may occur, adequate quantities of spill containment equipment (absorbent, pillows, etc.) will be stationed in the immediate area. The spill containment program must be sufficient to contain and isolate the entire volume of hazardous substances being handled.
- Drums or containers that cannot be moved due to their integrity, shall be emptied into a sound container.
- Fire extinguishing equipment meeting 29 CFR part 1910, subpart L, shall be on hand and ready if needed.

It is not anticipated that bulk hazardous materials will be handled as part of this scope of work such that spillage would constitute a danger to human health or the environment.

## 12.0 OTHER MISCELLANEOUS REQUIREMENTS

### Materials and Document

The HNUS FTL shall ensure the following materials/documents are taken to the project site and utilized as required.

- Incident Reports
- Material Safety Data Sheets for decontamination solutions and other substances brought to the site
- Follow-Up Reports (to be completed by the FT)
- OSHA Job Safety and Health Poster (posted in site trailer)
- Site-specific Training Documentation Form
- First Aid Supply Usage Form
- Emergency Reference Posting

**HASP ATTACHMENT A**  
**HASP REVIEW FORM**



**HASP ATTACHMENT B**  
**MATERIAL SAFETY DATA SHEETS**

# MATERIAL SAFETY DATA SHEET

## SECTION I - MATERIAL IDENTIFICATION

**PRODUCT NUMBER & NAME:** HT12 24/11 OZ GAS LINE A/F  
**CHEMICAL FAMILY:** ALIPHATIC ALCOHOL  
**TRADE NAME/SYNONYMS:** METHANOL, METHYL ALCOHOL, WOOD ALCOHOL, CARBINOL  
**NFPA CODE:** HEALTH=2; FLAMMABILITY=3; REACTIVITY=0  
**HMS CODE:** HEALTH=3; FLAMMABILITY=3; REACTIVITY=0  
**MANUFACTURER/DISTRIBUTOR:** GOLD EAGLE CO.  
 4400 S. KILDARE BLVD.  
 CHICAGO, IL 60632-4372  
**PRODUCT INFO:** 1-312-376-4400 **EMERGENCY INFO:** 1-800-535-5053 (INFOTRAC)

DATE ISSUED: 6/15/90  
 REVISED FROM: / /  
 PREPARED BY: M.P.  
 NA = NOT APPLICABLE  
 ND = NO DATA  
 NE = NOT ESTABLISHED  
 CTRL DATE: 01/23/91  
 PRODUCT: HT12

## SECTION II - HAZARDOUS INGREDIENTS/SARA 313 INFORMATION

COMPONENTS	CAS NUMBER	PERCENT	PEL/TVA	AGENCY
* METHYL ALCOHOL	67-56-1	100.0	200 PPM	NIOSH

THIS PRODUCT CONTAINS THE FOLLOWING CHEMICALS SUBJECT TO THE REPORTING REQUIREMENTS OF SARA 313 AND 40 CFR 372:

CAS NUMBER	(%)	CAS NUMBER	(%)
* METHANOL	67-56-1	100.0	

## SECTION III - PHYSICAL/CHEMICAL CHARACTERISTICS

**BOILING POINT:** 64 C (147) **SPECIFIC GRAVITY (H2O=1):** 0.795  
**VAPOR DENSITY (AIR=1):** 1.1 **EVAPORATION RATE:** 3.5  
**SOLUBILITY IN WATER:** SOLUBLE **% VOLATILES BY VOLUME:** 100  
**UNDILUTED PRODUCT pH:** NA **VAPOR PRESSURE mmHg:** 96  
**APPEARANCE AND ODOR:** CLEAR

**OTHER:** WATER WHITE LIQUID

### PHYSICAL HAZARD CLASSIFICATION (PER 29 CFR PART 1910.1200)

NO	COMBUSTIBLE	YES	FLAMMABLE	NO	PYROPHORIC
NO	COMPRESSED GAS	NO	ORGANIC PEROXIDE	NO	REACTIVITY
NO	EXPLOSIVE	NO	OXIDIZER	YES	STABLE

## SECTION IV - FIRE AND EXPLOSION HAZARD DATA

**FLASH POINT (CC):** 52 F. (12 C)  
**FLASH POINT (PMCC):** NA  
**FIRE POINT (CC):** NE  
**FLAMMABLE LIMITS (% BY VOLUME IN AIR):** LOWER: 6.0 UPPER: 36.5  
**EXTINGUISHING MEDIA:** DRY CHEMICAL, CO2, WATER SPRAY, FOAM  
**SPECIAL FIRE FIGHTING PROCEDURE:** SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.  
**UNUSUAL FIRE OR EXPLOSIVE HAZARD:** RUNOFF TO SEWER MAY CREATE FIRE OR EXPLOSION HAZARD.

## SECTION V - REACTIVITY DATA

**STABILITY:** STABLE  
**CONDITIONS CONTRIB. TO INSTABILITY:** HEAT, OPEN FLAME, SOURCES OF IGNITION  
**INCOMPATIBILITY (MATERIALS TO AVOID):** STRONG OXIDIZERS  
**HAZARDOUS DECOMPOSITION PRODUCTS:** CO, CO2  
**HAZARDOUS POLYMERIZATION:** WILL NOT OCCUR

CTRL GROUP: OSM

# MATERIAL SAFETY DATA SHEET

## SECTION VI - HEALTH HAZARD DATA

### HEALTH HAZARD CLASSIFICATION (PER 29 CFR PART 1910.1200)

(no) ) CARCINOGEN (no) ) MUTAGEN (no) ) IRRITANT (no) ) TARGET ORGAN  
(no) ) ANIMAL CARCINOGEN (no) ) HIGHLY TOXIC (no) ) SENSITIZER  
(no) ) SUSPECT CARCINOGEN (no) ) CORROSIVE (no) ) TERATOGEN  
PRODUCT LISTED AS CARINOGEN OR POTENTIAL CARCINOGEN BY:  
(no) ) NTP (no) ) IARC (no) ) OSHA (no) ) OTHER

### ACUTE EXPOSURE SYMPTOMS:

**INHALATION:** POISONOUS; MAY BE FATAL, IF INHALED AT HIGH VAPOR LEVELS.

**SKIN CONTACT:** SKIN IRRITANT

**EYE CONTACT:** EYE IRRITANT

**INGESTION:** POISONOUS, IF SWALLOWED

**CHRONIC EXPOSURE:** HIGH CONCENTRATIONS OF METHANOL SWALLOWED OR INHALED CAN PRODUCE HEADACHE, DROWSINESS, LIGHTHEADNESS, NAUSEA, BLINDNESS, AND DEATH.

**MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE:** NONE KNOWN

### FIRST AID AND EMERGENCY PROCEDURES FOR ACUTE EXPOSURE:

**INHALATION:** MOVE VICTIM TO FRESH AIR/CALL MEDICAL PERSONNEL. IF NOT BREATHING PERFORM ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.

**SKIN CONTACT:** IMMEDIATELY FLUSH SKIN WITH RUNNING WATER FOR AT LEAST 15 MINUTES. SEEK MEDICAL ATTENTION, IF NEEDED.

**EYE CONTACT:** FLUSH EYES WITH RUNNING WATER FOR AT LEAST 15 MINUTES. SEEK MEDICAL ATTENTION, IF NEEDED.

**INGESTION:** GET IMMEDIATE MEDICAL ATTENTION. IF VICTIM IS CONSCIOUS, USE SYRUP OF IPECAC OR OTHER METHOD TO MAKE VICTIM VOMIT.

## SECTION VII - SPILL OR LEAK PROCEDURES

**PROCEDURE IF MATERIAL IS SPILLED:** REMOVE SOURCES OF HEAT OR IGNITION. PROVIDE ADEQUATE VENTILATION. CONTAIN LEAK.

**SMALL SPILL:** ABSORB WITH SUITABLE MATERIAL, SUCH AS OIL DRY, SAND OR OTHER ABSORBENT, INERT, NON-COMBUSTIBLE MATERIAL.

**LARGE SPILL:** CONTAIN SPILL, TRANSFER TO SECURE CONTAINERS. IN THE EVENT OF AN UNCONTROLLED MATERIAL RELEASE, THE USER SHOULD DETERMINE IF RELEASE IS REPORTABLE UNDER APPLICABLE LAWS AND REGULATIONS.

**WASTE DISPOSAL:** DISPOSE OF PRODUCT IN ACCORDANCE WITH LOCAL, STATE, AND FEDERAL REGULATIONS. BEFORE ATTEMPTING CLEAN UP, REFER TO OTHER SECTIONS OF MSDS FOR HAZARD CAUTION INFORMATION.

## SECTION VIII - SPECIAL PROTECTION INFORMATION

### VENTILATION REQUIREMENTS:

PROVIDE PROPERLY ENGINEERED VENTILATION TO MAINTAIN METHANOL VAPORS BELOW NIOSH PEL.

### SPECIFIC PERSONNEL PROTECTIVE EQUIPMENT:

**RESPIRATORY:** NIOSH APPROVED RESPIRATOR FOR CONCENTRATION > 200 PPM.

**SKIN:** SOLVENT RESISTANT GLOVES.

**EYES:** SPLASH PROOF SAFETY GOGGLES.

### OTHER CLOTHING OR EQUIPMENT:

CHEMICAL RESISTANT APRON OR CLOTHING AS NEEDED.

DATE ISSUED: 06/18/90  
REVISED FROM: / /  
PREPARED BY: M.P.  
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CTRL DATE: 01/23/91  
PRODUCT: HT12

CTRL GROUP: OSM

# MATERIAL SAFETY DATA SHEET

## SECTION XI - TRANSPORTATION AND SPECIAL PRECAUTIONS

**STORAGE:** STORE IN COOL, DRY AREA. AVOID HEAT, SPARKS AND SOURCE OF IGNITION.

**CAUTION:** FLASH POINT IS 54 F., VAPORS MAY TRAVEL TO SOURCE OF IGNITION AND FLASHBACK, CONTAINER MAY EXPLODE IN HEAT OF FIRE.

**SHIPPING INFORMATION:**  
PROPER SHIPPING NAME : CONSUMER COMMODITY  
DOT HAZARD CLASS : ORM-D  
DOT ID NUMBER (UN NO.) : NONE ASSIGNED  
IMO CLASS : NA  
ICAO CLASS : 3 - 6.1  
EPA HAZARD SUBSTANCES : METHYL ALCOHOL  
PRECAUTIONARY LABELS : CPSC 9010.125 - APPENDIX I

### ENVIRONMENTAL DATA - SARA TITLE III:

#### SECTION 302(A) - EXTREMELY HAZARDOUS SUBSTANCES

COMPONENTS	CAS NUMBER	PERCENT	RQ LBS	TPQ LBS
METHYL ALCOHOL	67-56-1	> 99.0	5000	NA

(RQ = REPORTABLE QUANTITY) (TPQ = THRESHOLD PLANNING QUANTITY)

#### CLEAN WATER ACT:

UNDER SECTION 311 (b)(4) OF THE CLEAN WATER ACT, DISCHARGES OF CRUDE OIL AND PETROLEUM PRODUCTS OF ANY KIND OR FORM TO SURFACE WATERS MUST BE IMMEDIATELY REPORTED TO THE NATIONAL RESPONSE CENTER: 1-800-424-8802

#### CERCLA - SECTION 102 HAZARDOUS SUBSTANCES

COMPONENTS	CAS NUMBER	PERCENT	RQ LBS
	67-56-1	> 99.0	5000

(RQ = REPORTABLE QUANTITY)

## SECTION X - DISCLAIMER

INFORMATION PRESENTED HEREIN IS BELIEVED TO BE FACTUAL, AS IT HAS BEEN DERIVED FROM THE WORKS AND OPINIONS OF PERSONS BELIEVED TO BE QUALIFIED EXPERTS. HOWEVER, NOTHING CONTAINED IN THIS INFORMATION IS TO BE TAKEN AS WARRANTY OR REPRESENTATION FOR WHICH THE GOLD EAGLE CO. BEARS LEGAL RESPONSIBILITY. THE USER SHOULD REVIEW ANY RECOMMENDATIONS IN THE SPECIFIC CONTEXT OF THE INTENDED USE TO DETERMINE WHETHER THEY ARE APPROPRIATE.

DATE ISSUED: 06/18/90  
REVISED FROM: / /  
PREPARED BY: M.P.  
NA = NOT APPLICABLE  
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CTRL DATE: 01/23/91  
PRODUCT: HT12

CTRL GROUP: OSM

**Material Safety Data Sheet**

Required under USDL Safety and Health Regulations for Shipyard Employment (29 CFR 1915)

*ALLIUM TOWLER DETERGENT*  
**U.S. Department of Labor**  
 Occupational Safety and Health Administration

*04-322-4*



OMB No. 1218-0074  
 Expiration Date 05/31/86

PREPARED 1/2/85

**Section I**

Manufacturer's Name <b>ALCONOX, INC.</b>		Emergency Telephone Number <b>(212) 473-1300</b>	
Address (Number, Street, City, State, and ZIP Code) <b>215 PARK AVENUE SOUTH</b>		Chemical Name and Synonyms <b>N.A.</b>	
<b>NEW YORK, N.Y. 10003</b>		Trade Name and Synonyms <b>ALCONOX</b>	
		Chemical Family <b>ANIONIC DETERGENT</b>	
		Formula <b>N.A.</b>	

**Section II - Hazardous Ingredients**

Paints, Preservatives, and Solvents		% TLV (Units)		Alloys and Metallic Coatings		% TLV (Units)	
Pigments	NONE			Base Metal	NONE		
Catalyst	NONE			Alloys	NONE		
Vehicle	NONE			Metallic Coatings	NONE		
Solvents	NONE			Filler Metal Plus Coating or Core Flux	NONE		
Additives	NONE			Others	NONE		
Others	NONE						

**Hazardous Mixture of Other Liquids, Solids or Gases**

		% TLV (Units)	
NONE			

**RECEIVED**  
**AUG 1985**  
**RECEIVED**

**Section III - Physical Data**

Boiling Point (°F)	N.A.	Specific Gravity (H <sub>2</sub> O=1)	N.A.
Vapor Pressure (mm Hg.)	N.A.	Percent Volatile by Volume (%)	N.A.
Vapor Density (AIR=1)	N.A.	Evaporation Rate	N.A.

**Solubility in Water**

**APPRECIABLE**

**Appearance and Odor**

**WHITE POWDER INTERSPERSED WITH CREAM COLORED FLAKES - ODORLESS**

**Section IV - Fire and Explosion Hazard Data**

Flash Point (Method Used)	NONE	Flammable Limits	N.A.	Let	N.A.	Uel	N.A.
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**Extinguishing Media WATER, CO<sub>2</sub>, DRY CHEMICAL, FOAM, SAND/EARTH**

**Special Fire Fighting Procedures**

**FOR FIRES INVOLVING THIS MATERIAL, DO NOT ENTER WITHOUT PROTECTIVE EQUIPMENT AND SELF CONTAINED BREATHING APPARATUS**

**Unusual Fire and Explosion Hazards**

**NONE**

Section V - Health Hazard Data

Threshold Limit Value

NO DATA AVAILABLE - TREAT AS NUISANCE DUST

*ALCOXOX POWDER  
04-372-4  
04-372-5B, 5C, 5D*

Effects of Overexposure

PROLONGED EXPOSURE TO DUST MAY IRRITATE MUCOUS MEMBRANES

Emergency First Aid Procedures

EYES - FLUSH WITH PLENTY OF WATER FOR 15 MINUTES. SKIN-FLUSH WITH PLENTY OF WATER. INGESTION - DRINK LARGE QUANTITIES OF WATER TO DILUTE MATERIAL. GET MEDICAL ATTENTION FOR DISCOMFORT.

Section VI - Reactivity Data

Stability	Unstable	Conditions to Avoid	NONE
	Stable X		

Incompatibility (Materials to Avoid)

AVOID STRONG ACIDS

Hazardous Decomposition Products

MAY RELEASE CO<sub>2</sub> GAS ON BURNING

Hazardous Polymerization	May Occur	Conditions to Avoid	NONE
	Will Not Occur X		

Section VII - Spill or Leak Procedures

Steps to be Taken in Case Material is Released or Spilled

MATERIAL FOAMS PROFUSELY, SHOVEL AND RECOVER

AS MUCH AS POSSIBLE, RINSE REMAINDER TO SEWER. MATERIAL IS COMPLETELY BIODEGRADABLE.

Waste Disposal Method

SMALL QUANTITIES MAY BE DISPOSED OF IN SEWER. LARGE QUANTITIES SHOULD BE DISPOSED OF ACCORDING TO LOCAL REQUIREMENTS FOR NON-HAZARDOUS DETERGENT

Section VIII - Special Protection Information

Respiratory Protection: Specify Type

DUST MASK

Ventilation	Local Exhaust	NORMAL	Special	N.A.
	Mechanical (General)	N.A.	Other	N.A.

Protective Gloves

USEFUL - NOT REQUIRED

Eye Protection

USEFUL - NOT REQUIRED

Other Protective Equipment

NOT REQUIRED

Section IX - Special Precautions

Precautions to be Taken in Handling and Storing

SHOULD BE STORED IN A DRY AREA TO PREVENT CAKING

Other Precautions

NO SPECIAL REQUIREMENTS OTHER THAN THE GOOD INDUSTRIAL HYGIENE AND SAFETY PRACTICES EMPLOYED WITH ANY INDUSTRIAL CHEMICAL.

\*\*HYDROCHLORIC ACID, CONCENTRATED (36-37  
\*\*HYDROCHLORIC ACID, CONCENTRATED (36-37  
\*\*HYDROCHLORIC ACID, CONCENTRATED (36-37

-----  
MATERIAL SAFETY DATA SHEET

FISHER SCIENTIFIC  
CHEMICAL DIVISION  
1 REAGENT LANE  
FAIR LAWN NJ 07410  
(201) 796-7100

EMERGENCY NUMBER: (201) 796-7100  
CHEMTREC ASSISTANCE: (800) 424-9300

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-----  
SUBSTANCE IDENTIFICATION

CAS-NUMBER 7647-01-0

SUBSTANCE: \*\*HYDROCHLORIC ACID, CONCENTRATED (36-37%)\*\*

## TRADE NAMES/SYNONYMS:

CHLOROHYDRIC ACID; HYDROCHLORIDE; MURIATIC ACID; SPIRITS OF SALT;  
HYDROCHLORIC ACID, CONCENTRATED; HYDROGEN CHLORIDE, 23 EB; UN 1789; A-142;  
A-144; A-508; A-466;

CHEMICAL FAMILY:  
INORGANIC ACID

MOLECULAR FORMULA: H-CL

MOLECULAR WEIGHT: 36.46

CERCLA RATINGS (SCALE 0-3): HEALTH=3 FIRE=0 REACTIVITY=1 PERSISTENCE=0  
NFPA RATINGS (SCALE 0-4): HEALTH=3 FIRE=0 REACTIVITY=0

-----  
COMPONENTS AND CONTAMINANTS

COMPONENT: HYDROGEN CHLORIDE PERCENT: 37

COMPONENT: WATER PERCENT: 63

OTHER CONTAMINANTS: NONE

## EXPOSURE LIMITS:

HYDROGEN CHLORIDE (HYDROCHLORIC ACID):

5 PPM OSHA CEILING  
5 PPM ACGIH CEILING

500 POUNDS SARA SECTION 302 THRESHOLD PLANNING QUANTITY (GAS)  
5000 POUND SARA SECTION 304 REPORTABLE QUANTITY (GAS)  
5000 POUNDS CERCLA SECTION 103 REPORTABLE QUANTITY (LIQUID)  
SUBJECT TO SARA SECTION 313 ANNUAL TOXIC CHEMICAL RELEASE REPORTING

-----  
PHYSICAL DATA

DESCRIPTION: COLORLESS OR SLIGHTLY YELLOW FUMING LIQUID WITH A PUNGENT  
ODOR. BOILING POINT: 384 F (196 C) SPECIFIC GRAVITY: 1.2  
VAPOR PRESSURE: NOT AVAILABLE PH: 1.1 (0.1 N)  
SOLUBILITY IN WATER: SOLUBLE VAPOR DENSITY: 1.3

-----  
FIRE AND EXPLOSION DATA

FIRE AND EXPLOSION HAZARD:  
NEGLECTIBLE FIRE HAZARD WHEN EXPOSED TO HEAT OR FLAME.

FIREFIGHTING MEDIA:  
DRY CHEMICAL, CARBON DIOXIDE, WATER SPRAY OR REGULAR FOAM  
(1990 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.5).

FOR LARGER FIRES, USE WATER SPRAY, FOG OR REGULAR FOAM  
(1990 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.5).

FIREFIGHTING:  
MOVE CONTAINER FROM FIRE AREA IF YOU CAN DO IT WITHOUT RISK. APPLY COOLING  
WATER TO SIDES OF CONTAINERS THAT ARE EXPOSED TO FLAMES UNTIL WELL AFTER FIRE  
IS OUT. STAY AWAY FROM ENDS OF TANKS (1990 EMERGENCY RESPONSE GUIDEBOOK,  
DOT P 5800.5, GUIDE PAGE 60).

EXTINGUISH USING AGENTS SUITABLE FOR TYPE OF FIRE. USE FLOODING AMOUNTS OF  
WATER AS FOG. COOL CONTAINERS WITH FLOODING AMOUNTS OF WATER, APPLY FROM AS  
FAR A DISTANCE AS POSSIBLE. AVOID BREATHING CORROSIVE VAPORS, KEEP UPWIND.

-----  
TRANSPORTATION DATA

DEPARTMENT OF TRANSPORTATION HAZARD CLASSIFICATION 49 CFR 172.101:  
CORROSIVE MATERIAL

DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS 49 CFR 172.101 AND  
SUBPART E:  
CORROSIVE

DEPARTMENT OF TRANSPORTATION PACKAGING REQUIREMENTS: 49 CFR 173.263  
EXCEPTIONS: 49 CFR 173.244

-----  
TOXICITY

HYDROGEN CHLORIDE (HYDROCHLORIC ACID):

IRRITATION DATA:

ANHYDROUS: 100 MG RINSED EYE-RABBIT MILD.

HYDROCHLORIC ACID: 5 MG/30 SECONDS RINSED EYE-RABBIT MILD.

TOXICITY DATA:

HYDROGEN CHLORIDE (ANHYDROUS GAS): 4701 PPM/30 MINUTES INHALATION-RAT LC50;

EYE PROTECTION:

EMPLOYEE MUST WEAR SPLASH-PROOF OR DUST-RESISTANT SAFETY GOGGLES AND A  
FACESHIELD TO PREVENT CONTACT WITH THIS SUBSTANCE.

EMERGENCY WASH FACILITIES:

WHERE THERE IS ANY POSSIBILITY THAT AN EMPLOYEE'S EYES AND/OR SKIN MAY BE  
EXPOSED TO THIS SUBSTANCE, THE EMPLOYER SHOULD PROVIDE AN EYE WASH FOUNTAIN  
AND QUICK DRENCH SHOWER WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

AUTHORIZED - FISHER SCIENTIFIC, INC.  
CREATION DATE: 04/30/85 REVISION DATE: 12/03/90

-ADDITIONAL INFORMATION-

THIS INFORMATION IS BELIEVED TO BE ACCURATE AND REPRESENTS THE BEST  
INFORMATION CURRENTLY AVAILABLE TO US. HOWEVER, WE MAKE NO WARRANTY OF  
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SUCH INFORMATION, AND WE ASSUME NO LIABILITY RESULTING FROM ITS USE. USERS  
SHOULD MAKE THEIR OWN INVESTIGATIONS TO DETERMINE THE SUITABILITY OF THE  
INFORMATION FOR THEIR PARTICULAR PURPOSES.

THAT A RELEASE EQUAL TO OR GREATER THAN THE REPORTABLE QUANTITY FOR THIS SUBSTANCE BE IMMEDIATELY REPORTED TO THE LOCAL EMERGENCY PLANNING COMMITTEE AND THE STATE EMERGENCY RESPONSE COMMISSION (40 CFR 355.40). IF THE RELEASE OF THIS SUBSTANCE IS REPORTABLE UNDER CERCLA SECTION 103, THE NATIONAL RESPONSE CENTER MUST BE NOTIFIED IMMEDIATELY AT (800) 424-8802 OR (202) 426-2675 IN THE METROPOLITAN WASHINGTON, D.C. AREA (40 CFR 302.6).

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PROTECTIVE EQUIPMENT

VENTILATION:

PROVIDE LOCAL EXHAUST OR PROCESS ENCLOSURE VENTILATION TO MEET PUBLISHED EXPOSURE LIMITS.

RESPIRATOR:

THE FOLLOWING RESPIRATORS ARE RECOMMENDED BASED ON INFORMATION FOUND IN THE PHYSICAL DATA, TOXICITY AND HEALTH EFFECTS SECTIONS. THEY ARE RANKED IN ORDER FROM MINIMUM TO MAXIMUM RESPIRATORY PROTECTION. THE SPECIFIC RESPIRATOR SELECTED MUST BE BASED ON CONTAMINATION LEVELS FOUND IN THE WORK PLACE, MUST BE BASED ON THE SPECIFIC OPERATION, MUST NOT EXCEED THE WORKING LIMITS OF THE RESPIRATOR AND MUST BE JOINTLY APPROVED BY THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH AND THE MINE SAFETY AND HEALTH ADMINISTRATION (NIOSH-MSHA).

HYDROGEN CHLORIDE (HYDROCHLORIC ACID):

- 50 PPM- ANY SUPPLIED-AIR RESPIRATOR.  
ANY SELF-CONTAINED BREATHING APPARATUS.  
ANY CHEMICAL CARTRIDGE RESPIRATOR WITH CARTRIDGE(S) PROVIDING PROTECTION AGAINST HYDROCHLORIC ACID.  
ANY POWERED AIR-PURIFYING RESPIRATOR WITH CARTRIDGE(S) PROVIDING PROTECTION AGAINST HYDROCHLORIC ACID.
- 100 PPM- ANY SUPPLIED-AIR RESPIRATOR OPERATED IN A CONTINUOUS FLOW MODE.  
ANY SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE.  
ANY SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE.
- ESCAPE- ANY AIR-PURIFYING FULL FACEPIECE RESPIRATOR (GAS MASK) WITH A CHIN-STYLE OR FRONT- OR BACK-MOUNTED ACID GAS CANISTER.  
ANY APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:

- ANY SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.
- ANY SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE AND OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE IN COMBINATION WITH AN AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

CLOTHING:

EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE (IMPERVIOUS) CLOTHING AND EQUIPMENT TO PREVENT ANY POSSIBILITY OF SKIN CONTACT WITH THIS SUBSTANCE.

GLOVES:

EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE GLOVES TO PREVENT CONTACT WITH THIS SUBSTANCE.

\*\*STORAGE\*\*

THRESHOLD PLANNING QUANTITY (TPQ);  
THE SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA) SECTION 302 REQUIRES  
THAT EACH FACILITY WHERE ANY EXTREMELY HAZARDOUS SUBSTANCE IS PRESENT IN A  
QUANTITY EQUAL TO OR GREATER THAN THE TPQ ESTABLISHED FOR THAT SUBSTANCE  
NOTIFY THE STATE EMERGENCY RESPONSE COMMISSION FOR THE STATE IN WHICH IT IS  
LOCATED. SECTION 303 OF SARA REQUIRES THESE FACILITIES TO PARTICIPATE IN LOCAL  
EMERGENCY RESPONSE PLANNING (40 CFR 355.30).

PROTECT AGAINST PHYSICAL DAMAGE. STORE IN COOL, WELL-VENTILATED PLACE,  
SEPARATED FROM ALL OXIDIZING MATERIALS (NFPA 49, HAZARDOUS CHEMICALS DATA,  
1975).

\*\*\*\*\*  
CONDITIONS TO AVOID

MAY BURN BUT DOES NOT IGNITE READILY. FLAMMABLE, POISONOUS GASES MAY  
ACCUMULATE IN TANKS AND HOPPER CARS. MAY IGNITE COMBUSTIBLES (WOOD, PAPER,  
OIL, ETC.).

\*\*\*\*\*  
SPILL AND LEAK PROCEDURES

SOIL SPILL:  
DIG HOLDING AREA SUCH AS LAGOON, POND OR PIT FOR CONTAINMENT.

DIKE FLOW OF SPILLED MATERIAL USING SOIL OR SANDBAGS OR FOAMED BARRIERS SUCH  
AS POLYURETHANE OR CONCRETE.

USE CEMENT POWDER OR FLY ASH TO ABSORB LIQUID MASS.

NEUTRALIZE SPILL WITH SLAKED LIME, SODIUM BICARBONATE OR CRUSHED LIMESTONE.

AIR SPILL:  
KNOCK DOWN VAPORS WITH WATER SPRAY. KEEP UPWIND.

WATER USED TO KNOCK DOWN VAPORS MAY BECOME CORROSIVE OR TOXIC AND SHOULD BE  
CONTAINED PROPERLY FOR LATER DISPOSAL.

WATER SPILL:  
NEUTRALIZE WITH AGRICULTURAL LIME, SLAKED LIME, CRUSHED LIMESTONE, OR SODIUM  
BICARBONATE.

OCCUPATIONAL SPILL:  
DO NOT TOUCH SPILLED MATERIAL. STOP LEAK IF YOU CAN DO IT WITHOUT RISK. FOR  
SMALL SPILLS, TAKE UP WITH SAND OR OTHER ABSORBENT MATERIAL AND PLACE INTO  
CONTAINERS FOR LATER DISPOSAL. FOR SMALL DRY SPILLS, WITH CLEAN SHOVEL PLACE  
MATERIAL INTO CLEAN, DRY CONTAINER AND COVER. MOVE CONTAINERS FROM SPILL  
AREA. FOR LARGER SPILLS, DIKE FAR AHEAD OF SPILL FOR LATER DISPOSAL. KEEP  
UNNECESSARY PEOPLE AWAY. ISOLATE HAZARD AREA AND DENY ENTRY.

REPORTABLE QUANTITY (RQ): 1 POUND  
THE SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA) SECTION 304 REQUIRES

## MIXTURES WITH AIR.

## INCOMPATIBILITIES:

HYDROGEN CHLORIDE (HYDROCHLORIC ACID):

ACETIC ANHYDRIDE: VIOLENT REACTION.

ALCOHOLIC HYDROGEN CYANIDE: EXPLOSIVE REACTION.

ALUMINUM: EXPLOSION.

ALUMINUM-TITANIUM ALLOYS: IGNITES OR INCANDESCES WHEN HEATED.

2-AMINOETHANOL: VIOLENT REACTION.

AMMONIUM HYDROXIDE: VIOLENT REACTION.

BASES: VIOLENT REACTION.

BRASS: CORRODES.

BRONZE: CORRODES.

CALCIUM CARBIDE: REACTS WITH INCANDESCENCE.

CALCIUM HYPOCHLORITE: IGNITION.

CESIUM ACETYLIDE: IGNITES ON CONTACT.

CHLORINE + DINITROANILINES: VIGOROUS REACTION WITH RELEASE OF FLAMMABLE

HYDROGEN GAS FUMES.

CHLOROSULFONIC ACID: VIOLENT REACTION.

1,1-DIFLUOROETHYLENE: EXTREMELY EXOTHERMIC DECOMPOSITION REACTION.

DOWICIL 100: DECOMPOSES.

ETHYLENE DIAMINE: VIOLENT REACTION.

ETHYLENE IMINE: VIOLENT REACTION.

FLUORINE: IGNITES ON CONTACT.

HEXALITHIUM DISILICIDE: INCANDESCES.

IRON: CORRODES WITH EVOLUTION OF FLAMMABLE HYDROGEN GAS.

MAGNESIUM BORIDE: PRODUCES A SPONTANEOUSLY FLAMMABLE GAS.

MERCURIC SULFATE: VIOLENT REACTION AT 125 C.

METAL ACETYLIDES: VIOLENT REACTION.

METALS: SEVERE CORROSION WITH EVOLUTION OF FLAMMABLE HYDROGEN GAS.

OLEUM: VIOLENT REACTION.

OXIDIZERS (STRONG): VIOLENT REACTION.

OXYGEN + PLATINUM: IGNITES ON CONTACT.

PERCHLORIC ACID: VIOLENT REACTION.

PLASTICS, RUBBER, COATINGS: ATTACKS.

POTASSIUM PERMANGANATE: EXPLOSION HAZARD.

BETA-PROPIOLACTONE: VIOLENT REACTION.

PROPYLENE OXIDE: VIOLENT REACTION.

RUBIDIUM ACETYLIDE: IGNITES ON CONTACT.

SILICA (GEL): INCOMPATIBLE.

SODIUM: VIGOROUS OR EXPLOSIVE REACTION.

SULFURIC ACID: EXPLOSIVE REACTION WITH RELEASE OF TOXIC HYDROGEN CHLORIDE GAS.

TETRASELENIUM TETRANITRIDE: EXPLODES ON CONTACT.

VINYL ACETATE: VIOLENT REACTION.

## DECOMPOSITION:

THERMAL DECOMPOSITION MAY RELEASE CORROSIVE HYDROGEN CHLORIDE.

## POLYMERIZATION:

HAZARDOUS POLYMERIZATION HAS NOT BEEN REPORTED TO OCCUR UNDER NORMAL TEMPERATURES AND PRESSURES.

-----  
STORAGE AND DISPOSAL

OBSERVE ALL FEDERAL, STATE AND LOCAL REGULATIONS WHEN STORING OR DISPOSING OF THIS SUBSTANCE. FOR ASSISTANCE, CONTACT THE DISTRICT DIRECTOR OF THE

FIRST AID- REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (AT LEAST 15-20 MINUTES). IN CASE OF CHEMICAL BURNS, COVER AREA WITH STERILE, DRY DRESSING, BANDAGE SECURELY, BUT NOT TOO TIGHTLY. GET MEDICAL ATTENTION IMMEDIATELY.

## EYE CONTACT:

HYDROGEN CHLORIDE (HYDROCHLORIC ACID):

CORROSIVE.

ACUTE EXPOSURE- CONTACT MAY CAUSE SEVERE IRRITATION, CONJUNCTIVITIS, CORNEAL NECROSIS AND BURNS WITH IMPAIRMENT OR PERMANENT LOSS OF VISION. A DROP OF HYDROCHLORIC ACID SPLASHED IN THE EYE AND IMMEDIATELY WASHED OUT HAS PRODUCED A WHITE COAGULATION OF THE CORNEAL AND CONJUNCTIVAL EPITHELIUM. ANIMALS EXPOSED TO VAPOR CONCENTRATIONS OF 1350 PPM FOR ONE AND A HALF HOURS SHOWED CLOUDING OF THE CORNEA AND 300 PPM FOR 6 HOURS SHOWED SLIGHT EROSION OF THE CORNEAL EPITHELIUM. CONTACT WITH A COMPRESSED GAS MAY CAUSE FROSTBITE.

CHRONIC EXPOSURE- ANIMALS EXPOSED TO VAPOR AT 100 PPM FOR 6 HOURS DAILY FOR 50 DAYS SHOWED ONLY SLIGHT UNREST AND IRRITATION OF THE EYES, BUT NO OCULAR INJURY. EFFECTS ARE DEPENDENT UPON CONCENTRATION AND DURATION OF EXPOSURE. CONJUNCTIVITIS OR EFFECTS SIMILAR TO THOSE FOR ACUTE EXPOSURE MAY OCCUR.

FIRST AID- WASH EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (AT LEAST 15-20 MINUTES). CONTINUE IRRIGATING WITH NORMAL SALINE UNTIL THE PH HAS RETURNED TO NORMAL (30-60 MINUTES). COVER WITH STERILE BANDAGES. GET MEDICAL ATTENTION IMMEDIATELY.

## INGESTION:

HYDROGEN CHLORIDE (HYDROCHLORIC ACID):

CORROSIVE.

ACUTE EXPOSURE- INGESTION OF THE ACID MAY CAUSE BURNS OF THE MOUTH, THROAT, ESOPHAGUS AND STOMACH WITH CONSEQUENT PAIN, UNEASINESS, NAUSEA, SALIVATION, VOMITING, DIARRHEA, CHILLS, SHOCK AND INTENSE THIRST. NEPHRITIS, FEVER AND PERFORATION OF THE INTESTINAL TRACT, AND CIRCULATORY COLLAPSE MAY OCCUR. DEATH MAY BE DUE TO ESOPHAGEAL OR GASTRIC NECROSIS.

CHRONIC EXPOSURE- NO DATA AVAILABLE.

FIRST AID- DO NOT USE GASTRIC LAVAGE OR EMESIS. DILUTE THE ACID IMMEDIATELY BY DRINKING LARGE QUANTITIES OF WATER OR MILK. IF VOMITING PERSISTS, ADMINISTER FLUIDS REPEATEDLY. INGESTED ACID MUST BE DILUTED APPROXIMATELY 100 FOLD TO RENDER IT HARMLESS TO TISSUES. MAINTAIN AIRWAY AND TREAT SHOCK (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). GET MEDICAL ATTENTION IMMEDIATELY. IF VOMITING OCCURS, KEEP HEAD BELOW HIPS TO HELP PREVENT ASPIRATION.

## ANTIDOTE:

NO SPECIFIC ANTIDOTE. TREAT SYMPTOMATICALLY AND SUPPORTIVELY.

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REACTIVITY

## REACTIVITY:

REACTS EXOTHERMICALLY WITH WATER OR STEAM TO PRODUCE TOXIC AND CORROSIVE FUMES.

CONTACT WITH COMMON METALS PRODUCES HYDROGEN WHICH MAY FORM EXPLOSIVE

2644 PPM/30 MINUTES INHALATION-MOUSE LC50.  
 MONOHYDRATE: NO DATA AVAILABLE.  
 DIHYDRATE: NO DATA AVAILABLE.  
 TRIHYDRATE: NO DATA AVAILABLE.  
 HEXAHYDRATE: NO DATA AVAILABLE.  
 HYDROGEN CHLORIDE (AEROSOL): 5666 PPM/30 MINUTES INHALATION-RAT LC50; 2142 PPM/30 MINUTES INHALATION-MOUSE LC50.  
 HYDROCHLORIC ACID: 1300 PPM/30 MINUTES INHALATION-HUMAN LCLO; 3000 PPM/5 MINUTES INHALATION-HUMAN LCLO; 81 MG/KG UNREPORTED MAN LDLO; 3124 PPM/1 HOUR INHALATION-RAT LC50; 1108 PPM/1 HOUR INHALATION-MOUSE LC50; 1449 MG/KG INTRAPERITONEAL-MOUSE LD50; 900 MG/KG ORAL-RABBIT LD50; 4416 PPM/30 MINUTES INHALATION-RABBIT LCLO; 4416 PPM/30 MINUTES INHALATION-GUINEA PIG LCLO; 1000 MG/M3/2 HOURS INHALATION-MAMMAL LCLO; MUTAGENIC DATA (RTECS); REPRODUCTIVE EFFECTS DATA (RTECS).  
 CARCINOGEN STATUS: NONE.  
 LOCAL EFFECTS: CORROSIVE- INHALATION, SKIN, EYE AND INGESTION.  
 ACUTE TOXICITY LEVEL: MODERATELY TOXIC BY INHALATION, INGESTION.  
 TARGET EFFECTS: NO DATA AVAILABLE.

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HEALTH EFFECTS AND FIRST AID

INHALATION:

HYDROGEN CHLORIDE (HYDROCHLORIC ACID):

CORROSIVE. 100 PPM IMMEDIATELY DANGEROUS TO LIFE OR HEALTH.

ACUTE EXPOSURE- INHALATION OF GAS OR FUMES AT LEVELS OF 5-35 PPM MAY CAUSE IRRITATION AND BURNING OF THE THROAT, COUGHING AND CHOKING; 50-100 PPM MAY BE BARELY TOLERABLE FOR 1 HOUR. HIGH LEVELS MAY CAUSE INFLAMMATION AND OCCASIONALLY ULCERATION OF THE NOSE, THROAT OR LARYNX, BRONCHITIS, PNEUMONIA, PALPITATIONS AND HEADACHE. HIGHER CONCENTRATIONS MAY CAUSE NECROSIS OF THE TRACHEAL AND BRONCHIAL EPITHELIUM, NASOSEPTAL PERFORATION, ATELECTASIS, EMPHYSEMA, DAMAGE TO PULMONARY BLOOD VESSELS AND LESIONS OF THE LIVER AND OTHER ORGANS. DEATH MAY BE DUE TO LARYNGEAL SPASM, BRONCHOPNEUMONIA OR PULMONARY EDEMA. 1300-2000 PPM MAY BE DANGEROUS, EVEN ON BRIEF EXPOSURES. REPRODUCTIVE EFFECTS HAVE BEEN REPORTED IN ANIMALS.

CHRONIC EXPOSURE- REPEATED OR PROLONGED EXPOSURE MAY CAUSE EROSION AND DISCOLORATION OF EXPOSED TEETH, CHRONIC BRONCHITIS AND GASTRITIS.

FIRST AID- REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, GIVE ARTIFICIAL RESPIRATION. MAINTAIN AIRWAY AND BLOOD PRESSURE AND ADMINISTER OXYGEN IF AVAILABLE. KEEP AFFECTED PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. ADMINISTRATION OF OXYGEN SHOULD BE PERFORMED BY QUALIFIED PERSONNEL. GET MEDICAL ATTENTION IMMEDIATELY.

SKIN CONTACT:

HYDROGEN CHLORIDE (HYDROCHLORIC ACID):

CORROSIVE.

ACUTE EXPOSURE- CONTACT MAY CAUSE SEVERE IRRITATION, INFLAMMATION, ULCERATION, NECROSIS AND CHEMICAL BURNS. SHOCK SYMPTOMS MAY DEVELOP INCLUDING RAPID PULSE, SWEATING AND COLLAPSE. PHOTSENSITIZATION REACTIONS MAY OCCUR IN PERSONS PREVIOUSLY EXPOSED. CONTACT WITH A COMPRESSED GAS MAY CAUSE FROSTBITE.

CHRONIC EXPOSURE- REPEATED OR PROLONGED CONTACT WITH VAPORS OR DILUTE SOLUTIONS MAY CAUSE DERMATITIS. PHOTSENSITIZATION MAY OCCUR.

# Material Safety Data Sheet

From Genium's Reference Collection  
Genium Publishing Corporation  
1145 Catalyn Street  
Schenectady, NY 12303-1836 USA  
(518) 377-8855



No. 7

NITRIC ACID  
(Revision C)  
Issued: October 1980  
Revised: August 1988

## SECTION 1. MATERIAL IDENTIFICATION 26

**Material Name:** NITRIC ACID

**Description (Origin/Uses):** Used to dissolve noble metals, for etching and cleaning metals, to make organic nitrates and nitrocompounds, to destroy residues of organic matter, and in explosives.

**Other Designations:** Red Fuming Nitric Acid; HNO<sub>3</sub>; CAS No. 7697-37-2

**Manufacturer:** Contact your supplier or distributor. Consult the latest edition of the *Chemicalweek Buyers' Guide* (Genium ref. 73) for a list of suppliers.



NFPA

HMIS		
H	3	R 1
F	0	I 4
R	1	S 4
PPG*		K 0
*See sect. 8		

## SECTION 2. INGREDIENTS AND HAZARDS

INGREDIENTS AND HAZARDS	%	EXPOSURE LIMITS
Nitric Acid, CAS No. 7697-37-2	*	<p><b>OSHA PEL</b> 8-Hr TWA: 2 ppm, 5 mg/m<sup>3</sup></p> <p><b>ACGIH TLVs, 1987-88</b> TLV-TWA: 2 ppm, 5 mg/m<sup>3</sup> TLV-STEL: 4 ppm, 10 mg/m<sup>3</sup></p> <p><b>Toxicity Data**</b> Mouse, Inhalation, LC<sub>50</sub>: 67 ppm/4 Hrs</p>
<p>*Contact your supplier to determine the percent by weight of nitric acid in the purchased product. Water is the other component of the product. **See NIOSH, RTECS (QU5775000, QU5900000), for additional data with references to reproductive effects.</p>		

## SECTION 3. PHYSICAL DATA

<p><b>Bolling Point:</b> Ca 251°F (122°C)* <b>Specific Gravity (H<sub>2</sub>O = 1):</b> 1.4* <b>pH:</b> Very Acidic</p>	<p><b>Water Solubility (%):</b> Complete <b>Molecular Weight:</b> 63 Grams/Mole <b>Melting Point:</b> Ca -30°F (-34°C)*</p>
<p><b>Appearance and Odor:</b> A water white to slightly yellow liquid that darkens to a brownish color on aging and exposure to light; characteristic nitrogen dioxide (NO<sub>2</sub>) odor.</p>	
<p>*These properties are for the approximately 68%-by-weight nitric acid that is commercially available.</p>	

## SECTION 4. FIRE AND EXPLOSION DATA

SECTION 4. FIRE AND EXPLOSION DATA			LOWER	UPPER
Flash Point and Method	Autoignition Temperature	Flammability Limits in Air		
*	*	% by Volume	*	*

**Extinguishing Media:** \*Nitric acid does not burn. Use extinguishing agents that will put out the surrounding fire. Use a water spray to dilute nitric acid during fires and to absorb liberated oxides of nitrogen.

**Unusual Fire or Explosion Hazards:** Although nitric acid does not burn, it is a strong oxidizing agent that can react with combustible materials to cause fires. Also, it can react with metals to liberate extremely flammable hydrogen gas. If this happens, direct fire-fighting procedures at this evolved hydrogen gas.

**Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Choose protective equipment carefully (see sect. 5, Conditions to Avoid).

## SECTION 5. REACTIVITY DATA

Nitric acid is stable in closed containers at room temperature under normal storage and handling conditions. It cannot undergo hazardous polymerization.

**Chemical Incompatibilities:** Nitric acid reacts explosively with metallic powders, carbides, hydrogen sulfide, and turpentine. Contact with organic materials such as wood, paper, sawdust, or alcohol, etc., may cause fires. Combustible materials can attain an increased flammability after being exposed to nitric acid even if they do not immediately catch fire.

**Conditions to Avoid:** Avoid any contact with incompatible chemicals. Because it is so reactive, always establish another material's compatibility with nitric acid before mixing the two materials. This applies to the selection of safety and handling equipment, because nitric acid can attack some forms of coatings, plastics, and rubber.

**Hazardous Products of Decomposition:** Various nitrogen oxides, including nitric oxide (NO), nitrogen dioxide (NO<sub>2</sub>), nitrous oxide (N<sub>2</sub>O), as well as nitric acid mist or vapor, can be produced by the decomposition reactions that can affect the nitric acid during fires.

**SECTION 6. HEALTH HAZARD INFORMATION**

Nitric acid is not listed as a carcinogen by the NTP, IARC, or OSHA.

**Summary of Risks:** This material is corrosive to any body tissue it contacts. Dental erosion is also reported.

**Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Skin, eyes, mucous membranes of the respiratory tract, teeth. **Primary Entry:** Inhalation, skin contact. **Acute Effects:** Irritation and/or corrosive burns of skin, eyes, and upper respiratory tract (URT), delayed pulmonary edema, pneumonitis, bronchitis, and dental erosion. **Chronic Effects:** None reported.

**FIRST AID:** **Eyes.** Immediately flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes. Treat for eye burns. **Skin.** Immediately wash the affected area with soap and water. Watch for chemical skin burns and treat them accordingly. **Inhalation.** Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. If the exposure is severe, hospitalization with careful monitoring by trained medical personnel to detect the delayed onset of severe pulmonary edema (lungs filled with fluid) is recommended for at least 72 hours. **Ingestion.** Call a poison control center. Never give anything by mouth to someone who is unconscious or convulsing. Do not induce vomiting. If the exposed person is responsive, give him or her one or two glasses of milk or water to drink as quickly as possible after exposure.

**GET MEDICAL HELP (IN PLANT, PARAMEDIC, COMMUNITY) FOR ALL EXPOSURES.** Seek prompt medical assistance for further treatment, observation, and support after first aid. **NOTE TO PHYSICIAN:** Wash affected skin areas with a 5% solution of sodium bicarbonate (NaHCO<sub>3</sub>). If ingested, the risk versus the benefit of the passage of a naso-gastric tube is debatable. Activated charcoal is of no value. Do not give the exposed person bicarbonate to neutralize the material.

**SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES**

**Spill/Leak:** Notify safety personnel, provide ventilation, and eliminate all sources of ignition immediately in case contact with metals should produce highly flammable hydrogen gas. Cleanup personnel need protection against contact with and inhalation of nitric acid (see sect. 8). Contain large spills and collect waste. Use water sprays to direct nitric acid away from incompatible chemicals (see sect. 5). Neutralize the spilled nitric acid with soda ash or sodium bicarbonate. Use an absorbent such as sand, earth, or vermiculite on the resulting slurry and place the neutralized nitric acid material into containers suitable for eventual disposal, reclamation, or destruction.

**Waste Disposal:** Consider reclamation, recycling, or destruction rather than disposal in a landfill. Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

**OSHA Designations**

Air Contaminant (29 CFR 1910.1000 Subpart Z)

EPA Designations (40 CFR 302.4)

CERCLA Hazardous Substance, Reportable Quantity: 1000 lbs (454 kg), per Clean Water Act (CWA), Section 311 (b) (4)

**SECTION 8. SPECIAL PROTECTION INFORMATION**

**Goggles:** Always wear protective eyeglasses or chemical safety goggles. Where splashing of nitric acid solution is possible, wear a full face shield as a supplementary protective measure. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133).

**Respirator:** Consult the *NIOSH Pocket Guide to Chemical Hazards* (Genium ref. 88) for general recommendations on proper respiratory procedures. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine use (leaks or cleaning reactor vessels and storage tanks), wear an SCBA with a full facepiece operated in the pressure-demand or positive-pressure mode. **Warning:** Air-purifying respirators will not protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, gauntlets, etc., to prevent skin contact with nitric acid. Choose protective equipment carefully (see sect. 5, Conditions to Avoid).

**Ventilation:** Install and operate both general and local exhaust-ventilation systems powerful enough to maintain airborne concentrations of nitric acid below the OSHA PEL standard cited in section 2. Construct exhaust ducts and systems with material such as fiberglass, which resists attack by nitric acid. **Safety Stations:** Make emergency eyewash stations, washing facilities, and safety/quickdrench showers available in work areas. **Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them. Do not wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean nitric acid from shoes and equipment. **Comments:** Practice good personal hygiene; always wash thoroughly after using this material. Keep it off of your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do not eat, drink, or smoke in any work area. Provide preplacement and annual medical exams with emphasis on skin irritation to workers who are regularly exposed to nitric acid. Workers must receive training before handling this material in the workplace; even experienced workers should undergo refresher training periodically.

**SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS**

**Storage/Segregation:** Store nitric acid in a cool, dry, well-ventilated area away from incompatible chemicals (see sect. 5). Consider outside, isolated, or detached storage. Protect containers from direct sunlight.

**Special Handling/Storage:** Build all storage facilities of nonflammable materials that are resistant to chemical attack by nitric acid. Protect containers from physical damage. Preplan for routine use and emergency response.

**Engineering Controls:** Proper ventilation is essential in bulk storage areas; consider installing an automatic monitoring system to detect hazardous levels of nitrogen oxides that can develop from this material.

**Comments:** Separate nitric acid from hydrazine, diethylenetriamine, fluorides, and all other corrosives except sulfuric acid and sulfur trioxide when shipping or transferring it.

**Transportation Data (49 CFR 172.101-2)**

**DOT Shipping Name:** (I) Nitric Acid, Fuming or (II) Nitric Acid, Over 40% or (III) Nitric Acid, 40% or Less

**DOT Label:** (I) Oxidizer and Poison or (II) Oxidizer and Corrosive or (III) Corrosive

**DOT Hazard Class:** (I) and (II) Oxidizer or (III) Corrosive Material

**DOT ID Nos.** (I) UN2032; (II) UN2031; (III) NA1760

**IMO Class:** 8 (All Types of Nitric Acid)

**IMO Label:** (I) Corrosive, Oxidizer, Poison; or (II) and (III) Corrosive

**References:** 1, 2, 26, 38, 84-94, 100, 112, 113, 114.

Judgments as to the suitability of information herein for purchaser's purposes are necessarily purchaser's responsibility. Therefore, although reasonable care has been taken in the preparation of such information, Genium Publishing Corp. extends no warranties, makes no representations and assumes no responsibility as to the accuracy or suitability of such information for application to purchaser's intended purposes or for consequences of its use.

Prepared by PJ Igoe, BS

Industrial Hygiene Review: DJ Wilson, CIH

Medical Review: MJ Hardies, MD

**HASP ATTACHMENT C**  
**OSHA POSTER**

# JOB SAFETY & HEALTH PROTECTION

The Occupational Safety and Health Act of 1970 provides job safety and health protection for workers by promoting safe and healthful working conditions throughout the Nation. Provisions of the Act include the following:

## Employers

All employers must furnish to employees employment and a place of employment free from recognized hazards that are causing or are likely to cause death or serious harm to employees. Employers must comply with occupational safety and health standards issued under the Act.

## Employees

Employees must comply with all occupational safety and health standards, rules, regulations and orders issued under the Act that apply to their own actions and conduct on the job.

The Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor has the primary responsibility for administering the Act. OSHA issues occupational safety and health standards, and its Compliance Safety and Health Officers conduct jobsite inspections to help ensure compliance with the Act.

## Inspection

The Act requires that a representative of the employer and a representative authorized by the employees be given an opportunity to accompany the OSHA inspector for the purpose of aiding the inspection.

Where there is no authorized employee representative, the OSHA Compliance Officer must consult with a reasonable number of employees concerning safety and health conditions in the workplace.

## Complaint

Employees or their representatives have the right to file a complaint with the nearest OSHA office requesting an inspection if they believe unsafe or unhealthful conditions exist in their workplace. OSHA will withhold, on request, names of employees complaining.

The Act provides that employees may not be discharged or discriminated against in any way for filing safety and health complaints or for otherwise exercising their rights under the Act.

Employees who believe they have been discriminated against may file a complaint with their nearest OSHA office within 30 days of the alleged discriminatory action.

## Citation

If upon inspection OSHA believes an employer has violated the Act, a citation alleging such violations will be issued to the employer. Each citation will specify a time period within which the alleged violation must be corrected.

The OSHA citation must be prominently displayed at or near the place of alleged violation for three days, or until it is corrected, whichever is later, to warn employees of dangers that may exist there.

## Proposed Penalty

The Act provides for mandatory civil penalties against employers of up to \$7,000 for each serious violation and for optional penalties of up to \$7,000 for each nonserious violation. Penalties of up to \$7,000 per day may be proposed for failure to correct violations within the proposed time period and for each day the violation continues beyond the prescribed abatement date. Also, any employer who willfully or repeatedly violates the Act may be assessed penalties of up to \$70,000 for each such violation. A minimum penalty of \$5,000 may be imposed for each willful violation. A violation of posting requirements can bring a penalty of up to \$7,000.

There are also provisions for criminal penalties. Any willful violation resulting in the death of any employee, upon conviction, is punishable by a fine of up to \$250,000 (or \$500,000 if the employer is a corporation), or by imprisonment for up to six months, or both. A second conviction of an employer doubles the possible term of imprisonment. Falsifying records, reports, or applications is punishable by a fine of \$10,000 or up to six months in jail or both.

## Voluntary Activity

While providing penalties for violations, the Act also encourages efforts by labor and management, before an OSHA inspection, to reduce workplace hazards voluntarily and to develop and improve safety and health programs in all workplaces and industries. OSHA's Voluntary Protection Programs recognize outstanding efforts of this nature.

OSHA has published Safety and Health Program Management Guidelines to assist employers in establishing or perfecting programs to prevent or control employee exposure to workplace hazards. There are many public and private organizations that can provide information and assistance in this effort, if requested. Also, your local OSHA office can provide considerable help and advice on solving safety and health problems or can refer you to other sources for help such as training.

## Consultation

Free assistance in identifying and correcting hazards and in improving safety and health management is available to employers, without citation or penalty, through OSHA-supported programs in each State. These programs are usually administered by the State Labor or Health department or a State university.

## Posting Instructions

Employers in States operating OSHA approved State Plans should obtain and post the State's equivalent poster.

*Under provisions of Title 29, Code of Federal Regulations, Part 1903.2(a)(1) employers must post this notice (or facsimile) in a conspicuous place where notices to employees are customarily posted.*

## More Information

Additional information and copies of the Act, specific OSHA safety and health standards, and other applicable regulations may be obtained from your employer or from the nearest OSHA Regional Office in the following locations:

Atlanta, GA	(404) 347-3573
Boston, MA	(617) 565-7164
Chicago, IL	(312) 353-2220
Dallas, TX	(214) 767-4731
Denver, CO	(303) 844-3061
Kansas City, MO	(816) 426-5861
New York, NY	(212) 337-2378
Philadelphia, PA	(215) 596-1201
San Francisco, CA	(415) 744-6670
Seattle, WA	(206) 442-5930

To report suspected fire hazards, imminent danger safety and health hazards in the workplace, or other job safety and health emergencies, such as toxic waste in the workplace, call OSHA's 24-hour hotline: 1-800-321-OSHA.

Washington, DC  
1991 (Reprinted)  
OSHA 2203

*Lynn Martin*

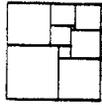
Lynn Martin, Secretary of Labor

**U.S. Department of Labor**

Occupational Safety and Health Administration



**APPENDIX B**  
**STANDARD OPERATING PROCEDURES**



**NUS**  
CORPORATION

**ENVIRONMENTAL  
MANAGEMENT GROUP**

# STANDARD OPERATING PROCEDURES

Number GH-1.3	Page 1 of 13
Effective Date 05/04/90	Revision 2
Applicability EMG	
Prepared Earth Sciences	
Approved <i>D. Senovich</i> D. Senovich	

Subject  
SOIL AND ROCK SAMPLING

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Subject  SOIL AND ROCK SAMPLING	Number GH-1.3	Page 2 of 13
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## 1.0 PURPOSE

The purpose of this procedure is to identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during field sampling activities.

## 2.0 SCOPE

The methods described within this procedure are applicable while collecting surface and subsurface soil samples; obtaining rock core samples for lithologic and hydrogeologic evaluation; excavation/foundation design and related civil engineering purposes.

## 3.0 GLOSSARY

Hand Auger- A sampling device used to extract soil from the ground in a relatively undisturbed form.

Thin-Walled Tube Sampler - A thin-walled metal tube (also called Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches O.D. and 18 to 54 inches long. A stationary piston device may be included in the sampler to reduce sampling disturbance and increase sample recovery.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split spoon sampler (used for performing Standard Penetration Tests) is 2 inches outside diameter (OD) and 1-3/8 inches inside diameter (ID). This standard spoon typically is available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively. These split-spoon samplers range in size from 2-inch O.D. to 3-1/2-inch O.D., depending upon manufacturer. The larger sizes are commonly used when a larger volume of material is required.

Rock Coring - A method in which a continuous solid cylindrical sample of rock or compact rock-like soil is obtained by the use of a double tube core barrel that is equipped with an appropriate diamond-studded drill bit which is advanced with a hydraulic rotary drilling machine.

Wire-Line Coring - As an alternate for conventional coring, this is valuable in deep hole drilling, since this method eliminates trips in and out of the hole with the coring equipment. With this technique the core barrel becomes an integral part of the drill rod string. The drill rod serves as both a coring device and casing.

## 4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for overall management of field activities and ensuring that the appropriate sampling procedures are being implemented.

Site Geologist - The site geologist directly oversees the sampling procedures, classifies soil and rock samples, and directs the packaging and shipping of soil samples. Such duties may also be performed by geotechnical engineers, field technicians, or other qualified field personnel.

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## 5.0 PROCEDURES

### 5.1 SUBSURFACE SOIL SAMPLES

Subsurface soil samples are used to characterize subsurface stratigraphy. This characterization can indicate the potential for migration of chemical contaminants in the subsurface. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of the soil samples. Where the remedial activities may include in-situ treatment or the excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

The procedures described here are representative of a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, DQOs, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

#### 5.1.1 Equipment

The following equipment is used for subsurface soil sampling and test boring:

- Drilling equipment, provided by subcontractor.
- Split barrel (split spoon) samplers, OD 2 inches, ID 1-3/8 inches, either 20-inch or 26 inches long. Larger O.D. samplers are available if a larger volume of sample is needed. A common size is 3-inch O.D. (2-1/2-inch I.D.).
- Thin walled tubes (Shelby), O.D. 2 to 5 inches, 18 to 54 inches long.
- Drive weight assembly, 140-lb. ( $\pm 2$  lb.) weight, driving head and guide permitting free fall of 30 inches ( $\pm 1$  inch).
- Drive weight assembly, 300-lb. ( $\pm 2$  lb.) weight, driving head and guide permitting free fall of 18 inches ( $\pm 1$  inch).
- Accessory equipment, including labels, logbook, paraffin, and sample jars.

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### 5.1.2 Split Barrel (Split Spoon) Sampling (ASTM D1586-84)

The following method will be used for split barrel sampling:

- Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation. In saturated sands and silts, withdraw the drill bit slowly to prevent loosening of the soil around the hole and maintain the water level in the hole at or above groundwater level.
- Side-discharge bits are permissible. A bottom-discharge bit shall not be used. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. Where casing is used, it may not be driven below the sampling elevation.
- Install the split barrel sampler and sampling rods into the boring to the desired sampling depth. After seating the sampler by means of a single hammer blow, three 6-inch increments shall be marked on the sampling rod so that the progress of the sampler can be monitored.
- The 2-inch OD split barrel sampler shall be driven with blows from a 140-lb. ( $\pm 2$  lb.) hammer falling 30 inches ( $\pm 1$  inch) until either a total of 50 blows have been applied during any one of the three 6-inch increments, a total of 100 blows have been applied, there is no observed advance of the sampler for 10 successive hammer blows, or until the sampler has advanced 18 inches without reaching any of the blow count limitation constraints described herein. This process is referred to as the Standard Penetration Test.
- A 300-lb. weight falling 18 inches is sometimes used to drive a 2-1/2-inch or 3-inch O.D. spoon sampler. This procedure is used where dense materials are encountered or when a large volume of sample is required. However, this method does not conform the ASTM specifications.
- Repeat this operation at intervals not greater than 5 feet in homogeneous strata, or as specified in the sampling plan.
- Record the number of blows required to effect each 6 inches of penetration or fraction thereof. The first 6 inches is considered to be seating drive. The sum of the number of blows required for the second and third 6 inches of penetration is termed the penetration resistance, N. If the sampler is driven less than 18 inches, the penetration resistance is that for the last 1 foot penetrated.
- Bring the sampler to the surface and remove both ends and one half of the split barrel so that the soil recovered rests in the remaining half of the barrel. Describe carefully the sample interval, recovery (length), composition, structure, consistency, color, condition, etc., of the recovered soil then put a representative portion of each sample into a jar, without ramming. Jars with samples not taken for chemical analysis shall be sealed with wax, or hermetically sealed (using a teflon cap liner) to prevent evaporation of the soil moisture, if the sample is to be later evaluated for moisture content. Affix labels to the jar and complete Chain-of-Custody and other required sample data forms. Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons stored in a protected area. Pertinent data which shall be noted on the label or written on the jar lid for each sample includes the project number, boring number, sample number, depth interval, blow counts, and date of sampling.

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- An addition to the sampler mentioned above is an internal liner, which is split longitudinally and has a thin-wall brass, steel, or paper liner inserted inside, which will preserve the sample. However, since the development of the thin-walled samplers (mentioned below) the split barrel sampler with liner has declined in use.

### 5.1.3 Thin Walled Tube (Shelby Tube) Sampling (ASTM D1587-83)

When it is desired to take undisturbed samples of soil, thin-walled seamless tube samplers (Shelby tubes) will be used. The following method will be used:

- Clean out the borehole to the sampling depth, being careful to minimize the chance for disturbance of the material to be sampled. In saturated materials, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and maintain the water level in the hole at or above groundwater level.
- The use of bottom discharge bits or jetting through an open-tube sampler to clean out the hole shall not be allowed. Any side discharge bits are permitted.
- A stationary piston-type sampler may be required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used. Prior to inserting the tube sampler in the hole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the sampling rods from pushing the sample out of the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.
- To minimize chemical reaction between the sample and the sampling tube, brass tubes may be required, especially if the tube is stored for an extended time prior to testing. While steel tubes coated with shellac are less expensive than brass, they are more reactive, and shall only be used when the sample will be tested within a few days after sampling or if chemical reaction is not anticipated. With the sampling tube resting on the bottom of the hole and the water level in the boring at the groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.
- Upon removal of the sampler tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a 1/2-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Newspaper or other types of filler must be placed in voids at either end of the sampler prior to sealing with wax. Place plastic caps on the ends of the sampler, tape in the caps place, and dip the ends in wax.
- Affix labels to the tubes as required and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "up" direction on the tube with indelible ink, and mark the end of the sample. Complete Chain-of-Custody and other required forms. Do not allow tubes to freeze and store the samples vertically (with the same orientation they had in the ground, i.e., top of sample is up) in a cool place out of the

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sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

Thin-walled undisturbed tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Denison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs and therefore their use shall be weighed against the increased cost and the need for an undisturbed sample. In any case, if a sample cannot be obtained with a tube sampler, an attempt shall be made with a split barrel sampler at the same depth so that at least a sample can be obtained for classification purposes.

#### 5.1.4 Continuous Core Soil Samples

The CME continuous sample tube system provides a method of sampling soil continuously during hollow stem augering. The 5-foot sample barrel fits within the lead auger of a hollow auger column. The sampling system can be used with a wide range of I.D. hollow stem augers (from 3-1/4-inch to 8-1/4-inch I.D.). This method has been used to sample many different materials such as glacial drift, hard clays and shales, mine tailings, etc. This method is particularly used when SPT samples are not required and a large volume of material is needed. Also, this method is useful when a visual description of the subsurface lithology is required.

#### 5.2 SURFACE SOIL SAMPLES

For loosely packed earth or waste pile samples, stainless steel scoops or trowels can be used to collect representative samples. For densely packed soils or deeper soil samples, a hand or power soil auger may be used.

The following methods are to be used:

- Use a soil auger for deep samples (6 to 24 inches) or a scoop or trowel for surface samples. Remove debris, rocks, twigs, and vegetation before collection of soil. Mark the location with a numbered stake if possible and locate sample points on a sketch of the site.
- Use a new or freshly-decontaminated sampler for each sample taken. Attach a label and identification tag. Record all required information in the field logbook and on the sample log sheet, Chain-of-Custody record, and other required forms.
- Pack and ship accordingly.
- When a representative composited sample is to be prepared (e.g., samples taken from a gridded area or from several different depths), it is best to composite individual samples in the laboratory where they can be more precisely composited on a weight or volume basis. If this is not possible, the individual samples (all of equal volume, i.e., the sample bottles shall be full) shall be placed in a decontaminated stainless steel bucket, mixed thoroughly using a stainless steel spatula or trowel, and a composite sample collected.

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### 5.3 WASTE PILE SAMPLES

The use of stainless steel scoops or trowels to obtain small discrete samples of homogeneous waste piles is usually sufficient for most conditions. Layered (nonhomogeneous) piles require the use of tube samplers to obtain cross-sectional samples.

- Collect small, equal portions of the waste from several points around the pile, penetrating it as far as practical. Use numbered stakes, if possible, to mark the sampling locations and locate sampling points on the site sketch.
- Place the waste sample in a glass container. Attach a label and identification tag. Record all the required information in the field logbook and on the sample log sheet and other required forms.

For layered, nonhomogeneous piles, grain samplers, sampling triers, or waste pile samplers must be used at several representative locations to acquire a cross-section of the pile. The basic steps to obtain each sample are

- Insert a sampler into the pile at a 0- to 45-degree angle from the horizontal to minimize spillage.
- Rotate the sampler once or twice to cut a core of waste material. Rotate the grain sampler inner tube to the open position and then shake the sampler a few times to allow the material to enter the open slits. Move the sampler into position with slots upward (grain sampler closed) and slowly withdraw from the pile.

### 5.4 ROCK SAMPLING (CORING) (ASTM D2113-83)

Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. It can, however, proceed for thousands of feet continuously, depending on the size of the drill rig. It yields better quality data than air rotary drilling, although at a substantially reduced drilling rate. Rate of drilling varies widely, depending on the characteristics of lithologies encountered, drilling methods, depth of drilling, and condition of drilling equipment. Average output in a 10-hour day ranges from 40 to over 200 feet. Downhole geophysical logging or television camera monitoring is sometimes used to complement the data generated by coring.

Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Attachment No. 1.

Core drilling is used when formations are too hard to be sampled by soil sampling methods and a continuous solid sample is desired. Usually, soil samples are used for overburden, and coring begins in sound bedrock. Casing is set into bedrock before coring begins to prevent loose material from entering the borehole, to prevent loss of drilling fluid, and to prevent cross contamination of aquifers.

**ATTACHMENT 1**

**STANDARD SIZES OF CORE BARRELS AND CASING**

Coring bit size	Nominal *		Set size *	
	O. D.	I. D.	O. D.	I. D.
RWT	$1 \frac{5}{32}$	$\frac{3}{4}$	1.160	.735
EWT	$1 \frac{1}{2}$	$\frac{29}{32}$	1.470	.905
EX, EXL, EWG, EWM	$1 \frac{1}{2}$	$\frac{13}{16}$	1.470	.845
AWT	$1 \frac{7}{8}$	$1 \frac{9}{32}$	1.875	1.281
AX, AXL, AWG, AWM	$1 \frac{7}{8}$	$1 \frac{3}{16}$	1.875	1.185
BWT	$2 \frac{3}{8}$	$1 \frac{3}{4}$	2.345	1.750
BX, BXL, BWG, BWM	$2 \frac{3}{8}$	$1 \frac{5}{8}$	2.345	1.655
NWT	3	$2 \frac{5}{16}$	2.965	2.313
NX, NXL, NWG, NWM	3	$2 \frac{1}{8}$	2.965	2.155
HWT	$3 \frac{29}{32}$	$3 \frac{3}{16}$	3.889	3.187
HWG	$3 \frac{29}{32}$	3	3.889	3.000
$2 \frac{3}{4} \times 3 \frac{7}{8}$	$3 \frac{7}{8}$	$2 \frac{3}{4}$	3.840	2.690
$4 \times 5 \frac{1}{2}$	$5 \frac{1}{2}$	4	5.435	3.970
$6 \times 7 \frac{3}{4}$	$7 \frac{3}{4}$	6	7.655	5.970
AX Wire line <u>L</u>	$1 \frac{7}{8}$	1	1.875	1.000
BX Wire line <u>L</u>	$2 \frac{3}{8}$	$1 \frac{7}{16}$	2.345	1.437
NX Wire line <u>L</u>	3	$1 \frac{15}{16}$	2.965	1.937

\* All dimensions are in inches; to convert to millimeters, multiply by 25.4.  
L Wire line dimensions and designations may vary according to manufacturer.

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ATTACHMENT 1  
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Size Designations		Casing O.D., inches	Casing coupling		Casing bit, O.D., inches	Core barrel bit O.D., inches*	Drill rod O.D., inches	Approximate core diameter	
Casing; Casing coupling; Casing bits; Core barrel bits	Rod; Rod couplings		O.D., inches	I.D., inches				Normal, inches	Thinwall, inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094	—	.735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	.845	.905
AX	A	2.250	2.250	1.906	2.345	1.875	1.625	1.185	1.281
BX	B	2.875	2.875	2.375	2.965	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4.500	3.938	4.625	3.890	3.500	3.000	3.187
RW	RW	1.437	Flush joint	No coupling	1.485	1.160	1.094	—	.735
EW	EW	1.812			1.875	1.470	1.375	.845	.905
AW	AW	2.250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875			2.965	2.345	2.125	1.655	1.750
NW	NW	3.500			3.615	2.965	2.625	2.155	2.313
HW	HW	4.500			4.625	3.890	3.500	3.000	3.187
PW	—	5.500			5.650	—	—	—	—
SW	—	6.625			6.790	—	—	—	—
UW	—	7.625			7.800	—	—	—	—
ZW	—	8.625			8.810	—	—	—	—
—	AX $\downarrow$	—	—	—	—	1.875	1.750	1.000	—
—	BX $\downarrow$	—	—	—	—	2.345	2.250	1.437	—
—	NX $\downarrow$	—	—	—	—	2.965	2.813	1.937	—

\* For hole diameter approximation, assume  $\frac{1}{32}$  inch larger than core barrel bit.

$\downarrow$  Wire line size designation, drill rod only, serves as both casing and drill rod. Wire line core bit, and core diameters vary slightly according to manufacturer.

NOMINAL DIMENSIONS FOR DRILL CASINGS AND ACCESSORIES. (DIAMOND CORE DRILL MANUFACTURERS ASSOCIATION). 288-D-2889.

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Drilling through bedrock is initiated by using a diamond-tipped core bit threaded to a drill rod (outer core barrel) with a rate of drilling determined by the downward pressure, rotation speed of drill rods, drilling fluid pressure in the borehole, and the characteristics of the rock (mineralogy, cementation, weathering).

#### **5.4.1 Diamond Core Drilling**

A penetration of typically less than 6 inches per 50 blows using a 140-lb. hammer dropping 30 inches with a 2-inch split spoon sampler shall be considered an indication that soil sampling methods may not be applicable and that coring may be necessary to obtain samples.

When formations are encountered that are too hard to be sampled by soil sampling methods, the following diamond core drilling procedure may be used.

- Firmly seat a casing into the bedrock or the hard material to prevent loose materials from entering the hole and to prevent the loss of drilling fluid return. Level the surface of the rock or hard material when necessary by the use of a fishtail or other bits. If the drill hole can be retained open without the casing and if cross contamination of aquifers in the unconsolidated materials is unlikely, it may be omitted.
- Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10 feet (3 m), remove the core barrel from the hole, and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately. In soft materials, a large starting size may be specified for the coring tools; where local experience indicates satisfactory core recovery or where hard, sound materials are anticipated, a smaller size or the single-tube type may be specified and longer runs may be drilled. NX/NW size coring equipment is the most commonly used size.
- When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split Barrel Sampling) or in Method D 1587 (Thin-Walled Tube Sampling) for Sampling of Soils (see Section 5.1.1 and 5.1.2). Resume diamond core drilling when refusal materials are again encountered.
- Since rock structures and the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described, take special care to obtain and record these features. If such broken zones or cavities prevent further advance of the boring, one of the following three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the next smaller size core barrel, as the conditions warrant.
- In soft, seamy, or otherwise unsound rock, where core recovery may be difficult, M-design core barrels may be used. In hard, sound rock where a high percentage of core recovery is anticipated, the single-tube core barrel may be employed.

#### **5.4.2 Rock Sample Preparation and Documentation**

Once the rock coring has been completed and the core recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in Procedure GH-1.5. If moisture content will be determined or if it is desirable to prevent drying (e.g.,

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to prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number, and the footage represented in each sleeve shall be included, as well as the top and bottom of the core run.

After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box unless accepted by the Site Geologist. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows. The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer, the top of the cored interval contained within the box is in the upper left corner of the box, and the bottom of the cored interval is in the lower right corner of the box (see Attachment 2). The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

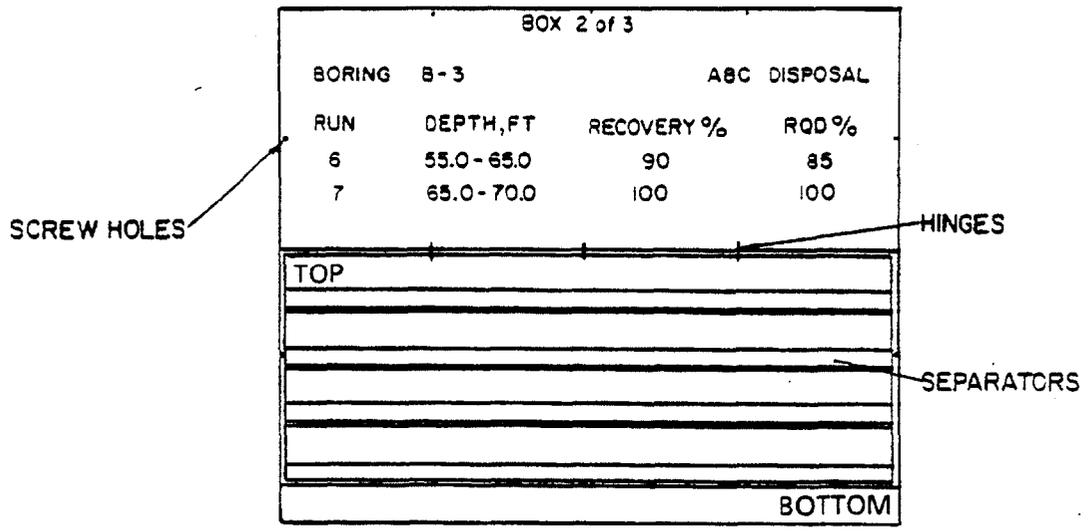
The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

- Project name
- Project number
- Boring number
- Run numbers
- Footage (depths)
- Recovery
- RQD (%)
- Box number and total number of boxes for that boring (Example: Box 5 of 7).

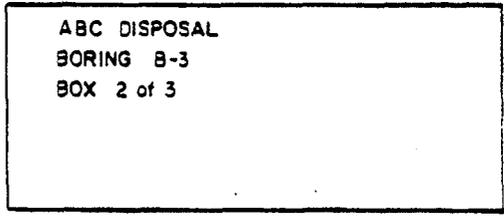
For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number. Attachment No. 2 illustrates a typical rock core box.

Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside cover shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).

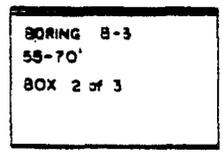
**ATTACHMENT 2**



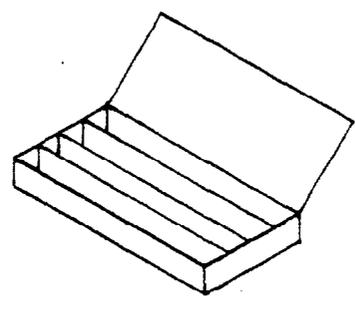
**CORE BOX (OBLIQUE VIEW)**



**CORE BOX (TOP VIEW)**



**CORE BOX (END VIEW)**



**TYPICAL ROCK CORE BOX**

NOT TO SCALE



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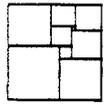
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## 7.0 RECORDS

None.



**NUS**  
CORPORATION

**ENVIRONMENTAL  
MANAGEMENT GROUP**

**STANDARD  
OPERATING  
PROCEDURES**

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Prepared Earth Sciences	
Approved <i>D. Senovich</i> D. Senovich	

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### 1.0 PURPOSE

The purpose of this procedure is to describe the methods, the sequence of operations and the equipment necessary to perform soil and rock borings.

### 2.0 SCOPE

This guideline addresses most of the accepted and standard drilling techniques, their benefits and drawbacks. It should be used generally to determine what type of drilling techniques would be most successful depending on site-specific geologic conditions and the type of sampling required.

### 3.0 GLOSSARY

Boulders - Rounded, semi-rounded or naturally angular particles of rock larger than 12 inches in diameter.

Clay - Fine grained soil or portions of soil having certain physical properties, composition and texture. Clay exhibits plastic properties within a range of water contents and exhibits considerable strength when air dried. Clay consists usually of fragments of hydrous aluminum or magnesium silicate minerals, and it consists predominantly of grains with diameters of less than 0.005 mm.

Cobbles - Rounded, semi-rounded or naturally angular particles of rock between 3 inches and 12 inches in diameter.

Gravel - Rounded or semirounded particles of rock that will pass a 3 inch sieve (7.62 cm) and be retained on a No. 4 U.S. standard sieve (4.76 mm). Coarse gravel is larger than 3/4-inches, while fine gravel is finer than 3/4-inches.

Stone - Crushed or naturally angular particles of rock that will pass a 3 inch sieve (7.62 cm) and be retained on a No. 4 U.S. standard sieve (4.76 mm).

Rock - Any consolidated or coherent and relatively hard, naturally formed mass of mineral matter.

Sand - Particles of rock that will pass a No. 4 U.S. standard sieve (4.76 mm) and be retained on a No. 200 U.S. standard sieve (0.074 mm). Coarse sand is larger than a No. 10 sieve, and fine sand is finer than a No. 40 sieve (0.42 mm).

Silt - Material passing the No. 200 U.S. standard sieve (0.074 mm) that is nonplastic or very slightly plastic and that exhibits little or no strength when air dried.

Soil - Sediments or other unconsolidated accumulations of solid particles that are produced by the physical and chemical disintegration of rock and that may contain organic matter.

Undisturbed Sample - A soil sample that has been obtained by methods in which every precaution has been taken to minimize disturbance to the sample.

Water Table - A surface in an aquifer where groundwater pressure is equal to atmospheric pressure.

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#### 4.0 RESPONSIBILITIES

Site Manager - In consultation with the project geologist, responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and geologic conditions at the site. He should also determine the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

Site Geologist/Rig Geologist - Responsible for insuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see Attachment A of Procedure GH-1.7). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan.

Field Operations Leader - Responsible for overall supervision and scheduling of drilling activities.

Drilling Subcontractor - Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the Field Operations Leader within 24 hours, and must provide advance written notification for any changes in field procedures describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the Field Operations Leader.

The drilling subcontractor will be responsible for following decontamination procedures specified in the Work Plan. Upon completion of the work, the Drilling Subcontractor will be responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

#### 5.0 PROCEDURES

##### 5.1 GENERAL

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site, and
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned using appropriate decontamination procedures (see Procedure GH-1.6 and SF-2.3) between samples and borings. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the rig geologist as they proceed (see Procedure GH-1.5) unless the FSAP specifically states that

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logging is not required. Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the rig geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately.

## 5.2 DRILLING METHODS

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, purpose of drilling, waste conditions at the site, and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

### 5.2.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of screwing augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as the material is brought to the surface. Sampling of such formations will require the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.
- No drilling fluids are required.
- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.
- The inside diameter of hollow stem augers used for well installation should be at least four inches greater than the well casing. Use of such large diameter hollow stem augers is more expensive than the use of small diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.
- The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.
- In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method of drilling is recommended, in particular for wells or boreholes deeper than 25 feet. Hollow stem auger drilling is the preferred method of drilling. Most alternative

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methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods great care must be taken to ensure that the method does not interfere with the collection of a representative sample which is the object of the construction. With this in mind, the preferred order of choice of drilling method after hollow stem augering (HSA) is:

- Cable tool
- Casing drive (air)
- Air rotary
- Mud rotary
- Drive and wash
- Jetting

However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The hollow stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

When taking soil samples for chemical analysis, the hollow-stem auger shall be plugged until the desired sampling depth is reached. Samples can be taken using split-spoon or thin wall tube samplers driven into the formation in advance of the auger (see Procedure GH-1.3). If the sample is to be taken at a relatively deep point, the auger may be advanced without a plug to within five feet of the sample depth. Then clean out the auger stem, insert a plug and continue to the sampling depth. The plug is then removed and samples taken as specified by the rig geologist. Samples should be taken according to the specifications of the sampling plan. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. The sequence shall be repeated for each sample desired.

The hollow-stem auger may be used without the plug when boring for geotechnical examination or for well installation.

When drilling below the water table, specially-designed plugs which allow passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the water table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see GH-1.7 for Well Development Procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedrock lithology must be determined, then a 5-foot confirmatory core run should be conducted (see Section 5.2.9).

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At the option of the Field Operations Leader, when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations it may be prudent to also grout borings which only penetrate the water table aquifer, since loose soil backfill in the boring would still provide a preferred pathway for surface liquids to reach the water table.

### 5.2.2 Continuous-Flight Solid-Stem Auger Drilling

This method is similar to hollow-stem augering. Practical application of this method is severely restricted as compared with hollow stem augers. Split barrel (split-spoon) sampling cannot be done without pulling the augers which may allow the hole to collapse. The method is therefore very time consuming and is not cost effective. Also, augers would have to be withdrawn before installing a monitoring well, which again, may allow the hole to collapse. Furthermore, geologic logging by examining the soils brought to the surface is unreliable as in the case of the hollow stem auger, and depth to water may be difficult to determine while drilling.

There would be very few situations where use of a solid stem auger would be preferable to other drilling methods. The only practical applications of this method would be to drill boreholes for well installation where no lithologic information is desired and the soils are such that the borehole can be expected to remain open after the augers are withdrawn. Alternatively, the technique can be used to find depth to bedrock in an area when no other information is required from drilling.

### 5.2.3 Rotary Drilling

Direct rotary drilling includes air-rotary and fluid-rotary drilling. Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole. Advantages of this method include:

- The drilling rate is high (even in rock).
- The cost per foot of drilling is relatively low.
- Air rotary rigs are common in most areas.
- No drilling fluid is required (except when water is injected to keep down dust).
- The borehole diameter is large, to allow room for proper well installation procedures.

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.
- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow.
- In-situ samples cannot be taken, unless the hole is cased.
- Casing must generally be used in unconsolidated materials.
- Air rotary drill rigs are large and heavy.

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A variation of the typical air-rotary drill bit is a down hole hammer which hammers the drill bit down as it drills. This makes drilling in hard rock faster. Air-rotary drills can also be adapted to use for rock coring although they are generally slower than other types of core drills. A major application of the air-rotary drilling method would be to drill holes in rock for well installation.

Fluid-Rotary drilling operates in a similar manner to air rotary drilling except that a drilling fluid ("mud") or clean water is used in place of air to cool the drill bit and remove cuttings. There are a variety of fluids that can be used with this drilling method, including bentonite slurry and synthetic slurries. If a drilling fluid other than water/cuttings is used, it must be a natural clay (i.e., bentonite) and a "background" sample of the fluid should be taken for analysis of possible organic or inorganic contaminants.

Advantages to the fluid-rotary drilling method include:

- The ability to drill in many types of formations.
- Relatively quick and inexpensive.
- Split barrel (split-spoon) or thin-wall tube samples can be obtained without removing drill rods if the appropriate size drill rods and bits (i.e., fish-tail or drag bit) are used.
- In some borings temporary casing may not be needed as the drilling fluids may keep the borehole open.
- Drill rigs are readily available in most areas.

Disadvantages to this method include:

- Formation logging is not as accurate as with hollow stem auger method if split barrel (split-spoon) samples are not taken (i.e., the depths of materials logged from cuttings delivered to the surface are approximate).
- Drilling fluids reduce permeability of the formation adjacent to the boring to some degree, and require more extensive well development than "dry" techniques (augering, air-rotary).
- No information on depth to water is obtainable while drilling.
- Fluids are needed for drilling, and there is some question about the effects of the drilling fluids on water samples obtained. For this reason as well, extensive well development may be required.
- In very porous materials (i.e., rubble fill, boulders, coarse gravel) drilling fluids may be continuously lost into the formation. This will require either constant replenishment of the drilling fluid, or the use of casing through this formation.
- Drill rigs are large and heavy, and must be supported with supplied water.
- Ground water samples can be potentially diluted with drilling fluid.

The procedures for performing direct rotary soil investigations and sampling shall conform with the applicable ASTM standards: D2113-83, D1587-83, and D1586-84.

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For air or fluid-rotary drilling, the rotary drill may be advanced to the desired depth by any power-operated drilling machine having sufficient torque and ram range to rotate and force the bit to the desired depth. The drilling machine must, however, be equipped with any accessory equipment needed to perform required sampling, or coring. Prior to sampling, any settled drill cuttings in the borehole must be removed.

Soil samples shall be taken as specified by the Work Plan or more frequently if requested by the field geologist. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool.

When field conditions prevent the advancement of the hole to the desired depth, a new boring may be drilled at the request of the Field Operations Leader. The original boring shall be backfilled using methods and materials appropriate for the given site and a new boring started a short distance away at a location determined by the site geologist.

#### 5.2.4 Reverse Circulation Rotary Drilling

The common reverse-circulation rig is a water or mud rotary rig with a large diameter drill pipe which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water-quality sampling wells because of the use of drilling muds and the large diameter hole which is created. A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe.

Advantages of the latter method include:

- The formation water is not contaminated by the drilling water.
- Formation samples can be obtained, from known depths.
- When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.
- Collapsing of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air rotary rig.

Disadvantages include:

- Double-wall, reverse-circulation drill rigs are very rare and expensive to operate.
- Placing cement grout around the outside of the well casing above a well screen often is difficult, especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.

#### 5.2.5 Drill-through Casing Driver

The driven-casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig or an air hammer and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driven down in stages (usually 5 feet per stage). A continuous record is kept of the blows per foot in driving the casing (see Procedure GH-1.5). The casing is normally advanced by a 300-pound

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hammer falling freely through a height of 30-inches. Simultaneous washing and driving of the casing is not recommended. If this procedure is used, the elevations between which water is used in driving the casing should be recorded.

The driven casing method is used in unconsolidated formations only. When the boring is to be used for later well installation, the driven casing used should be at least four inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:

- Split barrel (split-spoon) sampling can be conducted while drilling.
- Well installation is easily accomplished.
- Drill rigs used are relatively small and mobile.
- The use of casing minimizes flow into the hole from upper water-bearing layers; therefore multiple aquifers can be penetrated and sampled for rough field determinations of some water quality parameters.

Some of the disadvantages include:

- This method can only be used in unconsolidated formations.
- The method is slower than other methods (average drilling progress is 30 to 50 feet per day).
- Maximum depth of the borehole varies with the size of the drill rig and casing diameter used, and the nature of the formations drilled.
- The cost per hour or per foot of drilling may be substantially higher than other drilling methods.
- It is difficult and time consuming to pull back the casing if it has been driven very deep (deeper than 50 feet in many formations).

#### 5.2.6 Cable Tool Drilling

A cable tool rig uses a heavy, solid-steel, chisel-type drill bit ("tool") suspended on a steel cable, which when raised and dropped chisels or pounds a hole through the soils and rock. Drilling progress may be expedited by the use of "slip-jars" which serve as a cable-activated down hole percussion device to hammer the bit ahead.

When drilling through the unsaturated zone, some water must be added to the hole. The cuttings are suspended in the water and then bailed out periodically. Below the water table, after sufficient ground water enters the borehole to replace the water removed by bailing, no further water need be added.

When soft caving formations are encountered, it is usually necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is lowered through the casing, the hole created by the bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven into the hole (see Section 5.2.5 of this guideline).

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Advantages of the cable-tool method include the following:

- Information regarding water-bearing zones is readily available during the drilling. Even relative permeabilities and rough water quality data from different zones penetrated can be obtained by skilled operators.
- The cable-tool rig can operate satisfactorily in all formations, but is best suited for caving, boulder, coarse or coarse gravel type formations (e.g., glacial till) or formations with large cavities above the water table (such as limestones).
- When casing is used, the casing seals formation water out of the hole, preventing down-hole contamination and allowing sampling of deeper aquifers for field-measurable water quality parameters.
- Split barrel (split spoon) or thin-wall tube samples can be collected through the casing.

Disadvantages include:

- Drilling is slow compared with rotary rigs.
- The necessity of driving the casing in unconsolidated formations requires that the casing be pulled back if exposure of selected water-bearing zones is desired. This process complicates the well completion process and often increases costs. There is also a chance that the casing may become stuck in the hole.
- The relatively large diameters required (minimum of 4-inch casing) plus the cost of steel casing result in higher costs compared to rotary drilling methods where casing is not required, such as use of a hollow stem auger.
- Cable-tool rigs have largely been replaced by rotary rigs. In some parts of the U.S., availability may be difficult.

### 5.2.7 Jet Drilling (Washing)

Jet drilling, which should be used only for piezometer or vadose zone sampler installation, consists of pumping water or drilling mud down through a small diameter (1/2 to 2-inch) standard pipe (steel or PVC). The pipe may be fitted with a chisel bit or a special jetting screen. Formation materials dislodged by the bit and jetting action of the water are brought to the surface through the annulus around the pipe. As the pipe is jetted deeper, additional lengths of pipe may be added at the surface.

Jet percussion is a variation of the jetting method, in which the casing is driven with a drive weight. Normally, this method is used to place 2-inch diameter casing in shallow, unconsolidated sand formations but has been used to install 3- to 4-inch diameter casings to 200 feet.

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Jetting is acceptable in very soft formations, usually for shallow sampling, and when introduction of drilling water to the formation is acceptable. Such conditions would occur during rough stratigraphic investigation or installation of piezometers for water level measurement. Advantages of this method include:

- Jetting is fast and inexpensive.
- Because of the small amount of equipment required, jetting can be accomplished in locations where access by a normal drilling rig would be very difficult. For example, it would be possible to jet down a well point in the center of a lagoon at a fraction of the cost of using a drill rig.
- Jetting numerous well points just into a shallow water table is an inexpensive method for determining the water table contours, hence flow direction.

Disadvantages include the following:

- A large amount of foreign water or drilling mud is introduced above and into the formation to be sampled.
- Jetting is usually done in very soft formations which are subject to caving. Because of this caving, it is often not possible to place a grout seal above the screen to assure that water in the well is only from the screened interval.
- The diameter of the casing is usually limited to 2 inches; therefore, samples must be obtained by methods applicable to small diameter casings.
- Jetting is only possible in very soft formations that do not contain boulders or coarse gravel, and the depth limitation is shallow (about 30 feet without jet percussion equipment).
- Large quantities of water are often needed.

### 5.2.8 Drilling with a Hand Auger

This method is applicable wherever the formation, total depth of sampling, and the site and groundwater conditions are such as to allow hand auger drilling. Hand augering can also be considered at locations where drill rig access is not possible. All hand auger borings will be performed according to ASTM D1452-80.

Samples should be taken continuously unless otherwise specified by the Work Plan. Any required sampling is performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. Typical equipment used for sampling and advancing shallow "hand auger" holes are Iwan samplers (which are rotated) or post hole diggers (which are operated like tongs). This technique is slow but effective where larger pieces of equipment do not have access and where very shallow holes are desired (less than 5 feet). Surficial soils must be composed of relatively soft and non-cemented formations to allow penetration by the auger.

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### 5.2.9 Rock Drilling and Coring

When soil borings cannot be continued using augers or rotary methods due to the hardness of the soil or when rock or large boulders are encountered, drilling and sampling can be performed using a diamond bit corer in accordance with ASTM D2113.

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond studded bit attached to the outer core barrel in a double tube core barrel. The use of single tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation to this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required.

Core borings are made through the casing used for the soil borings. The casing must be driven and sealed into the rock formation to prevent seepage from the overburden into the hole to be cored (see Section 5.3 of this guideline). A double-tube core barrel with a diamond bit and reaming shell or equivalent should be used to recover rock cores of a size specified in the Work Plan. The most common core barrel diameters are listed in Attachment A. Soft or decomposed rock should be sampled with a driven split-barrel whenever possible or cored with a Denison or Pitcher sampler.

When coring rock, including shale and claystone, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled. Should any rock formation be so soft or broken that the pieces continually fall into the hole, causing unsatisfactory coring, the hole should be reamed and a flush joint casing installed to a point below the broken formation. The size of the flush joint casing must permit securing the core size specified. When soft or broken rock is anticipated, the length of core runs should be reduced to less than 5 feet to avoid core loss and minimize core disturbance.

Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).

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- Depth to water cannot accurately be determined if water is used for drilling.
- The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install larger diameter wells in coreholes, the hole must be reamed out to the proper size after boring, using air or mud rotary drilling methods.

#### 5.2.10 Drilling & Support Vehicles.

In addition to the drilling method required to accomplish the objectives of the field program, the type of vehicle carrying the drill rig and/or support equipment, and its suitability for the site terrain, will often be an additional deciding factor in planning the drilling program. The types of vehicles available are extensive, and depend upon the particular drilling subcontractor's fleet. Most large drilling subcontractors will have a wide variety of vehicle and drill types suited for most drilling assignments in their particular region, while smaller drilling subcontractors will usually have a fleet of much more limited diversity. The weight, size, and means of locomotion (tires, tracks, etc.) of the drill rig must be selected to be compatible with the site terrain, to assure adequate mobility between borehole locations. Such considerations also apply to necessary support vehicles used to transport water and/or drilling materials to the drill rigs at the borehole locations. When the drill rigs or support vehicles do not have adequate mobility to easily traverse the site, provisions must be made for assisting equipment, such as bulldozers, winches, timber planking, etc., to maintain adequate progress during the drilling program.

Some of the typical vehicles which are usually available for drill rigs and support equipment are:

- Totally portable drilling/sampling equipment, where all necessary components (tripods, samplers, hammers, catheads, etc.) may be hand-carried to the borehole site. Drilling/sampling methods used with such equipment include:
  - Hand augers and lightweight motorized augers
  - Retractable plug samplers-driven by hand (hammer)
  - Motorized cathead - a lightweight aluminum tripod with a small gas-engine cathead mounted on one leg, used to install small diameter cased borings. This rig is sometimes called a "monkey on a stick."
- Skid-mounted drilling equipment containing a rotary drill or engine-driven cathead (to lift hammers and drill string), a pump, and a dismantled tripod. The skid is pushed, dragged, or winched (using the cathead drum) between boring locations.
- Small truck-mounted drilling equipment uses a jeep, stake body or other light truck (4 to 6 wheels), upon which are mounted the drill and/or a cathead, a pump, and a tripod or small drilling derrick. On some rigs the drill and/or a cathead are driven by a power take-off from the truck, instead of by a separate engine.
- Track-mounted drilling equipment is similar to truck-mounted rigs, except that the vehicle used has wide bulldozer tracks for traversing soft ground. Sometimes a continuous-track "all terrain vehicle" is also modified for this purpose. Some types of tracked drill rigs are called "bombardier" or "weasel" rigs.
- Heavy truck-mounted drilling equipment is mounted on tandem or dual tandem trucks to transport the drill, derrick, winches, and pumps or compressors. The drill may be provided

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with a separate engine or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground sites, the drilling equipment is sometimes mounted on and off the road vehicle having low pressure, very wide diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.

- Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles includes:
  - Barrel float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallon drums or similar flotation units.
  - Barge-mounted drill rigs.
  - Jack-up platforms - drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.
  - Drill ships - for deep ocean drilling.

In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.

#### 5.2.11 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling components, so that they will fit properly in the boring or well.

For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the holes they drill (i.e., 5-7/8" or 7-7/8" bits will nominally drill 6" and 8" holes, respectively).

For obtaining split-barrel samples of a formation, samplers are manufactured in sizes ranging from 2-inches to 4-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used, and driven by a 140-pound ( $\pm 2$  pound) hammer dropping 30-inches ( $\pm 1$  inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the Work Plan.

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### 5.2.12 Estimated Drilling Progress

To estimate the anticipated rates of drilling progress for a site the following must be considered:

- The speed of the drilling method employed.
- Applicable site conditions (e.g., terrain, mobility between borings, difficult drilling conditions in bouldery soils, rubble fill or broken rock, etc.).
- Project-imposed restrictions (e.g., drilling while wearing personal protective equipment, decontamination of drilling equipment, etc.).

Based on recent experience in drilling average soil conditions (no boulders) and taking samples at 5-foot intervals, for moderate depth (30' to 50') boreholes (not including installation or development of wells), the following daily rates of total drilling progress may be anticipated for the following drilling methods:

Drilling Method	Average Daily Progress (linear feet)
Hollow-stem augers	75'
Solid-stem augers	50'
Mud Rotary Drilling	100' (cuttings samples)
Reverse Circulation Rotary	100' (cuttings samples)
Skid Rig with driven casing	30'
Rotary with driven casing	50'
Cable Tool	30'
Hand Auger	Varies
Continuous Rock Coring	50'

### 5.3 PREVENTION OF CROSS-CONTAMINATION

A telescoping or multiple casing technique minimizes the potential for the migration of contaminated groundwater to lower strata below a confining layer. The telescoping technique consists of drilling to a confining layer utilizing a spun casing method with a diamond cutting or augering shoe, (a method similar to the rock coring method described in Section 5.2.9, except that larger casing is used) or a driven-casing method (see Section 5.2.5 of this guideline), and installing a specified diameter steel well casing. The operation consists of three separate steps. Initially, a drilling casing usually of 8-inch diameter is installed followed by installation of the well casing (6-inch diameter is common for 2-inch wells). This well casing is driven into the confining layer to insure a tight seal at the bottom of the hole. The well casing is sealed at the bottom with a bentonite-cement slurry. The remaining depth of the boring is drilled utilizing a narrower diameter spun or driven casing technique within the outer well casing. A smaller diameter well casing with an appropriate length of slotted screen on the lower end is installed to the surface.

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Clean sand is placed in the annulus around and to a point about 2 feet above the screen prior to withdrawal of the drilling casing. The annular space above the screen and to a point 2 feet above the bottom of the outer well casing is sealed with a tremied cement-bentonite slurry which is pressure-grouted or displacement-grouted into the hole. The remaining casing annulus is backfilled with clean material and grouted at the surface, or it is grouted all the way to the surface.

#### 5.4 CLEANOUT OF CASING PRIOR TO SAMPLING

The boring hole must be completely cleaned of disturbed soil, segregated coarse material and clay adhering to the inside walls of the casing. The cleaning must extend to the bottom edge of the casing and, if possible, a short distance further (1 or 2 inches) to bypass disturbed soil resulting from the advancement of the casing. Loss of wash water during cleaning should be recorded.

For disturbed samples both above and below the water table and where introduction of relatively large volumes of wash water is permissible, the cleaning operation is usually performed by washing the material out of the casing with water; however, this cleaning should never be accomplished with a strong, downward directed jet which will disturb the underlying soil. When clean-out has reached the bottom of the casing or slightly below (as specified above), the string of tools should be lifted one foot off the bottom with the water still flowing, until the wash water coming out of the casing is clear of granular soil particles. In formations where the cuttings contain gravel and other larger particles, it is often useful to repeatedly raise and lower the drill rods and wash bit while washing out the hole, to surge these large particles upward out of the hole. As a time saver, the drilling contractor may be permitted to use a split barrel (split-spoon) sampler with the ball check valve removed as the clean out tool, provided the material below the spoon is not disturbed and the shoe of the spoon is not damaged. However, because the ball check valve has been removed, in some formations it may be necessary to install a flap valve or spring sample retainer in the split spoon bit, to prevent the sample from falling out as the sampler is withdrawn from the hole. The use of jet-type chopping bits is discouraged except where large boulders and cobbles or hard-cemented soils are encountered. If water markedly softens the soils above the water table, clean out should be performed dry with an auger.

For undisturbed samples below the water table, or where wash water must be minimized, clean out is usually accomplished with an appropriate diameter clean out auger. This auger has cutting blades at the bottom to carry loose material up into the auger, and up-turned water jets just above the cutting blades to carry the removed soil to the surface. In this manner there is a minimum of disturbance at the top of the material to be sampled. If any gravel material washes down into the casing and cannot be removed by the cleanout auger, a split-barrel sample can be taken to remove it. Bailers and sandpumps should not be used. For undisturbed samples above the groundwater table, all operations must be performed in a dry manner.

If all of the cuttings created by drilling through the overlying formations are not cleaned from the borehole prior to sampling, some of the problems which may be encountered during sampling include:

- When sampling is attempted through the cuttings remaining in the borehole, all or part of the sampler may become filled with the cuttings. This limits the amount of sample from the underlying formation which can enter and be retained in the sampler, and also raises questions on the validity of the sample.
- If the cuttings remaining in the borehole contain coarse gravel and/or other large particles, these may block the bit of the sampler and prevent any materials from the underlying formation from entering the sampler when the sampler is advanced.

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- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler.
- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the rig geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string; then to measure the height of this reference point above the ground surface. The difference of these measurements is the depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches for cuttings are encountered, the borehole must be recleaned prior to attempting sampling.

## 5.5 MATERIALS OF CONSTRUCTION

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in FT-7.01. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples for chemical analysis are to be collected. These slurry materials could be used for installation of long term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods and procedures for their use must be provided by the site geologist and approved by the site manager. The specific slurry composition and the concentration of selected chemicals for each site must be known.

For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in loose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field at the judgment of the site geologist and noted in the Site Logbook, and only after approval by the site manager, a vegetable oil or silicone based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

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## 6.0 REFERENCES

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## 7.0 ATTACHMENTS

Attachment A - Drilling Equipment Sizes

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ATTACHMENT A

DRILLING EQUIPMENT SIZES

<u>Drilling Component</u>	<u>Designation or Hole Size (in)</u>	<u>O.D. (in)</u>	<u>I.D. (in)</u>	<u>Coupling I.D. (in)</u>
Hollow-Stem Augers (Ref 7)	6 1/4	5	2 1/4	-
	6 3/4	5 3/4	2 3/4	-
	7 1/4	6 1/4	3 1/4	-
	13 1/4	12	6	-
Thin Wall Tube Samplers (Ref 7)	-	2	1 7/8	-
	-	2 1/2	2 3/8	-
	-	3	2 7/8	-
	-	3 1/2	3 3/8	-
	-	4 1/2	4 3/8	-
Drill Rods (Ref 7)	RW	1 3/32	23/32	13/32
	EW	1 3/8	15/16	7/16
	AW	1 3/4	1 1/4	5/8
	BW	2 1/8	1 3/4	3/4
	NW	2 5/8	2 1/4	1 3/8
	HW	3 1/2	3 1/16	2 3/8
	E	1 5/16	7/8	7/16
	A	1 5/8	1 1/8	9/16
	B	1 7/8	1 1/4	5/8
N	2 3/8	2	1	
Driven External Coupled Extra Strong Steel* Casing (Ref 8)	2 1/2	2.875	2.323	0.276
	3	3.5	2.9	0.300
	3 1/2	4.0	3.364	0.318
	4	4.5	3.826	0.337
	5	5.63	4.813	0.375
	6	6.625	5.761	0.432
	8	8.625	7.625	0.500
	10	10.750	9.750	0.500
	12	12.750	11.750	0.500

Wall  
Thickness (in)

\* Add twice the casing wall thickness to casing O.D. to obtain the approximate O.D. of the external pipe couplings.

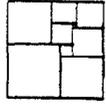
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ATTACHMENT A

DRILLING EQUIPMENT SIZES

<u>Drilling Component</u>	<u>Designation or Hole Size (in)</u>	<u>O.D. (in)</u>	<u>I.D (in)</u>	<u>Coupling I.D. (in)</u>
Flush Coupled Casing (Ref 7)	RX	1 7/16	1 3/16	1 3/16
	EX	1 13/16	1 5/8	1 1/2
	AX	2 1/4	2	1 29/32
	BX	2 7/8	2 9/16	2 3/8
	NX	3 1/2	3 3/16	3
	HX	4 1/2	4 1/8	3 15/16
Flush Joint Casing (Ref 7)	RW	1 7/16	1 3/16	
	EW	1 13/16	1 1/2	
	AW	2 1/4	1 29/32	
	BW	2 7/8	2 3/8	
	NW	3 1/2	3	
	HW	4 1/2	4	
	PW	5 1/2	5	
	SW	6 5/8	6	
	UW	7 5/8	7	
	ZW	8 5/8	8	
Diamond Core Barrels (Ref 7)	EWM	1 1/2	7/8	**
	AWM	1 7/8	1 1/8	**
	BWM	2 3/8	1 5/8	**
	NWM	3	2 1/8	
	HWG	3 7/8	3	
	2 3/4 X 3 7/8	3 7/8	2 11/16	
	4 X 5 1/2	5 1/2	3 15/16	
	6 X 7 3/4	7 3/4	5 15/16	
	AQ (wireline)	1 57/64	1 1/16	**
	BQ (wireline)	2 23/64	1 7/16	**
	NQ (wireline)	2 63/64	1 7/8	
HQ (wireline)	3 25/32	2 1/2		

\*\* Because of the fragile nature of the core and the difficulty to identify rock details, use of small diameter core (1 3/8") is not recommended.



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**STANDARD  
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Applicability  
EMG

Prepared  
Earth Sciences

Approved  
*D. Senovich*  
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Subject

**BOREHOLE AND SAMPLE LOGGING**

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## 1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

## 2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

## 3.0 GLOSSARY

None.

## 4.0 RESPONSIBILITIES

Site Geologist - Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used onsite the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

## 5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

### 5.1 MATERIALS NEEDED

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute HCl
- Ruler (marked in tenths and hundredths of feet)
- Hand Lens

### 5.2 CLASSIFICATION OF SOILS

All data shall be written directly on the boring log (Exhibit 4-1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

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### 5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Exhibit 4-2. This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse grained soils shall be divided into rock fragments, sand, or gravel. The terms sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as "(1/4 inch $\phi$ -1/2 inch $\phi$ )" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

### 5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

### 5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.2. Those designations are:

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Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140 pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, and SC (see Exhibit 4-2).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Exhibit 4-3. Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Exhibit 4-2).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength) or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are as follows:

Consistency	Unc. Compressive Str. Tons/Square Foot	Standard Penetration Resistance (Blows per Foot)	Field Identification Methods
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Very stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Hard	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

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#### 5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
trace	0 - 10 percent
some	11 - 30 percent
and or adjective form of the soil type (e.g., "sandy")	31 - 50 percent

Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

#### 5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

#### 5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Exhibit 4-4.

#### 5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).

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### 5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

### 5.3 CLASSIFICATION OF ROCKS

Rocks are grouped into three main divisions, including sedimentary, igneous and metamorphic rocks. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.
- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.
- Claystone - Vary fine grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.
- Shale - A fissile very fine grained rock. Fractures along bedding planes.
- Limestone - Rock made up predominantly of calcite (CaCO<sub>3</sub>). Effervesces strongly upon the application of dilute hydrochloric acid.
- Coal - Rock consisting mainly of organic remains.
- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. These include conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
- Other characteristics

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### 5.3.1 Rock Type

As described above, there are numerous names of sedimentary rocks. In most cases a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Exhibit 4-5 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a hand lens, the rock is a siltstone. If the grains are not distinguishable with a hand lens, the rock is a claystone.

### 5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

Rock Color Charts shall not be used unless specified by the project manager.

### 5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification will also be used for rock classification.

### 5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).
- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.
- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.
- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the words "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

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### 5.3.5 Fracturing

The degree of fracturing or brokenness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V. BR.) - Less than 2 in. spacing between fractures
- Broken (BR.) - 2 in. to 1 ft. spacing between fractures
- Blocky (BL.) - 1 to 3 ft. spacing between fractures
- Massive (M.) - 3 to 10 ft. spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

#### Method of Calculating RQD (After Deere, 1964)

$$RQD \% = r/l \times 100$$

$r$  = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

$l$  = Total length of the coring run.

### 5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.
- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.
- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.
- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

### 5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified)
- Description of any filled cavities or vugs.
- Cementation (calcareous, siliceous, hematitic)

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- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

### 5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inch or less), probably continuous layer.
- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."
- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."
- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."
- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.
- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.
- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.
- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.
- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse grained dark igneous rock.

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The following are some basic names that are applied to metamorphic rocks:

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.
- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.
- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.
- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.
- Quartzite - A fine to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

#### 5.4 ABBREVIATIONS

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C - Coarse	Lt - Light	Yl - Yellow
Med - Medium	BR - Broken	Or - Orange
F - Fine	BL - Blocky	SS - Sandstone
V - Very	M - Massive	Sh - Shale
Sl - Slight	Br - Brown	LS - Limestone
Occ - Occasional	Bl - Black	Fgr - Fine grained
Tr - Trace		

#### 5.5 BORING LOGS AND DOCUMENTATION

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceding sections shall be used to complete the logs. A sample boring log has been provided as Exhibit 4-6. The field geologist/engineer shall use this example as a guide in completing each borings log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided on the back of the boring log, for field use.

##### 5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.
- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology a 13.7 feet, shall be lined off at the proportional location between the 13 and 14 foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.

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- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.
- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.
- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart of back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.
- Enter color of the material in the appropriate column.
- Describe material using the USCS. Limit this column for sample description only. The predominate material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:
  - Trace 0 - 10 percent
  - Some 11 - 30 percent
  - And 31 - 50 percent
- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.
- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.
- The following information shall be entered under the Remarks Column and shall include, but is not limited by the following:
  - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.
  - Angularity - describe angularity of coarse grained particles using Angular, Subangular, Subrounded, Rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.
  - Particle shape - flat, elongated, or flat and elongated.
  - Maximum particle size or dimension.
  - Water level observations.
  - Reaction with HCl - none, weak or strong.

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- Additional comments:
  - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.
  - Indicate odor and HNu or OVA reading if applicable.
  - Indicate any change in lithology by drawing in line through the lithology change column and indicate the depth. This will help later on when cross-sections are constructed.
  - At the bottom of the page indicate type of rig, drilling method, hammer size and drop and any other useful information (i.e., borehole size, casing set, changes in drilling method).
  - Vertical lines shall be drawn (as shown in Exhibit 4.6) in columns 5 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.
  - Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

### 5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent and core recovery under the appropriate columns.
- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.
- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.
- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.
- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.
- Enter brokenness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.

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- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:
  - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
  - Indicate calcareous zones, description of any cavities or vugs.
  - Indicate any loss or gain of drill water.
  - Indicate drop of drill tools or change in color of drill water.
- Remarks at the bottom of Boring Log shall include:
  - Type and size of core obtained.
  - Depth casing was set.
  - Type of Rig used.
- As a final check the boring log shall include the following:
  - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.
  - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

### 5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5 foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date etc.). Cuttings shall be closely examined to determine general lithology.
- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.
- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.
- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.
- Record this and any other useful information onto the boring log as provided in Exhibit 4-1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split barrel and rock core sampling methods be used at selected boring locations during the field investigation to

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provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

### **5.6 REVIEW**

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs
- Checking for conformance to the guideline
- Checking to see that all information is entered in their respective columns and spaces

### **6.0 REFERENCES**

Unified Soil Classification System (USCS)

ASTM D2488, 1985

Earth Manual, U.S. Department of the Interior, 1974

### **7.0 RECORDS**

Originals of the boring logs shall be retained in the project files.



**SOIL TERMS**

UNIFIED SOIL CLASSIFICATION (USCS)										
COARSE GRAINED SOILS More than half of material is LARGER than No. 200 sieve size					FINE GRAINED SOILS More than half of material is SMALLER than No. 200 sieve size					
FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)			GROUP SYMBOL	TYPICAL NAMES	FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)			GROUP SYMBOL	TYPICAL NAMES	
GRAVELS 50% (+) > 4.75 mm	CLEAN GRAVELS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines.	Identification procedures on fraction smaller than No. 60 sieve size					
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.	SILTS & CLAYS Liquid limit > 50	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)			TOUGHNESS (Consistency Near Plastic Limit)
	Non plastic fines (for identification procedures see MLI)	GM	Silty gravels, poorly graded gravel-silt mixtures.	None to slight		Quick to slow	None			
	Plastic fines (for identification procedures see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.	Medium to high	None to very slow	Medium				
SANDS 50% (+) > 0.075 mm	CLEAN SANDS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.	SILTS & CLAYS Liquid limit < 50	Slight to medium	Slow to none	Slight to medium	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.		High to very high	None	High	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
	Non plastic fines (for identification procedures see MLI)	SM	Silty sands, poorly graded sand-silt mixtures.	Medium to high	None to very slow	Slight to medium	OL	Organic silts and organic silt-clays of low plasticity.	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
	Plastic fines (for identification procedures see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.	HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			OH	Organic clays of medium to high plasticity.	Pt

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example GW-GC, well graded gravel-sand mixture with clay binder.  
All sieve sizes on this chart are U.S. Standard.

DENSITY OF GRANULAR SOILS	
DESIGNATION	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT
Very loose	0-4
Loose	5-10
Medium dense	11-30
Dense	31-50
Very dense	Over 50

CONSISTENCY OF COHESIVE SOILS			
CONSISTENCY	UNC. COMPRESSIVE STR. TONS/SQ. FT.	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Very stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

**ROCK TERMS**

ROCK HARDNESS (FROM CORE SAMPLES)		
DESCRIPTIVE TERMS	SCREWDRIVER OR KNIFE EFFECTS	HAMMER EFFECTS
Soft	Easily gouged	Crushes when pressed with hammer
Medium soft	Can be gouged	Breaks (one blow) Crumbly edges
Medium hard	Can be scratched	Breaks (one blow) Sharp edges
Hard	Cannot be scratched	Breaks concoidally (several blows) Sharp edges

ROCK BROKENNESS		
DESCRIPTIVE TERMS	ABBREVIATION	SPACING
Very broken	(V. Br.)	0 - 2"
Broken	(Br.)	2" - 1'
Blocky	(Bl.)	1' - 3'
Massive	(M.)	3' - 10'

**LEGEND**

**SOIL SAMPLES - TYPES**

- S - 2" O.D. Split Barrel Sample
- ST - 3" O.D. Undisturbed Sample
- O - Other Samples, Specify in Remarks

**ROCK SAMPLES - TYPES**

- X - NX (Conventional) Core (~2-1/8" O.D.)
- Q - NQ (Wireline) Core (~1-7/8" O.D.)
- Z - Other Core Sizes, Specify in Remarks

**WATER LEVELS**

- 12-18
- 9-12.6' Initial Level = /Date & Depth
- 12-18
- 9-12.6' Stabilized Level = /Date & Dept

EXHIBIT 4-2

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**EXHIBIT 4-3**

**CONSISTENCY FOR COHESIVE SOILS**

Consistency	(Blows per Foot)	Unconfined Compressive Strength (tons/square foot by pocket penetration)	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented by thumbnail

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**EXHIBIT 4-4**

**BEDDING THICKNESS CLASSIFICATION**

Thickness (Metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	< 1/32"	Micro Laminated

(Weir, 1973 and Ingram, 1954)

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**EXHIBIT 4-5**

**GRAIN SIZE CLASSIFICATION FOR ROCKS**

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4-64 mm
Granules	2-4 mm
Very Coarse Sand	1-2 mm
Coarse Sand	0.5-1 mm
Medium Sand	0.25-0.5 mm
Fine Sand	0.125-0.25 mm
Very Fine Sand	0.0625-0.125 mm
Silt	0.0039-0.0625 mm

After Wentworth, 1922



<b>BORING LOG</b>	<b>NUS CORPORATION</b>
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PROJECT: **HEBELKA SITE** ..... BORING NO.: **MW 3A**  
 PROJECT NO.: **619Y** ..... DATE: **9-22-87** ..... DRILLER: **B. GOLLIHUE**  
 ELEVATION: ..... FIELD GEOLOGIST: **SJ. CONTI** .....  
 WATER LEVEL DATA: .....  
 (Date, Time & Conditions) .....

SAMPLE NO. & TYPE	DEPTH (ft.)	BLOWS 6" OR ROD (ft.)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION*			USCS	REMARKS
					SOIL DENSITY, CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
9-22	25.0				M.HARD	GRAY	SILTY SHALE (SILTSTONE) - FEW QUARTZ SEAMS	VBR	SHALE IS VBR W/ HORIZ TO 10 4 JNTS 26 TO 27 2- VERT JOINTS. IRON STAINS ON JNTS ROCK BECOMES AND BREAKS MORE LIKE A SILTSTONE WITH DEPTH.
0/0.0	2	99%	8-7/10.0					BR	232 TO 33 FEW QUARTZ PIECES W/ VUGS.
								VBR	SL. MICALOID S VF QUARTZ GRAINS IN MATRIX - 30X MAG.
	35.0				M.HARD	GRAY	SILTY SHALE (SILTSTONE) - FEW QUARTZ SEAMS	VBR	234 TO 35 - 2 VERT JOINTS 35.0 - 35.5 QUARTZ PIECES
								BR	BECOMES SL. CALCAR. 237 ± THIN CALCRE LAMINATIONS.
								VBR	WATER STAINED JNTS THRUOUT RUN MORE SO 35 - 37 ± 39.5 → 42.0
1-0/10.0	3	100%	9-3/10.0					BR	42.7 → 43.0 HI 4 JNT 42.4 → 42.7 VERT JNT
	45.0							VBR	45.3 → 45.5 VERT JNT. 2 VBR
								BR	47.5 VERT JOINT 48. HI 4 JNT SLIGHTLY CALCAROUS MORE CALCRE PRESENT

REMARKS \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

BORING MW 3A  
 PAGE 2 OF 3

\* See Legend on Back

<b>BORING LOG</b>	<b>NUS CORPORATION</b>
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PROJECT: <b>HEBELKA SITE</b>	BORING NO.: <b>MW3A</b>
PROJECT NO.: <b>619Y</b>	DATE: <b>9-22-87</b>
ELEVATION:	DRILLER: <b>B. GOLLHUE</b>
WATER LEVEL DATA:	FIELD GEOLOGIST: <b>SJ. CONTI</b>
(Date, Time & Conditions)	

SAMPLE NO. & TYPE	DEPTH (ft.)	BLOWS 6" OR ADD (")	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION*			USCS	REMARKS
					SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
1-9/100	④	19 0/10	10.9/10.0		M. HARD GRAY		SILTY SHALE (SILTSTONE)	VBR	50.5 → 51.0 VBR
							SL. CALcareous	BR	51.5 → 54.0 BR w/ SEV LO & JOINTS
	55.0								
									VBR POOR RECOVERY w/ SOFT ZONES.
0/10	⑤	00 0/10	1.8/10.0						
	65.0								
									68.0 - DRILLER NOTED SOFT AREA - LOSS OF 1/3 OF WATER - CHANGE IN COLOR OF DRILL WATER TO YELLOW BROWN
0/0	⑥	00 0/10	1.3/10.0						POOR RECOVERY FEW CALcareous ZONES.
	75.0								

REMARKS AT 75' @ 1:45 PM - PULLING TOOLS - TO REAM HOLE.  
 AT 1:50 PM CORED HOLE TO 75' REAMED TWICE  
 DUE TO RUNNING SAND (FRACTURE) AT 68', REAMED 2ND TIME TO 81'. SET WELL 66'-76'.  
 BORING MW3A  
 PAGE 3 OF 3

**EXHIBIT 4-6**

BORING LOG					NUS CORPORATION					
PROJECT: WESTLINE SITE		BORING NO.: MW 013								
PROJECT NO.: 473 Y		DATE: 7-7-87		DRILLER: B ERICSON						
ELEVATION: 1462.37		FIELD GEOLOGIST: S.J. CONTI		PENN - DRILL						
WATER LEVEL DATA: 5.54' @ 8:50 AM 7-23-87 T-PVC				ACKER AD-11						
(Date, Time & Conditions)										
SAMPLE NO. & TYPE OR ROD	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR ROD (ft.)	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREEN ENT.	MATERIAL DESCRIPTION			ROCK OR SOIL USES	REMARKS (HNU) (HEAD OF)	
					SOIL DENSITY, CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION			
S-1	0.0	5	14/1.5	6.0	Loose	BLK BRN	CLAYEY SILT AND CINDED	ML	MOIST (OPPM)	
		3					TR- COLL FRAGS		3/4" Ø FRAGS - NEAR OLD RR. LINE.	
		2						TR- CO. FRAG (FILL)		
S-2	5.0	1	1.3/1.5			V. LOOSE	RED BRN TO GRAY	SANDY SILT-TR OFG TO SILTY SAND-TR GRAVEL	GM	MOIST TO WET (OPPM)
	6.5	3								GENY SAND @ 6' ± HICKORYS LOOKS NATURAL
										DRILLER NOTE H2O 8-10'
S-3	10.0	11	1.2/1.5			DENSE	BRN	SILTY SAND AND S.S.	GM	WET (OPPM)
	11.5	27						FRAGS. (GRAY)		1" Ø SIZE MAX SIZE SUBANGULAR TO SUBROUNDED GRAVEL
S-4	15.0	7	1.0/1.5			V. DENSE	BRN	SILTY FINE TO C. SAND AND GRAVEL	GM	WET (OPPM)
	16.5	47								1" Ø SIZE MAX SIZE SUBANGULAR TO SUBROUNDED GRAVEL
		43								
S-5	20.0									
	20.9	17	1.0/1.9			V. DENSE	DRANG BRN	SILTY SAND - SOME GRAVEL AND S.S. FRAGS	GM	WET (OPPM)
										MOIST BECOMES MORE LIKE SANDY SILT AT BOTTOM OF SAMPLE

REMARKS: START @ 1:15 PM - 7-7-87 USING 4 1/4" ID HOLLOW STEELS  
S-4 @ 3:30 PM TO ADVANCE THE BOPUYS. USING  
S-5 @ 4:30 PM ACKER DRILL - MOUNTED ON  
 SAMPLES TAKEN USING 140 LB WT AND 30 INCH DROP.  
 BORING MW 013  
 PAGE 1 OF 4  
 FOLK 8000 TRUCK

**BORING LOG** **NUS CORPORATION**

PROJECT: WESTLINE SITE BORING NO.: 11W013  
 PROJECT NO.: 473Y DATE: 7-7-87 DRILLER: E. EDWINSON  
 ELEVATION: \_\_\_\_\_ FIELD GEOLOGIST: S.J. CONTI  
 WATER LEVEL DATA: \_\_\_\_\_  
 (Date, Time & Conditions)

SAMPLE NO. & TYPE OR RGD	DEPTH (ft.) OR RUN NO	BLOWS 6" OR ROD (1-)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREEN INT	MATERIAL DESCRIPTION			ROCK BLOWNESS USCS	REMARKS (H.H.)
					SOIL DENSITY, CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
S-6	25.0	6	1.5		DENSE	OLIVE BLUE	SILTY SAND - SOME GRAVEL - TR CLAY	GM	MOIST - WET (OPPM)
	26.5	30				GRAY	GRAVEL - TR CLAY		2.5" IS FEASIBLE FIRST CHANGE IN COLOR. NOT ENOUGH CLAY TO BE CONFINING
							TR. SS. FRAG.		NOTE: MAY SET ZONE 2 CASING @ 28'
	30.0								
S-7	31.5	17	1.5		V. DENSE	MOIST BRN	SILTY SAND - SOME GRAVEL - TR CLAY	EM	MOIST - WET (OPPM)
	34	27				GRAY	TR. SS. FRAG.	GM	2.5" IS FEASIBLE FIRST CHANGE IN COLOR. NOT ENOUGH CLAY TO BE CONFINING
	35.0								
S-8	35.9	30	0.7/0.9		V. DENSE	BLUE GRAY	SILTY F. TO C. SAND - SOME GRAVEL - TR. SS. FRAG.	EM	MOIST - WET (OPPM)
		39.4						GM	V. SL. TR. CLAY - LESS THAN S-7
	40.0								1" D FRAG - MORE COARSE SAND THAN ABOVE
S-9	41.5	31	1.2/1.5		V. DENSE	BLUE BRN GRAY	SILTY SAND (FINE TO M.) - SOME GRAVEL - TR. CLAY	SM	POSSIBLE 3 TO 4.5 SCREEN LOC. SUFFZ'D
		34						GM	MOIST - WET (OPPM)
	45.0								LITTLE MORE CLAY THAN S-8 SUBSINKLED GRAVEL
									VERY SLOW DRILLING 40-45 (RIG STALLS) LESS CLAY LAST 3" OF SAMPLE.
S-10	46.5	13	1.2/1.5		V. DENSE	BLUE BRN GRAY	SILTY SAND (FINE TO M.) - SOME GRAVEL - TR. CLAY	SM	MOIST - WET (OPPM)
		34						GM	1" D SIZE - HOLDS TO - GETTER WHEN SUFFZ'D BUT NOT COHESIVE CLASSIFICATION
									LOW DRILLING TO 50'

7/7  
7/8

REMARKS S-6 @ 4:40 PM  
S-8 @ 8:36 AM 7-8-87  
S-10 @ 10:40 AM 5-11-87

BORING MW013  
PAGE 2 OF 4

BORING LOG					NUS CORPORATION						
PROJECT: WESTLINE SITE					BORING NO.: MW 013						
PROJECT NO.: 473Y					DATE: 7-8-87						
ELEVATION:					DRILLER: B. ERICSON						
WATER LEVEL DATA:					FIELD GEOLOGIST: S. COVATY						
(Date, Time & Conditions)											
SAMPLE NO. & TYPE OR ROD	DEPTH (FE.) OR RUN NO.	BLOWS 6" OR ROD (FT.)	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE (DEPTH FE.) OR SCREEN INT.	MATERIAL DESCRIPTION			FOOT OR EQUIV. USCS	REMARKS		
					SOIL DENSITY, CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION				
S-11	50.0	15 41	1.9 1.3	58.0	V. DENSE	MUDY BRN	SILTY SAND - SOME GR.	GM	MOIST - (OPPM)		
	51.3	50/3					TR. CLAY	SM	MATERIAL W/ PCS OF BLACK COAL/LIGNITE. MORE CLAY THAN ABOVE PORTIONS OF SAMPLE - COHESIVE & STIFF.		
	55.0										
S-12		11 15	1.4 1.5		58.0	V. STIFF TO STIFF	GRAY ORANG BRN	SANDY CLAY / CLAYEY SAND	SC	MOIST → WET (OPPM)	
	56.5	26						SOME GRAVEL		NOTE COLOR CHANGE ALSO - MORE CLAY THAN ANY SAMPLES SURROUNDING GRAINS FIRST COHESIVE TYPE CLASSIF.	
	60.0	40									
S-13	60.9	50 74	0.7 0.9			58.0	V. DENSE	ORANG BRN	SANDY CLAY / CLAYEY SAND - SILTY GRAVEL	SC	MOIST → WET (OPPM)
											GW
	65.0										
7/13 S-14	65.8	37 57.5	0.7 0.8	68.0			V. DENSE	BRN ORANG	SILTY SAND - SOME GR. AND ROCK FRAG -	SM	MOIST (OPPM)
									TR. CLAY	GW	MORE CLAY TOWARDS TOP OF SAMPLE MAX 3/4" D SIZE
										COLOR CHANGE AT 68' MORE SAND PER DRILLER - BOTH OF SEMI CONS. LAYER?	
	70.0										
7/14 S-15		39 39	1.0 1.5		68.0		V. DENSE	YELLOW BRN	CLAYEY SAND (F. TO G.) SOME GRAVEL - TR.	SC	MOIST → WET (OPPM)
	71.5	41							ROCK FRAG.	GC	1" MAX GRAVEL
										MORE GRAVEL @ 72' PER DRILLER	

REMARKS: USING HOLLOW STEEL TO ADVANCE BORING - WASHING OUT THIN AGGREG. WHEN NEEDED TO OBTAIN SAMPLE

S-12 @ 1:46 PM

S-13 @ 3:32 PM - LOGGED IN BY 5:47 PM

SET 6" Ø STEEL CASING TO 68' - WILL DRILL BELOW CASING AFTER GROUT SETS UP. S-14 @ 3:20 PM 7-13-87

S-15 @ 7:57 AM 7-14-87

BORING MW 013  
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Subject

BOREHOLE AND SAMPLE LOGGING

Number

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Revision

2

Effective Date

05/04/90

## BORING LOG

NUS CORPORATION

PROJECT: WESTLINE SITE

BORING NO.: MW013

PROJECT NO.: 437Y

DATE: 7-13-87 / 7-14-87

DRILLER: B. ERICSON

ELEVATION:

FIELD GEOLOGIST: S.J. CONTI

WATER LEVEL DATA:

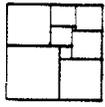
(Date, Time &amp; Conditions)

SAMPLE NO. & TYPE OR ROD	DEPTH (ft.) & RUN NO	BLOWS 6" OR ROD (")	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCR. DAY	MATERIAL DESCRIPTION			SOIL DENSITY: CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	BIRMINGHAM OR USCS	REMARKS (HNU)
					SOIL DENSITY: CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION					
S-16	75.0	37	0.9/1.0	75	V. DENSE	GRAY ORANG	FINE TO C. CLAYEY SAND - SOME	GC	WET (OPPM)			
	76.0	7.5				BRN	GRAVEL - TR ROCK FRAG (S.S.)				NOT AS MUCH CLAY AS S-15 - BOTM OF SAMPLE BECOMES MORE SANDY MAX 1" Ø FC.	
	80.0										NO SAMPLE @ 80' - DECIDED TO GO TO 85'	
	85.0	30	0.4/0.4		V. DENSE	GRAY ORANG	SILTY F. TO C. SAND - SOME	SW	WET (OPPM)			
S-17	85.4	4		85		BRN	GRAVEL - TR S.S. FRAG - TR CLAY				SUBROUNDED GRAINS V. SL TR CLAY - WILL GET SCREEN @ 75 TO 85' IN THIS BORING.	
							BOTM OF HOLE @ 85.0'					

REMARKS S-17 @ 2:20 PM 7-14-87 - METHOD BELONGS 6" CASING  
SPUN 4" Ø - 5 7/8" Ø @ 75' TO BOTM. USING WATER AS  
DRILLING FLUID

BORING MW 013

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**NUS**  
CORPORATION

**ENVIRONMENTAL  
MANAGEMENT GROUP**

**STANDARD  
OPERATING  
PROCEDURES**

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Applicability EMG	
Prepared Earth Sciences	
Approved <i>D. Senovich</i> D. Senovich	

Subject  
GROUNDWATER MONITORING POINT INSTALLATION

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## 1.0 PURPOSE

This procedure describes methods for proper monitoring well design, installation, and development.

## 2.0 SCOPE

This procedure is applicable to the construction of permanent monitoring wells at hazardous waste sites. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be ascertained during the development of the investigation and any required permits which may have to be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

## 3.0 GLOSSARY

Monitoring Well - A well which is properly screened (if screening is necessary), cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface to which water in an aquifer would rise by hydrostatic pressure.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

## 4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force to perform all phases of proper monitoring well installation and construction. He may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Rig Geologist - The rig geologist supervises well installation and construction by the Driller, documents all phases of well installation and construction, and insures that well construction is adequate to provide representative ground water data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

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## 5.0 PROCEDURES

### 5.1 EQUIPMENT/ITEMS NEEDED

Below is a list of items that may be needed while installing a monitoring well.

- Health and safety equipment as required by the site safety officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineers tape, water level indicator, retractable engineers rule electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installations tools (Sledge Hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

### 5.2 WELL DESIGN

The objectives for each monitoring well and its intended use must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials to be used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity)

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, these can be determined through the review of geologic data and the site terrain. In addition, production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary phase to determine groundwater flow direction.

#### 5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the levels at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contamination plume, since groundwater samples collected in wells that are screened over the full thickness of the water bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of

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contamination in water bearing zone. The well diameter would depend upon the hydraulic characteristics of the water bearing zone. Sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following information:

- The vertical location of the contaminant source in relation to the water bearing zone.
- The depth, thickness and uniformity of the water bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (1 to 2 feet) are usually required where flow lines are not horizontal, (ie., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs

Standard monitoring well diameters are 2, 4, 6, or 8 inches. However, drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open hole monitoring wells are required. In the smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced, however, the type of sampling devices that can be used are limited. In specifying well diameter, sampling requirements must be considered. Up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples. The water in the monitoring well available for sampling is dependent on the well diameter as follows:

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Casing Inside Diameter, Inch	Standing Water Depth to Obtain 1 Gal Water (feet)	Total Depth of Standing Water for 4 Gal. (feet)
2	6.13	25
4	1.53	6
6	0.68	3

However, if a specific well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells; however, in small diameter wells, in-situ permeability tests can be performed during drilling or after well installation is completed.

#### 5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength" and Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials in which the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC, galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive discussion on this topic). The two most commonly used materials are PVC and stainless steel for wells in which screens are installed and are compared in Attachment B. Stainless steel is preferred where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, and ease of manipulation; however, there are also some questions about organic chemical sorption and leaching that are currently being researched (see Barcelona et al., 1983). Concern about the use of PVC can be minimized if PVC wells are used strictly for geohydrologic measurements and not for chemical sampling. The crushing strength of PVC may limit the depth of installation, but schedule 80 materials normally used for wells greater than 50 feet deep may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps to be used for sampling or testing. Due to this problem, the minimum well pipe size recommended for schedule 80 wells is 4 inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe, may corrode and release metal ions or chemically react with organic constituents, but this is considered by some to be less of a problem than the problem associated with PVC material. Galvanized steel is not recommended for metal analyses, as zinc and cadmium levels in groundwater samples may be elevated from the zinc coating.

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Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints at slightly more costs. Welded-joint steel casing is also acceptable. Glued PVC may release organic contamination into the well and therefore should not be used if the well is to be sampled for organic contaminants.

When the water bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary and the screened interval is artificially packed with a fine sand. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The rig geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. (For example, as a standard procedure, a Morie No. 1 or Ottawa sand may be used with a 0.010-inch slot screen, however, with a 0.020-inch slot screen, the filter pack material must be the material retained on a No. 20 to No. 30 U.S. standard sieve.)

### 5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a fine to medium grained well graded, silica sand. The quantity of sand placed in the annular space is dependent upon the length of the screened interval but should always extend at least 1 foot above the top of the screen. At least one to three feet of bentonite pellets or equivalent shall be placed above the sand pack. The cement-bentonite grout or equivalent extends from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally, i.e., no artificial sand pack will be installed, and the natural formation material will be allowed to collapse around the well screen after the well is installed. This method has been utilized where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets to the surface. The grout effectively seals the well and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom of the hole upward, to prevent bridging and to provide a better seal. However, in boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of two assemblages of material, i.e., a cement-bentonite grout. A cement bentonite grout normally is a mixture of cement, bentonite and water at a ratio of one 90-pound bag of Portland Type I cement, 3-5 pounds of granular or flake-type bentonite and 6 gallons of water. A neat cement is made up of one ninety-pound bag of Portland Type I cement and 6 gallons of water.

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In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets or equivalent. A short (1'-2') section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

#### **5.2.4 Protective Casing**

When the well is completed and grouted to the surface, a protective steel casing is often placed over the top for the well. This casing generally has a hinged cap and can be locked to prevent vandalism. A vent hole shall be provided in the cap to allow venting of gases and maintain atmospheric pressure as water levels rise or fall in the well. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A Protective casing which is level with the ground surface is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter protective sleeve is set into the wet cement around the well with the top set level with the pavement. A manhole type lid placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

### **5.3 MONITORING WELL INSTALLATION**

#### **5.3.1 Monitoring Wells in Unconsolidated Sediments**

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineers rule to ensure proper well placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, then the sand pack can be installed. A weighted tape measure must be used during the procedure in order to carefully monitor installation progress. The sand is poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur.

After the sand pack is installed to the desired depth, (at least 1 foot above the top of the screen) then the bentonite pellet seal or equivalent, can be installed, in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack.

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The cement-bentonite grout is then mixed and either poured or tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

In stable formations where borehole collapse does not occur, the well can be installed as discussed above, and the use of a temporary casing is not needed. However, centralizers may have to be installed, one above, and one below the screen, to assure enough annular space for sand pack placement. A typical overburden monitoring well sheet is shown.

### 5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large diameter boring through the upper aquifer, 1 to 3 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting the outer casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells, with the exception of not using a temporary casing during installation. Sufficient time which will be determined by the rig geologist, must be allowed for setting of the grout prior to drilling through the confined layer. A typical confining layer monitoring well sheet is shown in Attachment C.

### 5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 feet into the bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout is cured, a smaller diameter boring is continued through the bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. However, if a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be installed temporary until final well installation is completed. Typical well construction forms for bedrock monitoring wells are shown in Attachment C.

### 5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be driven to depths exceeding 10 feet.

### 5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only one or two small-diameter tubes extending to the surface. Manufacturers of these types of samplers claim that four samplers can be installed in a 3-inch diameter borehole. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross contamination from sampling equipment. These samplers also perform well when the water table is within 25 feet from the surface (the typical range of suction pumps). Two manufacturers of these samplers are Timco Manufacturing Company, Inc., of

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Prairie du Sac, Wisconsin, and BARCAD Systems, Inc., of Concord, Massachusetts. Each offers various construction materials.

Two additional types of multilevel sampling systems have been developed. Both employ individual screened openings through a small-diameter casing. One of these systems (marketed by Westbay Instruments Ltd. of Vancouver, British Columbia, Canada) uses a screened port and a sampling probe to obtain samples and head measurements or perform permeability tests. This system allows sampling ports at intervals as close as 5 feet, if desired, in boreholes from 3 to 4.8 inches in diameter.

The other system, developed at the University of Waterloo at Waterloo, Ontario, Canada, requires field assembly of the individual sampling ports and tubes that actuate a simple piston pump and force the samples to the surface. Where the depth to ground water is less than 25 feet, the piston pumps are not required. The assembly is made of easily obtained materials; however, the cost of labor to assemble these monitoring systems may not be cost-effective.

#### 5.4 WELL DEVELOPMENT METHODS

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity and temperature taken during development may yield information (stabilized values) that sufficient development is reached. The selection of the well development method shall be made by the rig geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

Overpumping and Backwashing - Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

Surging with a Surge Plunger - A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is used to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

Compressed Air - Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level

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to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping the well is subsequently done with the air lift method.

High Velocity Jetting - In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

## 6.0 REFERENCES

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Cosby, and J. Fryberger, 1981. Manual of Groundwater Sampling Procedures. R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota, 1989 p.

## 7.0 RECORDS

A critical part of monitoring well installation is recording of significant details and events in the field notebook. The Geologist must record the exact depths of significant hydrogeological features screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (Attachment C) shall be used which allows the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information (shall) include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. The documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded depending on whether the well is completed in overburden, in a confined layer, in bedrock with a cased well, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The Geologist shall calculate the annular space volume and have a general idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in. Any problems with rig operation or down time shall be recorded and may determine the driller's final fee.

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**ATTACHMENT A**

**TABLE 7-4 RELATIVE COMPATIBILITY OF RIGID WELL-CASING MATERIAL (PERCENT)**

	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless steel 304	Stainless steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Miner Acid/High Solids	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials

- 1 Teflon®
- 2 Stainless Steel 316
- 3 Stainless Steel 304
- 4 PVC 1
- 5 Lo-Carbon Steel
- 6 Galvanized Steel
- 7 Carbon Steel
- \* Trademark of DuPont

**RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)**

	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton®*	Silicone	Neoprene	Teflon®*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/High Solids	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials

- 1 Teflon®
  - 2 Polypropylene (PP)
  - 3 PVC flexible/PE linear
  - 4 Viton®
  - 5 PE Conventional
  - 6 Plexiglas/Lucite (PMM)
  - 7 Silicone/Neoprene
- Source: Barcelona et al., 1983
- \* Trademark of DuPont

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**ATTACHMENT B**

**COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION**

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength not critical.
Weight	Relatively heavier	Lightweight, floats in water
Cost	Relatively expensive	Relatively inexpensive
Corrosivity	Deteriorates more rapidly in corrosive water	Non-corrosive--may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated HC
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work in the field.
Preparation for Use	Should be steam-cleaned for organics sampling	Never use glue fittings--pipes should be threaded or pressure-fitted. Should be steam cleaned if used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized	May sorb or release organic substances.

\* See also Attachment A.

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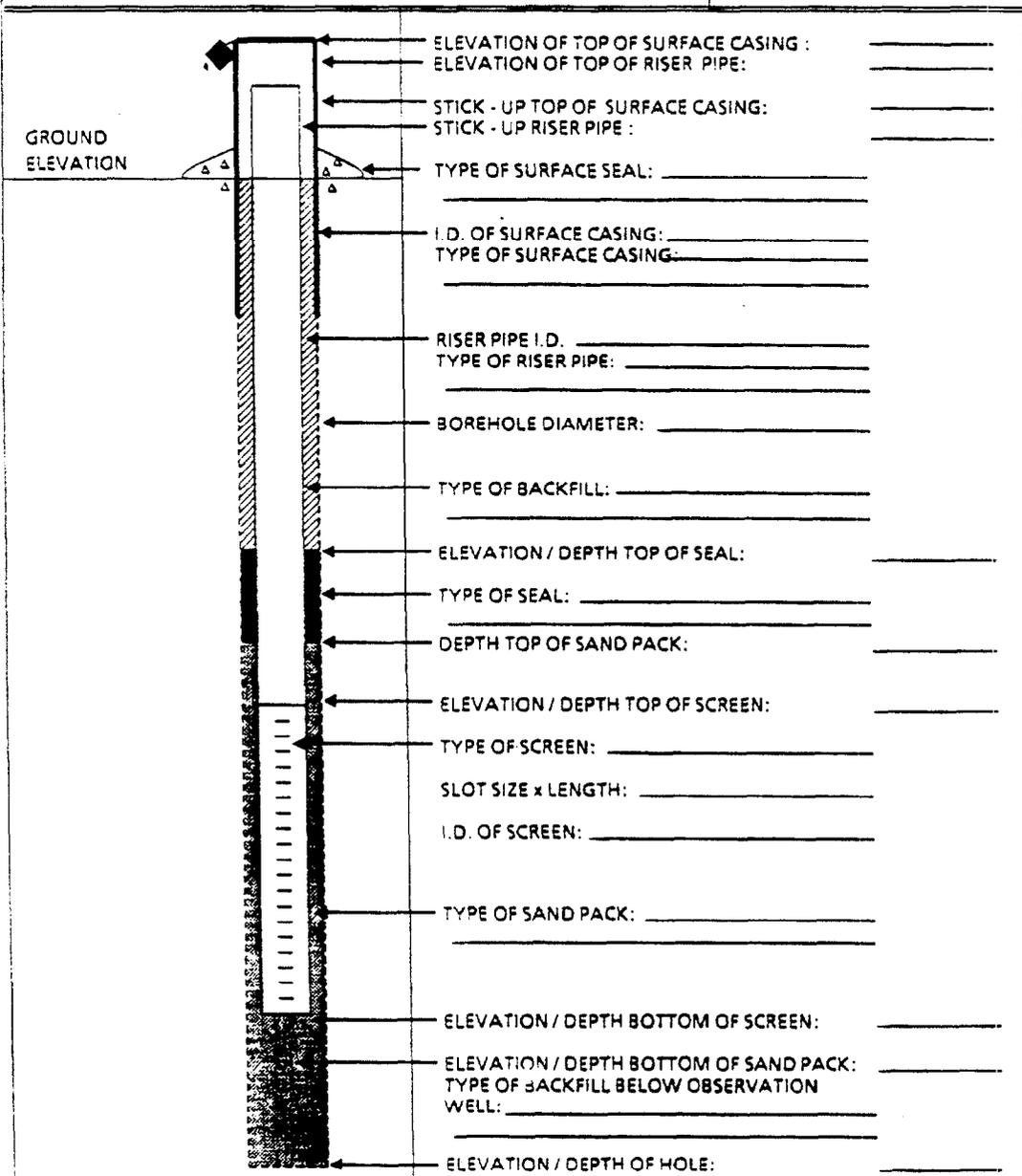
**ATTACHMENT C**



BORING NO. \_\_\_\_\_

**OVERBURDEN  
MONITORING WELL SHEET**

PROJECT: _____	LOCATION: _____	DRILLER: _____
PROJECT NO.: _____	BORING: _____	DRILLING METHOD: _____
ELEVATION: _____	DATE: _____	DEVELOPMENT METHOD: _____
FIELD GEOLOGIST: _____		



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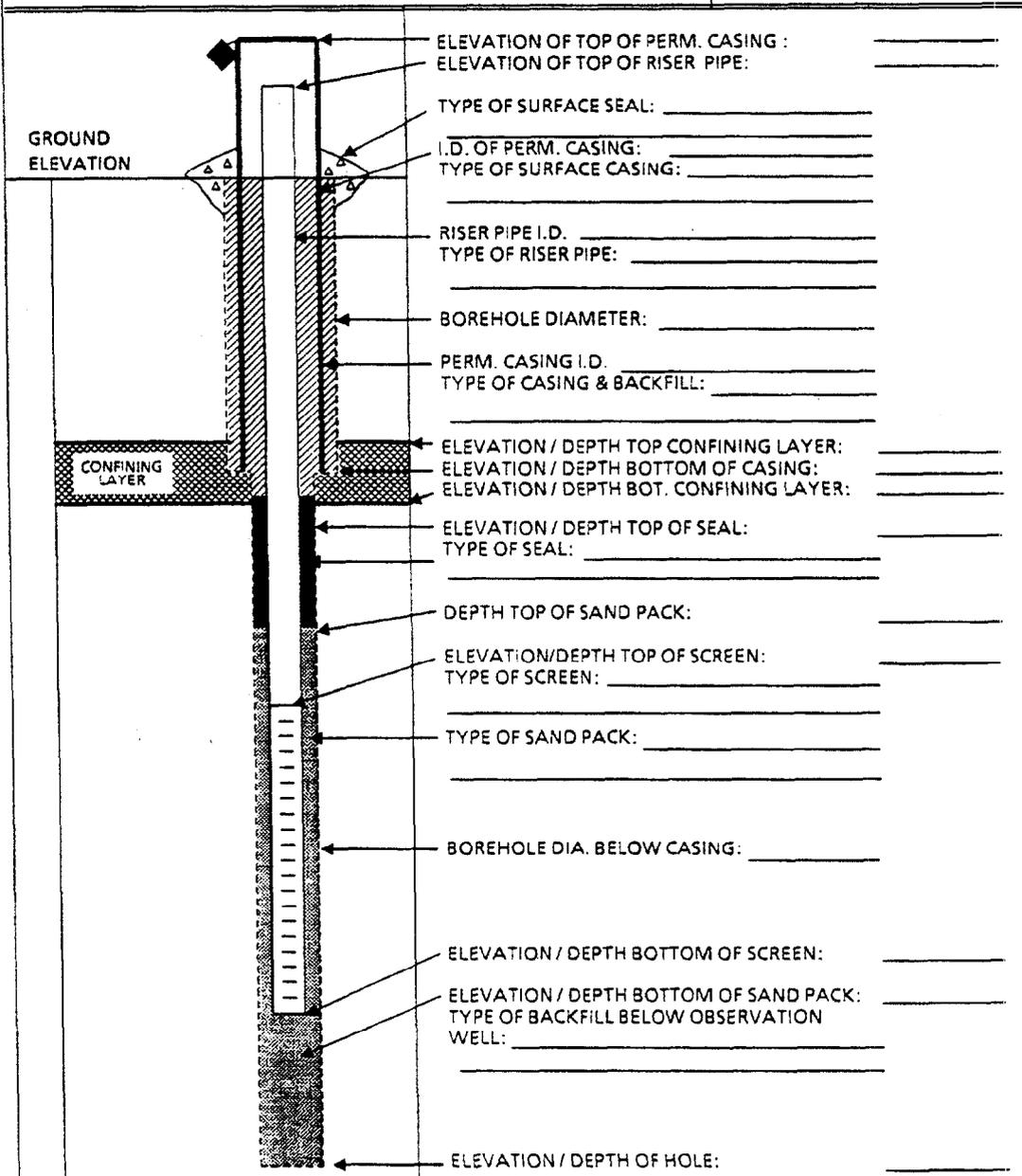
ATTACHMENT C  
PAGE TWO



BORING NO.: \_\_\_\_\_

CONFINING LAYER  
MONITORING WELL SHEET

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING METHOD _____
ELEVATION _____	DATE _____	DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____		



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ATTACHMENT C  
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BORING NO.: \_\_\_\_\_

BEDROCK  
MONITORING WELL SHEET  
OPEN HOLE WELL

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____

GROUND ELEVATION

ELEVATION OF TOP OF CASING: \_\_\_\_\_

STICK UP OF CASING ABOVE GROUND SURFACE: \_\_\_\_\_

TYPE OF SURFACE SEAL: \_\_\_\_\_

I.D. OF CASING: \_\_\_\_\_

TYPE OF CASING: \_\_\_\_\_

TEMP. / PERM.: \_\_\_\_\_

DIAMETER OF HOLE: \_\_\_\_\_

TYPE OF CASING SEAL: \_\_\_\_\_

T.O.R.

DEPTH TO TOP OF ROCK: \_\_\_\_\_

DEPTH TO BOTTOM CASING: \_\_\_\_\_

DIAMETER OF HOLE IN BEDROCK: \_\_\_\_\_

DESCRIBE IF CORE / REAMED WITH BIT:

\_\_\_\_\_

\_\_\_\_\_

DESCRIBE JOINTS IN BEDROCK AND DEPTH:

\_\_\_\_\_

\_\_\_\_\_

ELEVATION / DEPTH OF HOLE: \_\_\_\_\_

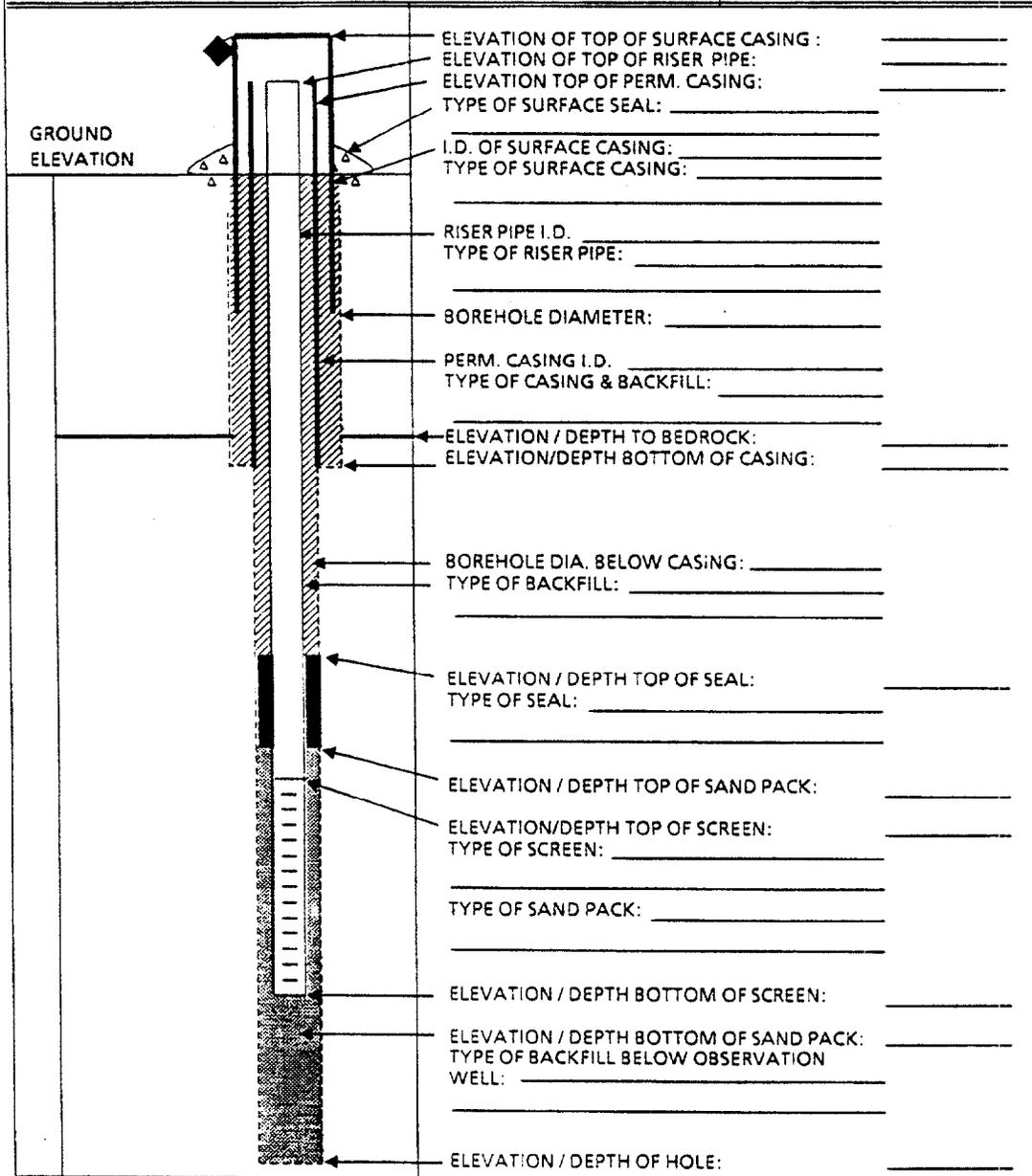
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**ATTACHMENT C  
PAGE FOUR**

BORING NO.: \_\_\_\_\_

**BEDROCK  
MONITORING WELL SHEET  
WELL INSTALLED IN BEDROCK**

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____



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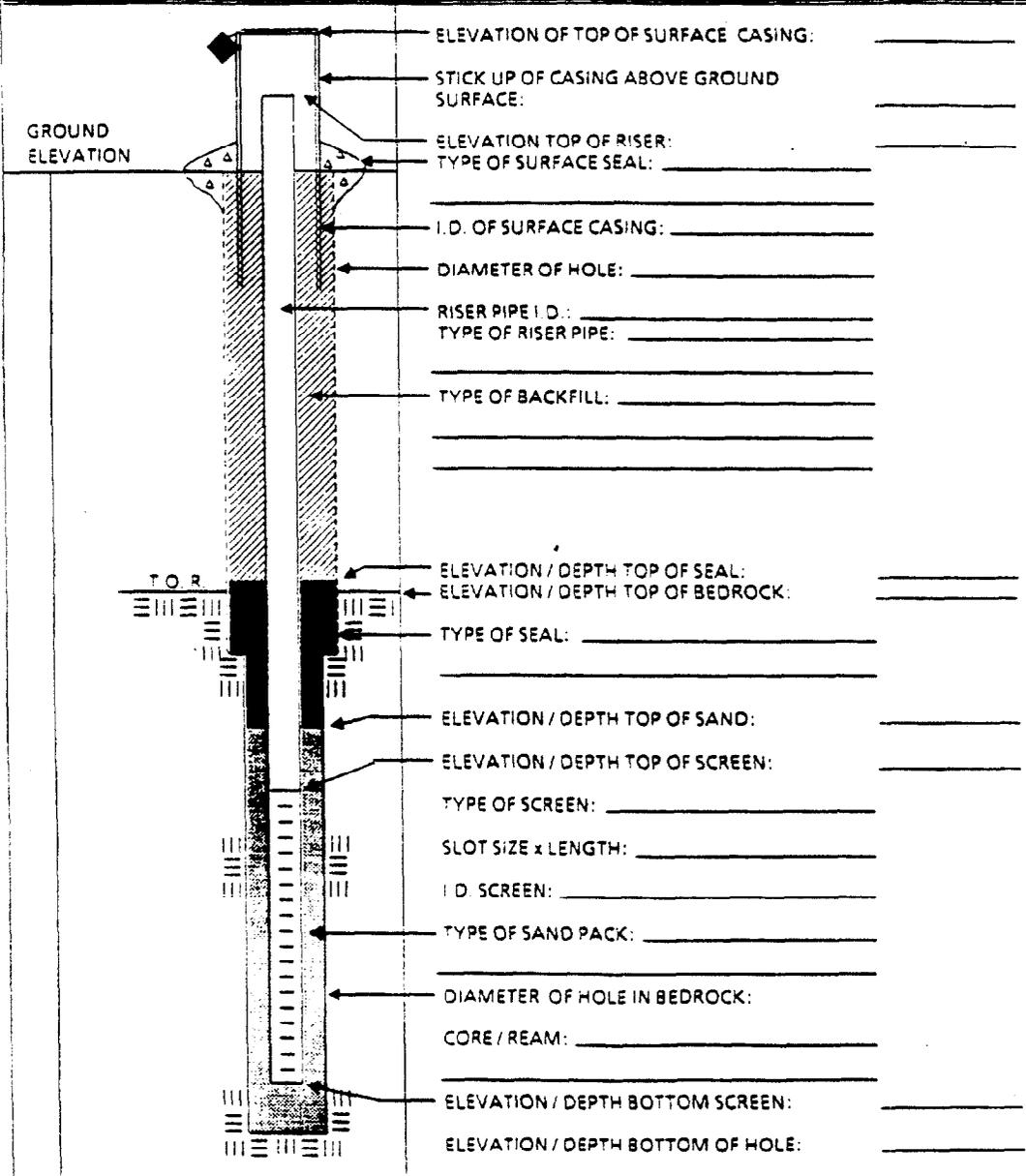
ATTACHMENT C  
PAGE FIVE

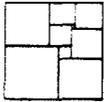


BORING NO.: \_\_\_\_\_

**BEDROCK  
MONITORING WELL SHEET  
WELL INSTALLED IN BEDROCK**

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____





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# STANDARD OPERATING PROCEDURES

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Revision  
2

Applicability  
EMG

Prepared  
Earth Sciences

Approved  
*D. Senovich*  
D. Senovich

Subject

EXCAVATION OF EXPLORATORY TEST PITS AND TRENCHES

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  - 5.2 TEST PIT AND TRENCH CONSTRUCTION
  - 5.3 BACKFILLING OF TRENCHES AND TEST PITS
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## 1.0 PURPOSE

This procedure describes methods for proper excavation of test pits and trenches.

## 2.0 SCOPE

These procedures give overall technical guidance and may be modified by site-specific requirements for field exploratory test pits and trenches. Conditions which would make trench excavation technically difficult (such as shallow water table), potentially dangerous (presence of explosive materials or underground utilities) or likely to cause even greater environmental problems (such as potential rupture of buried containerized wastes) would require modifications to the methods described herein and may prevent implementation of the exploratory excavation program. Furthermore, the costs and difficulties in disposing of potentially hazardous materials removed from test pits may constrain their use to areas where contamination potential is low. Consequently, the techniques described herein may be most applicable in areas of low apparent contamination and where potentially explosive materials are not expected to be present.

## 3.0 GLOSSARY

Trenches or test pit. - Open shallow excavations, typically longitudinal (if a trench) or rectangular (if a pit), to determine the shallow subsurface conditions for engineering, geological, and soil chemistry exploration and/or sampling purposes. These pits are excavated manually or by a machine, such as a backhoe, clamshell, trencher excavator, or bulldozer.

## 4.0 RESPONSIBILITIES

Site Manager - is responsible for determining, in consultation with other project personnel (geologist, geochemist, engineer), the need for test pits or trenches, their approximate locations, depths and sampling objectives.

Field Operation Leader (FOL) - is responsible for finalizing the location and depth of test pits/trenches based on site conditions and the site geologist's advice. The FOL is ultimately responsible for the proper construction and backfilling of test pits and trenches, including adherence to OSHA regulations if applicable (see Section 5.0).

Health and Safety Officer - responsible for air quality monitoring during test pit construction and sampling, to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. He/She may also be required to advise the FOL on other safety-related matters and mitigative measures to address potential physical hazards from unstable trench walls, puncturing of drums, or other hazardous objects, etc.

Site Geologist/Sampler - responsible for recording all information and data pertaining to the test pit excavation. Engineers, field technicians, or other properly trained personnel may also serve in this capacity.

## 5.0 PROCEDURES

### 5.1 APPLICABILITY

This subsection presents routine test pit or trench excavation techniques. Specialized techniques that are applicable only under certain conditions are not presented.

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During the excavation of trenches or pits at hazardous waste sites, several health and safety concerns arise and control the method of excavation. All excavations that are deeper than 4 feet must be stabilized (before entry into the excavation) by bracing the pit sides using wooden or steel support structures. Personnel entering the excavation may be exposed to toxic or explosive gases and oxygen-deficient environments. In these cases, substantial air monitoring is required before entry, and appropriate respiratory gear and protective clothing is mandatory. There must be at least two persons present at the immediate site before entry by one of the investigators. The reader shall refer to OSHA regulations 29 CFR 1926, 29 CFR 1910.120, and 29 CFR 1910.134.

Excavations are generally not practical where a depth of more than about 15 feet is desired. They are usually limited to a few feet below the water table. In some cases, a pumping system may be required to control water levels within the pits, providing that pumped water can be adequately stored or disposed. If data on soils at depths greater than 15 feet are required, the data are usually obtained through test borings instead of test pits.

In addition, hazardous wastes may be brought to the surface by excavation equipment. This material, whether removed from the site or returned to the subsurface, must be properly handled according to any and all applicable federal, state, and local regulations.

## 5.2 TEST PIT AND TRENCH EXCAVATION

These procedures describe the methods for excavating and logging test pits and trenches to determine subsurface soil and rock conditions.

Test pits and trenches may be excavated by hand or by power equipment to permit detailed description of the nature and contamination of the in situ materials. The size of the excavation will depend primarily on the following:

- The purpose and extent of the exploration
- The space required for efficient excavation
- The chemicals of concern
- The economics and efficiency of available equipment

Test pits normally have a cross section that is 4 to 10 feet square; test trenches are usually 3 to 6 feet wide and may be extended for any length required to reveal conditions along a specific line. The following table, which is based on equipment efficiencies, can give a rough guide for design consideration:

Equipment	Typical Widths, in Feet
Trenching machine	2
Backhoe	2-6
Track dozer	10
Track loader	10
Excavator	10
Scraper	20

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Fifteen feet is considered to be the economical vertical limit of excavation. However, larger and deeper excavations have been used when special problems justified the expense.

The lateral limits of excavation of trenches and the position of test pits shall be carefully marked on area base maps. If precise positioning is required to indicate the location of highly hazardous waste materials, nearby utilities, or dangerous conditions, the limits of the excavation shall be surveyed. Also, if precise determination of the depth of buried materials is needed for design or environmental assessment purposes, the elevation of the ground surface at the test pit or trench location shall also be determined by survey. It may be necessary to record several elevations for irregular or sloping surfaces. If the test pit/trench will not be surveyed immediately, it shall be backfilled and its position identified with stakes placed in the ground at the margin of the excavation for later surveying. For regional studies test pits and trenches may be located by survey or by using existing topographic maps and plans.

The construction of test pits and trenches shall be planned and designed in advance as much as possible. However, field conditions may necessitate revisions to the initial plans. The final depth and construction method shall be determined by the field geologist. The actual layout of each test pit, temporary staging area and spoils pile will be predicated on site conditions and wind direction at the time the test pit is made. Prior to excavation, the area can be surveyed by magnetometer or metal detector to identify the presence of underground utilities or drums.

The test pits and trenches shall be excavated in compliance with applicable safety regulations as specified by the health and safety officer.

If the depth exceeds 4 feet and people will be entering the pit or trench, Occupational Safety and Health Administration (OSHA) requirements must be met: Walls must be braced with wooden or steel braces, ladders must be in the hole at all times, and a temporary guardrail must be placed along the surface of the hole before entry. It is advisable to stay out of test pits as much as possible; if possible the required data or samples shall be gathered without entering the pit. Samples of leachate, groundwater, or sidewall soils can be taken with telescoping poles, etc.

Stabilization of the sides of test pits and trenches, when required, generally is achieved by sloping the walls at a sufficiently flat angle or by using sheeting. Benching or terracing can be used for deeper holes. Shallow excavations are generally stabilized by sheeting. Test pits excavated into fill are generally much more unstable than pits dug into natural in-place soil.

Sufficient space shall be maintained between trenches or pits to place soil that will be stockpiled for cover, as well as to allow access and free movement by haul vehicles and operating equipment. Excavated soil shall be stockpiled to one side in one location, preferably downwind, away from the edge of the pit to reduce pressure on the pit walls.

Dewatering may be required to assure the stability of the side walls, to prevent the bottom of the pit from heaving, and to keep the excavation dry. This is an important consideration for excavations in cohesionless material below the groundwater table. Liquids removed as a result of dewatering operations must be handled as potentially contaminated materials. Procedures for the collection and disposal of such materials should be discussed in the site-specific Work Plan.

The overland flow of water from excavated saturated soils and the erosion or sedimentation of the stockpiled soil shall be controlled. A temporary detention basin and a drainage system shall be planned to prevent the contaminated wastes from spreading, if necessary.

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### 5.3 BACKFILLING OF TRENCHES AND TEST PITS

Before backfilling, the onsite crew shall photograph all significant features exposed by the test pit and trench and shall include in the photograph a scale to show dimensions. Photographs of test pits shall be marked to include site number, test pit number, depth, description of feature, and date of photograph. In addition, a geologic description of each photograph shall be entered in the logbook. All photographs shall be indexed and maintained for future reference.

After inspection, backfill material shall be returned to the pit under the direction of the field supervisor.

If a low permeability layer is penetrated (resulting in groundwater flow from an upper contaminated flow zone into a lower uncontaminated flow zone), backfill material must represent original conditions or be impermeable. Backfill could consist of a soil-bentonite mix prepared in a proportion specified by the field supervisor (representing a permeability equal to or less than original conditions). Backfill can be covered by "clean" soil and graded to the original land contour. Revegetation of the disturbed area may also be required.

### 6.0 REFERENCES

NUS and CH<sub>2</sub>MHill, August, 1987. Compendium of Field Operation Methods. Prepared for the U.S. EPA.

OSHA, 1979. Excavation, Trenching and Shoring 29 CFR 1926.650-653.

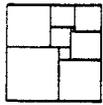
### 7.0 RECORDS

Test pits and trenches shall be logged by the field geologist in accordance with Procedure GH-1.5.

Test pit logs shall contain a sketch of pit conditions (see Attachment A, Test Pit Log Form). In addition, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Test pit locations shall be documented by tying in the location of two or more nearby permanent landmarks (trees, house, fence, etc.) and shall be located on a site map. Surveying may also be required, depending on the requirements of each project. Other data to be recorded in the field logbook include the following:

- Name and location of job.
- Date of excavation.
- Approximate surface elevation.
- Total depth of excavation.
- Dimensions of pit.
- Method of sample acquisition.
- Type and size of samples.
- Soil and rock descriptions.
- Photographs.
- Groundwater levels.
- Organic gas or methane levels.
- Other pertinent information, such as waste material encountered.





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**ENVIRONMENTAL  
MANAGEMENT GROUP**

# STANDARD OPERATING PROCEDURES

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GH-2.5

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Effective Date  
05/04/90

Revision  
1

Applicability  
EMG

Prepared  
Earth Sciences

Approved  
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Subject

WATER LEVEL MEASUREMENT/CONTOUR MAPPING

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## 1.0 PURPOSE

The objective of this procedure is to provide general reference information and technical guidance on the measurement of hydraulic head levels and the determination of the direction of groundwater flow, using contour maps of the water table or the potentiometric surface of an unconfined or confined aquifer.

## 2.0 SCOPE

This procedure gives overall technical guidance for obtaining hydraulic head measurements in wells (frequently conducted in conjunction with groundwater sampling) and preparation of groundwater contour maps. The specific methods could be modified by requirements of project-specific plans.

## 3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

Water Table - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

Potentiometric Surface - A surface which is defined by the levels to which water will rise in wells which are screened or open in a specified zone of an unconfined or confined aquifer.

Unconfined (water table) Aquifer - An aquifer in which the water table forms the upper boundary.

Confined Aquifer - An aquifer confined between two low permeability layers (aquitards).

Artesian Conditions - A common condition in a confined aquifer in which the water level in a well completed within the aquifer rises above the top of the aquifer.

Flow Net - A diagram of groundwater flow, showing flow lines and equipotential lines.

Flow Line - A line indicating the direction of groundwater movement within the saturated zone. Flow lines are drawn perpendicular to equipotential lines.

Equipotential Line - A contour line on the potentiometric surface or water table showing uniform hydraulic head levels. Equipotential lines on the water table are also called water-table contour lines.

## 4.0 RESPONSIBILITIES

Project Hydrogeologist - has overall responsibility for obtaining water level measurements and developing groundwater contour maps. The hydrogeologist shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number of data points needed and which wells shall be used for a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - must have a basic familiarity with the equipment and procedures involved in obtaining water levels, and must be aware of any project-specific requirements.

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## 5.0 PROCEDURES

### 5.1 GENERAL

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well evacuation or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the geologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment A), along with the date and time of the reading. The total depth of the well shall be measured and recorded, if not already known. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and barometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. The reference point shall be noted in the field notebook. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater if required.

Water level readings shall be taken regularly, as required by the site hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map shall be made in the shortest practical time to minimize effects due weather changes, and at least during the same day.

### 5.2 WATER LEVEL MEASURING TECHNIQUES

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the onsite hydrogeologist.

In most instances, preparation of accurate potentiometric surface requires that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, the Chalked Tape or Electrical Water Level Indicator methods have been found best, and thus are the most often utilized. Other, less precise methods, such as the Popper or Bell Sound or Bailer Line methods, may be appropriate for developing preliminary estimates of hydraulic conditions. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use the Float Recorder or Pressure Transducer methods. When conditions in the well limit readings (i.e., turbulence in the

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water surface or limited access through small diameter tubing), less precise, but appropriate, methods such as the Air Line or Capillary Tubing methods can be used.

### 5.2.1 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment as required.
2. Record all information specified below in the geologist's field notebook or on the Groundwater Level Measurement Sheet.
  - a. Well number.
  - b. Record water level to the nearest 0.01 foot (0.3 cm). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing.
  - c. Record the time and day of the measurement.

Water level measuring devices with permanently marked intervals shall be used when possible. If water level measuring devices marked by metal or plastic bands clamped at intervals along the measuring line are used, the spacing and accuracy of these bands shall be checked frequently as they may loosen and slide up or down the line, resulting in inaccurate reference points (see Section 5.2.3).

### 5.2.2 Water Level Measuring Devices

#### Chalked Steel Tape

The water level is measured by chalking a weighted steel tape and lowering it a known distance (to any convenient whole foot mark) into the well or borehole. The water level is determined by subtracting the wetted chalked mark from the total length lowered into the hole.

The tape shall be withdrawn quickly from the well because water has a tendency to rise up the chalk due to capillary action. A water finding paste may be used in place of chalk. The paste is spread on the tape the same way as the chalk, and turns red upon contacting water.

Disadvantages to this method include the following: depths are limited by the inconvenience of using heavier weights to properly tension longer tape lengths; ineffective if borehole/well wall is wet or inflow is occurring above the static water level; chalking the tape is time consuming; difficult to use during periods of precipitation.

#### Electric Water Level Indicators

These devices consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

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For accurate readings, the probe shall be lowered slowly into the well. The electric tape is marked at the measuring point where contact with the water surface was indicated. The distance from the mark to the nearest tape band is measured using an engineer's folding ruler or steel tape and added to the band reading to obtain the depth to water. If band is not a permanent marking band, spacing shall be checked periodically as described in Section 5.2.3.

#### Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

#### Float Recorder

A float or an electromechanically actuated water-seeking probe may be used to detect vertical changes of the water surface in the hole. A paper-covered recording chart drum is rotated by the up and down motion of the float via a pulley and reduction gear mechanism, while a clock drive moves a recording pen horizontally across the chart. To ensure continuous records, the recorder shall be inspected, maintained, and adjusted periodically. This type of device is useful for continuously measuring periodic water level fluctuations, such as tidal fluctuations or influences of pumping wells.

#### Air Line

An air line is especially useful in pumped wells where water turbulence may preclude the use of other devices. A small-diameter weighted tube of known length is installed from the surface to a depth below the lowest water level expected. Compressed air (from a compressor, bottled air, or air pump) is used to purge the water from the tube, until air begins to escape the lower end of the tube, and is seen (or heard) to be bubbling up through the water in the well. The pressure needed to purge the water from the air line multiplied by 2.307 (feet of water for 1 psi) equals the length in feet of submerged air line. The depth to water below the center of the pressure gauge can be calculated by subtracting the length of air line below the water surface from the total length of the air line.

The disadvantages to this method include the need for an air supply and lower level of accuracy (unless a very accurate air pressure gauge is used, this method cannot be used to obtain water level readings to the nearest 0.01 ft).

#### Capillary Tubing

In small diameter piezometer tubing, water levels are determined by using a capillary tube. Colored or clear water is placed in a small "U"-shaped loop in one end of the tube (the rest of the tube contains air). The other end of the capillary tube is lowered down the piezometer tubing until the water in the loop moves, indicating that the water level has been reached. The point is then measured from the bottom of the capillary tube or recorded if the capillary tube is calibrated. This is the best method for very small diameter tubing monitoring systems such as Barcad and other multilevel samples. Unless the capillary tube is calibrated, two people may be required to measure the length of capillary tubing used to reach the groundwater. Since the piezometer tubing and capillary tubing usually are somewhat coiled when installed, it is difficult to accurately measure absolute water level elevations using this method. However, the method is useful in accurately measuring differences or changes in water levels (i.e., during pumping tests).

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### **Pressure Transducer**

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

### **Borehole Geophysics**

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost-effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

### **Bailer Line Method**

Water levels can be measured during a bailing test of a well by marking and measuring the bailer line from the bottom of the bailer (where water is first encountered) to the point even with the top of the well casing. This is a useful technique during bailing tests (particularly if recovery is rapid) if the bailer is heard hitting the water. However, it is not recommended for measuring static water levels because it is not usually as accurate as some of the other methods described above.

#### **5.2.3 Data Recording**

Water level measurements, time, data, and weather conditions shall be recorded in the geologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements shall be measured from a known reference point. The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point shall be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

#### **5.2.4 Specific Quality Control Procedures for Water Level Measuring Devices**

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells.

Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy periodically. A water level indicator calibration sheet shall be completed each time the measuring device is checked. A water level indicator calibration form is shown in Attachment A. The "actual reading" column on the sheet is the actual length of the interval from the end of the indicator to the appropriate marked depth interval. In many cases, these measurements are different because the water level measuring device is connected to the end of the measuring tape or line, and may extend beyond "0" feet on the measuring line.

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### 5.3 POTENTIOMETRIC SURFACE MAPPING

#### 5.3.1 Selection of Wells

All wells used to prepare a flow net in a plan or map view should represent the same hydrogeologic unit, be it aquifer or aquitard. All water level measurements used shall be collected on the same day.

Before mapping, review the recorded water levels and monitoring-well construction data, site geology and topographic setting to ascertain that the wells are completed in the same hydrogeologic unit and to determine if strong vertical hydraulic gradients may be present. Such conditions will be manifested by a pronounced correlation between well depth and water level, or by a difference in water level between two wells located near each other but set to different depths or having different screen lengths. Professional judgment of the hydrogeologist is important in this decision. If vertical gradients are significant, the data to be used must be limited vertically, and only wells finished in a chosen vertical zone of the hydrogeologic unit can be used.

At least three wells must be used to provide an estimation of the direction of groundwater flow, and many more wells will be needed to provide an accurate contour map. Generally, shallow systems require more wells than deep systems for accurate contour mapping.

#### 5.3.2 Construction of Equipotential Lines

Plot the water elevations in the chosen wells on a site map. Other hydrogeologic features associated with the zone of interest -- such as seeps, wetlands, and surface-water bodies -- should also be plotted along with their elevations.

The data should then be contoured, using mathematically valid and generally accepted techniques. Linear interpolation is most commonly used, as it is the simplest technique. However, quadratic interpolation or any technique of trend-surface analysis or data smoothing is acceptable. Computer-generated contour maps may be useful for large data sets. Contour lines shall be drawn as smooth, continuous lines which never cross one another.

Inspect the contour map, noting known features, such as pumping wells and site topography. The contour lines must be adjusted in accordance with these, utilizing the professional judgment of the hydrogeologist. Closed contours should be avoided unless a known sink exists. Groundwater mounding is common under landfills and lagoons; if the data imply this, the feature must show in the contour plot.

#### 5.3.3 Determination of Groundwater-Flow Direction

Flow lines shall be drawn so that they are perpendicular to equipotential lines. Flow lines will begin at high head elevations and end at low head elevations. Closed highs will be the source of additional flow lines. Closed depressions will be the termination of some flow lines. Care must be used in areas with significant vertical gradients to avoid erroneous conclusions concerning gradients and flow directions.

### 5.4 HEALTH AND SAFETY CONSIDERATIONS

Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a Health/Safety hazard which must be considered. Initial monitoring of the well headspace and breathing zone

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concentrations using a PID (HNU) or FID (OVA) and combustible gas meters shall be performed to determine required levels of protection.

#### 6.0 REFERENCES

Freeze, R. A. and J. A. Cherry, 1979. Groundwater. Prentice-Hall, Englewood Cliffs, New Jersey, 604 pp.

Cedergren, H. R., 1977. Seepage, Drainage and Flow Nets (2nd edition). John Wiley and Sons, New York.

Fetter, C. W., 1980. Applied Hydrogeology. McGraw-Hill, Columbus, Ohio, 488 pp.

#### 7.0 ATTACHMENTS

Attachment A - Groundwater Level Measurement Sheet

Attachment B - Water Level Indicator Calibration Sheet.



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**ATTACHMENT B**

**WATER LEVEL INDICATOR CALIBRATION SHEET**

Project Name \_\_\_\_\_ Date \_\_\_\_\_

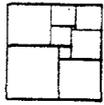
Project No. \_\_\_\_\_

Equipment No. \_\_\_\_\_

Equipment Name \_\_\_\_\_

Water Level Indicator Marking (Feet)	Actual Reading* (Feet)
0.0	
5.0	
10.0	
15.0	
20.0	
25.0	
30.0	
35.0	
40.0	
45.0	
50.0	
55.0	
60.0	
65.0	
70.0	
75.0	
80.0	
85.0	
90.0	
95.0	
100.0	

\* Record readings to the nearest 0.01 foot. The actual reading may be different than marking because the water level measuring device (electrode, popper, etc.) may extend beyond the "0" feet mark on the measuring line.



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Prepared Earth Sciences	
Approved <i>D. Senovich</i> D. Senovich	

Subject

GROUNDWATER SAMPLE ACQUISITION

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## 1.0 PURPOSE

The purpose of this procedure is to provide general reference information on the sampling of groundwater wells. The methods and equipment described are for the collection of water samples from the saturated zone of the subsurface.

## 2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

## 3.0 GLOSSARY

None.

## 4.0 RESPONSIBILITIES

Site Hydrogeologist or Geochemist - responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, documenting these in the Project Operations Plan (POP), and properly briefing the site sampling personnel.

Site Geologist - The Site Geologist is primarily responsible for the proper acquisition of the groundwater samples. When appropriate, such responsibilities may be performed by other qualified personnel (engineers, field technicians).

Site Manager - The Site Manager is responsible for reviewing the sampling procedures used by the field crew and for performing in-field spot checks for proper sampling procedures.

## 5.0 PROCEDURES

### 5.1 GENERAL

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of testing in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

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1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical.
2. For wells that can be purged to dryness with the sampling equipment being used, the well shall be evacuated and allowed to recover prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is preferred.
3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:
  - A submersible pump, intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level decreases. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished a bailer may be used to collect the sample for chemical analysis.
  - The inlet line of the sampling pump (or the submersible pump itself) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a rate equal to the well's recovery rate.

Stratification of contaminants may exist in the aquifer formation, both in terms of a concentration gradients due to mixing and dispersion processes in a homogeneous layer, and in layers of variable permeability into which a greater or lesser amount of the contaminant plume has flowed. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point, and thus result in the collection of a non-representative sample.

## 5.2 SAMPLING, MONITORING, AND EVACUATION EQUIPMENT

Sample containers shall conform with EPA regulations for the appropriate contaminants.

The following equipment shall be on hand when sampling ground water wells:

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate packing containers and filler, ice, labels and chain-of-custody documents.
- Field tools and instrumentation - Thermometer; pH paper/meter; camera and film; tags; appropriate keys (for locked wells); engineers rule; water-level indicator; where applicable, specific-conductivity meter.
- Pumps
  - Shallow-well pumps--Centrifugal, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.
  - Deep-well pumps--submersible pump and electrical power generating unit, or air-lift apparatus where applicable.

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- Other sampling equipment - Bailers and monofilament line with tripod-pulley assembly (if necessary). Bailers shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.
- Pails - Plastic, graduated.
- Decontamination solutions - Distilled water, Alconox, methanol, acetone.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, sterilized, and reused, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well flushing and sample collection.

### 5.3 CALCULATIONS OF WELL VOLUME

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the field logbook and on the field data form (Attachment A):

- Obtain all available information on well construction (location, casing, screens, etc.).
- Determine well or casing diameter.
- Measure and record static water level (depth below ground level or top of casing reference point).
- Determine depth of well (if not known from past records) by sounding using a clean, decontaminated weighted tape measure.
- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).
- Calculate one static well volume in gallons ( $V = 0.163Tr^2$ ).

where:

- V = Static volume of well in gallons.
- T = Thickness of water table in the well measured in feet, i.e., linear feet of static water.
- r = Inside radius of well casing in inches.
- 0.163 = A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Determine the minimum amount to be evacuated before sampling.

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## 5.4 EVACUATION OF STATIC WATER (PURGING)

### 5.4.1 General

The amount of flushing a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, electrical conductance, and pH have stabilized. Onsite measurements of these parameters shall be recorded on the field data form.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce significant groundwater flow from other areas. Generally three to five well volumes are considered effective for purging a well.

The site hydrogeologist, geochemist and risk assessment personnel shall define the objectives of the groundwater sampling program in the Work Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

### 5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment B provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

#### 5.4.2.1 Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- There is minimal outgassing of volatile organics while the sample is in the bailer.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

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#### 5.4.2.2 Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump (therefore not suitable for well purging) that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. The pitcher pump is a common farm hand-pump.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics. In addition, the complex internal components of these pumps may be difficult to decontaminate.

#### ~~5.4.2.3 Gas-Lift Samplers~~

~~This group of samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Gas lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation or loss of volatile organics.~~

#### 5.4.2.4 Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components is difficult and time-consuming.

### 5.5 SAMPLING

#### 5.5.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the ~~POP~~ <sup>FSP</sup> prior to the field work:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

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- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
- Sample preservation requirements.
- Working schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

#### 5.5.2 Sampling Methods

The collection of a groundwater sample is made up of the following steps:

1. HSO or designee will first open the well cap and use volatile organic detection equipment (HNU or OVA) on the escaping gases at the well head to determine the need for respiratory protection.
2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data in a well sampling data sheet (Attachment A); then calculate the fluid volume in the well pipe.
3. Calculate well volume to be removed as stated in Section 5.3.
4. Select appropriate purging equipment (see Attachment B). If an electric submersible pump with packer is chosen, go to Step 10.
5. Lower purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner. Lower the purging device, as required, to maintain submergence.
6. Measure rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters.
7. Observe peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. Never collect volatile organics samples using a vacuum pump.
8. Purge a minimum of three-to-five casing volumes before sampling. In low permeability strata (i.e., if the well is pumped to dryness), one volume will suffice.
9. If sampling using a pump, lower the pump intake to midscreen or the middle of the open section in uncased wells and collect the sample. If sampling with a bailer, lower the bailer to sampling level before filling (this requires use of other than a 'bucket-type' bailer).

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Purged water shall be collected in a designated container and disposed of in an acceptable manner.

10. (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. Purge a volume equal to at least twice the screened interval or unscreened open section volume below the packer before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.
11. In the event that recovery time of the well is very slow (e.g., 24 hours), sample collection can be delayed until the following day. If the well has been bailed early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the logbook.
12. Add preservative if required. Label, tag, and number the sample bottle(s).
13. Replace the well cap. Make sure the well is readily identifiable as the source of the samples.
14. Pack the samples for shipping. Attach a custody seal to the front and back of the shipping package. Make sure that traffic reports and chain-of-custody forms are properly filled out and enclosed or attached.
15. Decontaminate all equipment

### 5.5.3 Sample Containers

For most samples and analytical parameters, either glass or plastic containers are satisfactory.

### 5.5.4 Preservation of Samples and Sample Volume Requirements

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. Procedure SF-1.2 describes the sample preservation and volume requirements for most of the chemicals that will be encountered during hazardous waste site investigations. Procedure SA-4.3 describes the preservation requirement for microbial samples.

### 5.5.5 Handling and Transporting Samples

After collection, samples shall be handled as little as possible. It is preferable to use self-contained "chemical" ice (e.g., "blue ice") to reduce the risk of contamination. If water ice is used, it shall be bagged and steps taken to ensure that the melted ice does not cause sample containers to be submerged and thus possibly become cross-contaminated. All sample containers shall be enclosed in plastic bags or cans to prevent cross-contamination. Samples shall be secured in the ice chest to prevent movement of sample containers and possible breakage. Sample packing and transportation requirements are described in SA-6.2.

### 5.5.6 Sample Holding Times

Holding times (i.e. allowed time between sample collection and analysis) for routine samples are given in Procedure SF-1.2.

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## 5.6 RECORDS

Records will be maintained for each sample that is taken. The sample log sheet will be used to record the following information:

- Sample identification (site name, location, project number; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.
- Purge data - prior to removal of each casing volume and before sampling, pH, electrical conductance, temperature, color, and turbidity shall be measured and recorded.
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method).
- Sample disposition (preservatives added; lab sent to, date and time; lab sample number, EPA Traffic Report or Special Analytical Services number, chain-of-custody number.
- Additional remarks - (e.g., sampled in conjunction with state, county, local regulatory authorities; samples for specific conductance value only; sampled for key indicator analysis; etc.).

## 5.7 CHAIN-OF-CUSTODY

Proper chain-of-custody procedures play a crucial role in data gathering. Procedure SA-6.1 describes the requirements for a correct chain-of-custody.

## 6.0 REFERENCES

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**7.0 ATTACHMENTS**

Attachment A - Well Sampling Data Sheet  
Attachment B - Purging Equipment Selection

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**ATTACHMENT A  
SAMPLE LOG SHEET**



**SAMPLE LOG SHEET**

- Monitoring Well Data
- Domestic Well Data
- Other \_\_\_\_\_

Page \_\_\_\_\_ of \_\_\_\_\_  
Case # \_\_\_\_\_  
By \_\_\_\_\_

Project Site Name \_\_\_\_\_ Project Site Number \_\_\_\_\_  
NUS Source No. \_\_\_\_\_ Source Location \_\_\_\_\_

Total Well Depth:		Purge Data				
Well Casing Size & Depth:		Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level:						
One Casing Volume:						
Start Purge (hrs.):						
End Purge (hrs.):						
Total Purge Time (min)		REFER TO APPENDIX D FOR UPDATED SAMPLE LOG SHEET				
Total Amount Purged						
Monitor Reading:						
Purge Method:						
Sample Method:						
Depth Sampled:						
Sample Date & Time:		Sample Data				
		pH	S.C.	Temp. (°C)	Color & Turbidity	
Sampled By:						
Signature(s):		Observations / Notes:				
Type of Sample <input type="checkbox"/> Low Concentration <input type="checkbox"/> High Concentration <input type="checkbox"/> Grab <input type="checkbox"/> Composite <input type="checkbox"/> Grab - Composite						
Analysis:	Preservative		Organic	Inorganic		
		Traffic Report #				
		Tag #				
		AB #				
		Date Shipped				
		Time Shipped				
		Lab				
		Volume				

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**ATTACHMENT B  
PURGING EQUIPMENT SELECTION**

**Purging Equipment Selection**

Diameter Casing	Ballor	Peristaltic Pump	Vacuum Pump	Airlift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
<b><u>1.25-inch</u></b>								
Water level <25 ft		X	X	X	X			
Water level >25 ft				X				
<b><u>2-inch</u></b>								
Water level <25 ft	X	X	X	X	X	X		
Water level >25 ft	X			X		X		
<b><u>4-inch</u></b>								
Water level <25 ft	X	X	X	X	X	X	X	X
Water level >25 ft	X			X		X	X	X
<b><u>6-inch</u></b>								
Water level <25 ft				X	X		X	X
Water level >25 ft				X			X	X
<b><u>8-inch</u></b>								
Water level <25 ft				X	X		X	X
Water level >25 ft				X			X	X

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Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 ft of submergence	220-350	requires compressed gas; custom sizes and materials available; acts as piezometer
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015- 20 pump head	500-600	AC/DC; variable speed control available; other models may have different flow rates
ECO Pump Corp.	SAMPLifier	portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	400-700	AC, DC, or gasoline driven motors avail- able; must be primed
Galtek Corp.	Basler 219-4	portable; grab (positive dis- placement)	1.66/38	Teflon®	no limit	1076 mL	120-135	other sizes available
GeoEngineering, Inc.	GEO-MONITOR	dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	probably 0-150	app. 1 liter for each 10 ft of submergence	185	acts as piezometer; requires compressed gas
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	portable; bladder (positive dis- placement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2800 mL/min	1500-3000	requires compressed gas; other models available; AC, DC, manual operation possible
IEA	Syringe Sampler	portable; grab (positive dis- placement)	1.75/43	SS, Teflon®	no limit	850 mL sample vol.	1100	requires vacuum and/or pressure from hand pump
Instrument Special- ties Co. (ISCO)	Model 2600 Well Sampler	portable; bladder (positive dis- placement)	1.75/50	PC, silicone, Teflon®, PP, PE, Delrin®, acetal	0-150	0-7500 mL/min	990	requires compressed gas (40 psi minimum)
Keck Geophysical Instruments, Inc.	SP-81 Submer- sible Sampling Pump	portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4500 mL/min	3500	DC operated
Leonard Mold and Die Works, Inc.	GeoFilter Small Dia. Well Pump (#0500)	portable; bladder (positive dis- placement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3500 mL/min	1400-1500	requires compressed gas (55 PSI minimum); pneumatic or AC/DC control module
Oil Recovery Systems, Inc.	Surface Sampler	portable; grab (positive dis- placement)	1.75/12	acrylic, Delrin®	no limit	app. 250 mL	125-160	other materials and models available; for measuring thick- ness of "floating" contaminants
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	dedicated; bladder (positive dis- placement)	1.66/36	PVC	0-230	0-2000 mL/min	300-400	requires compressed gas; piezometric level indi- cator; other materials available

Source: Barcelona et al., 1983

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Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	portable; per- istaltic (suction)	<0.5/N/A	(not submersible) rubber, Tygon®, or Neoprene®	0-30	see comments	1200-1300	flow rate dependent on motor and tubing selec- ted, AC operated; other models available
Robert Bennett Co.	Model 180	portable; piston (positive dis- placement)	1.8/22	SS, Teflon®, Del- rin®, PP, Viton®, acrylic, PE	0-500	0-1800 mL/min	2600-2700	requires compressed gas; water level indicator and flow meter; custom models available
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1100	250 mL/flush- ing cycle	250-350	requires compressed gas; SS available; piezometer model available; dedi- cated model available
Solinst Canada Ltd.	5W Water Sampler	portable; grab (positive dis- placement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	1300-1800	requires compressed gas; custom models available
TIMCO Mfg. Co., Inc.	Std. Bailer	portable; grab (positive dis- placement)	1.66/ custom	PVC, PP	no limit	250 mL/ft of bailer	20-60	other sizes, materials, models available; op- tional bottom-emptying device available; no solvents used
TIMCO	Air or Gas Lift Sampler	portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flush- ing cycle	100-200	requires compressed gas; other sizes, materials, models available; no solvents used
Tole Devices Co.	Sampling Pump	portable; bladder (positive dis- placement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4000 mL/min	800-1000	compressed gas re- quired; DC control module; custom built

## Construction Materials Abbreviations

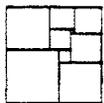
PE Polyethylene  
PP Polypropylene  
PVC Polyvinyl Chloride  
SS Stainless Steel  
PC Polycarbonate  
EPDM Ethylene-Propylene Diene  
(synthetic rubber)

## Other Abbreviations

NA Not Applicable  
AC Alternating Current  
DC Direct Current

NOTE: Other manufacturers market pumping devices which could be used for ground-water sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983



**NUS**  
CORPORATION

**ENVIRONMENTAL  
MANAGEMENT GROUP**

# STANDARD OPERATING PROCEDURES

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Applicability  
EMG

Prepared  
Earth Sciences

Approved  
*D. Senovich*  
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Subject  
SAMPLE IDENTIFICATION AND CHAIN-OF-CUSTODY

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### 1.0 PURPOSE

This purpose of this procedure is to provide information on chain-of-custody procedures to be used under the NUS Program.

### 2.0 SCOPE

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of all samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities. Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis and its introduction as evidence. This procedure identifies the necessary custody records and describes their completion.

This procedure does not take precedence over region-specific or site-specific requirements for chain-of-custody.

### 3.0 GLOSSARY

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. A Chain-of-Custody Record Form is a controlled document, provided by the regional office of EPA.

The chain-of-custody form is a two-page carbon-copy type form. The original form accompanies the samples during shipment, and the pink carbon-copy is retained in the project file.

Controlled Document - A consecutively-numbered form released by EPA or Program Management Office (PMO) for use on a particular work assignment. All unused forms must be returned or accounted for at the conclusion of the assignment.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under your custody if:

- It is in your actual possession.
- It is in your view, after being in your physical possession.
- It was in your physical possession and then you locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

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#### 4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record and maintaining custody of samples until they are relinquished to another custodian, to the shipper, or to the common carrier.

Remedial Investigation Leader - Responsible for determining that chain-of-custody procedures have been met by the sample shipper and analytical laboratory.

#### 5.0 PROCEDURES

##### 5.1 OVERVIEW

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is what it is represented to be. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom and, secondly, provide security for the evidence as it is moved and/or passes from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain of possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

##### 5.2 SAMPLE IDENTIFICATION

The method of identification of a sample depends on the type of measurement or analysis performed. When in-situ measurements are made, the data are recorded directly in bound logbooks or other field data records, with identifying information.

###### 5.2.1 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling Plan. Each sample container is identified by a sample label (see Attachment B). Sample labels are provided by the PMO. The information recorded on the sample label includes:

- **Project:** EPA Work Assignment Number (can be obtained from the Sampling Plan).
- **Station Location:** The unique sample number identifying this sample (can be obtained from the Sampling Plan).
- **Date:** A six-digit number indicating the day, month, and year of sample collection; e.g., 12/21/85.
- **Time:** A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- **Medium:** Water, soil, sediment, sludge, waste, etc.

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- **Concentration:** The expected concentration (i.e., low, medium, high).
- **Sample Type:** Grab or composite.
- **Preservation:** Type of preservation added and pH levels.
- **Analysis:** VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- **Sampled By:** Printed name of the sampler.
- **Case Number:** Case number assigned by the Sample Management Office.
- **Traffic Report Number:** Number obtained from the traffic report labels.
- **Remarks:** Any pertinent additional information.

Using just the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site).

### 5.2.2 Sample Identification Tag

A Sample Identification Tag (Attachment F) must also be used for samples collected for CLP (Contract Laboratory Program) analysis. The Sample Identification Tag is a white, waterproof paper label, approximately 3-by-6 inches, with a reinforced eyelet, and string or wire for attachment to the neck of the sample bottle. The Sample Tag is a controlled document, and is provided by the regional EPA office. Following sample analysis, the Sample Tag is retained by the laboratory as evidence of sample receipt and analysis.

The following information is recorded on the tag:

- **Project Code:** Work Assignment Number.
- **Station Number:** The middle portion of the Station Location Number, (between the hyphens).
- **Month/Day/Year:** Same as Date on Sample Label.
- **Time:** Same as Time on Sample Label.
- **Designate - Comp/Grab:** Composite or grab sample.
- **Station Location:** Same as Station Location on Sample Label.
- **Samplers:** Same as Sampled By on Sample Label.
- **Preservative:** Yes or No.
- **Analyses:** Check appropriate box(es).

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- **Remarks:** Same as Remarks on Sample Label (make sure the Case Number and Traffic Report numbers are recorded).
- **Lab Sample Number:** For laboratory use only.

The tag is then tied around the neck of the sample bottle.

If the sample is to be split, it is aliquoted into similar sample containers. Identical information is completed on the label attached to each split.

Blank, duplicate, or field spike samples shall not be identified as such on the label, as they may compromise the quality control function. Sample blanks, duplicates, spikes, and splits are defined in Procedure SA-6.6.

### 5.3 CHAIN-OF-CUSTODY PROCEDURES

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed of.

#### 5.3.1 Field Custody Procedures

- Samples are collected as described in the site-specific Sampling Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the sample log sheet and Chain-of-Custody Record exactly.
- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.
- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once developed, the photographic prints shall be serially numbered, corresponding to the logbook descriptions.
- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions, e.g., a logbook notation would explain that a pencil was used to fill out the sample label because a ballpoint pen would not function in freezing weather.

#### 5.3.2 Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. Chain-of-Custody Record Forms used in EPA Regions I-IV are shown in Attachments A through D. The appropriate form shall be obtained from the EPA Regional Office. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as follows:

- Enter header information (project number, samplers, and project name -- project name can be obtained from the Sampling Plan).
- Sign, date, and enter the time under "Relinquished by" entry.

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- Enter station number (the station number is the middle portion of the station location number, between the hyphens).
- Check composite or grab sample.
- Enter station location number (the same number as the station location on the tag and label).
- Enter the total number of containers per station number and the type of each bottle.
- Enter either the inorganic traffic report number, the organic traffic report number, or the SAS number for each station number in the remarks column.
- Enter the tag number from the bottom of the sample identification tag in the remarks column for each station location.
- Make sure that the person receiving the sample signs the "Received by" entry, or enter the name of the carrier (e.g., UPS, Federal Express) under "Received by." Receiving laboratory will sign "Received for Laboratory by" on the lower line and enter the date and time.
- Enter the bill-of-lading or Federal Express airbill number under "Remarks," in the bottom right corner, if appropriate.
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in the appropriate sample shipping package. Retain the pink copy with field records.
- Sign and date the custody seal, a 1-by 3-inch white paper label with black lettering and an adhesive backing. Attachment G is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals are provided by ZPMO on an as-needed basis.
- Place the seal across the shipping container opening so that it would be broken if the container is opened.
- Complete other carrier-required shipping papers.

The custody record is completed using black waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the sample container (enclosed with other documentation in a plastic zip-lock bag). As long as custody forms are sealed inside the sample container and the custody seals are intact, commercial carriers are not required to sign off on the custody form.

If sent by mail, the package will be registered with return receipt requested. If sent by common carrier or air freight, proper documentation must be maintained.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

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### 5.3.3 Receipt for Samples Form

Whenever samples are split with a private party or government agency, a separate Receipt for Samples Record Form is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the party or agency shall require the signature of a representative of the appropriate party acknowledging receipt of the samples. If a representative is unavailable or refuses to sign, this is noted in the "Received by" space. When appropriate, as in the case where the representative is unavailable, the custody record shall contain a statement that the samples were delivered to the designated location at the designated time. This form must be completed and a copy given to the owner, operator, or agent-in-charge even if the offer for split samples is declined. The original is retained by the Field Operations Leader.

### 6.0 REFERENCES

U.S. EPA, 1984. User's Guide to the Contract Laboratory Program, Office of Emergency and Remedial Response, Washington, D.C.

### 7.0 ATTACHMENTS

- Attachment A - Chain-of-Custody Record Form for use in Region I
- Attachment B - Chain-of-Custody Record Form for use in Region II
- Attachment C - Chain-of-Custody Record Form for use in Region III
- Attachment D - Chain-of-Custody Record Form for use in Region IV
- Attachment E - Sample Label
- Attachment F - Sample Identification Tag
- Attachment G - Chain-of-Custody Seal

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ATTACHMENT A  
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION I  
(Original is 8-1/2 by 11)

					PROJECT NAME	NO. OF CON- TAINERS	REMARKS				
SAMPLERS: (Signature)											
STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION						
Relinquished by: (Signature)			Date / Time		Received by: (Signature)		Relinquished by: (Signature)		Date / Time		Received by: (Signature)
Relinquished by: (Signature)			Date / Time		Received by: (Signature)		Relinquished by: (Signature)		Date / Time		Received by: (Signature)
Relinquished by: (Signature)			Date / Time		Received for Laboratory by: (Signature)		Date / Time		Remarks:		

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**ATTACHMENT B**  
**CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION II**  
(Original is 8 by 10-1/2)  
**CHAIN OF CUSTODY RECORD**

ENVIRONMENTAL PROTECTION AGENCY - REGION II  
SURVEILLANCE & ANALYSIS DIVISION  
EDISON, NEW JERSEY 08817

Name of Unit and Address						
Sample Number	Number of Containers	Description of Samples				
Person Assuming Responsibility for Sample					Time	Date
Sample Number	Relinquished By	Received By	Time	Date	Reason for Change of Custody	
Sample Number	Relinquished By	Received By	Time	Date	Reason for Change of Custody	
Sample Number	Relinquished By	Received By	Time	Date	Reason for Change of Custody	
Sample Number	Relinquished By	Received By	Time	Date	Reason for Change of Custody	

0334901

ENVIRONMENTAL PROTECTION AGENCY  
Office of Enforcement

REGION 3  
Curtis Bldg., 6th & Walnut Sts.  
Philadelphia, Pennsylvania 19106

CHAIN OF CUSTODY RECORD

PROJ. NO.		PROJECT NAME					NO. OF CON- TAINERS	REMARKS				
SAMPLERS: <i>(Signature)</i>												
STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION							
Relinquished by: <i>(Signature)</i>		Date / Time		Received by: <i>(Signature)</i>		Relinquished by: <i>(Signature)</i>		Date / Time		Received by: <i>(Signature)</i>		
Relinquished by: <i>(Signature)</i>		Date / Time		Received by: <i>(Signature)</i>		Relinquished by: <i>(Signature)</i>		Date / Time		Received by: <i>(Signature)</i>		
Relinquished by: <i>(Signature)</i>		Date / Time		Received for Laboratory by: <i>(Signature)</i>		Date / Time		Remarks				

Distribution: Original Accompanies Shipment, Copy to Coordinator Field Files

3-15966

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ATTACHMENT C  
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION III  
(Original is 8-1/2 x 11-3/4")



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**ATTACHMENT E  
SAMPLE LABEL**

<input type="checkbox"/> <b>NUB</b> PROJECT: _____ <small>COOPERATION</small>	
STATION LOCATION: _____	
DATE: ____/____/____ TIME: _____ hrs.	
MEDIA: WATER <input type="checkbox"/> SOIL <input type="checkbox"/> SEDIMENT <input type="checkbox"/>	
CONCENTRATION: LOW <input type="checkbox"/> MED <input type="checkbox"/> HIGH <input type="checkbox"/>	
TYPE: GRAB <input type="checkbox"/> COMPOSITE <input type="checkbox"/>	
ANALYSIS	
VOA <input type="checkbox"/>	BNA's <input type="checkbox"/>
PCB's <input type="checkbox"/>	PESTICIDES <input type="checkbox"/>
METALS: TOTAL <input type="checkbox"/>	DISSOLVED <input type="checkbox"/>
CYANIDE <input type="checkbox"/>	
PRESERVATION	
	Cool to 4°C <input type="checkbox"/>
	HNO <sub>3</sub> to pH <2 <input type="checkbox"/>
	NAOH to pH >12 <input type="checkbox"/>
_____ <input type="checkbox"/>	
Sampled by: _____	
Case No.: _____ Traffic Report No.: _____	
Remarks:	

ACFILE: FORMS\BOTLABL

**ATTACHMENT F  
SAMPLE IDENTIFICATION TAG**

☆ GPO 505-552

Designate:	Grab	Preservative: Yes <input type="checkbox"/> No <input type="checkbox"/>																																								
	Comp.																																									
Time	Samplers (Signatures)	<b>ANALYSES</b>																																								
		<table border="1"> <tr> <td>BOD</td> <td>Amons</td> <td></td> </tr> <tr> <td>Solids (TSS)</td> <td>(TDS) (SS)</td> <td></td> </tr> <tr> <td colspan="2">COD, TOC, Nutrients</td> <td></td> </tr> <tr> <td colspan="2">Phenolics</td> <td></td> </tr> <tr> <td colspan="2">Mercury</td> <td></td> </tr> <tr> <td colspan="2">Metals</td> <td></td> </tr> <tr> <td colspan="2">Cyanide</td> <td></td> </tr> <tr> <td colspan="2">Oil and Grease</td> <td></td> </tr> <tr> <td colspan="2">Organics GC/MS</td> <td></td> </tr> <tr> <td colspan="2">Priority Pollutants</td> <td></td> </tr> <tr> <td colspan="2">Volatile Organics</td> <td></td> </tr> <tr> <td colspan="2">Pesticides</td> <td></td> </tr> <tr> <td colspan="2">Mutagenicity</td> <td></td> </tr> <tr> <td colspan="2">Bacteriology</td> <td></td> </tr> </table>	BOD	Amons		Solids (TSS)	(TDS) (SS)		COD, TOC, Nutrients			Phenolics			Mercury			Metals			Cyanide			Oil and Grease			Organics GC/MS			Priority Pollutants			Volatile Organics			Pesticides			Mutagenicity			Bacteriology
BOD	Amons																																									
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Pesticides																																										
Mutagenicity																																										
Bacteriology																																										
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Station No.																																										
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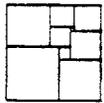
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY



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ATTACHMENT G  
CHAIN-OF-CUSTODY SEAL

<u>Signature</u>			<b>CUSTODY SEAL</b>
<u>Date</u>			<u>Date</u>
<b>CUSTODY SEAL</b>			<u>Signature</u>



**NUS**  
CORPORATION

**ENVIRONMENTAL  
MANAGEMENT GROUP**

**STANDARD  
OPERATING  
PROCEDURES**

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Applicability  
EMG

Prepared  
Earth Sciences

Approved  
*D. Senovich*  
D. Senovich

Subject  
SAMPLE PACKAGING AND SHIPPING

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**6.0 REFERENCES**

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## 1.0 PURPOSE

This procedure provides instruction for sample packaging and shipping in accordance with U.S. Department of Transportation (DOT) regulations.

## 2.0 SCOPE

Samples collected at hazardous waste sites usually have to be transported elsewhere for analysis. This requires that the samples be appropriately preserved to prevent or minimize chemical alteration prior to analysis, and be transported to protect their integrity, as well as to protect against any detrimental effects from leakage or breakage. Regulations for packaging, marking, labeling, and shipping hazardous materials and wastes are promulgated by the U.S. Department of Transportation and described in the Code of Federal Regulations (49 CFR 171 through 177, in particular 172.402h, Packages Containing Samples). In general, these regulations were not intended to cover shipment of samples collected at controlled or uncontrolled hazardous waste sites or samples collected during emergency responses. However, the EPA has agreed through a memorandum of agreement to package, mark, label, and ship samples observing DOT procedures. The information presented here is for general guidance.

This procedure is applicable to all samples taken from uncontrolled hazardous substance sites for analysis at laboratories away from the site.

## 3.0 GLOSSARY

Carrier - A person or firm engaged in the transportation of passengers or property.

Hazardous Material - A substance or material in a quantity and form which may pose an unreasonable risk to health and safety or property when transported in commerce ("commerce" here to include any traffic or transportation). Defined and regulated by DOT (49 CFR 173.2) and listed in Attachment A of this guideline.

Hazardous Waste - Any substance listed in 40 CFR Subpart D (§261.20 et seq) or otherwise characterized as ignitable, corrosive, reactive, or EP toxic as specified under 40 CFR Subpart C (§261.20 et seq) that would be subject to manifest requirements specified in 40 CFR 262. Defined and regulated by EPA.

Marking - Applying the descriptive name, instruction, cautions, weight, or specification marks or combination thereof required to be placed outside containers of hazardous materials.

n.o.i. - Not otherwise indicated.

n.o.s. - Not otherwise specified.

ORM - Other regulated material.

Packaging - The assembly of one or more containers and any other components necessary to assure compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, multiunit tank car tanks.

Placard - Color-coded, pictorial sign depicting the hazard class symbol and name to be placed on all four sides of a vehicle transporting certain hazardous materials.

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Reportable Quantity (RQ) - A parenthetical note of the form "(RQ-1000/454)" following an entry in the DOT Hazardous Materials table (49 CFR 172.101) indicates the reportable quantity of the substance in pounds and kilograms. If a spill of that amount or more of the substance occurs during transit or storage, a report must be filed with DOT according to 49 CFR 171.15-15 concerning hazardous materials incidents reports. If the material spilled is a hazardous waste, a report must always be filed, regardless of the amount, and must include a copy of the manifest. If the RQ notation appears, it must be shown either immediately before or after the proper shipping name on the shipping paper (or manifest). Most shipping papers and manifests will have a column designated "HM" which may be used for this purpose.

#### 4.0 RESPONSIBILITIES

Field Operations Leader or Team Sampling Leader - responsible for determining that samples are properly packaged and shipped.

Sampling Personnel - responsible for implementing the packaging and shipping requirements.

#### 5.0 PROCEDURES

##### 5.1 INTRODUCTION

Samples collected for shipment from a site shall be classified as either environmental or hazardous material (or waste) samples. In general, environmental samples are collected off-site (for example from streams, ponds, or wells) and are not expected to be grossly contaminated with high levels of hazardous materials. On-site samples (for example, soil, water, and materials from drums or bulk storage tanks, obviously contaminated ponds, lagoons, pools, and leachates from hazardous waste sites) are considered hazardous. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples. If there is any doubt, a sample shall be considered hazardous and shipped accordingly.
- Protect the health and safety of laboratory personnel receiving the samples. Special precautions are used at laboratories when samples other than environmental samples are received.

##### 5.2 ENVIRONMENTAL SAMPLES

###### 5.2.1 Packaging

Environmental samples may be packaged following the procedures outlined in Section 5.4 for samples classified as "flammable liquids" or "flammable solids." Requirements for marking, labeling, and shipping papers do not apply.

Environmental samples may also be packed without being placed inside metal cans as required for flammable liquids or solids.

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- Place sample container, properly identified and with a sealed lid, in a polyethylene bag, and seal the bag.
- Place sample in a fiberboard container or metal picnic cooler which has been lined with a large polyethylene bag.
- Pack with enough noncombustible, absorbent, cushioning materials to minimize the possibility of the container breaking.
- Seal large bag.
- Seal or close outside container.

### 5.2.2 Marking Labeling

Sample containers must have a completed sample identification tag and the outside container must be marked "Environmental Sample." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling are required.

### 5.2.3 Shipping Papers

No DOT shipping papers are required. However, the appropriate chain-of-custody forms must be included with the shipment.

### 5.2.4 Transportation

There are no DOT restrictions on mode of transportation.

## 5.3 DETERMINATION OF SHIPPING CLASSIFICATION FOR HAZARDOUS MATERIAL SAMPLES

Samples not determined to be environmental samples, or samples known or expected to contain hazardous materials, must be considered hazardous material samples and transported according to the requirements listed below.

### 5.3.1 Known Substances

If the substance in the sample is known or can be identified, package, mark, label and ship according to the specific instructions for that material (if it is listed) in the DOT Hazardous Materials Table, 49 CFR 172.101.

Unz and Company have published the following steps to help in locating a proper shipping name from the Hazardous Materials Table, 49 CFR 172.101.

1. Look first for the chemical or technical name of the material, for example, ethyl alcohol. Note that many chemicals have more than one technical name, for example, perchloroethylene (not listed in 172.101) is also called tetrachloroethylene (listed 172.101). It may be useful to consult a chemist for all possible technical names a material can have. If your material is not listed by its technical name then. . . . .

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2. Look for the chemical family name. For example, pentyl alcohol is not listed but the chemical family name is: alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed then. . . . .
3. Look for a generic name based on end use. For example, Paint, n.o.s or Fireworks, n.o.s. If a generic name based on end use is not listed then. . . . .
4. Look for a generic family name based on end use, for example, drugs, n.o.s. or cosmetics, n.o.s. Finally, if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazardous classes, then. . . . .
5. You will have to go the the general hazard class for a proper shipping name. For example, Flammable Liquid, n.o.s, or Oxidizer, n.o.s.

**5.3.2 Unknown Substances**

For samples of hazardous substances of unknown content, select the appropriate transportation category according to the DOT Hazardous Materials Classification (Attachment A), a priority system of transportation categories.

The correct shipping classification for an unknown sample is selected through a process of elimination, utilizing Attachment A. Unless known or demonstrated otherwise (through the use of radiation survey instruments), the sample is considered radioactive and appropriate shipping regulations for "radioactive material" followed.

If a radioactive material is eliminated, the sample is considered to contain "Poison A" materials (Attachment B), the next classification on the list. DOT defines "Poison A" as extremely dangerous poisonous gases or liquids of such a nature that a very small amount of gas, or vapor of the liquids, mixed with air is dangerous to life. Most Poison A materials are gases or compressed gases and would not be found in drum-type containers. Liquid Poison A would be found only in closed containers; however, all samples taken from closed drums do not have to be shipped as Poison A, which provides for a "worst case" situation. Based upon information available, a judgment must be made whether a sample from a closed container is a Poison A.

If Poison A is eliminated as a shipment category, the next two classifications are "flammable" or "nonflammable" gases. Since few gas samples are collected, "flammable liquid" would be the next applicable category. With the elimination of radioactive material, Poison A, flammable gas, and nonflammable gas, the sample can be classified as flammable liquid (or solid) and shipped accordingly. These procedures would also suffice for shipping any other samples classified below flammable liquids in the DOT classification table (Attachment A). For samples containing unknown materials, categories listed below flammable liquids/solids on Attachment A are generally not used because showing that these materials are not flammable liquids (or solids) requires flashpoint testing, which may be impractical and possibly dangerous at a site. Thus, unless the sample is known to consist of materials listed as less hazardous than flammable liquid (or solid) on Attachment A, it is considered a flammable liquid (or solid) and shipped as such.

For any hazardous material shipment, utilize the shipping checklist (Attachment C) as a guideline to ensure that all sample-handling requirements are satisfied.

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#### 5.4 PACKAGING AND SHIPPING OF SAMPLES CLASSIFIED AS FLAMMABLE LIQUID (OR SOLID)

##### 5.4.1 Packaging

Applying the word "flammable" to a sample does not imply that it is in fact flammable. The word prescribes the class of packaging according to DOT regulations.

1. Collect sample in the prescribed container with a nonmetallic, Teflon-lined screw cap. To prevent leakage, fill container no more than 90 percent full.
2. Complete sample label and sample identification tag and attach securely to sample container.
3. Seal container and place in 2-mil thick (or thicker) polyethylene bag, one sample per bag. Position sample identification tag so that it can be read through bag. Seal bag.
4. Place sealed bag inside metal can and cushion it with enough noncombustible, absorbent material (for example, vermiculite or diatomaceous earth) between the bottom and sides of the can and bag to prevent breakage and absorb leakage. Pack one bag per can. Use clips, tape, or other positive means to hold can lid securely, tightly and permanently. Mark can as indicated in Paragraph 1 of Section 5.4.2, below.
5. Place one or more metal cans (or single 1-gallon bottle) into a strong outside container, such as a metal picnic cooler or a DOT-approved fiberboard box. Surround cans with noncombustible, absorbent cushioning materials for stability during transport. Mark container as indicated in Paragraph 2 of Section 5.4.2.

##### 5.4.2 Marking/Labeling

1. Use abbreviations only where specified. Place the following information, either hand-printed or in label form, on the metal can (or 1-gallon bottle):
  - Laboratory name and address.
  - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."

Not otherwise specified (n.o.s) is not used if the flammable liquid (or solid) is identified. Then the name of the specific material is listed before the category (for example, Acetone, Flammable Liquid), followed by its appropriate UN number found in the DOT Hazardous Materials table (49 CFR 172.101).

2. Place all information on outside shipping container as on can (or bottle), specifically:
  - Proper shipping name.
  - UN or NA number.
  - Proper label(s).
  - Addressee and sender.

Place the following labels on the outside shipping container: "Cargo Aircraft Only" and "Flammable Liquid" (or "Flammable Solid"). "Dangerous When Wet" label shall be used if the solid has not been exposed to a wet environment. "Laboratory Samples" and "THIS SIDE UP" or "THIS END UP" shall also be marked on the top of the outside container, and upward-pointing arrows shall be placed on all four sides of the container.

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### 5.4.3 Shipping Papers

1. Use abbreviations only where specified. Complete the carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form, see Attachment D). Provide the following information in the order listed (one form may be used for more than one exterior container).
  - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."
  - "Limited Quantity" (or "Ltd. Qty.").
  - "Cargo Aircraft Only."
  - Net weight (wt) or net volume (vol), just before or just after "Flammable Liquid, n.o.s." or "Flammable Solid, n.o.s.," by item, if more than one metal can is inside an exterior container.
  - "Laboratory Samples" (if applicable).
2. Include Chain-of-Custody Record, properly executed in outside container.
3. "Limited Quantity" of "Flammable Liquid, n.o.s." is limited to one pint per inner container. For "Flammable Solid, n.o.s.," net weight of inner container plus sample shall not exceed one pound; total package weight shall not exceed 25 pounds.

### 5.4.4 Transportation

1. Transport unknown hazardous substance samples classified as flammable liquids by rented or common carrier truck, railroad, or express overnight package services. Do not transport by any passenger-carrying air transport system, even if they have cargo-only aircraft. DOT regulations permit regular airline cargo-only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that only carry cargo.
2. For transport by government-owned vehicle, including aircraft, DOT regulations do not apply. However, procedures described above, with the exception of execution of the bill of lading with certification, shall still be used.

### 6.0 REFERENCES

U.S. Department of Transportation, 1983. Hazardous Materials Regulations, 49 CFR 171-177.

NUS Standard Operating Procedure SA-6.1 - Sample Identification and Chain-of-Custody

NUS Standard Operating Procedure SA-1.2 - Sample Preservation

NUS Standard Operating Procedure SF-1.5 - Compatibility Testing

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## 7.0 ATTACHMENTS

- Attachment A - DOT Hazardous Material Classification (49 CFR 173.2)
- Attachment B - DOT List of Class "A" Poisons (49 CFR 172.101)
- Attachment C - Hazardous Materials Shipping Checklist
- Attachment D - Standard Industry Certification Form

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**ATTACHMENT A**

**DOT HAZARDOUS MATERIAL CLASSIFICATION (49 CFR 173.2)**

1. Radioactive material (except a limited quantity)
2. Poison A
3. Flammable gas
4. Nonflammable gas
5. Flammable liquid
6. Oxidizer
7. Flammable Solid
8. Corrosive material (liquid)
9. Poison B
10. Corrosive material (solid)
11. Irritating material
12. Combustible liquid (in containers having capacities exceeding 110 gallons [416 liters])
13. ORM-B
14. ORM-A
15. Combustible liquid (in containers having capacities of 110 gallons [416 liters] or less)
16. ORM-E

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**ATTACHMENT B**

**DOT LIST OF CLASS "A" POISON (49 CFR 172.101)**

Material	Physical State at Standard Temperature
Arsine	Gas
Bromoacetone	Liquid
Chloropicrin and methyl chloride mixture	Gas
Chloropicrin and nonflammable, nonliquefied compressed gas mixture	Gas
Cyanogen chloride	Gas (> 13.1°C)
Cyanogen gas	Gas
Gas identification set	Gas
Gelatin dynamite (H. E. Germaine)	----
Grenade (with Poison "A" gas charge)	----
Hexaethyl tetraphosphate/compressed gas mixture	Gas
Hydrocyanic (prussic) acid solution	Liquid
Hydrocyanic acid, liquefied	Gas
Insecticide (liquefied) gas containing Poison "A" or Poison "B" material	Gas
Methyldichloroarsine	Liquid
Nitric oxide	Gas
Nitrogen peroxide	Gas
Nitrogen tetroxide	Gas
Nitrogen dioxide, liquid	Gas
Parathion/compressed gas mixture	Gas
Phosgene (diphosgene)	Liquid

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**ATTACHMENT C  
HAZARDOUS MATERIALS SHIPPING CHECKLIST**

**PACKAGING**

1. Check DOT 172.500 table for appropriate type of package for hazardous substance.
2. Check for container integrity, especially the closure.
3. Check for sufficient absorbent material in package.
4. Check for sample tags and log sheets for each sample, and chain-of-custody record.

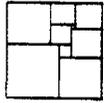
**SHIPPING PAPERS**

1. Check that entries contain only approved DOT abbreviations.
2. Check that entries are in English.
3. Check that hazardous material entries are specially marked to differentiate them from any nonhazardous materials being sent using same shipping paper.
4. Be careful all hazardous classes are shown for multiclass materials.
5. Check total amounts by weight, quantity, or other measures used.
6. Check that any limited-quantity exemptions are so designated on the shipping paper.
7. Offer driver proper placards for transporting vehicle.
8. Check that certification is signed by shipper.
9. Make certain driver signs for shipment.

**RCRA MANIFEST**

1. Check that approved state/federal manifests are prepared.
2. Check that transporter has the following: valid EPA identification number, valid driver's license, valid vehicle registration, insurance protection, and proper DOT labels for materials being shipped.
3. Check that destination address is correct.
4. Check that driver knows where shipment is going.
5. Check that the driver is aware of emergency procedures for spills and accidents.
6. Make certain driver signs for shipment
7. Make certain one copy of executed manifest and shipping document is retained by shipper.





**NUS**  
CORPORATION

**ENVIRONMENTAL  
MANAGEMENT GROUP**

# STANDARD OPERATING PROCEDURES

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05/04/90

Revision  
2

Applicability  
EMG

Prepared  
Earth Sciences

Approved  
*D. Senovich*  
D. Senovich

Subject

SITE LOGBOOK

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## 1.0 PURPOSE

This procedure describes the process for keeping a site logbook.

## 2.0 SCOPE

The site logbook is a controlled document which records all major on-site activities during a Remedial Investigation/Feasibility Study. At a minimum, the following activities/events shall be recorded in the site logbook:

- Arrival/departure of site visitors
- Arrival/departure of equipment
- Sample pickup (chain-of-custody form numbers, carrier, time)
- Sampling activities/sample logsheet numbers
- Start or completion of borehole/trench/monitoring well installation or sampling activities
- Health and Safety issues

The site logbook is initiated at the start of the first on-site activity (e.g., initial reconnaissance survey). Entries are made for every day that on-site activities take place which involve RI/FS contractor personnel. One current site logbook is maintained per site.

The site logbook becomes part of the permanent site file maintained in the RI contractor's office. Because information contained in the site logbook may be admitted as evidence in cost recovery or other legal proceedings, it is critical that this document be properly maintained.

## 3.0 GLOSSARY

Site Logbook - The logbook is a bound notebook with consecutively numbered pages that cannot be removed. Upon entry of data, the logbook requires signature by the responsible site leader (see Section 5.1).

## 4.0 RESPONSIBILITIES

The site logbook is issued by the Regional Manager (or his designee) to the Site Manager for the duration of the project. The Site Manager releases the site logbook to the Field Operations Leader or other person responsible for the direction of on-site activities (e.g., Reconnaissance Survey Team Leader, Sampling Team Leader). It is the responsibility of this person (or his designee) to keep the site logbook current while in his possession, and return it to the Site Manager or turn it over to another field team. Following the completion of all fieldwork, the site logbook is returned to the Site Manager for inclusion in the permanent site files.

## 5.0 PROCEDURES

### 5.1 GENERAL

The cover of each site logbook contains the following information:

- Project Name
- NUS Project Number
- RI/FS Contractor and Site Manager's Name
- Sequential Book Number

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- Start Date
- End Date

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded:

- Date
- Start time
- Weather
- All field personnel present
- Any visitors present

During the day, a summary of all site activities and level of personal protection shall be recorded in the logbook. The information need not duplicate that recorded in other field notebooks (e.g., sample logbook, Site Geologist's notebook, Health and Safety Officer's notebook, etc.), but shall summarize the contents of these other notebooks and refer to the page locations in these notebooks for detailed information. An example of a site logbook page is shown in Attachment A.

The sample logsheet for each sample collected (see Procedure SA-6.6) must be referenced. If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the notebook and page number(s) on which they are recorded (see Attachment A).

All entries shall be made in black pen. No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook must be signed. It must also be signed by the Field Operations Leader or responsible site leader at the end of each day.

## 5.2 PHOTOGRAPHS

When movies, slides, or photographs are taken of a site or any monitoring location, they are numbered to correspond to logbook entries. The name of the photographer, date, time, site location, site description, and weather conditions are entered in the logbook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook. If possible, such techniques shall be avoided, since they can adversely affect the admissibility of photographs as evidence. Chain-of-custody procedures depend upon the subject matter, type of film, and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Adequate logbook notation and receipts may be used to account for routine film processing. Once processed, the slides of photographic prints shall be serially numbered and labeled according to the logbook descriptions.

## 6.0 REFERENCES

None.

## 7.0 ATTACHMENTS

Attachment A - Typical Site Logbook Entry

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**ATTACHMENT A  
TYPICAL SITE LOGBOOK ENTRY**

START TIME: \_\_\_\_\_ DATE: \_\_\_\_\_

SITE LEADER: \_\_\_\_\_

PERSONNEL:

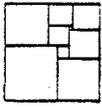
NUS	DRILLER	EPA
_____	_____	_____
_____	_____	_____
_____	_____	_____

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenny and fire hoses were set up.
2. Drilling activities at well \_\_\_\_\_ resumes. Rig geologist was \_\_\_\_\_. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4 inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well \_\_\_\_\_.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well \_\_\_\_\_.
4. Well \_\_\_\_\_ drilled. Rig geologist was \_\_\_\_\_. See Geologist's Notebook, No. 2, page \_\_\_\_\_ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well \_\_\_\_\_ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on-site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit \_\_\_\_\_.
8. Test pit \_\_\_\_\_ dug with cuttings placed in dump truck. Rig geologist was \_\_\_\_\_. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit \_\_\_\_\_ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel offsite, gate locked.

\_\_\_\_\_  
Field Operations Leader



**NUS**  
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MANAGEMENT GROUP**

**STANDARD  
OPERATING  
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2

Applicability  
EMG

Prepared  
Earth Sciences

Approved  
*D. Senovich*  
D. Senovich

Subject  
ONSITE WATER QUALITY TESTING

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## 1.0 PURPOSE

This procedure describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen (DO) Concentration
- Oxidation Reduction Potential
- Certain Dissolved Constituents Using Specific Ion Elements

## 2.0 SCOPE

This procedure is applicable for use in an on-site groundwater quality monitoring program to be conducted during a remedial investigation or site investigation program at a hazardous or non-hazardous site. The procedures and equipment described are applicable to nearly all aqueous samples, including potable well water, monitoring well water, surface water, leachate and drummed water, etc. and are not, in general, subject to solution interferences from color, turbidity and colloidal material, or suspended matter.

This procedure provides generic information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use.

## 3.0 GLOSSARY

### 3.1 pH MEASUREMENT

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution pH.

### 3.2 SPECIFIC CONDUCTANCE MEASUREMENT

Ohm - Standard unit of electrical resistance (R). A siemen (or umho) is the standard unit of electrical conductance, the inverse of the ohm

Resistance - A measure of the solution's ability to oppose the passage of electrical current. For metals and solutions, resistance is defined by Ohm's law,  $E = IR$ , where E is the potential difference, I is the current, and R is the resistance.

Conductance - The conductance of a conductor 1 centimeter long and 1 square centimeter in cross-sectional area. Conductivity and specific conductance are used synonymously.

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### 3.3 TEMPERATURE MEASUREMENT

None.

### 3.4 DISSOLVED OXYGEN MEASUREMENT

Galvanic Cell - An electrochemical cell in which chemical energy is spontaneously converted to electrical energy. The electrical energy produced is supplied to an external circuit.

Electrolytic Cell - An electrochemical cell in which electrical energy is supplied from an external source. This cell functions in much the same way as a galvanic cell, only in the opposite direction due to the external source of applied voltage.

### 3.5 OXIDATION-REDUCTION POTENTIAL MEASUREMENT

Oxidation - The process in which an atom or group of atoms loses electrons to achieve an increasing positive charge.

Reduction - The gaining of electrons by an atom or group of atoms and subsequent increase in negative charge.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode, immersed in water, as referenced against a standard hydrogen electrode.

### 3.6 SPECIFIC ION ELECTRODES MEASUREMENT

Specific Ion Electrode - An electrode which develops a potential difference across a membrane in response to the concentration differences for selected ions on either side of that membrane.

### 4.0 RESPONSIBILITIES

Site Manager - in consultation with the Project Geochemist, is responsible for determining which on-site water quality measurements can contribute to the RI, when these measurements shall be made, and the data quality objectives (DQOs) for these measurements. The Project Operations Plan (POP) shall contain details of type, frequency and locations of the desired measurements.

Project Geochemist - primarily responsible for determining the type, frequency and locations for on-site water quality measurements as presented in the POP and for interpreting the results, including determination of which measurements are unrepresentative.

Field Operations Leader - responsible for implementing the POP, and also for deciding under what field conditions a particular on-site measurement will be unrepresentative or unobtainable.

Field Samplers/Analysts - responsible for the actual analyses that take place, including calibration, quality control and recording of results, as well as for the care and maintenance of the equipment in the field.

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## 5.0 GUIDELINES

### 5.1 MEASUREMENT OF pH

#### 5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control, is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Measurements of pH can also be used to check the quality and corrosivity of soil and solid waste samples. However, these samples must be immersed in water prior to analysis, and specific techniques are not described.

Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required, and the pH meter when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

#### 5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or basicity of the solution with the indicator compound on the paper. Depending on the indicator and the pH range of interest, a variety of different colors can be used. Typical indicators are weak acids or bases, or both. Process chemistry and molecular transformations leading to the color change are variable and complex.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to hydrogen ion concentration across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to hydrogen ion concentration can be generated and measured.

#### 5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Accumet 150 portable pH meter, or equivalent.
- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.
- pH indicator paper, such as Hydrion or Alkacid, to cover the pH range 2 through 12.
- Buffer solutions of pH 4, 7 and 10, or other buffers which bracket the expected pH range.

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#### 5.1.4 Measurement Techniques for Field Determination of pH

##### 1. pH Meter

The following procedure is used for measuring pH with a pH meter (Standardization is according to manufacturers instructions):

- a. The instrument and batteries shall be checked and calibrated prior to initiation of the field effort.
- b. The accuracy of the buffer solutions used for field and laboratory calibration shall be checked. Buffer solutions need to be changed often due to degradation upon exposure to the atmosphere.
- c. Immerse the tip of the electrodes in water overnight. If this is not possible due to field conditions, immerse the electrode tip in water for at least an hour before use. The electrode tip may be immersed in a rubber or plastic sack containing buffer solution for field transport or storage. This is not applicable for all electrodes as some must be stored dry.
- d. Make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
- e. Immerse the electrode(s) in a pH-7 buffer solution.
- f. Adjust the temperature compensator to the proper temperature (on models with automatic temperature adjustment, immerse the temperature probe into the buffer solution). Alternately, the buffer solution may be immersed in the sample and allowed to reach temperature equilibrium before equipment calibration. It is best to maintain buffer solution at or near expected sample temperature before calibration.
- g. Adjust the pH meter to read 7.0.
- h. Remove the electrode(s) from the buffer and rinse well with demineralized water. Immerse the electrode(s) in pH-4 or 10 buffer solution (depending on the expected pH of the sample) and adjust the slope control to read the appropriate pH. For best results, the standardization and slope adjustments shall be repeated at least once.
- i. Immerse the electrode(s) in the unknown solution, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a chemical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.
- j. Read and record the pH of the solution, after adjusting the temperature compensator to the sample temperature. pH shall be recorded to the nearest 0.1 pH unit. Also record the sample temperature.
- k. Rinse the electrode(s) with deionized water.
- l. Keep the electrode(s) immersed in deionized water when not in use.

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The sample used for pH measurement shall never be saved for subsequent conductivity or chemical analysis. All pH electrodes leak small quantities of electrolytes (e.g., sodium or potassium chloride) into the solution. Precipitation of saturated electrolyte solution, especially at colder temperatures, or in cold water, may result in slow electrode response. Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

## 2. pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper.

## 5.2 MEASUREMENT OF SPECIFIC CONDUCTANCE

### 5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

### 5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, while the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not disassociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

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### 5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- YSI Model 33 portable conductivity, meter, or equivalent
- Probe for above meter

A variety of conductivity meters are available which may also be used to monitor salinity and temperatures. Probe types and cable lengths vary, so equipment may be obtained to meet the specific requirement of the sampling program.

### 5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturers instructions):

- Check batteries and calibrate instrument before going into the field.
- Calibrate the instrument daily when used. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used. Attachment A may be used for guidance.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity. Adjust the temperature setting to the sample temperature.
- Read and record the results in a field logbook or sample log sheet.

If the specific conductance measurements become erratic, or inspection shows that any platinum black has flaked off the electrode, replatinization of the electrode is necessary. See the manufacturer's instructions for details.

Note that specific conductance is occasionally reported at temperatures other than ambient.

## 5.3 MEASUREMENT OF TEMPERATURE

### 5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

### 5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury filled or dial-type thermometers. In addition, various meters such as specific conductance or dissolved oxygen meters, which have temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

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### 5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used on a collected water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.
- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is to be used, the instrument shall be calibrated according to manufacturer's recommendations with an approved thermometer before each measurement or group of closely spaced measurements.

## 5.4 MEASUREMENT OF DISSOLVED OXYGEN CONCENTRATION

### 5.4.1 General

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time if the sample is not adequately preserved.

The method monitoring discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and are free from interference caused by color, turbidity, colloidal material or suspended matter.

### 5.4.2 Principles of Equipment Operation

Dissolved oxygen probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, but to leave the surface of the solution undisturbed.

Dissolved oxygen probes are relatively free of interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide which are not

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easily depolarized from the indicating electrode. If the gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

#### 5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- YSI Model 56 dissolved oxygen monitor or equivalent.
- Dissolved oxygen/temperature probe for above monitor.
- Sufficient cable to allow the probe to contact the sample.

#### 5.4.4 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration:

- The equipment shall be calibrated and have its batteries checked in the laboratory before going to the field.
- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
- The instrument shall be calibrated in the field before each measurement or group of closely spaced measurements by placing the probe in a water sample of known dissolved oxygen concentration (i.e., determined by Winkler method) or in a freshly air-saturated water sample of known temperature. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment B).
- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane, either by stirring the sample, or placing the probe in a flowing stream. Probes without stirrers placed in wells can be moved up and down.
- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.
- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This however, may not always be practical. Be sure to record whether the liquid was analyzed in-situ, or if a sample was taken.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen solubilization and positive test interferences.

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## 5.5 MEASUREMENT OF OXIDATION-REDUCTION POTENTIAL

### 5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendency of organic or inorganic compounds to exist in an oxidized state. The technique therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of oxidized to reduced species in the sample.

### 5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and will be dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

### 5.5.3 Equipment

The following equipment is needed for measuring the oxidation-reduction potential of a solution:

- Accumet 150 portable pH meter or equivalent, with a millivolt scale.
- Platinum electrode to fit above pH meter.
- Reference electrode such as a calomel, silver-silver chloride, or equivalent.

### 5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring oxidation-reduction potential:

- The equipment shall be calibrated and have its batteries checked before going to the field.
- Check that the platinum probe is clean and that the platinum bond or tip is unoxidized. If dirty, polish with emery paper or, if necessary, clean the electrode using aqua regia, nitric acid, or chromic acid, in accordance with manufacturer's instructions.
- Thoroughly rinse the electrode with demineralized water.
- Verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of the test solution is altered. The ORP will increase when the pH of the test solution decreases and the ORP will decrease if the test solution pH is increased. Place the sample in a clean glass beaker and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added, the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions. If the ORP does not respond as above when the caustic is added, the electrodes shall be cleaned and the above procedure repeated.
- After the assembly has been checked for sensitivity, wash the electrodes with three changes of water or by means of a flowing stream of water from a wash bottle. Place the sample in a clean glass beaker or sample cup and insert the electrodes. Set temperature

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compensator throughout the measurement period. Read the millivolt potential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful ORP. Record all results in a field logbook, including ORP (to nearest 10 mV), sample temperature and pH at the time of measurement.

## 5.6 SPECIFIC ION ELECTRODE MEASUREMENTS

### 5.6.1 General

Use of specific ion electrodes can be beneficial in the field for determining the presence and concentration of dissolved inorganic species which may be associated with contaminant plumes or leachate. Thus, electrodes can be used for rapid screening of water quality and determination of water migration pathways.

This procedure provides generic information for specific ion electrodes commonly used in groundwater quality monitoring programs and describes the essential elements of a field investigation program. Analytical methods using some specific ion electrodes have not been approved by the USEPA. In addition, calibration procedures and solutions, interferences and conditions and requirements for use for various electrodes vary greatly. Consequently, review of manufacturer's literature is mandatory prior to use.

### 5.6.2 Principles of Equipment Operation

All specific ion electrode measurements involve the use of a reference electrode, a pH meter, and a specific ion electrode (SIE). When the SIE and the reference electrode are immersed in a solution of the ion to be measured, a potential difference is developed between the two electrodes. This potential can be measured by a pH meter and related to the concentration of the ion of interest through the use of standard solutions and calibration curves.

Several different types of SIEs are in use: glass, solid-state, liquid-liquid membrane, and gas-sensing. All of the electrodes function using an ion exchange process as the potential determining mechanism. Glass electrodes are used for pH measurement. The glass in the tip of the electrode actually acts as a semi-permeable membrane to allow solution. Solid-state electrodes replace the glass membrane with an ionically-conducting membrane, (but act in essentially the same manner) while liquid-liquid membrane electrodes have an organic liquid ion exchanger contained in the pores of a hydrophobic membrane. Maintenance of the conducting interface, in combination with a reference electrode, allows completion of the electrical circuit and subsequent measurement of the potential difference. Gas-sensing electrodes have a membrane that permits the passage of gas only, thus allowing for the measurement of gas concentration. Regardless of the mechanism involved in the electrode, most SIEs are easy to use under field conditions. The sensitivity and applicable concentration range for various membranes and electrodes will vary.

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### 5.6.3 Equipment

The following equipment is required for performing quantitative analyses using a specific ion electrode:

- A pH meter with a millivolt scale, or equivalent.
- The specific ion electrode for the parameter to be measured. A partial list of ions which can be measured includes cyanide, sulfide, ammonia, lead, fluoride and chloride.
- A suitable reference electrode to go with the above SIE.

Specific electrodes for other ions have also been developed, but are not widely used for field investigation efforts at this time. Note that of the specific electrodes referenced above, only fluoride and ammonia have analytical methods approved by the U.S. EPA.

### 5.6.4 Measurement Techniques for Inorganic Ions Using Specific Ion Electrodes

Different types of electrodes are used in slightly different ways and are applicable for different concentration ranges. Following the manufacturer's instructions, the general steps given below are usually followed:

- Immerse the electrode in water for a suitable period of time prior to sample analysis.
- Standardize the electrode according to the manufacturer's instructions, including necessary chemical additions for ionic strength adjustment, etc. Standard solutions normally differ by factors of ten in concentration. Constant stirring is needed for accurate readings.
- Immerse the electrode in the sample. Allow the reading to stabilize and record the results in a site logbook. Stir the sample at the same rate as the standards. Air bubbles near the membrane shall be avoided, since this may cause interference in millivolt readings.

(NOTE: Each SIE has substances which interfere with proper measurement. These may be eliminated using pretreatment methods as detailed by the manufacturer. It is important to know if interferences are present so that suspect readings may be noted as such.)

- If the pH meter does not read out directly, plot millivolts versus concentration for the standards and then determine sample concentration.

## 6.0 REFERENCES

American Public Health Association, 1980. Standard Methods for the Examination of Water and Wastewater, 15th Edition, APHA, Washington, D.C.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.

U.S. Geological Survey, 1984. National Handbook of Recommended Methods for Water Data Acquisition, Chapter 5: Chemical and Physical Quality of Water and Sediment. U.S. Department of the Interior, Reston, Virginia.

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**7.0 ATTACHMENTS**

Attachment A - Specific Conductance of KCl Solutions at 25 degrees Centigrade

Attachment B - Variation of Dissolved Oxygen Concentration in Water as a a Function of Temperature and Salinity.

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**ATTACHMENT A**

**SPECIFIC CONDUCTANCE OF M KCl  
AT VARIOUS TEMPERATURES<sup>1</sup>**

Temperature (°C)	Specific Conductance (µmhos/cm)
15	1,147
16	1,173
17	1,199
18	1,225
19	1,251
20	1,278
21	1,305
22	1,332
23	1,359
24	1,368
25	1,413
26	1,441
27	1,468
28	1,496
29	1,524
30	1,552

<sup>1</sup> Data derived from the International Critical Tables 1-3-8.

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**ATTACHMENT B**

**VARIATION OF DISSOLVED OXYGEN CONCENTRATION  
IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY**

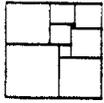
Temperature °C	Dissolved Oxygen mg/l					
	Chloride Concentration in Water					Difference/100 mg chloride
	0	5,000	10,000	15,000	20,000	
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.016
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010
15	10.2	9.7	9.1	8.6	8.1	0.010
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008

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**ATTACHMENT B  
 VARIATION OF DISSOLVED OXYGEN CONCENTRATION  
 IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY  
 PAGE TWO**

Temperature °C	Dissolved Oxygen mg/l					
	Chloride Concentration in Water					Difference/100 mg chloride
	0	5,000	10,000	15,000	20,000	
25	8.4	8.0	7.6	7.2	6.7	0.008
26	8.2	7.8	7.4	7.0	6.6	0.008
27	8.1	7.7	7.3	6.9	6.5	0.008
28	7.9	7.5	7.1	6.8	6.4	0.008
29	7.8	7.4	7.0	6.6	6.3	0.008
30	7.6	7.3	6.9	6.5	6.1	0.008
31	7.5					
32	7.4					
33	7.3					
34	7.2					
35	7.1					
36	7.0					
37	6.9					
38	6.8					
39	6.7					
40	6.6					
41	6.5					
42	6.4					
43	6.3					
44	6.2					
45	6.1					
46	6.0					
47	5.9					
48	5.8					
49	5.7					
50	5.6					

Note: In a chloride solution, conductivity can be roughly related to chloride concentration (and therefore used to correct measured D.O. concentration) using Attachment A.



**NUS**  
CORPORATION

**ENVIRONMENTAL  
MANAGEMENT GROUP**

# STANDARD OPERATING PROCEDURES

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1

Applicability  
EMG

Prepared  
Health and Safety

Approved  
*D. Senovich*  
D. Senovich

Subject

OVA 128 ORGANIC VAPOR ANALYZER

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- 2.0 SCOPE
- 3.0 GLOSSARY
- 4.0 RESPONSIBILITIES
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  - 5.2 GAS CHROMATOGRAPH FUNCTION
  - 5.3 CALIBRATION
  - 5.4 LIMITATIONS
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- 6.0 REFERENCES
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## 1.0 OBJECTIVE

To establish procedures for the use, maintenance, and calibration of the OVA 128 Vapor Analyzer.

## 2.0 SCOPE

Applies to each usage of the OVA instrument in implementation of the NUS/EMG Program.

## 3.0 GLOSSARY

None.

## 4.0 RESPONSIBILITIES

Office Health and Safety Supervisor (OHSS) - The OHSS shall insure that the user has been appropriately trained and certified in the usage of the OVA. He shall also insure that the instrument is properly maintained and calibrated prior to its release for field service.

Instrument User - The user should be personally secure that he or she has been adequately trained, understands the operation of the OVA, and limitations of the instrument. He or she should also be sure that the instrument has been calibrated and is working properly.

## 5.0 PROCEDURES

### 5.1 PRINCIPLE OF OPERATION

The OVA operates in two different modes. In the survey mode, it can determine the approximate concentration of all detectable species in air. With the gas chromatograph option, individual components can be detected and measured independently, with some detection limits as low as a few parts per billion.

### 5.2 GAS CHROMATOGRAPH FUNCTION

In the Gas Chromatograph (GC) mode, a small sample of ambient air is injected into a chromatographic column and carried through the column by a stream of hydrogen gas. Contaminants with different chemical structures are retained on the column for different lengths of time (known as retention times) and, hence, are detected separately by the flame ionization detector. A strip chart recorder can be used to record the retention times, which are then compared to the retention times of a standard with known chemical constituents. The sample can be injected into the column either from the air-sampling hose or directly from a gas-tight syringe.

### 5.3 CALIBRATION

The OVA is internally calibrated to methane by the manufacturer. When measuring methane, it indicates the true concentration. In response to all other detectable compounds, however, the instrument reading may be higher or lower than the true concentration. Relative response ratios for substances other than methane are available. To interpret the readout correctly, it is necessary either to make calibration charts relating the instrument readings to the true concentrations or to adjust the instrument, so that it reads correctly. This second procedure is done by turning the 10-turn, gas-select knob, which adjusts the response of the instrument. The knob is normally set at 300 when calibrated

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to methane. Secondary calibration to another gas is done by sampling a known concentration of the gas and adjusting the gas-select knob, until the instrument reading equals the true concentration.

#### 5.4 LIMITATIONS

The OVA has an inherent limitation in that it can detect only organic molecules. Also, it should not be used at temperatures lower than about 40°F, because gases condense in the pump and column. It has no temperature control and, since retention times vary with ambient temperatures for a given column, absolute determinations of contaminants are difficult. Despite these limitations, the GC mode can often provide tentative information on the identity of contaminants in air without relying on costly, time-consuming laboratory analysis.

#### 5.5 CAUTIONS

The instrument can monitor only certain vapors and gases in air. Many nonvolatile liquids, toxic solids, particulates, and other toxic gases and vapors cannot be detected. Because the types of compounds that the OVA can potentially detect are only a fraction of the chemicals possibly present at an incident, a zero reading does not necessarily signify the absence of air contaminants.

The instrument is nonspecific, and its response to different compounds is relative to the calibration setting. Instrument readings may be higher or lower than the true concentrations. These discrepancies can be especially serious problems when monitoring for total contaminant concentrations, if several different compounds are being detected at once. In addition, the response of this instrument is not linear over the entire detection range. Care must, therefore, be taken when interpreting the data. All identifications should be reported as tentative until they can be confirmed by more precise analysis. Concentrations should be reported in terms of the calibration gas and span potentiometer or gas-select knob setting.

This instrument cannot be used as an indicator for combustible gases or oxygen deficiency.

#### 6.0 REFERENCES

Century Systems (Foxboro). Service Procedures: Organic Vapor Analyzer; 128GC.

#### 7.0 ATTACHMENTS

- Attachment A - Start-up and Shutdown Procedures (2 Sheets)
- Attachment B - Maintenance and Calibration Schedule
- Attachment C - Calibration Procedure (2 Sheets)
- Attachment D - Pump System Checkout
- Attachment E - Burner Chamber Cleaning
- Attachment F - Quad Ring Service
- Attachment G - Troubleshooting (2 Sheets)
- Attachment H - Shipping
- Attachment I - D.O.T. Exemption Permit (2 Sheets)
- Attachment J - D.O.T. Exemption Permit Extension
- Attachment K - Hydrogen Recharging
- Attachment L - Particle Filter Servicing
- Attachment M - Flow Diagram - Gas Handling System

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## ATTACHMENT A

### START-UP AND SHUTDOWN PROCEDURES

#### START-UP

1. Connect the probe/read out connectors to the side-pack assembly.
2. Check battery condition and hydrogen supply.
3. For measurement taken as methane equivalent, check that the GAS SELECT Dial is set at 300.
4. Turn the electronics on by moving the INSR switch to the ON position and allow five (5) minutes for warm-up.
5. Set CALIBRATE switch to X10, use CALIBRATE knob to set indicator at 0.
6. Open the H<sub>2</sub> tank valve and the H<sub>2</sub> supply valve all the way. Check that the hydrogen supply gauge reads between 8.0 and 12.0 psig.
7. Turn the PUMP switch ON and check the flow system, according to the procedures in Attachment D.
8. Check that the BACKFLUSH and INJECT valves are in the UP position.
9. To light the flame, depress the igniter switch until a meter deflection is observed. The igniter switch may be depressed for up to five (5) seconds. Do not depress for longer than five (5) seconds, since it may burn out the igniter coil. If the instrument does not light, allow it to run several minutes and repeat ignition attempt.
10. Confirm OVA operational state by sniffing an organic source, such as a magic marker.
11. Establish a background level in a clean area, by using the charcoal scrubber (depress the sample inject valve) and recording measurements referenced to background.
12. Set the alarm level, if desired.

#### SHUT DOWN

1. Close H<sub>2</sub> supply valve and H<sub>2</sub> tank valve (Do Not Overtighten Valves).
2. Turn INSTR switch to OFF.
3. Wait until H<sub>2</sub> supply gauge indicates system is purged of H<sub>2</sub>, then switch off pump.
4. Put instrument on electrical charger at completion of day's activities.

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## ATTACHMENT B

### MAINTENANCE AND CALIBRATION SCHEDULE

- Check Particle Filters                      Weekly or as-needed
- Check Quad Rings                            Monthly or as-needed
- Clean Burner Chamber                      Monthly or as-needed
- Secondary Calibration Check              Prior to project start-up
- Primary Calibration Check                Monthly or if secondary check is off by more than  $\pm 10\%$
- Check Pumping System                      Prior to project start-up
- Replace Charcoal                              120 hours of use or when background readings are higher with the inject valve down than with the inject valve up, in a clean environment.
- Factory Service                                At least annually

\* Instruments which are not in service for extended periods of time need not meet the above schedule. However, they must be given a complete check-out prior to their first use addressing the above maintenance items.

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## ATTACHMENT C

### CALIBRATION PROCEDURE

#### PRIMARY CALIBRATION

1. Remove instrument components from the instrument shell.
2. Turn on Electronics and Zero instrument on X10 scale. Gas select dial to 300.
3. Turn on Pump and Hydrogen. Ignite Flame. Go to Survey Mode.
4. Introduce a Methane Standard near 100 ppm.
5. Adjust R-32 Trimpot on Circuit Board to make meter read to standard.
6. Turn off hydrogen flame and adjust meter needle to read 40 ppm (calibrate @ X10) using the calibration adjust knobs.
7. Switch to X100 Scale. The meter should indicate 0.4 on the 1-10 meter markings (0.4 x 100 = 40 ppm). If the reading is off, adjust with R33 Trimpot.
8. Return to X10 Scale and adjust meter needle to 40 ppm with calibration adjust knob, if necessary.
9. At the X10 Scale, adjust meter to read 0.4 on the 1-10 meter markings using the calibration adjust. Switch to X1 scale. The meter should read 4 ppm. If the reading is off, adjust using the R-31 Trimpot.

#### SECONDARY CALIBRATION

1. Fill an air sampling bag with 100 ppm (Certified) methane calibration gas.
2. Connect the outlet of the air sampling bag to the air sampling line of the OVA.
3. Record the reading obtained off the meter onto the calibration record.

#### DOCUMENTATION

Each office shall develop a system, whereby the following calibration information is recorded.

- a. Instrument calibrated (I.D. or Serial No.)
- b. Date of calibration
- c. Method of calibration
- d. Results of the calibration
- e. Identification of person who calibrated the instrument
- f. Identification of the calibration gas (source, type, concentration, Lot No.)

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#### ATTACHMENT D

#### PUMP SYSTEM CHECKOUT

1. With pump on hold unit upright and observe flow gauge.
2. Ball level significantly below a reading of 2 is inadequate flow.
3. Check connections at the sample hose.
4. Clean or replace particle filters, if flow is impaired or it is time for scheduled service.
5. Reassemble and retest flow.
6. If flow still inadequate, replace pump diaphragm and valves.
7. If flow normal, plug air intake. Pump should slow and stop.
8. If no noticeable change in pump, tighten fittings and retest.
9. If still no change, replace pump diaphragm and valves.
10. Document this function in the maintenance records.

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**ATTACHMENT E**

**BURNER CHAMBER CLEANING**

1. Remove plastic exhaust port cover.
2. Unscrew exhaust port.
3. Use wire brush to clean burner tip and electrode. Use wood stick to clean Teflon.
4. Brush inside of exhaust port.
5. Blow out chamber with a gentle air flow.
6. Reassemble and test unit.
7. Document this function in the maintenance records.

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**ATTACHMENT F**  
**QUAD RING SERVICE**

1. Remove OVA guts from protective shell.
2. Remove clip ring from bottom of valve.
3. Unscrew nut from top of valve.
4. Gently pull valve shaft upward and free of housing.
5. Observe rings for signs of damage - replace as necessary.
6. Lightly grease rings with silicone grease.
7. Reassemble valve - do not pinch rings during shaft insertion.
8. Document this function in the maintenance records.

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**ATTACHMENT G**  
**TROUBLESHOOTING**

Indication	Possible Causes
● High Background Reading (More than 10 ppm)	1. Contaminated Hydrogen 2. Contaminated Sample Line
● Continual Flameout	1. Hydrogen Leak 2. Dirty Burner Chamber 3. Dirty Air Filters
● Low Air Flow	1. Dirty Air Filter 2. Pump Malfunction 3. Line Obstruction
● Flame Will Not Light	1. Low Battery 2. Ignitor Broken 3. Hydrogen Leak 4. Dirty Burner Chamber 5. Air Flow Restricted
● No Power to Pump	1. Low Battery 2. Short Circuit
● Hydrogen Leak (Instrument Not in Use)	1. Leak in Regulator 2. Leak in Valves

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**ATTACHMENT G  
TROUBLESHOOTING  
PAGE TWO**

To be performed by qualified technician only.

1. No meter response in any switch position (including BATT CHK).
  - A. Broken meter movement.
    - (1) Tip instrument rapidly from side to side. Meter needle should move freely and return to zero.
  - B. Electrical connection to meter is broken.
    - (1) Check all wires leading to meter and clean the contacts of quick-disconnects.
  - C. Battery is completely dead.
    - (1) Disconnect battery and check voltage with a volt-ohm meter.
  - D. If none of the above solves the problem, consult the factory.
2. Meter responds in BATT CHK position, but reads zero or near zero for all others.
  - A. Power supply defective.
    - (1) Check power supply voltages per Figure 11 of the HNU owner's manual. If any voltage is out of specification, consult the factory.
  - B. Input transistor or amplifier has failed.
    - (1) Check input connector on printed circuit board. The input connector should be firmly pressed down.
    - (2) Check components on back side of printed circuit board. All connections should be solid and no wires should touch any other object.
    - (3) Check all wires in readout for solid connections.

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**ATTACHMENT H**

**SHIPPING**

Since the OVA-128 contains hydrogen, it is subject to shipping restrictions.

**As Personal Luggage**

The OVA-128 can be taken on a plane as luggage, since a permit has been issued from the Department of Transportation to the manufacturer (Foxboro). Please refer to the original permit (Attachment 9) and the extended permit (Attachment 10).

**Air Express**

The following labels must be affixed to both sides of the OVA case when shipping OVA by Air Express.

- Danger - Peligro
- Flammable Gas
- Inside Container Complies with D.O.T. Regulations
- Hydrogen UN #1049
- Name and Address of Recipient

A hazardous air bill must be filled out. The following information is requested.

Proper Shipping Name	Hydrogen
Classification	Flammable Gas
I.D. No.	UN 1049
Net Quantity	75 Cubic Centimeters

In addition, the shipping's certification must be signed and marked **CARGO AIRCRAFT ONLY**.

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**ATTACHMENT I  
D.O.T. EXEMPTION PERMIT**



DEPARTMENT OF TRANSPORTATION  
RESEARCH AND SPECIAL PROGRAMS  
WASHINGTON, DC 20590  
DOT-E 7607  
**DRAFT**  
(FIRST REVISION - CORRECTED COPY)

1. Century Systems Corporation, Arkansas City, Kansas, is hereby granted an exemption from those provisions of this Department's Hazardous Materials Regulations specified in paragraph 5 below to offer packages proscribed herein of a flammable gas for transportation in commerce subject to the limitations and special requirements specified herein. This exemption authorizes the shipment of hydrogen in certain non-DOT specification cylinders as described in paragraph 7 below, and provides no relief from any regulation other than as specifically stated. Each of the following is hereby granted the status of a party to this exemption:

U.S. Department of Health, Education and Welfare, Rockville, Maryland - PTE-1.

2. BASIS. This exemption is based on Century Systems Corporation's application dated March 10, 1978, submitted in accordance with 49 CFR 107.105 and the public proceeding thereon. The granting of party status is based on the following application submitted in accordance with 49 CFR 107.111 and the public proceeding thereon:

The U.S. Department of Health, Education and Welfare's application dated March 13, 1978.

3. HAZARDOUS MATERIALS (Descriptor and class). Hydrogen, flammable gas.
4. PROPER SHIPPING NAME (49 CFR 172.101). Hydrogen.
5. REGULATION AFFECTED. 49 CFR 172.101, 175.3.
6. MODE OF TRANSPORTATION AUTHORIZED. Passenger-carrying aircraft.
7. SAFETY CONTROL MEASURES. Packaging prescribed is a non-DOT specification seamless stainless steel cylinder of not more than 7.22 cubic inch water capacity; each cylinder to be pressure tested to at least 4000 psig, and charged to not more than 2100 psig at 70°F. The cylinder is a component part of a portable gas chromatograph.
8. SPECIAL PROVISIONS.
  - a. Each device must be shipped in a strong outside packaging as prescribed in 49 CFR 173.301(h).
  - b. A copy of this exemption must be carried aboard each aircraft used to transport packages covered by this exemption.
  - c. The pilot in command must be advised when the gas chromatograph is placed on board the aircraft.
  - d. The gas chromatograph must be appropriately secured.

Subject  OVA 128 ORGANIC VAPOR ANALYZER	Number ME-02	Page 14 of 18
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Continuation of 1st Rev. DOT-E 7607 corrected copy

**DRAFT**

9. REPORTING REQUIREMENTS. Any incident involving loss of contents of the package must be reported to the Office of Hazardous Materials Regulation as soon as practicable.

10. EXPIRATION DATE. May 1, 1980.

Issued at Washington, D.C.:

*Alan L. Roberts*

9-7-78

(DATE)

Alan L. Roberts  
Associate Director for  
Hazardous Materials Regulation  
Materials Transportation Bureau

Address all inquiries to: Associate Director for Hazardous Materials Regulation, Materials Transportation Bureau, Research and Special Programs Administration, Department of Transportation, Washington, D.C., 20590. Attention: Exemptions Branch.

Dist: 3 of 2, FAA



DEPARTMENT OF TRANSPORTATION  
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION  
WASHINGTON, D.C. 20590

DOT-E 7607  
(PTE)

In accordance with 49 CFR 107.111 of the Department of Transportation (DOT) Hazardous Materials Regulations the party(s) listed below are granted the status of party to DOT-E 7607.

The expiration date of the exemption is March 11, 1982 for the party(s) listed below. This authorization forms part of the exemption and must be attached to it.

*J. Roberts for*

13 JUN 1980

(DATE)

Alan L. Roberts  
Associate Director for  
Hazardous Materials Regulation  
Materials Transportation Bureau

Dist: FAA

EXEMPTION HOLDER

APPLICATION DATE

Clayton Environmental Consultants, Inc.  
Southfield, Michigan

December 5, 1979

Foxboro Company  
Burlington, MA

March 24, 1980

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ATTACHMENT J

D.O.T. EXEMPTION PERMIT EXTENSION



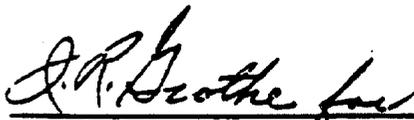
U.S. Department  
of Transportation  
  
Research and  
Special Programs  
Administration

400 Seventh Street, S.W.  
Washington, D.C. 20590

DOT-E 7607  
(EXTENSION)

In accordance with 49 CFR 107.105 of the Department of Transportation (DOT) Hazardous Materials Regulations DOT-E 7607 is hereby extended by changing the expiration date in paragraph 10 from December 1, 1983 to September 1, 1985.

This extension applies only to party(s) listed below based on the application received in accordance with 49 CFR 107.105. All other terms of the exemption remain unchanged. This extension forms part of the exemption and must be attached to it.

  
\_\_\_\_\_  
Alan I. Roberts  
Associate Director for  
Hazardous Materials Regulation  
Materials Transportation Bureau

OCT 27 1983  
\_\_\_\_\_  
(DATE)

Dist: FAA

EXEMPTION HOLDER

Foxboro Company  
South Norwalk, Ct.

APPLICATION DATE

September 16, 1983

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## ATTACHMENT K

### HYDROGEN RECHARGING

1. High grade hydrogen (99.999%) is required.
2. Connect the fill hose to the REFILL FITTING on the side Pack Assembly, with the FILL/BLEED valve in the OFF position.
3. Open H<sub>2</sub> supply bottle valve.
4. Place FILL/BLEED valve on fill hose in BLEED position momentarily to purge any air out of the system.
5. Crack the instrument TANK VALVE.
6. Open REFILL valve on instrument.
7. Place FILL/BLEED valve in FILL position until the instrument PRESSURE GAUGE equalizes with the H<sub>2</sub> SUPPLY BOTTLE PRESSURE GAUGE.
8. Shut REFILL valve, FILL/BLEED valve, and H<sub>2</sub> SUPPLY BOTTLE valve, in quick succession.
9. Turn FILL/BLEED valve to BLEED until hose pressure equalizes to atmospheric pressure.
10. Turn FILL/BLEED valve to FILL Position, then to BLEED position, then to OFF.
11. Close TANK on instrument.
12. Disconnect the FILL HOSE and replace protective nut on the REFILL FITTING.

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## ATTACHMENT L

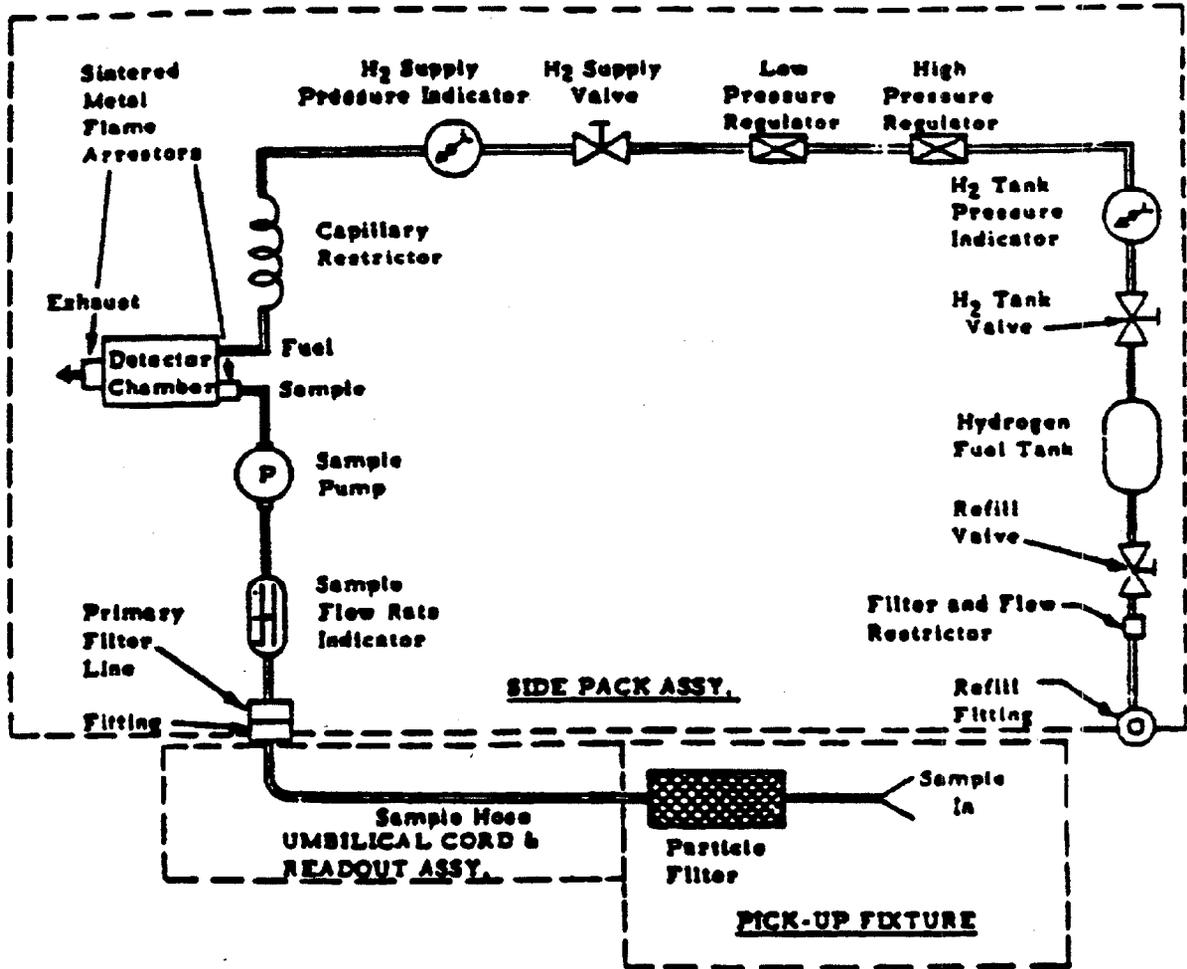
### PARTICLE FILTER SERVICING

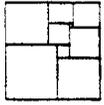
There are two points in the air sampling line of the OVA where filters have been placed to keep particulates from entering the instrument. The location of these filters are indicated on the figure in Attachment M. The first filter is located in the probe assembly and the second filter (primary filter) is located on the side pack assembly. Cleaning procedures are as follows:

1. Detach the probe assembly from the readout assembly.
2. Disassemble the probe (the components unscrew).
3. The particle filter located within the probe can be cleaned by blowing air through the filter.
4. Reassemble the probe.
5. The primary filter, located behind the sample inlet connector on the side pack assembly, is accessed by removing the sample inlet connector with a thin-walled 7/16 inch socket wrench. Remove the filter and clean as above.
6. Reassemble the sample inlet fitting and filter to the side pack assembly.
7. Check sample flow rate.

ATTACHMENT M

FLOW DIAGRAM - GAS HANDLING SYSTEM





**NUS**  
CORPORATION

**ENVIRONMENTAL  
MANAGEMENT GROUP**

# STANDARD OPERATING PROCEDURES

Number  
SF-2.3

Page  
1 of 4

Effective Date  
05/04/90

Revision  
1

Applicability  
EMG

Prepared  
Earth Sciences

Approved  
*D. Senovich*  
D. Senovich

Subject  
DECONTAMINATION OF CHEMICAL SAMPLING  
AND FIELD ANALYTICAL EQUIPMENT

## TABLE OF CONTENTS

### SECTION

- 1.0 PURPOSE
- 2.0 SCOPE
- 3.0 GLOSSARY
- 4.0 RESPONSIBILITIES
- 5.0 PROCEDURES
  - 5.1 ACCESS FOR SAMPLING
    - 5.1.1 Bailers and Bailing Line
    - 5.1.2 Sampling Pumps
    - 5.1.3 Filtering Equipment
  - 5.2 FIELD ANALYTICAL EQUIPMENT
    - 5.2.1 Water Level Indicators
    - 5.2.2 Probes
- 6.0 REFERENCES
- 7.0 RECORDS

Subject DECONTAMINATION OF CHEMICAL SAMPLING AND FIELD ANALYTICAL EQUIPMENT	Number SF-2.3	Page 2 of 4
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## 1.0 PURPOSE

The purpose of these procedures is to provide a general methodology, protocol, and reference information on the proper decontamination procedures to be used on chemical sampling and field analytical equipment.

## 2.0 SCOPE

This procedure addresses chemical sampling and field analytical equipment only, and should be consulted when equipment decontamination procedures are being developed as part of project-specific plans.

## 3.0 GLOSSARY

None.

## 4.0 RESPONSIBILITIES

Site Manager - responsible for ensuring that project-specific plans and the implementation of field investigations are in compliance with these guidelines.

Field Operations Leader - responsible for ensuring that decontamination procedures for all chemical sampling and field analytical equipment are programmed prior to the actual field effort and that personnel required to accomplish the task have been briefed and trained to execute the task.

## 5.0 PROCEDURES

In order to assure that chemical analysis results are reflective of the actual concentrations present at sampling locations, chemical sampling and field analysis equipment must be properly decontaminated prior to the field effort, during the sampling program (i.e., between sample points) and at the conclusion of the sampling program. This will minimize the potential for cross-contamination between sample points and the transfer of contamination offsite.

This procedure incorporates only those aspects of decontamination not addressed in other procedures. Specifically it incorporates those items involved in decontamination of chemical sampling and field analytical equipment.

### 5.1 ACCESS FOR SAMPLING

#### 5.1.1 Bailers and Bailing Line

The potential for cross-contamination between sampling points via the use of common bailer, or its attached line, is high unless strict procedures for decontamination are followed. It is preferable, for the aforementioned reason, to dedicate an individual bailer and its line to each sample point, although this does not eliminate the need for decontamination of dedicated bailers. For non-dedicated sampling equipment, the following conditions and/or decontamination procedures should be followed.

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Before the initial sampling and after each succeeding sampling point, the bailer must be decontaminated. The following steps should be followed if sampling for organic contaminants:

- Potable water rinse
- Alconox or Liquinox detergent wash
- Scrubbing of the line and bailer with a scrub brush may be required if the sample point is heavily contaminated with heavy or extremely viscous compounds
- Potable water rinse
- Rinse with 10 percent nitric acid solution\*
- Deionized water rinse
- Acetone or methanol rinse
- Hexane rinse\*\*
- Distilled/Deionized water rinse
- Air dry

If sampling for organics only, the nitric acid, acetone, methanol, and hexane rinses may be omitted. Contract-specific requirements may permit alternative procedures.

Braided nylon or polypropylene lines may be used with a bailer, however, the same line must not come in contact with the sample medium, otherwise, the line must be discarded in an approved receptacle and replaced. Prior to use, the bailer should be wrapped in aluminum foil or polyethylene sheeting.

#### 5.1.2 Sampling Pumps

Most sampling pumps are normally low volume (less than 2 gpm) pumps. These include peristaltic, diaphragm, air-lift, pitcher and bladder pumps, to name a few. If these pumps are used for sampling from more than one sampling point, they must be decontaminated.

The procedures to be used for decontamination of sampling pumps compare to those used for a bailer except the 10 percent nitric acid solution is omitted. Each of the liquid fractions is to be pumped through the system. The amount of pumping is dependent upon the size of the pump and the length of the intake and discharge hoses. Certain types of pumps are unacceptable for sampling purposes.

An additional problem is introduced when the pump relies on absorption of water via an inlet or outlet hose. For organic sampling, this hose should be Teflon. Other types of hoses leach organics into the water being sampled (especially the phthalate esters) or adsorb organics from the sampled water. For all other sampling, the hose should be Viton, polyethylene, or polyvinyl chloride (in order of preference). Whenever possible, dedicated hoses should be used.

---

\* Due to the leaching ability of nitric acid, on stainless steel, this step is to be omitted if a stainless steel sampling device is being used and metals analysis is required with detection limits less than approximately 50 ppb; or the sampling equipment is dedicated.

\*\* If sampling for pesticides, PCBs, or fuels.

Subject DECONTAMINATION OF CHEMICAL SAMPLING AND FIELD ANALYTICAL EQUIPMENT	Number SF-2.3	Page 4 of 4
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### 5.1.3 Filtering Equipment

Part of the sampling plan may incorporate the filtering of groundwater samples, and subsequent preservation. This should occur as soon after sample retrieval as possible; preferably in the field as soon as the sample is obtained. To this end, three basic filtration systems are most commonly used - the in-line disposable Teflon filter, the inert gas over-pressure filtration system, and the vacuum filtration system.

For the in-line filter, decontamination is not required since the filter cartridge is disposable, however, the cartridge must be disposed of in an approved receptacle and the intake and discharge lines must still be decontaminated.

For the over-pressure and the vacuum filtration systems, the portions of the apparatus which come in contact with the sample must be decontaminated as outlined in the paragraphs describing the decontamination of bailers. (Note: Varieties of both of these systems come equipped from the manufacturer with Teflon-lined surfaces for those that would come into contact with the sample. These filtration systems are preferred when decontamination procedures must be employed.)

## 5.2 **FIELD ANALYTICAL EQUIPMENT**

### 5.2.1 Water Level Indicators

Water level indicators that come into contact with groundwater must be decontaminated using the following steps:

- Rinse with potable water
- Rinse with deionized water
- Acetone or methanol rinse
- Rinse with deionized water

Water level indicators that do not come in contact with the groundwater but may encounter incidental contact during installation or retrieval need only undergo the first and last steps stated above.

### 5.2.2 Probes

Probes, e.g., pH or specific ion electrodes, geophysical probes, or thermometers which would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise; in those cases, the methods of decontamination must be clearly described in the FSAP. Probes that contact a volume of groundwater not used for laboratory analyses can be rinsed with deionized water. For probes which make no direct contact, e.g., OVA equipment, the probe will be wiped with clean paper-towels or cloth wetted with alcohol.

## 6.0 **REFERENCES**

None.

## 7.0 **RECORDS**

None.

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Geochemical and Environmental Research Group  
STANDARD OPERATING PROCEDURES

Page 1 of 12  
SOP-9013

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**QUANTITATIVE DETERMINATION OF BUTYLTINS**

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Written by

Terry L. Wade

This document presents the protocol, materials, and quality control used in the performance of the above analysis.

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Laboratory Manager  
Terry L. Wade

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Date

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Quality Control Officer  
Thomas J. Jackson

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Date

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Rev. 2

Approved

*Mable C. Kennicut* 5/27/92

May 27, 1992

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## QUANTITATIVE DETERMINATION OF BUTYLTINS

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### 1.0 INTRODUCTION

The quantitative method described in this document determines butyltins in extracts of water, sediments and tissues. The method is based on high resolution, capillary gas chromatography using flame photometric detection (GC/FPD). This method quantitatively determines tetrabutyltin (4BT), tributyltin (TBT), dibutyltin (DBT) and monobutyltin (MBT).

Extracts should be prepared as described in GERG SOP's-9010, 9011 and 9012 for water, sediment and biological tissues, respectively.

Sample collection, preservation and storage times are discussed under the analytical procedures for sample extraction and purification.

### 2.0 APPARATUS AND MATERIALS

A gas chromatograph with a split/splitless injection system, capillary column capability and a flame photometric detector (FPD) equipped with a tin selective 610 nm filter. The output from the detector is collected and processed by an automated HP-LAS 3357 data acquisition software package.

#### 2.1 GC Column

Use a 30-m long x 0.32-mm I.D. fused silica capillary column with DB-5 bonded phase (J&W Scientific or equivalent).

#### 2.2 Autosampler

The autosampler is capable of making 1-4  $\mu$ l injections.

### 3.0 REAGENTS

#### 3.1 Calibration Solution

The calibration solution is comprised of 4BT, TBT, DBT and MBT.

Prepare calibration standards in the concentration range of 1.25 to 50 ng Sn/ $\mu$ l (at five concentrations) at a minimum. Add internal standard and surrogate compounds at 20 ng Sn/ $\mu$ l to all calibration standards.

### **3.2 Surrogate Spiking Solution**

The surrogate compound for all sample types is tripropyltin chloride. Make the surrogate solution by weighing an appropriate amount of pure material into a volumetric flask and dilute to volume with methylene chloride. Add the surrogates to each sample at a concentration of  $\sim 10\times$  the MDL (i.e., 100  $\mu$ l of 20 ng Sn/ $\mu$ l to a final volume of 1 ml).

### **3.3 Internal Standard Solution**

The internal standard for this analysis is tetrapropyltin. Make the internal standard solution by weighing an appropriate amount of pure material into a volumetric flask and dilute to volume with methylene chloride. Add the internal standard to each sample extract to obtain a final concentration of approximately 2 ng Sn/ $\mu$ l. For higher concentrations of oil the internal standard concentration is appropriately increased.

### **3.4 Matrix Recovery Spiking Solution**

The matrix spiking solution consists of 4BT, TBT, DBT and MBT.

Add the matrix spike to samples at a concentration  $\sim 10\times$  the MDL.

### **3.5 Retention Index Solution**

Use the calibration mixture as a retention index solution.

## **4.0 PROCEDURE**

### **4.1 Sample Extraction and Purification**

Water samples are extracted and purified (optional) following GERG SOP-9010. Sediment samples are extracted and purified following GERG SOP-9011. Tissue samples are extracted and purified following GERG SOP-9012.

## 4.2 High Resolution GC-FPD Analysis

### 4.2.1 GC Conditions

For the analysis of butyltins, the analytical system, or its equivalent, should include at a minimum:

<b>Instrument:</b>	Hewlett-Packard 5880A or HP 5890 Gas Chromatograph
<b>Features:</b>	Split/splitless capillary inlet system, HP-1000 LAS 3357 data acquisition system
<b>Inlet:</b>	Splitless
<b>Detector:</b>	Flame photometric, 610 nm filter
<b>Column:</b>	0.32-mm I.D. x 30-m DB-5 fused silica capillary column (J&W Scientific)
<b>Gases:</b>	
Carrier:	Helium 2 ml/min.
Make-Up:	Helium 33 ml/min.
Detector:	Air 100 ml/min. Hydrogen 80 ml/min.
<b>Temperatures:</b>	
Injection port:	300°C
Detector:	225°C
Oven Program:	60°C to 300°C, hold 10 min.

The GC oven temperature program may be modified to improve resolution.

<b>Daily Calibration:</b>	Mid-level calibration solution; Retention index solution
---------------------------	---

(20 µg/ml)

**Quantification:** Internal standard/calibration

Note: The GC must be capable of the baseline resolution of all target compounds surrogates, and internal standards from each other and from interfering compounds.

**4.2.2 Calibration**

Prior to every sample set perform the GC calibration at a minimum of three concentrations. One of the concentration levels is near, but above the MDL. The remaining concentrations correspond to the expected range of the sample analytes. A concentration range of 1.25 to 50 ng Sn/µl is recommended. The detector is linear within this range. An average calibration factor from the authentic standard of each individual compound is used to calculate sample analyte concentrations. The initial calibration is verified by the measurement of calibration standards after at least every 12 samples. When possible, the RF for each individual butyltin is calculated from authentic material.

Analyze a mid-level standard immediately prior to conducting any analyses, and after each group of 12 samples. The response factor criteria for an in control calibration check is ±30%.

**4.2.3 Retention Time Windows**

Retention time windows are established and maintained according to procedures outlined in EPA Method 8000, Section 7.5. Three times the standard deviation of the retention time determined from the calibration solutions is used to calculate a window size.

**4.2.4 Sample Analysis**

If the instrument is in calibration initiate butyltin analyses with a calibration check, followed by 12 samples, and ending with a calibration check (Table 1). If the response factor for any analyte in the calibration check fails to meet the criteria established in Section 4.2.2, the instrument is recalibrated. All samples that were injected after the standard exceeded the criteria must be reinjected or recalculated based on the analysts review of the data.

Sample injections of 1 to 4  $\mu$ l are made with an autosampling device.

If the response for any peak exceeds the highest calibration solution, dilute and reanalyze the extract.

Table 1. Minimum Sample Distribution to Meet QA Requirements During a Typical TBT Analysis.

Sample No.	Description	Function
1	Solvent Blank	Establish instrument background
2	Cal Ck*	Confirm "in calibration" condition
3	Sample #1	Unknown Analysis
4	Sample #2	Unknown Analysis
5	Sample #3	Unknown Analysis
6	Sample #4	Unknown Analysis
7	Sample #5	Unknown Analysis
8	Sample #6	Unknown Analysis
9	Sample #7	Unknown Analysis
10	Sample #8	Unknown Analysis
11	Sample #9	Unknown Analysis
12	Sample #10 (duplicate)**	Unknown Analysis
13	System Blank	Confirm method blank
14	Spiked Blank/Fortified Sample/SRM	Complete Analytical QA***
15	Cal Ck	Confirm "in calibration" condition

\* Criteria  $\pm 30\%$  an individual analyte

\*\* 10% of samples analyzed in duplicate

\*\*\* Criteria  $\pm 30\%$  for all analytes

#### 4.2.5 Calculations

Calculations are based on the methods of internal standards. The general formula for calculating butyltins is found in Section 7.8.2 of EPA SW-846 Method 8000. See Section 6.1 of this method for details of the calculations. This method is modified in that all analyte concentrations are corrected for the surrogate recoveries and all concentrations are reported as  $\mu$ g Sn/l or g.

## 5.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) REQUIREMENTS

### 5.1 Initial Calibration and Continuing Calibration Checks

Prior to the analyses, a three-point response factor calibration curve establishes the linear range of the detector.

Analyze each calibration standard and calculate the response factor (RF) of each compound at each concentration level from the area of the peak and the calculated Sn concentration.

Use the following formula to calculate the response factors of the internal standard relative to each of the calibration standards.

$$RF = (A_S C_{IS}) / (A_{IS} C_S)$$

where:

$A_S$  = Area for the analyte to be measured.

$A_{IS}$  = Area for the internal standard (tetrapropyltin).

$C_{IS}$  = Concentration of the internal standard (ng/ $\mu$ l)

$C_S$  = Concentration of the analyte to be measured (ng/ $\mu$ l).

For every 12 sample analyses or at least once daily, determine the response factor for each compound of interest relative to the internal standard.

Compare the daily response factor for each compound to the initial calibration curve. Calculate the percent difference using the following equation:

$$\text{Percent Difference} = \frac{RFI - RFC}{RFI} \times 100$$

where:

RFI = Average response factor from initial calibration.

RFC = Response factor from current verification check standard.

If the average daily response factors for all analytes is within  $\pm 15$  percent of the corresponding calibration curve value, the analysis may proceed. If, for any individual analyte, the daily response factor exceeds  $\pm 30$  percent of the corresponding calibration curve value, a three-point calibration curve must be repeated for that compound prior to the analysis of the samples. All samples are calculated from the initial calibration.

### 5.2 Method Blank Analysis

An acceptable method blank analysis does not contain any target compound at concentration 3 times greater than the MDL. If the method blank does not meet these criteria, the analytical system is out of control and the source of the contamination must be investigated, corrective measures taken, and documented before further sample analysis proceeds.

### 5.3 Surrogate Compound Analysis

Spike all samples and quality control samples with TPT. Spike the surrogate solution into the sample prior to extraction to measure individual sample matrix effects associated with sample preparation and analysis.

The laboratory will take corrective action whenever the recovery of the surrogate is below 30 percent for water, sediment and tissue matrices.

Take the following corrective action when an out of control event occurs:

- a. Check calculations to assure that no errors have been made.
- b. Check the internal standard and surrogate solutions for degradation, contamination, etc., and check instrument performance is checked.
- c. If the surrogate could not be measured because the sample required a dilution, no corrective action is required. The surrogate recovery is properly annotated.
- d. If the steps above fail to reveal a problem, reanalyze the sample or extract. If reanalysis of the extract yields surrogate recoveries within the stated limits, then report the reanalysis data. If upon reinjection QA criteria are still violated, the sample will be submitted for re-extraction if sufficient sample is available. If the sample was

completely consumed, the data will be reported but designated as outside the QA criteria.

#### **5.4 Matrix Spike Analysis**

The laboratory spikes and analyzes a matrix spike every 12 samples or with every sample set, whichever is more frequent. A sample is randomly chosen, split into two subsamples and the subsample is fortified with the matrix spike. The acceptable matrix spike recovery criteria for water, sediment and tissue analysis are:

- The acceptable average recoveries are  $90 \pm 20\%$  for 4BT, TBT, DBT and  $60 \pm 25\%$  for MBT.

If the matrix spike criteria are not met, reinject the matrix spike on the GC. If the reinjected matrix spike analysis meets the criteria, then report the reanalysis data. If not, submit the entire batch of samples for re-extraction if sufficient sample is available. If the sample was completely consumed, report the data but designate as outside the QA criteria.

#### **5.5 Method Detection Limit**

The method detection limit is determined following the procedures outlined in Federal Register (1984), Vol. 49, No. 209: 198- 199.

#### **5.6 GC Resolution**

The target compounds, and internal standard must be resolved from one another and from interfering compounds.

#### **5.7 Reference Sample Analysis**

When available, analyze reference material. Analyze one sample per batch of samples, and use the results to establish laboratory QC charts. The result should agree within  $\pm 30\%$  of the mean of the previously reported data. Use the data produced to construct control charts.

## 6.0 CALCULATIONS

### 6.1 Butyltin Calculations

All calculations are based on the methods of internal standards from Section 7.8.2 of EPA SW-846 Method 8000 with the modification that all values are corrected for surrogate recoveries:

- RF = average of  $(A_s \times C_{is}) / (A_{is} \times C_s)$

where:

$A_s$  = Area of analyte to be measured

$A_{is}$  = Area of internal standard tetrapropyltin

$C_{is}$  = Concentration of the internal standard tetrapropyltin  
(ng Sn/ $\mu$ l)

$C_s$  = Concentration of the analyte to be measured (ng Sn/ $\mu$ l).

$$C_e = \frac{(A_s)(I_s)}{(A_{is})(RF)}$$

where:

$C_e$  = Sample extract concentration (ng Sn/ $\mu$ l).

$A_s$  = Area of the analyte to be measured.

$A_{is}$  = Area of the the internal standard (tetrapropyltin).

$I_s$  = Amount of internal standard added to each extract divided by the final extract volume ( $V_e$ ).

The actual sample concentration (C) for each compound is calculated by the following formula:

$$C = (C_e) \times \frac{V_e}{V_s}$$

where:

C = Concentration in sample (ng Sn/l or g).

$V_E$  = The final extract volume (ml).

$V_s$  = The original volume of sample extracted (l or g).

Correct the calculated value to one hundred percent recovery based on the surrogate recovery.

### 6.3 Calculation Notes

**6.3.1** To each sample, add a specific amount of surrogate. Monitor the recovery of this surrogate in each sample using the response of the I.S. that is added to the final extract.

$$\text{Percent SUR recovery} = (A_{\text{SUR}} \times C_{\text{IS}}) / (C_{\text{SUR}} \times A_{\text{IS}} \times R_{\text{FSUR}})$$

where:

$A_{\text{IS}}$  = Area of tetrapropyltin

$A_{\text{SUR}}$  = Area of tripropyltin.

$C_{\text{SUR}}$  = ng Sn in tripropyltin added to  
the sample

$C_{\text{IS}}$  = ng Sn in tetrapropyltin added to the sample extract

$R_{\text{FSUR}}$  = Response factor for tripropyltin.

Correct all analyte concentrations for surrogate recoveries.

## 7.0 REPORTING

### 7.1 Reporting Units

Report units in ng Sn/L for water and ng/g for sediments and biological tissue .

### 7.2 Minimum Method Performance Criteria

The minimum method performance standard for water is detection of 5 ng Sn/L for butyltins. Criteria for sediments and tissues is 5ng Sn/g.

### 7.3 Significant Figures

Report results to three (3) significant figures.

**7.4 Surrogate Recovery**

Report surrogate recoveries for every sample analyzed.

**7.5 Matrix Spike**

Report matrix spike recoveries for each batch of samples analyzed.

**7.6 Reference Materials**

When available, report the results of the analysis standard reference materials for each batch of samples analyzed.

Note: The effective minimum performance standard can be adjusted by decreasing final sample volume, increasing sample amount and/or increasing volume injected on the GC-FPD.

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS  
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT  
Division of Groundwater and Individual Sewage Disposal Systems

Rules and Regulations for GROUNDWATER QUALITY



July 1993

Promulgated: May 1992  
Amended: July 1993

Code of Rhode Island Rules Number 12-100-006, July 1993

**AUTHORITY:** These regulations are adopted in accordance with Chapter 42-35 pursuant to Chapters 46-12, 46-13.1, 23-18.9, 23-19.1, 42-17.6 and 42-17.1 of the Rhode Island General Laws of 1956, as amended.

## APPENDIX I

### Required Monitoring Well Construction Standards and Abandonment Procedures

- 1.0 Purpose: to provide minimum standards for; (a) the procurement of samples representative of groundwater; and (b) abandonment procedures for removing the vertical conduit to groundwater.
- 2.0 Applicability: The monitoring well construction standards herein apply to all permanent monitoring wells installed pursuant to these regulations. Pursuant to Section 12.02 of these regulations, wells installed at the direction of other programs are exempt from Sections 4.0 through 12.0 of this Appendix. A monitoring well is designated permanent if it exists for more than 180 days. Section 13 of this appendix on monitoring well abandonment applies to all permanent and non-permanent monitoring wells subject to these regulations. Section 13 also applies to those piezometers where improper abandonment would result in a reasonable likelihood of groundwater pollution. Additional requirements may be specified by the Director.
- 3.0 Prevention of Groundwater Pollution: During well construction and abandonment, every appropriate precaution shall be taken to prevent introducing pollutants into the groundwater. This shall include, but not be limited to, steam cleaning and washing of drilling equipment and proper cleaning and storage of well casing. Only potable water shall be used in well construction and abandonment unless otherwise approved by the Director.
- 4.0 Construction and Abandonment Standards: The procedures described in this Appendix incorporate minimum standards. The Director may waive the requirements and allow deviation from these procedures where such deviations are necessary to procure representative groundwater samples. All deviations from the procedures shall be documented and provided to the Director. If the Director determines that the deviation from these procedures will not or does not result in the procurement of samples representative of groundwater, the Director may require the installation of a new monitoring well.
- 5.0 Well Casing: All permanent groundwater monitoring wells shall be constructed of PVC well casing material. All casing shall have a minimum inside diameter of 2.0 inches. Monitoring wells constructed in unconsolidated material less than 100 feet in depth shall be constructed using a minimum of schedule 40 PVC. Wells greater than 100 feet shall be constructed using a minimum of schedule 80 PVC.
- 5.1 Assembly and Installation: All casing shall be constructed of flush threaded joints or threaded coupling joints. All joints shall be fitted with an "O" ring or wrapped with teflon tape. Solvent welded joints are not permissible without prior written permission of the Director.
- 5.2 Exceptions: The Director may allow alternate well casing material if the pollutant concentrations or geologic setting require an alternative construction. Alternative materials include but are not limited to: (a) Teflon; (b) stainless steel; or (c) uncoated or galvanized steel.

6.0 Well Screen: The well screen slot size shall retain at least 90% of the grain size of a filter pack or at least 60% of the grain size of the collapsed formation. Well screens on wells and piezometers shall not exceed the length necessary to collect a representative groundwater sample or to determine water table elevation. Well screens shall be factory slotted. A bottom cap and sump sediment trap shall be installed.

7.0 Filter Pack: The filter pack shall be chemically inert, well rounded and well sorted glass beads or silica-based sand or gravel of uniform grain size. The filter pack must minimize the amount of fine material entering the well and shall not inhibit the flow of water into the well. The filter pack shall extend a minimum of one foot, but no more than 5 feet above the well screen. The filter pack shall not pollute groundwater.

## 8.0 Sealing Requirements

8.1 Filter Pack Seal: All monitoring wells installed with a filter pack shall be constructed with a filter pack seal, such as bentonite flakes or pellets. The seal shall extend to approximately one foot above the filter pack and shall be properly hydrated.

8.2 Annular Space Seal: All monitoring wells shall be installed with an annular space seal that has a permeability of  $1 \times 10^{-7}$  centimeters per second or less. Materials that meet this criterion include but are not limited to neat cement grout and cement-bentonite grout. The annular space seal shall extend to the ground surface seal, except where a road box meeting the requirements of Section 10.0 is used.

8.3 Ground Surface Seal: All monitoring wells shall be constructed with a continuous pour concrete ground surface seal. To avoid frost heaving and to anchor the well, the ground surface seal shall extend to a minimum of 40 inches below the land surface, unless the well meets one of the requirements of the exemption described in Section 8.4. The ground surface seal shall be flared such that the diameter at the top is greater than the diameter at the bottom. The top of the ground surface seal shall be sloped away from the well casing and shall be imprinted with the designation of the monitoring well.

8.4 Exemption from 40 Inch Ground Surface Seal Requirement: As stated in Section 8.3, the ground surface seal shall extend at least 40 inches down the hole from the land surface. Exemptions from the rule are limited to the following circumstances: 1) where the seal would interfere with proper placement or functioning of the well screen; and 2) where a road box is used and sand is placed inside and directly below the road box in such a way as to ensure that any seepage into the road box drains away from the well.

9.0 Protective Cover Pipe: The protective pipe shall consist of a minimum 4 inch diameter metal casing with locking cap. The protective pipe shall extend from the bottom of the ground surface seal to a minimum of 24 inches above the land surface. There shall be no more than 4 inches between the top of the well casing and the top of the protective pipe. The monitoring well designation shall be indicated clearly on the protective cover pipe. A gas vent and a drain hole shall be installed. A high visibility guard post to prevent destruction of the well may be required. The Director may request additional protective devices as necessary.

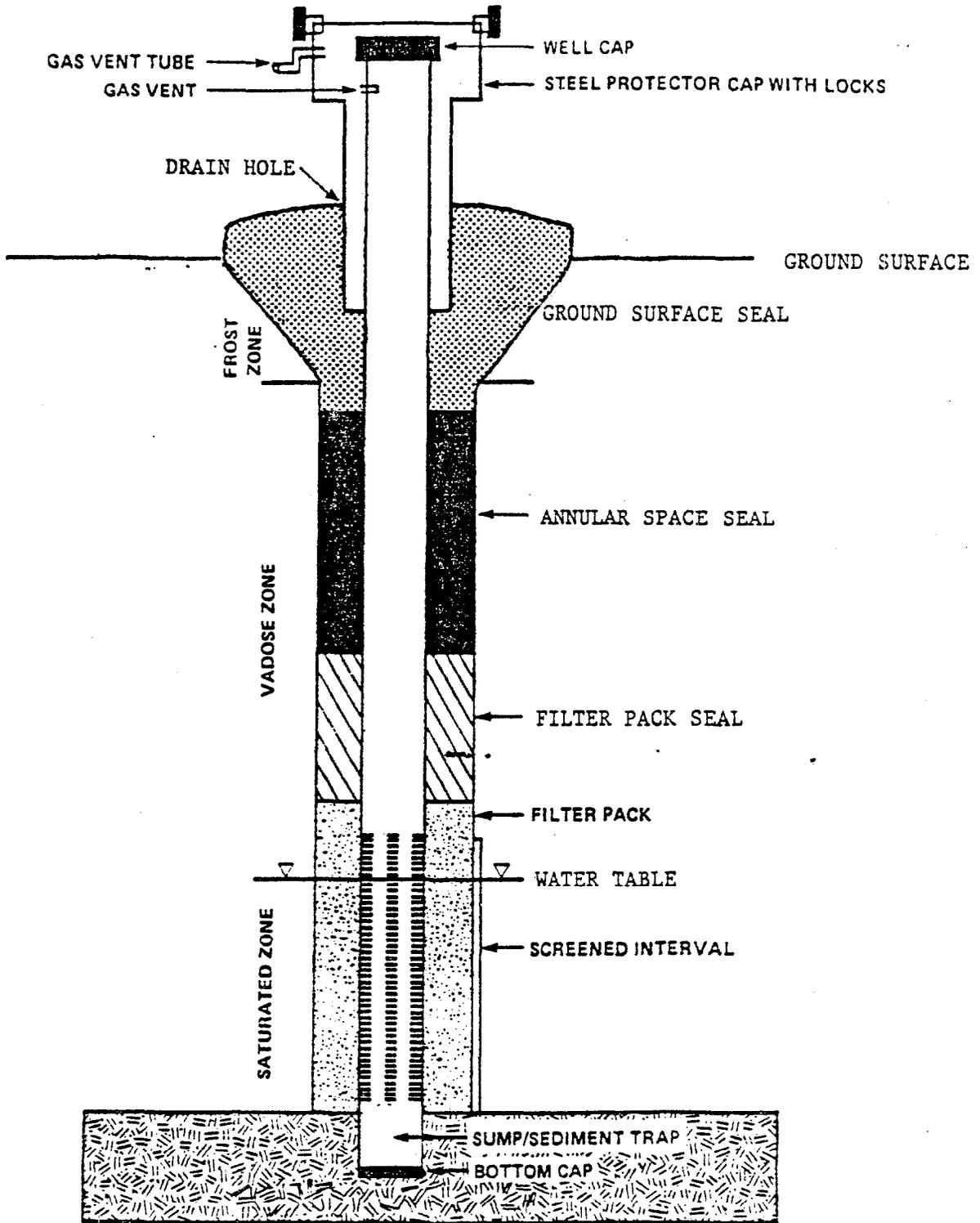
- 10.0 Road Box: Road boxes are acceptable in locations where protective cover pipes are not suitable. All road boxes shall be secured and water tight and prevent easy access to the well. The well shall be fitted with a locking, water tight cap. The ground surface seal for the road box shall be competent such that vehicle traffic will not cause it to fail. The annular space seal shall extend upward to within one foot of the ground surface seal. One or two feet of permeable material may be emplaced between the ground surface seal and the annular space seal in order to allow for the drainage of runoff which may leak into the road box from the ground surface.
- 11.0 Well Development: Development of all monitoring wells shall be performed no earlier than 48 hours after completion and before the initial water quality samples are taken. The goal of well development is to produce water free of fine sand, coarser material, drill cuttings, and drilling fluids. The formation shall be allowed to stabilize for at least 24 hours before groundwater sampling.
- 12.0 Innovative Well Installation: Innovative wells, including but not limited to Microwells or Geoprobos, that are small-diameter and are non-destructive to the formation, and which are capable of providing samples representative of groundwater, need not meet the construction requirements set forth in Sections 4.0 through 11.0 of this appendix.
- 13.0 Monitoring Well and Piezometer Abandonment:

13.1 General:

- (a): All monitoring wells and applicable piezometers as described in section 1.0 of this appendix that are no longer used to gather information on geologic or groundwater properties shall be abandoned pursuant to the provisions of section 13.2 of this appendix. Well abandonment shall take place within 60 days after its use has been terminated, unless a written exemption is received from the Director for continued use.
- (b) Innovative wells: Innovative wells as described in Section 12.0 of this Appendix shall be abandoned at the end of use in order to remove the conduit to groundwater. Abandonment of innovative wells shall consist of removal of the well and grouting of the borehole. Innovative wells are exempted from the abandonment procedures described in Section 13.2 of this Appendix.
- 13.2 Abandonment Procedures: The well shall be inspected from the land surface through the entire depth of the well before it is sealed to ensure against the presence of any obstructions that will interfere with sealing operations.

- (a) Wells constructed with an impermeable annular seal shall be abandoned by cutting off the casing a minimum of 4 feet below land surface. The remaining casing shall be completely filled with a neat cement grout or bentonite-cement grout. The remaining hole volume shall be backfilled with natural material, with the following exception: where backfilling with natural material would result in a grout plug less than 4 feet long, the hole shall be filled to approximately one foot from the ground surface with the neat cement grout or bentonite-cement grout.

- (b) Wells not known to be constructed with an impermeable annular seal shall be abandoned by completely removing the well casing and sealing with neat cement or bentonite-cement grout to approximately one foot from the ground surface. If the casing cannot be removed during the abandonment of a well, the casing shall be thoroughly ripped or perforated from top to bottom, except that perforations will not be required over intervals of the well that are sealed with cement. The screened portion of the well and the annular space between the casing and the drillhole wall shall be effectively and completely filled with cement or bentonite-cement grout applied under pressure.



**CROSS-SECTION OF TYPICAL MONITORING WELL**

Rhode Island Department of Environmental Management  
Division of Groundwater and ISDS  
Groundwater Section

**PUBLICATION ORDER FORM**

"Rules and Regulations for Groundwater Quality" (July 1993)  
\_\_\_\_\_ copies at \$8.00 per copy = \$ \_\_\_\_\_

Groundwater Classification Map (July 1993) (35" x 50")  
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Rhode Island Wellhead Protection Program (February 1990)  
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Rhode Island Wellhead Protection Area Map (February 1993) (35" x 50")  
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Inventory of Potential Sources of Groundwater Contamination in Wellhead Protection  
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U.S. ENVIRONMENTAL PROTECTION AGENCY  
REGION I

LOW FLOW (minimum stress) PURGING AND SAMPLING PROCEDURE  
FOR THE COLLECTION OF GROUND WATER SAMPLES  
FROM MONITORING WELLS

I. SCOPE & APPLICATION

The purpose of this standard operating procedure (SOP) is to provide information on the collection of ground water samples that are "representative" of mobil organic and inorganic loads in the vicinity of the selected open well interval, at near natural flow conditions. The minimum stress procedure emphasizes negligible water level drawdown and low pumping rates in order to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 2 inches or more and a saturated screen, or open interval, length of ten feet or less. Samples obtained are suitable for analyses of common types of ground water contaminants (volatile and semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This procedure is not designed to collect samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs) using pumps.

The procedure is flexible for various well construction and ground water yields. The goal of the procedure is to obtain a turbidity level of less than 5 NTU and to achieve a water level drawdown of less than 0.3 feet during purging and sampling. If these goals cannot be achieved, sample collection can take place provided the remaining criteria in this procedure are met.

II. EQUIPMENT

Adjustable rate, submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon). Peristaltic pumps may be used only for inorganic sample collection.

Disposable clear plastic bottom filling bailers may be used to check for and obtain samples of LNAPLs or DNAPLs.

Tubing - Teflon, Teflon lined polyethylene or stainless steel tubing must be used to collect samples for organic analysis. For samples collected for inorganic

analysis, Teflon or Teflon lined polyethylene, PVC, Tygon, polyethylene or stainless steel tubing may be used.

Water level measuring device, 0.01 foot accuracy, (electronic devices are preferred for tracking water level drawdown during all pumping operations).

Flow measurement supplies (e.g., graduated cylinder and stop watch).

Interface probe, if needed.

Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.

Indicator parameter monitoring instruments - pH (EPA Methods 150.1 or 9040), turbidity (EPA Method 180.1), specific conductance (EPA Methods 120.1 or 9050), and temperature (EPA Method 170.1). Use of a flow-through cell is recommended. Optional Indicators - eH and dissolved oxygen (EPA Method 360.1), flow-through cell is required. Standards to perform field calibration of instruments.

Decontamination supplies.

Logbook(s), and other forms (e.g. well purging forms).

Sample Bottles.

Sample preservation supplies (as required by the analytical methods).

Sample tags or labels.

Well construction data, location map, field data from last sampling event.

Field Sampling Plan.

PID or FID instrument for measuring VOCs (volatile organic compounds).

### III. PRELIMINARY SITE ACTIVITIES

Check well for damage or evidence of tampering, record pertinent observations.

Lay out sheet of polyethylene for monitoring and sampling equipment.

Remove well cap and immediately measure VOCs at the rim of the well with a PID or FID instrument and record the reading in the field logbook.

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 if water level data will be used to construct potentiometric surface map(s) then a synoptic water level measurement round should be performed (in the shortest possible time) before any purging and sampling activities begin.

Measure and record the depth to water (to 0.01 ft) in the well to be sampled before any purging begins. Care should be taken to minimize disturbance of any particulate attached to the sides or at the bottom of the well.

Measure and record (as appropriate) the depth of any DNAPLs or LNAPLs with an interface probe. Care should be given to minimize disturbance of any sediment which has accumulated at the bottom of the well. If LNAPLs or DNAPLs are present, a decision needs to be made as to whether to collect samples of the free phase liquid(s) and/or the dissolved phase.

#### IV. PURGING AND SAMPLING PROCEDURE

Use a submersible pump to purge and sample monitoring wells which have a 2.0 inch or greater well casing diameter.

Measure and record the water level again just prior to placing the pump in the well.

Lower pump, safety cable, tubing and electrical lines slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbid free water samples may be difficult if there is three feet or less of standing water in the well.

When starting the pump, slowly increase the pump speed until a discharge occurs. Check water level. Adjust pump speed until there is little or no water level drawdown. The target drawdown should be less than 0.3 feet and it should stabilize. If the target of less than 0.3 feet cannot be achieved or maintained, the sampling is acceptable if remaining criteria in the procedure are met. Subsequent

sampling rounds will probably have intake settings and extraction rates that are comparable to those used in the initial sampling rounds.

Monitor water level and pumping rate every three to five minutes (or as appropriate) during purging. Record pumping rate adjustments and depths to water. Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (e.g., 0.1 - 0.2 l/min) to ensure stabilization of indicator parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During initial pump start-up, drawdown may exceed the 0.3 feet target and then recover as pump flow adjustments are made (minimum purge volume calculations should utilize stabilized drawdown values, not the initial drawdown). If the recharge rate of the well is less than minimum capability of the pump do not allow the water level to fall to the intake level (if the static water level is above the screen, avoid lowering the water level into the screen). Shut off the pump if either of the above is about to occur and allow the water level to recover. Repeat the process until field indicator parameters stabilize and the minimum purge volume is removed. The minimum purge volume with negligible drawdown (0.3 feet or less) is two saturated screen length volumes. In situations where the drawdown is greater than 0.3 feet and has stabilized, the minimum purge volume is two times the saturated screen volume plus the stabilized drawdown volume. After the minimum purge volume is attained (and field parameters have stabilized) begin sampling. For low yield wells, commence sampling as soon as the well has recovered sufficiently to collect the appropriate volume for all anticipated samples.

During well purging, monitor field indicator parameters (turbidity, temperature, specific conductance, pH, etc.) every three to five minutes (or as appropriate). Purging is complete and sampling may begin when all field indicator parameters have stabilized (variations in values are within ten percent of each other, pH +/- 0.2 units, for three consecutive readings taken at three to five minute intervals). If the parameters have stabilized, but turbidity remains above 5 NTU goal, decrease pump flow rate, and continue measurement of parameters every three to five minutes. If pumping rate cannot be decreased any further and stabilized turbidity values remain above 5 NTU goal record this information. Measurements of field parameters should be obtained using a flow-through cell (preferred method) or taken in a clean container (a glass beaker is suitable). However, if measurements for dissolved oxygen and eH are to be obtained, they must be obtained using a flow-through cell in a manner in which the sample is not exposed to air prior to the measurement. Prior to collecting the samples for laboratory analyses, the flow-through cell must be disconnected. Note, turbidity,

temperature, specific conductance and pH measurements must be recorded. If these measurements are missing, the resulting sampling data may not be acceptable. If the optional indicator parameters, dissolved oxygen and eH, are measured, they must be recorded.

VOCs samples are preferably collected first and directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples: (1) Collect the non-VOCs samples first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample and record the new flow rate; (2) reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel), or clamp which should reduce the flow rate by constricting the end of the tubing; (3) insert a narrow diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, collect sample from the narrow diameter tubing.

Preserve all samples immediately after they are collected.

Check the pH for all samples requiring pH adjustment to assure that the proper pH has been obtained. For VOC samples, this will require that a test sample be collected during purging to determine the amount of preservative that needs to be added to the sample containers prior to sampling.

If dissolved metal concentrations are desired, collect filtered water samples. The use of an in-line filter is preferred. An in-line 0.45 um particulate filter should be pre-rinsed with approximately 25 - 50 ml of groundwater prior to sample collection. After filtering the sample, preserve the water sample immediately. Note that filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations representative of total mobile loads.

Label each sample as collected. Samples requiring cooling (volatile organics, cyanide, etc.) will be placed into an ice cooler for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

After collection of the samples, the pump tubing may either

be dedicated to the well for resampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth.

Secure the well.

## V. DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well. Pumps will not be removed between purging and sampling operations. The pump and tubing (including support cable and electrical wires which are in contact with the well) will be decontaminated by one of the procedures listed below.

### Procedure 1

Steam clean the outside of the submersible pump.

Pump hot water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump tap water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

### Procedure 2

The decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump or the pump can be disassembled and flushed with the decontaminating solutions. It is recommended that

detergent and isopropyl alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is flushed out. The outside of the pump and the electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with tap or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Flush with isopropyl alcohol. If equipment blank data shows that the level of contaminants is insignificant, then this step may be skipped.

Flush with distilled/deionized water. The final water rinse must not be recycled.

## VI. FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the ground water samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples shall be collected for each batch of samples (a batch may not exceed 20 samples). Trip blanks are required for the VOC samples at a frequency of one per sample cooler.

Field duplicate.

Matrix spike.

Matrix spike duplicate.

Equipment blank.

Trip blank (VOCs).

Sampling should proceed from wells with the lowest contaminant concentration to the highest concentration. Collect equipment blanks after sampling from contaminated wells and not after background wells.

When field duplicates or split samples are to be collected,

they will be collected consecutively for the same parameters.

All monitoring instrumentation must be operated in accordance with EPA analytical methods and the operating instructions as supplied by the manufacturer. The instruments must be calibrated at the beginning of each day and the calibration checked at least once throughout the day (i.e. at the end of the day) to verify that the instruments remained in calibration. Temperature measuring equipment, thermometers and thermistors, should be checked for accuracy prior to field use according to the EPA Method 170.1 and the manufacturer's instructions.

## VII. FIELD LOGBOOK

A field log must be kept each time ground water monitoring activities are conducted in the field. The field logbook should document the following:

Well identification.

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 the appropriate time intervals; calculated or measured 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).

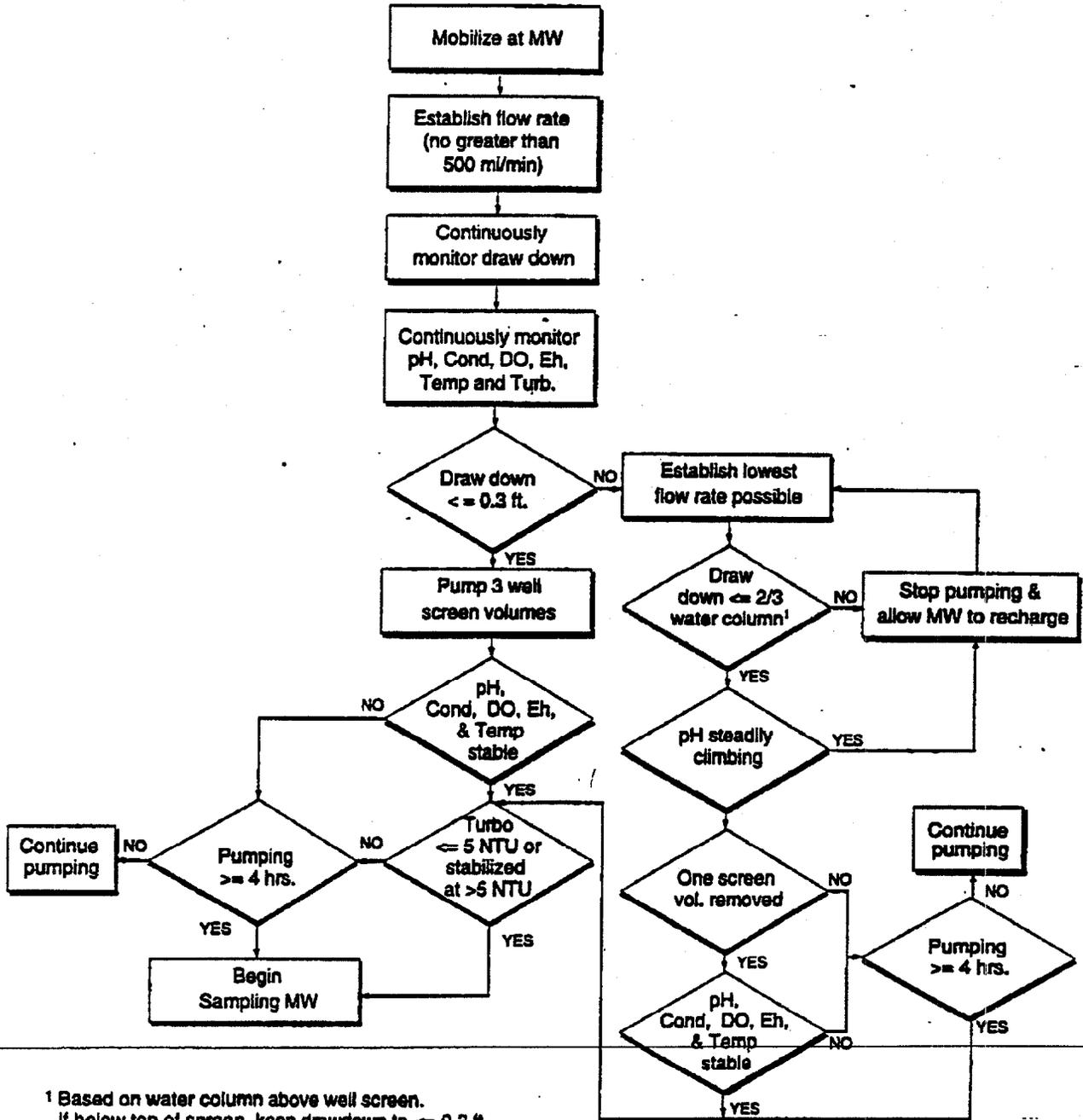
Weather conditions.

QA/QC data for field instruments.

# Decision Tree

## Rhode Island Department of Environmental Management Recommended Low-Flow Groundwater Sample Collection

Source: Metcalf & Eddy



<sup>1</sup> Based on water column above well screen.  
If below top of screen, keep drawdown to  $\leq 0.3$  ft.

UIC Regs

File No.

NAVY-1N-264

RECEIVED  
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STATE OF RHODE ISLAND  
DIVISION OF WATER RESOURCES

Underground Injection Control Program

Rules and Regulations

State of Rhode Island and Providence Plantations  
Department of Environmental Management  
Division of Water Resources

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Section 1

PURPOSE

It is the purpose of these regulations to preserve the quality of the groundwater of the State and thereby protect groundwater from contamination by discharge from injection wells and other subsurface waste disposal of hazardous and other wastes. It is the policy of the Department of Environmental Management to assure the proper location, design, construction, maintenance and operation of injection wells and other subsurface disposal systems to prevent such groundwater contamination. Therefore, it is in the public interest that the following regulations be enforced pursuant to the authority of Chapter 42-17.1 and Chapter 46-12 of the Rhode Island General Laws.

Section 2: Definitions

- 2.01 Aquifer - a geologic formation, group of formations, or part of a formation that is capable of yielding a significant amount of water to a well or spring.
- 2.02 Director - the Director of the Department of Environmental Management or any designee.
- 2.03 Disposal - discharge, deposit, injection, dumping, spilling, leaking, or placing any waste into or on any land.
- 2.04 Domestic Sewage - wastewaters originating from residential dwellings and consisting primarily of human and household wastes.
- 2.05 Facility - any injection well, either state, privately or federally owned, or any other structure or equipment subject to the provisions of these rules and regulations.
- 2.06 Fluid - any material or substance which flows or moves whether in a semi-solid, liquid, sludge, gas, or any other form or state.
- 2.07 Formation - a mappable unit of consolidated or unconsolidated rock characterized by a degree of lithologic homogeneity.
- 2.08 Groundwater - water below the land surface in a zone of saturation.
- 2.09 Hazardous Waste - defined as in the Rhode Island Hazardous Waste Management Act (Title 23 Chapter 19.1).
- 2.10 Person - an individual, trust, firm, joint stock company, corporation, (including a quasi-government corporation) partnership, association, syndicate, municipality, municipal or state agency, fire district, club, non-profit agency or any subdivision, commission, department, bureau, agency or department of state or federal government (including quasi-government corporation) or of any interstate body.
- 2.11 Pollution - the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water.
- 2.12 Public Water System - a system providing the public with piped water for human consumption; provided such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily for at least 60 days out of the year.
- 2.13 Underground Source of Drinking Water (USDW) - an aquifer or its portion which:
- a) (1) supplies any public water system; or

(2) contains a sufficient quantity of groundwater to supply a public water system; and

i. currently supplies drinking water for human consumption; or

ii. contains fewer than 10,000 mg/l total dissolved solids.

2.14 Well - a bored, drilled or driven shaft, or a dug hole, whose depth is greater than the largest surface dimension.

2.15 Well Injection - the subsurface emplacement of fluids through a well.

### Section 3: Application

3.01 These rules apply to injection wells, subsurface disposal systems of a non-domestic nature and multiple dwelling, community or regional system for the injection of domestic wastes. These rules do not apply to injection wells or subsurface disposal systems used to dispose of individual or single family residential domestic waste.

3.02 These rules do not apply to the disposal of domestic waste discharged to a subsurface disposal system except in the case of utilization of a well, septic tank or cesspool or any other means which meets the definition of a bored, drilled or driven shaft, or a dug hole, whose depth is greater than the largest surface dimension.

### Section 4: Effective Date and Notification

4.01 These rules shall be effective when adopted by the Director and filed in the Office of the Secretary of State pursuant to Chapters 42-17.1 and 46-12 of the General Laws of Rhode Island of 1956, as amended.

4.02 Any person operating a system to inject fluid into the ground at the time of the effective date of these rules and regulations shall notify the Director of the existence of such system and shall have one (1) year from the effective date of these rules and regulations to apply for the necessary order of approval.

### Section 5: Prohibitions

5.01 No person shall install, construct, alter, repair, or cause to be installed, constructed, altered, or repaired any Class I, II, III or IV injection wells as defined in 11.01.

- 5.02 No person shall dispose of hazardous waste into any other subsurface disposal system unless it is in accordance with the Hazardous Waste Management Facility Operating Rules and Regulations pursuant to the General Laws of 1956, Chapters 42-35, 42-17.3 and 23-19.1.
- 5.03 No person shall operate any facility which:
- (a) pollutes or endangers the groundwater quality of the state; or
  - (b) violates any rule, regulation or standard of any Federal or State agency.
- 

#### Section 6: Orders of Approval

- 6.01 No person shall inject fluid into the ground unless such person has first obtained an order of approval from the Director.
- 6.02 No person shall install, construct, alter, repair, or cause to be installed, constructed, altered, or repaired, any injection well until such person has obtained written approval of the plans and specifications of the work from the Director.
- 6.03 No person shall dispose of fluid through other means of subsurface disposal unless such person has first obtained an order of approval from the Director.
- 6.04 No person shall install, construct, alter, repair, or cause to be installed, constructed, altered, or repaired, any subsurface disposal system used to dispose of waste of a non-domestic nature until such person has obtained written approval of the plans and specifications of the work from the Director.

#### Section 7: Conditions for Approval

- 7.01 An order of approval shall be obtained by providing the Director with plans, specifications, sample analysis for priority pollutants and other information that is required to establish affirmative evidence that the facility for which the application is being made will be in compliance with the rules and regulations that are lawfully prescribed under Chapters 42-17.1, 46-12, and 23-19.1.
- 7.02 An order of approval shall be granted only for those facilities which the applicant can show by a preponderance of evidence, will be located, designed, constructed and operated so as to prevent the following:
- a) pollution or endangerment of the groundwater quality in the State,
  - b) violation of any rule or regulation or standard of any Federal or State agency.

Section 8: Order of Compliance

8.01 If any person is found by the Director to be in violation of these regulations, the Director shall make his findings in writing to that effect and shall enter an order directing such person to cease discharging and close the injection well or to adopt, use, or to operate properly, as the case may be some practicable and reasonably available system. Such order may specify the particular system or means to be adopted, used or operated. However, in the case where there is more than one such practicable and reasonably available system or means, such order shall give to the person violating these regulations the right to adopt or use such one of said systems or means as said person may choose.

Section 9: Approval of System Selected

9.01 The person against whom such order of compliance is entered shall, in a manner consistent with the provisions of these rules and regulations, submit to the Director a plan or statement describing the system or means which he proposes to adopt before proceeding to install any such system or means.

9.02 In case such person subsequently desires to make any substantial change in such system or means so adopted, he shall, before proceeding to do so, file with the Director a plan or statement describing such change.

Section 10: Proceedings for Enforcement

10.01 The Superior Court of Providence County shall have jurisdiction in equity to enforce the provisions of these rules and regulations or order issued pursuant thereto. Proceedings for enforcement shall be instituted and prosecuted in the name of the Director and in such proceeding in which injunctive relief is sought, it shall not be necessary for the Director to show that without such relief the injury which will result will be irreparable or that the remedy at law is inadequate.

Section 11: Injection Well Classification System

11.01 Injection wells shall be approved or prohibited according to the following system:

(a) Class I (Prohibited)

1) Wells used by generators or hazardous waste or owners or

operators of hazardous waste management facilities to inject hazardous waste beneath the lowermost formation containing, within one quarter mile of the well bore, an underground source of drinking water.

- 2) Other industrial and municipal disposal wells which inject fluids beneath the lowermost formation containing, within one quarter mile of the well bore, an underground source of drinking water.

(b) Class II (Prohibited) Wells which inject fluids:

- 1) Which are brought to the surface in connection with conventional oil or natural gas production and may be commingled with wastewaters from gas plants which are an integral part of production operations, unless those waters are classified as a hazardous waste at the time of injection.
- 2) For enhanced recovery of oil or natural gas; and
- 3) For storage of hydrocarbons which are liquid at standard temperature and pressure.

(c) Class III. (Prohibited) Wells which inject for extraction of minerals including:

- 1) Mining of sulfur by the Frasch process;
- 2) In situ production of uranium or other metals; this category includes only in situ production from ore bodies which have not been conventionally mined. Solution mining of conventional mines such as stopes leaching is included in Class V.
- 3) Solution mining of salts or potash.

(d) Class IV (Prohibited)

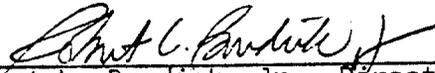
- 1) Wells used by generators of hazardous waste or of radioactive waste, by owners or operators of hazardous waste management facilities, or by owners or operators of radioactive waste disposal sites to dispose of hazardous waste or radioactive waste into a formation which within one quarter ( $\frac{1}{4}$ ) mile of the well contains an underground source of drinking water.
- 2) Wells used by generators of hazardous waste or of radioactive waste, by owners or operators of hazardous waste management facilities, or by owners or operators of radioactive waste disposal sites to dispose of hazardous waste or radioactive waste above a formation which within one quarter ( $\frac{1}{4}$ ) mile of the well contains an underground source of drinking water.

- 3) Wells used by generators of hazardous waste or owners or operators of hazardous waste management facilities to dispose of hazardous waste, which cannot be classified under paragraphs (a)(1) or (d)(1) and (2) of this section (e.g., wells used to dispose of hazardous waste into or above a formation which contains an aquifer).

(e) Class V wells include:

- 1) Cesspools or other devices that receive wastes, which have an open bottom and sometimes have perforated sides. (The UIC requirements do not apply to single family residential cesspools.)
- 2) Dry wells used for the injection of wastes into a subsurface formation.
- 3) Septic system wells used to inject the waste or effluent from a multiple dwelling, business establishment, community or regional business establishment septic tank; or for a multiple dwelling, community or regional cesspool. (The UIC requirements do not apply to single family waste disposal systems.)
- 4) Air conditioning return flow wells used to return to the supply aquifer the water used for heating or cooling in a heat pump.
- 5) Cooling water return flow wells used to inject water previously used for cooling.
- 6) Drainage wells used to drain surface fluid, primarily storm runoff, into a subsurface formation.
- 7) Recharge wells used to replenish the water in an aquifer.
- 8) Salt water intrusion barrier wells used to inject water into a fresh water aquifer to prevent the intrusion of salt water into the fresh water.
- 9) Sand backfill wells used to inject a mixture of water and sand, mill tailings or other solids into mined out portions of subsurface mines.
- 10) Subsidence control wells (not used for the purpose of oil or natural gas production) used to inject fluids into a non-oil or gas producing zone to reduce or eliminate subsidence associated with the overdraft of freshwater.
- 11) Wells used for the storage of hydrocarbons which are gases at standard temperature and pressure.
- 12) Geothermal wells used in heating and aquaculture.
- 13) Nuclear disposal wells.

The foregoing rules and regulations, after due notice and hearing, are hereby adopted and filed with the Secretary of State this \_\_\_\_\_ day of \_\_\_\_\_, 1984, to become effective twenty (20) days thereafter, in accordance with the provisions of Chapter 46-12, 42-17 and 42-35 of the General Laws of Rhode Island, 1956, as amended.



Robert L. Bendick, Jr., Director  
Department of Environmental Management

Notice given on July 21, 1983

Hearing held on August 24, 1983

Effective \_\_\_\_\_, 1984

The foregoing rules and regulations are hereby approved for filing with the Secretary of State in accordance with the provisions of the General Laws of Rhode Island, 1956, as amended, Chapter 42-35, specifically Section 42-17.3-2 and the Public Law of Rhode Island, 1978, Chapter 229 and Chapter 46-2.

Attest a true copy.

ENVIRONMENTAL STANDARDS BOARD

17 May 1984  
Date

Joseph E. Cannon  
Joseph E. Cannon, M.D., M.P.H.  
Director of Health

18 May 1984  
Date

Donald Rohrer  
Donald Rohrer  
Director of Administration

May 10, '84  
Date

Robert L. Bendick, Jr.  
Robert L. Bendick, Jr.  
Director of Environmental Management



**APPENDIX C**

**SAMPLE SCREENING FOR VOLATILE ORGANIC COMPOUNDS**

# SCREENING OF VOLATILE ORGANIC COMPOUNDS USING A PHOTOVAC GAS CHROMATOGRAPH

## 1.0 SCOPE

This procedure details the steps required to screen soil and aqueous samples for volatile organic compounds of interest at the Derecktor Shipyard. It is not a detailed operation manual for Photovac Gas Chromatographs nor a treatise on the principals of gas chromatography.

## 2.0 SUMMARY OF METHOD

The Photovac Gas Chromatograph (GC) is calibrated with analytical standards prior to the analysis of any samples. All of the samples are prepared prior to analysis. The chromatogram is monitored during the analytical run to note if any dilutions or re-injections may be necessary. Blank injections, check standards and duplicate sample injections are made at specific intervals to monitor the analytical system. The analyses are recorded in a logbook and the sample results are reported in a standard format.

This operation is to be performed in a temperature controlled environment such as a heated or air conditioned trailer with temperature regulated between 20 °C and 28 °C. All analytical operations shall be performed in a separate room isolated from foot traffic and normal entrance/exit.

## 3.0 APPARATUS

### 3.1 Photovac 10S50 Gas Chromatograph

The GC is designed for air and headspace analyses only. Injecting liquids into the instrument will damage and possibly ruin parts of the GC system. Samples are introduced through the injection port of choice, their constituents separated by the column and a built in strip chart recorder plots the peaks and prints a report. The length of the analytical run is selected to allow all peaks of interest to leave the column prior to injecting the next sample. Once the instrument is set up, it will move through the analytical cycle on its own. The only input from the operator will be pressing the "Start/Stop" switch, the "Enter" switch and then injecting the sample.

### 3.2 Glassware

Laboratory glassware required for sample analysis consists of 50 ml volumetric flasks, 150 to 200 ml beakers, VOA bottles, disposable pipets and 10  $\mu$ l, 25  $\mu$ l, 50  $\mu$ l, 100  $\mu$ l, and 250  $\mu$ l gas tight syringes (Hamilton Microliter or equivalent). The syringe barrels are fragile and their needles sharp: use them with care. Syringes should never be heated to temperatures greater than 500 C. A special syringe needle heater with vacuum is available for syringe cleaning. Use this method first before attempting to flush the syringe with methanol.

### 3.3 Reagents

3.3.1 - Analytical Standards. The standards used for this analysis are custom made by Supleco, Inc. (Quote # 5473) and contain 12 compounds of varying concentrations. Some are known carcinogens.

3.3.2 - Reagent Water. This water is free of any organic contaminants which may interfere with sample analysis. Reagent Grade HPLC Water can be boiled for several minutes to remove almost all contaminants of concern.

**3.3.3 - Reagent Grade Methanol.** This solvent is used for rinsing syringes if contamination is noted and rinsing glassware to ensure cleanliness. It is very important that no methanol be injected into the GC.

**3.4 Miscellaneous equipment**

Disposable gloves should be worn while handling samples and standards. Aluminum foil is used to cover the bench area to minimize contamination. Paper towels are used to wipe moisture off of sample bottles and to keep the area clean.

**4.0 ANALYTICAL STANDARDS**

**4.1** The standard used for this analysis contains the following compounds listed in the order they elute from the CPSil-5 CB (Blue) column and their concentrations:

	<u>Neat Std.</u>	<u>Daily Std.</u>
trans-1,2-Dichloroethene	46.0 µg/ml	0.0092 ppm
cis-1,2-Dichloroethene	50.1	0.0100
1,1,1-Trichloroethane	324.0	0.0648
Benzene	40.1	0.00802
Trichloroethene	40.0	0.0080
Toluene	40.0	0.0080
Tetrachloroethene	40.1	0.00802
Ethylbenzene	40.0	0.0080
m-Xylene	40.0	0.0080
o-Xylene	40.0	0.0080

**4.2** The analytical standard solution is received from the supplier in sealed ampoules. The ampoules should be kept cold in a cooler with ice or in a refrigerator prior to use. Upon opening a fresh ampoule, the solution should immediately be divided evenly between two crimp top or two 1 ml screw top vials and sealed. After preparing the daily standard, the meniscus is marked on the vials for reference. The crimp seals are replaced daily on the crimp top vials.

**4.3** The Daily Standard is prepared in the following manner:

- Fill a clean 50 ml volumetric flask to the mark with reagent water.
- 10.0 µl of the analytical standard solution is added to the wide part of the volumetric via a 10 or 25 µl syringe. The syringe containing the stock standard solution should be inserted into the neck of the volumetric flask until the syringe barrel is almost touching the water surface. The syringe plunger is then quickly and smoothly depressed. Withdraw the syringe quickly after injection and stopper the flask.
- The flask is inverted three times to mix the solution. With minimum agitation, the solution is slowly poured into a clean VOA vial completely filling the vial.
- A clean vent needle is inserted through the septum of the VOA vial and 10 ml of the solution is removed through the septum using a 10 or 25 ml syringe. This procedure leaves a 10 ml headspace inside the VOA vial.

- The standard is shaken and allowed to equilibrate for a minimum of 30 minutes. The remaining solution is discarded. This standard solution is also used as the Daily Check Standard.

## 5.0 SAMPLE PREPARATION

- 5.1 Two types of environmental samples will be analyzed with the GC: aqueous and soil samples. Two types of blank samples will also be analyzed.
- 5.2 Aqueous samples. Remove 10 ml of the aqueous sample as described above in Section 4.3. Shake the vial for one minute and allow the prepared sample to equilibrate to the regulated temperature of the field laboratory for at least 30 minutes prior to analysis.
- 5.3 Soil Samples. Soil samples will be collected in the field by sampling personnel to approximately one-half the volume of the VOA vial. If necessary, discard an aliquot of the soil sample to bring the volume of soil in the VOA vial to one-half of the vial volume.

Soil samples are prepared in the following manner:

- The mass of the soil in the VOA vial is determined using a top loading balance. Tare the balance with an empty VOA vial making sure any protective cover on the septum has been removed if the sample vial's cover has been removed.
  - The empty vial is replaced with a sample vial and the soil mass is recorded to the nearest 0.1 g. Remove the septum guard, if any.
  - Add a volume of reagent water to the vial to bring the water/soil level in the vial to the same height as the Daily Standard. Use the standard as a side-by-side guide. Be sure all air bubbles in the soil sample are removed by the reagent water.
  - Shake the sample vial and allow the prepared sample to equilibrate at room temperature for at least 30 minutes prior to analysis.
- 5.4 Zero Air Blank. Fill a Tedlar bag with carrier gas from the carrier gas bottle. Injecting this blank will check for syringe and system contamination.
- 5.5 Reagent Water Blank. An injection of the headspace of this blank will check the cleanliness of the standard preparation water and the VOA vials. This blank is prepared the same way the Daily Standard is made except no analytical standard solution is added.

## 6.0 ANALYSIS

- 6.1 Prior to analysis, instrument linearity will be demonstrated by injecting three different concentrations of Daily Standards. The standards are prepared as above, substituting 2.0  $\mu$ l and 20.0  $\mu$ l as volumes of the analytical standard solution added to 50.0 ml of reagent water. This sequence is performed once at the beginning of the project.
- 6.2 The analytical sequence will be as follows:
1. Zero Air Blank - from Tedlar bag of carrier gas
  2. Reagent Water Blank - prepared daily
  3. Daily Standard

4. Duplicate Daily Standard - should agree within 80 of injection 1 3. If not, repeat injections 3 and 4.
5. Sample 1
6. Sample 2
7. Sample 3
8. Sample 4
9. Sample 5
10. Sample 6
11. Sample 7
12. Sample 8
13. Sample 9
14. Sample 10
15. Daily Check Standard after every 10 samples
16. Zero Air Blank
17. Sample 11
18. Sample 12
19. Sample 13
20. Sample 14
21. Sample 15
22. Sample 16
23. Sample 17
24. Sample 18
25. Sample 19
26. Sample 20
27. Daily Check Standard
28. Zero Air Blank
29. Reagent Water Blank
30. Duplicate Sample - containing compounds of interest
31. Sample 21

Sequence continues ...

- A maximum of ten samples will be analyzed between check standards. A check standard will always be run at the end of the analytical day.
- A duplicate sample will be analyzed once for every twenty samples. Choose a sample containing compounds of interest and one that does not require a dilution.
- A Zero Air Blank should be analyzed after any significantly contaminated samples to check for contamination carry-over and after every Daily Check Standard.
- A Reagent Water Blank is analyzed once for every twenty field sample analyses.

### 6.3 Instrument operation

Detailed operating instructions may be found in the Photovac operations manual regarding the GC. General operating instructions are given here.

**6.3.1 Set Up.** The instrument flows should be established at ~10 ml/min and balanced as directed on page 4-7 of the Photovac operating manual. The run parameters are:

Gain:	50 or 100, start at 100
Chart Speed:	1.0 cm/min
Slope sensitivity:	4, 4, 2 mV/sec

Window: 5-10 percent  
 Minimum Area: 100. mV/sec  
 Timer Delay: 0.0 sec  
 Analysis Time: ~ 600.0 sec (may vary with column)  
 Cycle Time: 0 min

The event set up is as follows:

<u>Event</u>	<u>On Time</u>	<u>Off Time</u>
1	8.0	10.0
3	0	90.0 (may vary with column)

No other events are necessary.

The gain should be adjusted for the individual instrument's sensitivity so the benzene and the trichloroethene peaks are greater than 50 % of scale but not off-scale when 100  $\mu$ l of standard headspace is injected. These values will vary from instrument to instrument.

### 6.3.2 Injection.

- Using a 250  $\mu$ l gas tight syringe, withdraw 100  $\mu$ l of the headspace from above the sample or standard. Do not allow any liquid to enter the syringe! Always choose a syringe with a greater capacity than the volume you wish to inject, i.e. 25  $\mu$ l for a 10  $\mu$ l injection, but not one greater than three times larger than the injection volume.
- Press the "Start/Stop" key then press the "Enter" key. Position the syringe needle over the septum in injection port 1.
- The buzzer will sound eight seconds after pressing the "Enter" key. The injection is made the moment the buzzer stops. Inject the sample smoothly and quickly. Allow the syringe to remain in the injection port for approximately 2 seconds after injection.

6.3.3 Analysis. Observe the analysis for off-scale peaks indicating a dilution is necessary or the lack of peaks indicating a mis-injection may have occurred. Peaks that are off-scale should be reanalyzed by increasing the gain to bring the peaks onscale. Maintaining the same injection volume as the Daily Standard will allow the instrument to calculate the compound concentrations automatically without manual manipulations.

6.3.4 Compound Identification and Quantitation. The GC allows the user to build a library to identify and calculate compound concentrations automatically. A detailed discussion of this function may be found in the Photovac operations manual beginning on page 4-11.

6.3.5 Continuing Calibration. The library can be updated with each continuing check standard. If the check standard does not agree with the initial daily standard within 10 %, the calibration needs to be updated. Instructions for updating the library can be found on page 4-16 of the Photovac operations manual.

6.3.6 Completion of Analytical Runs. A final standard should be injected to note instrument stability after all of the samples to be run that day have been injected. After completion of all analyses for the day, change the septum in injection port 1 and note

that sufficient carrier gas remains in the cylinder to supply the instrument overnight. The instrument is typically left on overnight (including oven and carrier gas) to maintain stability and minimize start up time.

## 7.0

### QUALITY CONTROL

All analyses, instrument parameters, soil sample weights and other data should be recorded in the field screening logbook and on the Data Forms (copy attached) in a legible manner. The Data Forms should include all injections listed in order and should be filled out completely. Any errors should be crossed out with a single line, initialed and dated. Each page of the logbook should be signed and dated by the analyst.

Individual analyses should be separated by cutting the strip chart and taping the chromatograms securely to the pages of the Field Screening Logbook in the order of analysis.

Analytical results should be reported to the Project Manager or his or her designee when they become available.

#### Quality Control Checklist:

- Calibration standards will be run twice at the beginning of each day, after every 10 injections and at the end of the day.
- Duplicate sample analyses are performed once for every twenty field sample analyses. Be sure to choose a sample containing some compounds of interest.
- Zero Air Blanks are analyzed once for every ten field sample analyses, after any high concentration injections, after Daily Check Standards and anytime contamination may be expected.
- A Reagent Water Blank is analyzed once for every twenty field sample analyses.

#### Abbreviations used on log sheet:

DCE = 1,2-Dichloroethene  
TCA = 1,1,1-Trichloroethane  
TCE = Trichloroethene  
PCE = Tetrachloroethene

**APPENDIX D**

**SAMPLE SCREENING BY X-RAY FLUORESCENCE**

## HALLIBURTON NUS

### OPERATING PROCEDURE FOR METAL SCREENING USING SPECTRACE 9000 XRF

1. Turn on the Spectrace 9000 XRF instrument and allow it to warm-up for approximately 10 minutes.
2. Iron-Response Check. To confirm the x-ray response place the iron reference sample over the center of the probe window and follow the directions detailed in the Spectrace manual. The Fe intensity must be greater than 0.96 and the Co and Mn intensities must be less than 0.003. Record these readings. If the Fe, Co, and Mn intensities are outside the required limits, follow the Spectrace instructions to check the instrument. Reanalyze the Fe reference sample.
3. Analytical Background Check. Verify that the probe window is free of contaminant materials. Place the Teflon sample on the probe window and measure for 200 seconds on each of the three sources. Check that the readings for the target metals are within a range of three times the standard deviation value above or below "zero". If results are outside the limits follow the "Acquire Background" procedure in the Spectrace manual. The analytical background check must be performed daily in the environment of the Spectrace operation. The nearby presence of an operating CRT monitor or a Walkie-Talkie can affect the results.
4. Calibration Verification. Use certified standards of concentrations ranging from the lower reporting limit to the higher expected sample concentration for the target metals. Analyze the certified standards using the appropriate counting times on each source. The counting time must be the same as will be used for the sample analysis. Analyze the certified standards and calculate the Percent Recovery (%R) from the true values. Compare the %R to preestablished control limits (42-128%) which are set at  $\pm 3$  standard deviations from the true value. If %R is out of control limits, repeat steps 2 and 3 or consult the manual for calibration check procedures. Limits must be met prior to sample analysis. Control limits are updated periodically.
5. Sample Analysis. Homogenize the soil in the sample container using a spatula. Remove big roots, leaves, and rocks. Fill the XRF cup to 3/4 capacity with the homogenized soil. Cover the cup with mylar film and secure with a plastic sealing ring. The mylar film should be free of wrinkles or creases that may interfere with the X-rays. Invert the cup and tap on

Spectra Operating Procedure  
Page Two

a clean surface (counter top). Write the sample identification number on the side of the sample cup with a permanent marker.

Place the sample cup into the XRF probe and start the counting sequence. Record the sample number, date, time, counting time and sample value for the target metals.

6. Sample Duplicate. Analyze one of every ten samples in duplicate. For sample duplicate analysis, a second sample aliquot is prepared in a second cup and labeled as duplicate. Calculate the relative percent difference (RPD) between the original and duplicate analysis results. The RPD should be less than 30%. If this limit is exceeded, reanalyze the sample and the duplicate.
7. Continuing Calibration Check. Analyze one certified standard every ten samples and at the end of the analytical sequence. Calculate the %R. If the %R is outside the control limits (42-128%), repeat steps 2, 3, and 4 before continuing with the sample analysis.
8. Sign the analysis record pages and have all data reviewed by a senior analyst prior to reporting.

**APPENDIX E**  
**FORMS FOR FIELD INVESTIGATIONS**





**Halliburton NUS**  
CORPORATION

**TASK MODIFICATION REQUEST**

Project Name \_\_\_\_\_ Project Number \_\_\_\_\_ TMR Number \_\_\_\_\_

To \_\_\_\_\_ Location \_\_\_\_\_ Date \_\_\_\_\_

Description:  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Reason for Change:  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Recommended Disposition:  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Field Operations Leader (Signature) \_\_\_\_\_ Date \_\_\_\_\_

Disposition:  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Project Manager \_\_\_\_\_ Date \_\_\_\_\_

Distribution: Program Manager \_\_\_\_\_  
Quality Assurance Officer \_\_\_\_\_  
Project Manager \_\_\_\_\_  
Field Operations Leader \_\_\_\_\_

Others as required \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_











