OUTLYING LANDING FIELD IMPERIAL BEACH, CALIFORNIA

INSTALLATION RESTORATION PROGRAM
SITE INSPECTION
DRAFT SOLID WASTE WATER QUALITY ASSESSMENT TEST PROPOSAL AND SITE INSPECTION WORK PLAN INCLUDING THE QUALITY ASSURANCE/PROJECT PLAN AND THE HEALTH AND SAFETY PLAN

5 OCTOBER 1990

VOLUME II

SOUTHWEST DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
1220 PACIFIC HIGHWAY
SAN DIEGO, CALIFORNIA 92132-5190

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IMPERIAL BEACH, CALIFORNIA

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Appendix A

QUALITY ASSURANCE PROJECT PLAN

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1.0 INTRODUCTION

The Field Quality Assurance Project Plan (QAPP) presented herein for the Outlying Landing Field (OLF), Imperial Beach includes elements of a Field Investigation Plan (FIP) and a Quality Assurance/Quality Control (QA/QC) Plan. The QAPP has been prepared to conduct groundwater and soil sampling in a manner that will provide results of consistent quality. This consistency will be accomplished through the formal standardization and documentation of field techniques and activities. Sample analysis results will be used to confirm the presence of contamination at various sites on the OLF and to determine if contamination is migrating offsite.

All field activities will be planned in advance and reviewed by the Internal Technical Review Committees to ensure consistency with overall project objectives. Actual field and laboratory activities will be performed by trained and qualified personnel and will conform to standard operating procedures (SOPs) listed in this plan. Spikes and replicate samples will be used to develop estimates of the quality of the analytical data. Field audits of sampling, field measurements, and chain-of-custody procedures will be conducted to assure that proper techniques are being followed. Field data compilation, tabulation, and analyses will be checked for accuracy. Quality control of project deliverables is provided through technical review by peers and senior staff, and through periodic audits.

Topics including quality assurance objectives, sampling, analytical, QA/QC, calibration procedures, and audits and project records are discussed in the following sections.

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2.0 QUALITY ASSURANCE OBJECTIVES

The primary goals of sampling during the field activity are to:

1. Verify that sites identified in the Initial Assessment Study (IAS) are contaminated
2. Determine the nature of disposed or stored wastes

In addition, where feasible, a secondary objective is to attempt to estimate potential contaminant migration routes.

Data collected from the Solid Wastewater Quality Assessment Test (SWAT) Proposal and Site Inspection (SI) effort will be used to:

1. Eliminate from further consideration those sites that pose no threat or potential threat to the public or the environment
2. Determine the need for removal actions
3. Characterize the site for effective and rapid initiation of the remedial investigation/feasibility study (RI/FS), if applicable

The project team will obtain all samples in accordance with Jacobs' SOPs. Copies of SOPs relevant to this assignment are included in Appendix C and are referenced within this plan, where applicable.

Samples collected at the sites will be analyzed by a Navy certified laboratory. After review of the Naval Energy and Environmental Support Activity (NEESA) document, "Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program," it is determined that the appropriate level of analytical QC for the Naval Station sites is Level C. Level C is appropriate for a non-National Priorities List (NPL) site near a populated area that is not likely to be undergoing litigation. Routine analytical services (RAS) will be used. Precision and accuracy of laboratory will be consistent with contract laboratory protocols and Navy guidelines.

Laboratory methods are established for each measurement parameter in accordance with Navy certified protocols or the U.S. Environmental Protection Agency (EPA) methods outlined in SW-846, "Test Methods for Evaluating Solid Wastes," 3rd edition. The minimum QC requirements for RAS consist of both an initial and ongoing demonstration of laboratory capability to generate acceptable precision and accuracy with contract methods in the analysis of soil and groundwater samples. Accuracy statements can be generated if the analysis of a spike sample (containing a known concentration of the desired parameter) is analyzed at the same time as the field sample. Precision statements can be generated through the collection and analysis of duplicate samples. Navy certification defines extensive QC procedures that must be performed and documented and criteria that must be met.

EPA-approved methods, or state-approved modifications of EPA methods, will be used for all laboratory analyses. The analyses will meet or exceed EPA Contract Laboratory Program (CLP) contract required detection limits (CRDLs) for inorganic constituents and contract required quantitation limits (CRQLs) for organic constituents.

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3.0 BACKGROUND

The OLF is located on the south side of Imperial Beach. The area is bordered on the north by residential houses, on the east by residential homes and the City of San Diego, and on the west by Oneonta Slough and the Pacific Ocean, and on the south by agricultural lands and the Tijuana River.

Site topography is relatively flat, with less than 30 feet of total relief.

At completion of the IAS for the OLF in February 1986, four potentially contaminated sites were identified. They are Sites 6, 7, 8, and 9. All of the four sites are located on the Naval Facility. A description of Sites 6 through 9 is presented in the Solid Wastewater Quality Assessment Test Proposal and Site Inspection Work Plan.

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4.0 MAP

Sites 6 through 9 located on the OLF are shown in Figure A-1. These sites were identified in the IAS as being potentially contaminated.

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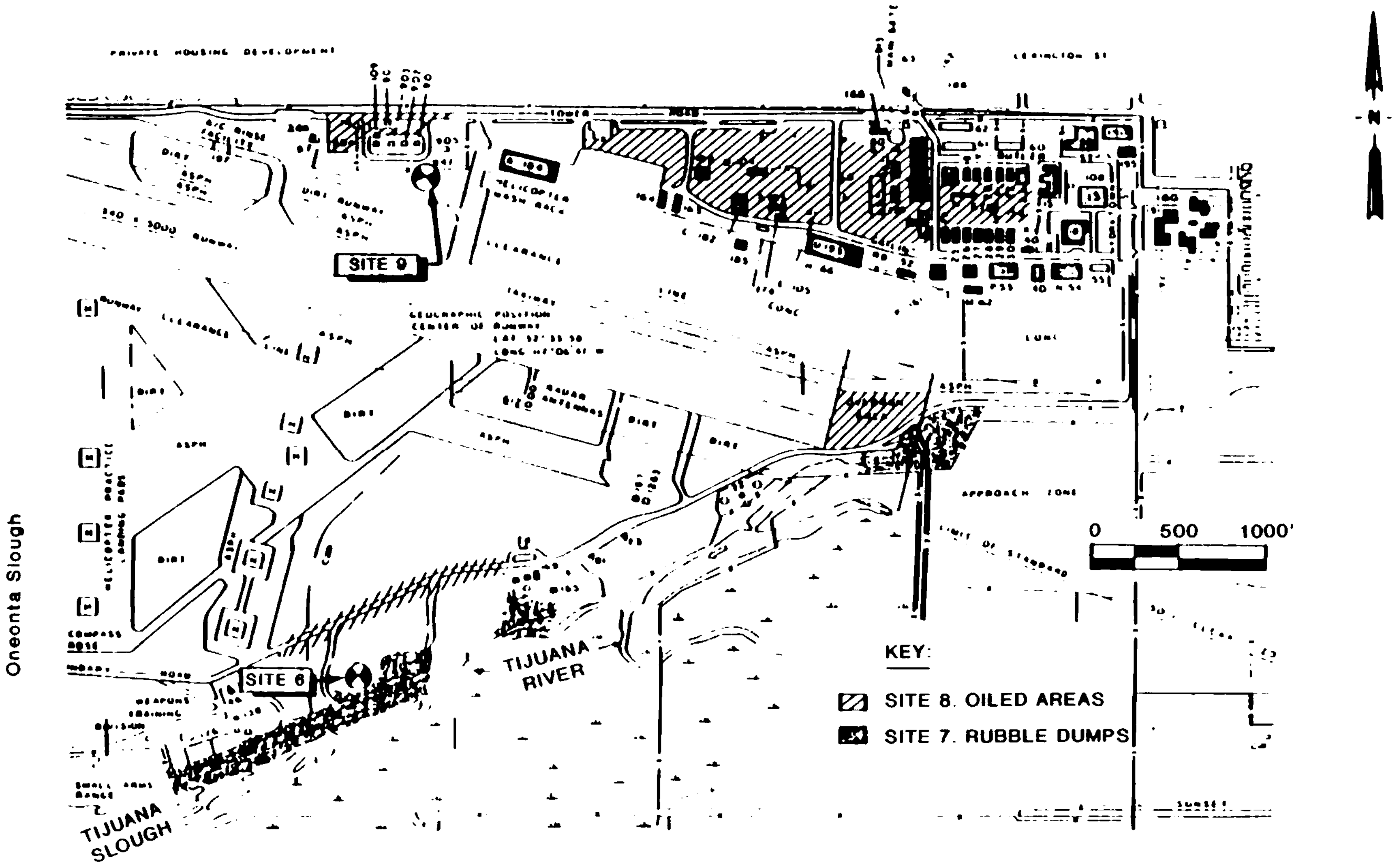

SOURCE: Initial Assessment Study, Naval Energy and
Environmental Support Activity, February 1986.

FIGURE A-1
PAST DISPOSAL SITES AT OUTLYING
LANDING FIELD IMPERIAL BEACH,
CALIFORNIA

CH2M HILL

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5.0 ANALYTICAL PARAMETERS AND METHODS

The IAS was reviewed to identify groundwater and soil sampling locations on and in the vicinity of Sites 6 through 9. Figures 5-1, 5-2, 5-3, and 5-4, SWAT Proposal and in the Site Inspection Work Plan, show the soil boring and groundwater monitoring well locations at each of the four OLF sites. Table A-1 in Appendix A summarizes information on sampling locations, number of samples, depth at which samples will be collected, and analytical methods. Described below, by site, is the selection of analytical parameters and EPA Methods that will be used to analyze the samples. The Solid Wastewater Quality Assessment Test Proposal and Site Inspection Work Plan, Section 2.0, General History of the Outlying Landing Field, presents details of hazardous substances reportedly disposed of at the Naval Station sites. EPA Methods for sample analysis are selected to analyze for these substances.

The purpose of the SI is to confirm the nature of hazardous substances contamination and not to define the extent of contamination. Therefore, not all soil borings at each site will be completed as monitoring wells. Groundwater samples collected at each monitoring well are adequately to satisfy the SI objective. Also, at most sites the borings are in close proximity of each other and it is expected that groundwater sampled at each location will contain similar constituents.

The summary of the site specific analytical parameters and methods are presented in Table A-1.

Table A-1
Summary of Site-Specific Analytical Parameters and Methods

Sheet 1 of 3

Site No. and Name	Contaminants of Concern	Analytical Parameter	U.S. EPA Method No.		Comments
			Soil	Water	
6 Firefighting Training Area	Gasoline	BTXE gasoline	CLP^a CA LUFT^b	CLP^a CA LUFT^b	
	Diesel	Total fuel hydrocarbons as diesel	CA LUFT^b	CA LUFT^b	
	Kerosene/JP-5	Total fuel hydrocarbons as kerosene	CA LUFT^b	CA LUFT^b	Single point standard
	Waste oil	Total recoverable hydrocarbons	418.1^c	418.1^c	
	Hydraulic fluid	Total recoverable hydrocarbons	418.1^c	418.1^c	
	Transformer fluid	Total recoverable hydrocarbons PCBs	418.1^c CLP^a	418.1^c CLP^a	
	Solvents	Halocarbon Aromatic hydrocarbon	CLP^a CLP^a	CLP^a CLP^a	Laboratory will be requested to report all peaks.
	Indicator parameter for landfill leachate	Chemical oxidation demand	--	410.2,^{c} 410.3,^{c} or 410.4^c	
	Sandblast grit	Metals and major canions	CLP^a	CLP^a	

Table A-1
Summary of Site-Specific Analytical Parameters and Methods

Sheet 2 of 3

Site No. and Name	Contaminants of Concern	Analytical Parameter	U.S. EPA Method No.		Comments
			Soil	Water	
	Major anions	Bicarbonate, carbonate chloride, nitrate and nitrite, sulfate	Standard Method 403 300.0 (ion chromatography	Standard Method 403 300.0 (ion chromatography	
	Oils and fuels	Semivolatiles	CLP^a	CLP^a	
7 Rubble Disposal Areas	Oiled soil	Total recoverable hydrocarbons	418.1^c	418.1^c	
	Creosoted pilings	Total recoverable hydrocarbons	418.1^c	418.1^c	
	Sandblast grit	Metals	CLP^a	CLP^a	
8 Oiled Areas	Waste oils	Total recoverable hydrocarbons	418.1^c	418.1^c	
	Hydraulic fluids	Total recoverable hydrocarbons	418.1^c	418.1^c	
	Mineral spirits	Total recoverable hydrocarbons	418.1^c	418.1^c	
	Transformer fluids	Total recoverable hydrocarbons PCBs	418.1^c CLPa	418.1^c CLP^a	

Table A-1
Summary of Site-Specific Analytical Parameters and Methods

Sheet 3 of 3

Site No. and Name	Contaminants of Concern	Analytical Parameter	U.S. EPA Method No.		Comments
			Soil	Water	
	Solvents	Halocarbon Aromatic hydrocarbon	CLP[a] CLP[a]	CLP[a] CLP[a]	Laboratory will be requested to report all peaks.
	Kerosene	Total fuel hydrocarbon as kerosene	CA LUFT[b]	CA LUFT[b]	
9 Fuel Farm Area	Gasoline	BTXE gasoline	CLP[a] CA LUFT[b]	CA LUFT[b]	
	PD-680	BTXE gasoline	CLP[a] CA LUFT[b]	CA LUFT[b]	
	JP-5	Total fuel hydrocarbons as kerosene	CA LUFT[b]	CA LUFT[b]	
	Waste oil	Total recoverable hydrocarbons	418.1[c]	418.1[c]	
	Toluene	Toluene	CLP[a]	CLP[a]	
	Trichloroethylene	Trichloroethylene	CLP[a]	CLP[a]	
	Isopropanol	Isopropanol	CA LUFT[b]	CA LUFT[b]	

[a] Contract Laboratory Program (CLP) procedures and quality control limits are defined in EPA contracts IFBS WA-85-J664/J680 and WP-85-J838/J839 or latest contracts.

[b] California Regional Water Quality Control Board, Leaking Underground Fuel Tank Field Manual: Guidelines for Site Assessment, Cleanup, and Underground Storage Tank Closure. December 1987.

[c] QA/QC specifications: 5-point calibration, 10 percent blanks, 10 percent accuracy, 10 percent precision.

5.1 Site 6 - Firefighting Training Area

Substances potentially disposed of at this site include JP-5, gasoline, diesel fuel, kerosene, solvents, waste motor oils, hydraulic fluids, and transformer fluids.

The analyses to be performed on the soil and groundwater samples are as follows:

Media Environmental	Parameter	EPA Method[1]
Soil and Groundwater	BTXE gasoline	Mod 8020/8015
	Total Fuel Hydrocarbons as Diesel	Mod 8015
	Total Fuel Hydrocarbons as Kerosene	Mod 8015
	Total Petroleum Hydrocarbons	418.1
	PCB and Pesticides	8080
	Halocarbon	8010
	Aromatic Hydrocarbon	Mod 8020
	Metals and Major Cations	6010/7000
	IP Scan for Metals	200.7
	Chemical Oxidation Demand	410.4
	Semivolatiles	8270/625
	Major Anions	300.0, Standard Method 403

[1] EPA Method modifications according to California Department of Health Services

5.2 Site 7 - Rubble Disposal Areas

Substances potentially disposed at this location include mainly rubble and demolition debris with some sandblast grit, oily soil, and creosoted pilings.

The analyses to be performed on the soil and groundwater samples are as follows:

Media Environmental	Parameter	EPA Method
Soil and Groundwater	IP Scan for Metals	200.7
	Total Petroleum Hydrocarbons	418.1

5.3 Site 8 - Oiled Areas

Substances potentially disposed at this location include mostly waste oils and hydraulic fluids with some solvents, kerosene, mineral spirits, and transformer fluids.

The analyses to be performed on the soil and groundwater samples are as follows:

Media Environmental	Parameter	EPA Method[1]
Soil and Groundwater	Total Petroleum Hydrocarbons	418.1
	PCBs	8080
	Halocarbon	8010
	Aromatic Hydrocarbon	Mod 8020
	Total Fuel Hydrocarbon as Kerosene	Mod 8010

[1] EPA Method modifications according to California Department of Health Services

5.4 Site 9 - Fuel Farm Area

Substances potentially disposed at this site include JP-5, gasoline, waste oils, detergents, PD-680, toluene, trichloroethylene, and isopropanol.

The analyses to be performed on the soil and groundwater samples are as follows:

Media Environmental	Parameter	EPA Method[1]
Soil and Groundwater	BTXE Gasoline	Mod 8020/8015
	Total Fuel Hydrocarbons as Kerosene	Mod 8015
	Total Petroleum Hydrocarbons	418.1
	Toluene	Mod 8020
	Trichloroethylene	8010
	Isopropanol	Mod 8015

[1] EPA Method modifications according to California Department of Health Services

5.5 Background Samples

Two background samples will be collected at the OLF. Background samples at the OLF, will be located along the northern perimeter of OLF because disposal activities are not known to have occurred at these locations according to the OLF Officer-in-Charge, Captain Chapelle. For purposes of this SI, the sampling frequency will be:

> One soil sample will be collected per boring at a depths of 5, 10, 15, and 20 feet.

At the background borings, drilling will continue until groundwater is encountered. Estimated depth to groundwater at the OLF is 20 feet to 40 feet, depending on location. For purposes of this SI, the sampling frequency will be:

> One groundwater sample at each well after well completion and development.

The analyses to be performed on the soil and groundwater samples are as follows:

Media Environmental	Parameter	EPA Method
Soil and Groundwater	BTXE Gasoline	Mod 8020/8015
	Total Fuel Hydrocarbon as Diesel	Mod 8015
	Total Fuel Hydrocarbon as Kerosene	Mod 8015
	Total Petroleum Hydrocarbon	418.1
	Halocarbon, Trichloroethylene	8010
	Aromatic Hydrocarbon, Toluene	Mod 8020
	Isopropanol	Mod 8015
	PCBs	8080
	ICP Scan for 23 Metals	200.7

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6.0 FIELD PROCEDURES

6.1 Introduction

This section describes the routine procedures to be followed by personnel obtaining field samples or conducting preparatory work for the collection of such samples at the OLF. Field procedures described in this section are:

- Soil sampling
- Groundwater monitoring well installation and sampling

The field procedures are designed so that:

1. Monitoring and sampling installations are constructed properly and in accordance with established methodology

2. Samples collected at the sites are consistent with project objectives

3. Samples are collected in a manner such that data are representative of the actual site conditions

Specific field guidelines provided in this document are: sample handling, equipment operation, QC, and personnel training. The Navy-approved Jacobs' SOPs for these field guidelines are included in Appendix C and referenced in this section. Field personnel must review the SOPs prior to conducting field work.

6.2 Field Work

Various environmental media, including groundwater, soil, and rubble, will be sampled during the SI and SWAT effort. Sampling procedures for these environmental media are discussed below.

6.2.1 Soil Sampling

All drilling will be done using the hollow-stem continuous-flight auger method (see SOP No. 20). Borehole samples will be obtained by ceasing drilling and lowering a split-spoon sampler into the hollow auger. The samples will be collected in the split-spoon sampler lined on the inside with three 6-inch-long brass rings by hammering the sampler into the soil. The rings will be sealed using Teflon tape, caps, and electrical tape. The outside diameter of the spoon will normally be 3 inches. The type of material being drilled will determine the type of catchers that will be used. The samples within each borehole will be obtained at intervals specified in Section 5.0, Sample Locations, Number, and Types. Two of the three samples collected at each interval will be utilized in the field for analysis. The middle ring will be used for scanning with a photoionization detector to determine whether volatile and organic vapors are present. The top most ring will be used for borehole logging purposes. The deepest ring will be forwarded to the laboratory for analysis of contaminants of concern.

Samples of the drill cuttings will be obtained at 5-foot intervals for each borehole drilled, and logged by an experienced geologist or hydrogeologist, 2.5-foot intervals will be used for the upper 10 feet of oiled areas. In addition, drilling characteristics, including drill rates, particle size, and driller's estimates of formation hardness will be recorded. If applicable, blow counts will also be recorded.

The steps discussed below will be followed during sampling:

Before entering the field:

1. Review Section 5.0 which specifies analytical parameters.

2. Select a qualified drilling contractor who has equipment capable of performing the work.

In the field:

1. Explain the purpose of sampling to the driller.

2. Record weather conditions and other onsite particulars.

3. Record sample locations and conditions.

4. Direct the drilling so that samples are collected at proper intervals.

5. Prior to each sampling interval, wash the sampler and brass rings in nonphosphate soap; rinse in tap water and final rinse in deionized water.

6. Obtain from driller the number of blows required to drive the sampler 18 inches into the ground and record. The blow count is recorded for each 6-inch increment.

7. Record the amount of recovery of sample from the sampler. Also, describe the sample lithology on the basis of exposed areas at the end of the brass rings and, if present, the materials within the tip of the split-spoon sampler. Maintain a borehole log for each borehole drilled.

8. For samples containing volatile constituents, cap the ends of the brass rings with Teflon, plastic caps, and electrical tape.

9. Label each sample container using a predetermined numbering system and complete appropriate chain-of-custody (COC) forms and Analytical Request forms. Preserve, package the samples, and ship to the appropriate analytical laboratory (see Section 7.0).

10. Samples to be analyzed for their physical properties will be labeled in a similar fashion to chemical samples.

After sampling:

1. Clean the split-spoon sampler prior to the next sampling interval.

2. Decontaminate down-hole drilling equipment by steam-cleaning prior to moving to the next location.

6.2.2 Monitoring Well Installation

During SI, soil borings at all sites will be developed into monitoring wells. Standard procedures (see SOP Nos. 36, 38, and 40) for well design and construction, geological logging, water level measurement, and sampling activities shall be followed.

Construction

Before proceeding to the field to drill and install groundwater monitor wells, a well drilling contractor will be selected. A group of qualified well drilling contractors will be identified through a prequalification process. Criteria that will be used to qualify the drilling contractors will be based on the projected types of drilling to be done. Only drillers with the required experience and equipment will be allowed to bid on the contract.

Well specifications will be prepared and submitted for review by the project hydrogeologist. After the drill specifications are finalized, they will be submitted to the pool of prequalified contractors for bidding. The qualified low-cost bidder will be awarded the drilling contract.

Borehole Logging

A log of geologic conditions encountered during drilling will be maintained for each borehole drilled as a part of the monitoring well installation program. The logs will characterize sediments encountered during drilling and all conditions (including problems) encountered during drilling. Observations of a general nature related to daily activities will be recorded in a field notebook, along with any other information deemed pertinent by the field supervisor.

Lithologic and hydrogeologic descriptions, along with notations on drilling speed, blow counts, drill rig behavior, and cuttings return rates will be recorded on the borehole log sheet.

Major measurements/observations to be documented in the log are:

- The project geologist will obtain a sample of the drill cuttings as grab samples at a minimum of 5-foot intervals. Cutting depth will be noted.
- The description of the drill cuttings will include the following:
  - Soil name
  - Color
  - Moisture content

- Relative density or consistency
- Soil structure
- Mineralogy
- Unified Soil Classification System group symbol

o The depth at which groundwater is first encountered will be noted.

o Drilling speed and rig behavior will be noted to help verify the nature of the material encountered.

o The geologist will be responsible for the documentation of the above information on a borehole log sheet.

Development

Each well will be developed by using mechanical surging (see SOP No. 37). Field monitoring equipment will be used to monitor electrical conductivity (EC), pH, and temperature of the pumped water. EC, pH, and temperature shall be measured before and after well development. Development will continue until the fine-grained sediment (clay or silt) has been removed. Water produced during development will be contained onsite in 55-gallon drums.

Well Evacuation and Sampling

The discussion of evacuation and sampling is presented in Subsection 6.2.3.

Water Level and Pressure Head Measurements

Measurements of water levels and pressure heads in monitoring wells will be conducted as described in Subsection 6.2.3.2

6.2.3 Groundwater Evacuation and Sampling

The following descriptions and operational guidelines will address all sampling equipment that might be employed or encountered during SI and SWAT work (see SOP No. 25).

Prior to collecting groundwater samples from monitoring wells, the well will be developed by following the guidelines presented in Section 6.2.3.1.

Bailers

One of the quickest and simplest methods of sampling wells is by bailer. The bailer consists of a 1.66" x 3' (1,000 ml) Teflon well bailer with Teflon cord. The advantages of using the bailer are that it requires no external power source, it is quick and easy to use, and it is economical and convenient enough that a separate bailer may be dedicated to each well to minimize cross-contamination. The primary disadvantage of using bailers is that they are not practical to evacuate large volumes of water, typically when the casing diameter exceeds 2 inches.

Sampling procedures for the bailer are as follows:

1. Evacuate the well as required, with a different apparatus if necessary.
2. Place the sampling vial in a steam-cleaned bailer.
3. Lower the bailer to the pre-determined sampling elevation. Open the collection port on the bailer. Wait 2 minutes for the sample collection.
4. Withdraw the bailer and remove the sample vial. Cap the vial immediately, making certain that no air is trapped.
5. Steam-clean the bailer between uses in different wells.

Pneumatic Displacement Pumps

This system consists of a collapsible membrane inside a long, rigid housing. Appropriate control units regulate the compressed gas (usually nitrogen) input and water sample discharge. When the pump is submerged, water enters the area around the collapsible membrane through the bottom check valve. After this area is filled, gas pressure is applied downward into the bladder through tubing connected to a control box and gas source. The influx of gas pressure pushes the water sample upward through a check valve. When the pressure is released, the top check valve prevents the sample from flowing back down the discharge line. Water in the casing then enters the pump through the bottom check valve.

Submersible Pumps

The evacuation of groundwater prior to sampling is often required in quantities and at rates that exceed the limitations of available sampling equipment. This typically occurs in casings larger than 2 inches. A submersible pump is often used to evacuate well points when the above conditions occur, while samples may be collected with a bailer or portable pneumatic displacement pumps. The submersible pump system includes an electrical line and winch and spool cable assembly. A portable generator provides electricity.

There are several advantages to using submersible pumps. Depending upon the size of the pump and pumping depths, relatively large pumping rates are possible compared to pneumatic displacement pumps. A portable submersible pump can be used to sample several wells in a brief period of time. The disadvantages of using submersible pumps are: 1) they require a minimum well casing inside diameter of 3 inches, and 2) off-gassing of certain constituents may occur at the point of sample discharge.

6.2.3.1 Evacuation Volumes

A predetermined volume of water will be evacuated from the casing prior to sample collection. It is recommended to evacuate a minimum of three well volumes and/or to evacuate well water until discharge water parameters (pH and conductivity) are stabilized (Barcelona et al, 1985; Scalf et al, 1981). If the well is pumped dry before the intended well evacuation is reached, it will be allowed to recover for 1 to 2 hours and then sampled. If it does not recover within 2 hours, it will be resampled the next day. Conductivity, pH, and temperature will be measured throughout the evacuation procedure, typically at the initial and each subsequent one-well volume evacuation.

The static water level of each individual well point is measured prior to evacuation.

6.2.3.2 Field Measurement/Observations

This section describes the following field measurements or observations:

- pH, conductivity, temperature
- Water condition
- Static water level

pH, Conductivity, Temperature

Measurements and observations to be recorded include pH, temperature, conductivity, well pumping rate, sample condition (clarity, color, odor), and water level drawdown.

As discussed in "Evacuation Volumes" (above), measurements of pH, conductivity, and temperature will be routinely taken at each well during each sampling event. The appropriate probes will be suspended into a clean bucket in which the well water discharge has been collected. These parameters will be used to evaluate general aquifer conditions as well as physical conditions specific to the well being sampled. Measurements of pH and conductivity will be reported at the temperature at which they are measured. The calibration, operation, and maintenance of these instruments are discussed in SOP Nos. 12, 13 and 14.

Water Condition

The general condition of the sampled groundwater will be described initially, at designated evacuation volume intervals, and at the final collection point. The general condition includes a description of color, odor, and clarity. Occurrence of variable density liquids or nonliquid phases will be noted.

Static Water Level

At the start of each sampling event, a measurement will be made of the static water level and total well depth of each well. This information will be logged and used to determine horizontal flow gradients, and to establish when wells have been fully recharged. Field measurements will be taken to the nearest 0.01 foot, and will include depth to standing water and total depth of the well. Measurements will be taken with reference to adjacent ground level elevation. This information is used to calculate the volume of stagnant water within the well and to provide a check of the integrity of the well (e.g., identify siltation problems). Water level measurement techniques are presented in SOP No. 38.

6.2.4 Groundwater Sample Collection

Groundwater samples will be withdrawn from the monitoring wells using a peristaltic pump, gas pressure displacement pump, Teflon bailer, or portable submersible pump. The samples will be analyzed for various chemical groups, including purgeable and extractable organics, metals, total petroleum hydrocarbons, and PCBs.

Well water to be used for metals analysis will be filtered either at the laboratory or in the field. If the sample is field-filtered, use an electric peristaltic pump and 142 μm/0.45 filter (see SOP No. 27). Samples to be analyzed for volatile compounds will be obtained in such a manner so that the holding container is air free. All such samples will be collected in a 40-ml vial. Care must be taken to minimize turbulence by positioning the bottle so that water flows smoothly down the inner surface. In installations where applicable, the discharge line will be inserted near the bottom of the container and withdrawn gradually as the container is filled. The container must then be immediately capped so that volatilization is minimized. This will be achieved by filling the container to slightly overflowing, forming a meniscus at the mouth of the container. Then to check that the sample is "air-free," the container will be inverted gently and the cap gently tapped. The absence of an air bubble indicates a successful seal. When an air bubble is discovered in the container in the field, the entire sample will be discarded, and the water sample will be recollected to assure that an accurate sample is obtained.

All sampling equipment will be thoroughly decontaminated by washing with nonphosphate detergent and triple rinsed with deionized water before each sample is taken (see SOP No. 26).

6.2.5 Residuals Management

Soil boring and monitoring well installation conducted during the SI and SWAT will generate cuttings, drilling fluids, and water that may be contaminated. Methods of handling these potentially contaminated materials are outlined below.

Solids Disposal

Residual solids will be generated during SI and SWAT activities. Those that will be of the most concern, with respect to proper disposal, will be soils and refuse displaced by soil boring activities. All material removed from individual boreholes will be placed directly into steel 55-gallon drums that can be sealed. The drums will be labeled with the borehole number and date of collection, and stored in a secure area at the OLF, Imperial Beach, until analytical results of the samples collected from the borehole are received. Contents of drums that are not identified as hazardous waste on the basis of analytical results will be spread thinly over open designated areas of the OLF, Imperial Beach. Drums containing hazardous waste will be shipped to a Resource Conservation and Recovery Act (RCRA)-permitted commercial hazardous waste management facility. Transport and disposal of drummed hazardous wastes is the responsibility of the Navy.

Residual solids and drilling fluids resulting from monitoring well installation will be disposed of in the same manner as discussed above.

Wastewater Disposal

During the SI, water will be produced from newly installed monitoring wells during well development and water quality sampling. Water will be collected in drums and sealed. The drums will be labeled with the well number and date of collection and stored in a secure area at the OLF, Imperial Beach. Water determined to be hazardous will be treated in the same manner as discussed for soils in the preceding section. Nonhazardous liquids will be disposed of in the appropriate municipal wastewater system.

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7.0 SAMPLE CUSTODY

7.1 Preservation

Preservatives will be added to the appropriate sampling container by the participating laboratory prior to field sampling. These sample containers will be made available to the sampling team at least 1 day before the scheduled sampling event. Samples that require cooling will be immediately placed on ice subsequent to collection.

7.2 Sample Labeling, Chain-of-Custody, and Traffic Reports

The information contained on the sample label, the Chain-of-Custody (COC) form and the traffic report (see SOP No. 30) will correspond to each other. The purpose and description of each of these is presented below.

7.2.1 Sample Labels

The sample label is used to identify each individual sample. The label will correspond to information contained in the COC forms. The sample label will include the complete sample identification (ID) number, the date and time the sample was taken, and the analysis request.

7.2.2 Chain-of-Custody Record

The COC record is initiated by the field technician who collects the field sample. Whenever a sample is transferred to another responsible party, for example, to the field supervisor for transport to the laboratory, the COC is signed off by the receiving agent. The laboratory will sign off after all transported samples are checked against the COC records. One COC record will accompany samples in each transport cooler.

The COC record will be used to document the following:

- Project and work item number
- Customer name
- Station number - The sample ID number may serve as the station number
- Date - The date the sample was taken
- Time - The time the sample was taken
- Station Location - The well or well point designation may serve as the station location
- Number of Containers - The number of sample containers taken from the station and by each method of sampling (e.g., two 40-ml, 1 gallon, etc.)

- Analysis Requested - Type of analysis to be performed on the sample
- Remarks - Additional information about the sample, such as the type of media sampled
- Relinquished by - The signature of the sampler(s)
- Date/Time - The date and time the sample was relinquished
- Received by - Whoever received the sample
- Received for laboratory by - The signature of the person at the laboratory who officially accepted the samples
- Date/Time - The date and time when the sample was received by the laboratory
- Remarks - Final remarks about the samples after acceptance by the laboratory

A copy of the COC records will be submitted to the project office on a daily basis as well as returned by the laboratory with the analytical results.

7.2.3 Traffic Reports

A traffic report is completed to complement the COC form in tracking hazardous samples. Except for hazardous samples, an analysis request form may be used in place of the traffic report form to inform labs of requested analyses. Individual traffic reports will be completed for each hazardous sample. The information includes the sample ID, date, matrix, volume, and contact person and phone. All shipping information will be maintained by project personnel in a separate file.

7.3 Sample Handling, Packaging, and Shipping

Contained in this section and outlined in SOP No. 31, are the sample handling, packaging, and shipping procedures. Specific procedures for sample handling are determined by the assigned sample classification. Samples are classified as either environmental samples or hazardous samples.

7.3.1 Environmental Samples

Environmental samples are normally low concentration and do not require the specific handling, packaging, and shipping procedures used with concentrated samples.

These samples are typical environmental matrices that include groundwaters or soils. These samples, in many cases, will be collected at a distance from any direct source of contamination or have had a substantial reduction in contaminant concentration due to dilution. It is expected that the majority of the samples collected during the SI and SWAT shall be classified as environmental samples.

7.3.2 Hazardous Samples

Hazardous samples are high-concentration substances requiring specific handling, packaging, and shipping procedures. The classification may apply to those samples collected onsite and from areas where there is evidence of direct contamination.

Samples in this classification are suspected to contain individual chemical contaminants (organic or inorganic) in the concentration range from 15 to 100 percent. All high-concentration samples are shipped to a laboratory that has the appropriate facilities for extraction and preparation of these hazardous samples. If any analysis indicates that an environmental sample from a given sampling station contains at least 15 percent of a single contaminant, samples from this station will be treated as hazardous samples in subsequent sampling periods.

Procedures for high-concentration hazardous samples are the following:

Organic Water Analysis

High concentration samples should be collected in sufficient volume to ensure optimum detection limits; however, as these samples are potentially hazardous, excess volume should be avoided. Samples suspected to contain contaminants in the upper range of the high classification require less volume and should be collected in clean, 8-ounce glass jars filled one-half to three-fourths full with the sample. Samples suspected to be substantially less contaminated, or which may contain fractions in the low concentration range, require at least 1 liter--preferably 2 liters--of sample to achieve appropriate detection limits. Collect these samples in clean, glass bottles filled three-fourths full. The laboratory will prepare a portion of each sample for base neutral extractables analysis and a portion for purgeable organics analysis.

For each case of samples, a field blank should be prepared, identified as a separate sample, and included with field samples shipped to a contract laboratory. Samples must be packaged and shipped according to the California Department of Transportation (DOT) regulations. Ice or other preservatives will not be used when shipping high-concentration samples.

Package the samples in a polyethylene bag, one sample per bag. Place sealed bag inside a metal can with incombustible cushioning material (vermiculite) to prevent breakage, one bag per can. Close the can and use clips and tape to hold the lid securely and tightly. Label and package the cans in the shipping containers.

Inorganic Water Analysis

Inorganic samples should be collected in 4-ounce quantities. One 8-ounce glass vial per sample is recommended. NOTE: high-concentration samples must not be preserved. For each case of samples, a field blank should be prepared and included with field samples shipped to the contract laboratory. Samples must be packed and shipped according to DOT regulations specified for hazardous samples.

Organic and Inorganic Soil Analysis

High-concentration soil/sediment samples should be collected in a capped brass sample sleeve. The laboratory will prepare a portion of each high-concentration sample for base neutral extractables analysis, pesticides analysis, and volatile organics analysis. For each case of samples a field blank will be prepared, identified as a separate sample, and included with field samples shipped to a contract laboratory. Ice or other preservatives will not be used when shipping high concentration samples.

Pack samples to avoid breakage or contamination. Samples must be packed and shipped according to the DOT regulations specified for hazardous samples.

7.3.3 Summary of Sample Packing and Shipment

1. Review CLP manual.
2. Collect samples in appropriate containers.
3. Add correct preservatives as necessary.
4. Print clearly, using a ballpoint pen, on the proper sample stickers the preservative that has been added to each aliquot.
5. Attach sample sticker to the correct aliquot after the sample has been collected and the container is cleaned and dried off. Cover the sample

stickers with one layer of strapping tape if it appears that adhesion to the sample container may be a problem.

6. Fill out Traffic Report or Analysis Request form.

7. Separate samples according to analysis. Organics may be shipped to one laboratory and inorganics to another.

8. Assign airbills to coolers and complete Traffic Reports and COC forms using the correct airbill numbers. Use one COC form per cooler.

9. Place samples into coolers according to laboratory destination. Each cooler must weigh less than 70 pounds, including ice. Keep sample upright and well protected from shipping damage. Pack hazardous samples in vermiculite or its equivalent.

10. Ice samples if necessary.

11. Seal the copies of each Traffic Report or Analysis Request form and the COC form inside of a zip-close style bag. Use strapping tape to hold the packet on the inside lid of the cooler.

12. Seal cooler with strapping tape. Several 12-inch strips are enough to do the job. Place a custody seal on each cooler and cover it with strapping tape to protect it.

13. Coolers must be labeled correctly. "Fragile" and "This-End-Up" labels go on all four sides of each cooler. Additionally, flammable liquids are labeled "Flammable Liquid NOS UN No. 1993," and "Cargo Aircraft Only" labels must go on all four sides of coolers containing hazardous samples. These labels must be completely uncovered and clearly 100 percent visible.

14. Ship samples. Be sure to keep coolers and airbills organized so that shipping destinations are correct.

15. Telephone the laboratory(ies) with airbill numbers and sample data within 24 hours of sample shipment. Use COC forms to keep this information organized.

7.4 Laboratory Acceptance of Samples and Handling

The final sign-off on the COC form will be done by the laboratory receiving the samples to be analyzed. The receiving agent for the laboratory is responsible for inspecting all transport coolers, verifying the integrity of their contents, and confirming that each sample received is as denoted on the attached COC record. Any problems in the transportation or condition of samples will be related as soon as possible to the responsible project officer(s).

7.5 Field Notebooks

A field log will be routinely maintained on a daily basis by the field supervisor(s). The log is an accounting of the accomplishment of scheduled activities. Any problems or deviations from scheduled activities will be duly noted in the field supervisor's log. Any observations relating to the field program will be recorded in this log. The log will be maintained by the field supervisor and filed with the Project Office at the end of the sampling period.

8.0 LABORATORY PROCEDURES

8.1 General

The laboratory selected to conduct the SI and SWAT sample analyses will be certified by U.S. Navy (NEESA) and the State of California to conduct analyses for the required organic and inorganic parameters. The laboratory must provide documentation of proven experience and excellence in the areas of QA/QC, methodologies, equipment, personnel, and data management. An audit of competing laboratories will be conducted in order to evaluate the above criteria. The laboratories that will receive Requests for Proposals are private contract laboratories.

Samples collected during this project will be analyzed in accordance with standard analytical procedures approved by NEESA. The purpose of using SOPs is to provide analytical data of known quality. In general, the laboratory will adhere to the Level D requirements of established NEESA methodology.

The laboratory will follow SOPs for each analysis. The SOPs will include considerations of the following subjects:

- Concentration ranges and detection limits
- Safety precautions
- Required equipment and materials

- Standards
- Precision and accuracy information

Samples received in the laboratory will be inspected for physical damage. The integrity of the sample seal will be checked. The sample identification number will be compared with COC records. Samples will be logged and secured in controlled refrigerated sample storage areas as necessary prior to analysis.

8.2 Chemical Analysis Procedures

Standard EPA Methods will be used for analyzing water and soil samples except where the methods were modified by the California Department of Health Services.

9.0 EQUIPMENT CALIBRATION, OPERATION, AND MAINTENANCE

9.1 Preventive Maintenance

Preventive maintenance procedures are integral to each task requiring the use of field sampling or laboratory analytical equipment. The descriptions of equipment used in all field tasks are provided in Sections 6.2.1 through 6.2.4. Maintenance procedures specific to this equipment are included in Sections 9.2 through 9.6 and SOP Nos. 12, 13, 14, and 15. The laboratory will maintain a log for each laboratory instrument used in the SI program. The log will account for instrument startup and down time, any service performed on the instrument, and all instrument calibration results. Laboratory equipment calibration, operation, and maintenance is discussed in Section 10.0.

Routine calibration of equipment will provide daily quality assurance checks on all equipment used in the SI and SWAT. Equipment that consistently falls out of calibration or exceeds manufacturer's critical limits will be appropriately cleaned or serviced.

9.2 pH, Conductivity, Temperature

All meters will be in good working condition. Each meter will have an individual ID number affixed. This number will be transcribed on field data records when using a particular meter for a sampling event.

A two-buffer calibration of instruments (pH and conductivity) will be performed in the morning (or before the sampling episode begins), at a mid-day or mid-event point, and at the end of the day. Calibration of the meters will be checked prior to each measurement using a single buffer. A table of the average prior measurements will be carried by the crew in the field. A significant deviation from previous values will indicate either a problem with the equipment or a change in environmental conditions. The meter will be recalibrated at this point. If properly calibrated, it will be assumed that the meter is in proper working order and the measurement is valid. Temperature may be checked with a thermometer (a minimum of once a week or more frequently when necessitated by field conditions).

On a routine basis, meter electrodes will be inspected for scratches, cracks, salt crystal buildup, and membrane/junction deposits. Probes will be cleaned on the above basis with soap and water or with a weak acid solution (0.1 M HCl or HNO_3 for about one-half hour) if necessary. After acid soaking, the electrodes will be thoroughly washed off with deionized, distilled water.

Procedures for measuring field parameters are described in SOP Nos. 12, 13, and 14. At least two individual observations in sequence will be recorded when pH, temperature, or conductivity are measured in the field. If the second measurement differs more than 10 percent from the first measurement, a third measurement will be recorded. The two closest measurements will be averaged and recorded on the field data sheet.

9.3 Water Levels

No calibration of steel tapes will be required since they will be graduated with permanent markings (at intervals of 0.01 foot).

9.4 Air Monitoring - Perimeter Volatiles Monitoring

Field organic vapor/gas analyzers (photoionization detectors [PID] or flameionization detectors [FID]) will be calibrated and maintained as described in SOP No. 15.

9.5 Groundwater Monitoring

All submersible pumps and discharge tubing will be dedicated to individual wells during SI and SWAT sampling. The condition of each apparatus will be assessed, and required repairs or replacement of equipment will be accomplished.

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10.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

In general, QC will be assured through adherence to standard laboratory operating procedures and Jacobs field SOPs. Specific laboratory and field QC analysis requirements are listed in Table A-2 and discussed below.

10.1 Laboratory QA/QC

The laboratory QC program will include:

- Adherence to general laboratory requirements (described below)
- Analysis of QC samples, including duplicates, matrix spikes, certified standards, etc.
- Equipment maintenance and operations following established procedures
- Documentation of QC data (precision data, accuracy data, calibration results)

10.1.1 General Requirements

Purity of Standards, Solvents, and Reagents

Reagents will be of the highest standard laboratory quality available. Where applicable, the reference standard solution will be traceable to National Bureau of Standards (NBS). Each new lot of reagent grade chemicals will be tested for quality. Organic standards will be tested by injection into a GC to evaluate the extent of interferences in the GC profile.

Table A-2
Quality Assurance/Quality Control Precision and Accuracy Objectives
Outlying Landing Field, Imperial Beach, California

Sheet 1 of 2

Parameter[a]	Matrix	Laboratory Matrix Spare[b]	Matrix Spare Duplicate[b]	Field Blank[b]	Laboratory Method Blank[b]	Recovery (%)	Field Precision (% Difference)	Method Detection Limit
BTEX Gasoline	Soil	5%	5%	10%	10%	C	50	1
	Water	5%	5%	10%	10%	C	50	1
Total Fuel Hydrocarbons as Diesel	Soil	5%	5%	N/A	10%	C	50	10
	Water	5%	5%	N/A	10%	C	50	0.5
Total Fuel Hydrocarbons as Kerosene	Soil	5%	5%	N/A	10%	C	50	10
	Water	5%	5%	N/A	10%	C	50	0.5
Total Petroleum Hydrocarbons	Soil	5%	5%	N/A	10%	C	25	1.6
	Water	5%	5%	N/A	10%	C	25	50
Hydrocarbon/ Trichloroethylene	Soil	5%	5%	10%	10%	C	50	1
	Water	5%	5%	10%	10%	C	50	1
Aromatic Hydrocarbon/ Toluene	Soil	5%	5%	10%	10%	C	50	1
	Water	5%	5%	10%	10%	C	50	1
Isopropanol	Soil	5%	5%	N/A	10%	C	50	1
	Water	5%	5%	N/A	10%	C	50	1
PCB	Soil	N/A	N/A	N/A	10%	N/A	50	0.1 to 0.2[e]
	Water	N/A	N/A	N/A	10%	N/A	50	0.5 to 2[e]

Table A-2
Quality Assurance/Quality Control Precision and Accuracy Objectives
Outlying Landing Field, Imperial Beach, California

Sheet 2 of 2

Parameter[a]	Matrix	Laboratory Matrix Spare[b]	Matrix Spare Duplicate[b]	Field Blank[b]	Laboratory Method Blank[b]	Recovery (%)	Field Precision (% Difference)	Method Detection Limit
ICP Scan for 23 Metals	Soil	5%	d	N/A	10%	d	50	0.2 to 10[f]
	Water	5%	d	N/A	10%	d	50	1 to 25[f]

[a] Methods in Sections 5.1, 5.2, 5.3, 5.4, and 5.5 of Site Inspection Work Plan.
[b] One per analytical batch if greater than the percent value.
[c] Laboratory generated recovery limits.
[d] Duplicate sample, difference from matrix spike to ≤20 percent.
[e] Detection limit depends on type of PCB compound.
[f] Detection limit is metal dependent.

N/A - Not Applicable

Glassware

All glassware used in organic analyses requires special cleaning. Plasticware will not be used because other organic compounds may be extracted by solvents and produce interfering peaks on the gas chromatogram. Glassware and other sample containers should be prepared and cleaned in accordance with established NEESA methodology (NEESA, 1988). The method of cleaning should be adapted to both the substances that are to be removed and the determination to be performed.

Analyses

1. Laboratory pure water is prepared by a special deionized water system augmented by individual filter cartridge and polisher located at each outlet point. The polishers include special particulate filters, organic resins, and inorganic resins.

2. Specially deionized water that has been boiled and purged with nitrogen gas will be used for volatile/priority pollutant analyses. Water prepared in this manner should be free of contamination and interference peaks when injected into the GC.

3. Calibration Standards

   A calibration standard is prepared in the laboratory by dissolving a known amount of pure compound in an appropriate matrix. The final concentration calculated from the known quantities is the true value of the standard. The results obtained from these standards are used to generate a standard curve and thereby quantitate the compound in the environmental sample. A minimum of three calibration standards will be used in generating a standard curve for all analyses.

4. Blanks

A blank/spike control will be analyzed with each batch and will be plotted on control charts. The control charts will be used to monitor the results of laboratory sample preparation and analysis and determine whether an out-of-control condition exists. For metals, anions, and other Water Extraction Test (WET) chemical analyses, a method blank will also be processed with each batch and will contain less than the method detection limit for compounds of interest. The laboratory's distilled and/or deionized water will be used as the blank material for aqueous samples. Soil or sand of known composition certified by the supplier will be analyzed as the blank material alongside soil or waste samples. A blank spike is prepared by adding a known amount of pure compound to the blank material.

5. Matrix Spike (Accuracy)

A sample spike is prepared by adding a known amount of pure compound to the environmental sample (before extraction for extractables). The compound is the same as that being assayed for in the environmental sample. These spikes simulate the background and interferences found in the actual samples and the calculated percent recovery of the spike is taken as a measure of the accuracy of the total analytical method. When there is no change in volume due to the spike, it is calculated as follows:

$$P = 100\,(O - X)/T \text{ or } \frac{100(O-X)}{T}$$

Where:

P = percent recovery

O = measured value of analyte

X = measured value of analyte concentration in the sample before the spike is added

T = true value of spike

6. Matrix Spike/Duplicate (Precision)

Aliquots of the same sample are made in the laboratory and each aliquot is treated exactly the same throughout the analytical method. Spikes are added at approximately 10 times the method detection limit. The percent difference between the values of the aliquot duplicates, as calculated below, is taken as a measure of the precision of the analytical method.

$$PD = \frac{2(D_1 - D_2)}{(D_1 + D_2)} \times 100$$

Where:

PD = percent difference

D_1 = first sample value

D_2 = second sample value (duplicated)

10.1.2 Equipment Calibration, Operation, and Maintenance

Calibration Curves

Each calibration curve will consist of a blank and three standards that span the linear range of the instrument. The calibration curve will be checked at least once at a mid-day point and/or after analyzing the last batch of the day. NEESA procedures will be followed precisely. A log book will be maintained by the laboratory to document the preparation of standards.

10.1.3 Documentation of QC Data

Documentation of QC data is needed to demonstrate adherence to QC guidelines. As required to maintain Level D QC, a CLP data package will be delivered by the laboratory, which includes initial and continuing calibration, matrix spikes, matrix spike duplicates, blanks, duplicates, surrogate recoveries, chromatograms, mass spectra, and absorbance data. For methods that are not defined by CLP (i.e., the GC Methods 8010 and 8020), the calibration information, method blanks, blank/spikes, chromatograms, absorbance, matrix spikes, and matrix spike duplicates will be reported. The control charts associated with the blank/spikes will be presented with the data.

10.2 Field QA/QC

Specific field quality assurance (QA) methods are discussed with the description of each individual field activity in the appropriate sections. Section 5.0 includes the presentation of field procedures for all anticipated activities. Field data quality will be ensured by the proper calibration, operation, and maintenance of field equipment.

In addition to the above QA procedures, the following specific measures will be implemented. Table 10-1 lists the percentage of Field QC samples that will be collected per sampling event.

10.2.1 Sampling

- Samples for VOC analyses will be collected and transported in duplicate to ensure that usable samples are obtained. Ten percent of the VOC field duplicates will be analyzed.

- Field duplicates for other parameters besides volatile organics will be collected and analyzed on a 10 percent basis. The relative percent difference between duplicate measurements provides an estimate of field precision.

- A trip blank will be included in each travel cooler and analyzed for volatile organics.

- Equipment rinsate blanks will be used to ensure that the nondedicated sampling devices (bailer, filtering pump, etc.) have been effectively decontaminated. Field equipment will be filled with Type II reagent grade water, transferred to a sample bottle, and returned to the laboratory for analysis.

- Field blanks consist of the source water used in decontamination of field equipment. Deionized, distilled laboratory water is placed into sample containers by the sample collection crew, and shipped with the other field samples. One field blank from each from each sampling event and each source of water will be collected and analyzed for the same parameters as the related samples. Field blanks are used to demonstrate the lack of contamination during sampling.

- Field pH, conductivity, and temperature measurements on each sample day will be compared to previous measurements.

10.2.2 Water Levels

- A minimum of three measurements are to be taken at each location or time interval until observed measurements are repeated.
- Data are to be compared to previous measurements obtained in order to identify potential anomalous measurements.

10.3 Data Evaluation

Data analyses of groundwater and soil will be subjected to a two-step evaluation process. First, the validity of the data will be assessed. The valid data will be evaluated to assess if they are sufficient to adequately characterize the distribution of chemical constituents.

Data from the initial analyses will be assessed for validity through review of QA/QC measures accomplished during both sampling and laboratory analysis. Jacobs will validate the data per the CLP criteria outlined in EPA, 1985a; EPA, 1985b; and EPA, 1985c. Data judged invalid will be noted and archived. Any samples that have not exceeded holding times will be re-analyzed.

Otherwise, depending on the importance of the observation, new samples will be collected. Data obtained from these re-analyses will also be subjected to this evaluation process.

After the evaluation process, valid data will be assessed for representativeness and completeness. If the data are insufficient, selected archived samples will be analyzed and, if necessary, new samples will be collected during an additional phase of the investigation.

Data collected during the SI and SWAT will not be entered on the computer. The small number of samples collected and analyzed do not warrant the use of an extensive data management tool.

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11.0 DATA VALIDATION

Field data forms will be submitted to and reviewed by the assigned field supervisor. Data will be checked for completeness, accuracy, and adherence to sampling protocols. Inconsistencies or deviations from planned sampling will thus be identified in a timely manner and dealt with immediately.

Analytical data will be routinely screened by the assigned Jacobs data validator as it is received from the laboratory in preformatted data result forms. This validation screening will consist of reviewing each data sheet for completeness of required information. A complete set of information for each parameter consists of the sample result, limit of detection, and dilution factor.

QC results for each sample event will be tabulated by the Jacobs data validator. Field and laboratory precision and accuracy measurements, and field and trip blank results will be evaluated. If any of the above QC measurements are found to exceed established criteria, appropriate field and laboratory data records (including field data forms and laboratory calibration curves and control charts) will be reviewed. If the evidence indicates that a specific field or laboratory procedure resulted in a nonrepresentative observation result, it will be discarded. If evidence shows that the observation is questionable but may still be representative, the data will be assigned a code to indicate its questionable nature. Data results will be routinely reported to the internal Technical Review Committee by presenting both raw data results as well as submitting summary information.

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12.0 FIELD AUDITS

The quality assurance officer may schedule audits of field activities at various times to evaluate the execution of sample identification, sample control, COC procedures, field documentation, instrument calibrations, and field measurement and sampling operations. The evaluation is based on the extent to which the applicable SOPs as described in the SI Work Plan and SWAT Proposal are being followed.

Field documents pertaining to sample identification and control will be reviewed to see that all entries are dated and signed and that the contents are legible, written in ink, and contain accurate and inclusive documentation of project activities. The auditor will also check to see that COC procedures are being followed and that samples are being kept in custody at all times.

Sampling operations will be evaluated to assess if they are performed as stated in this document or as directed by the project manager. The auditor checks to assess if the appropriate number of samples are being collected, samples are placed in proper containers, and proper preservation, packaging, and shipment protocols are being followed.

Field measurement activities will be evaluated to assess if they are performed according to guidelines presented in this document. The auditor will spot-check various instruments for proper calibration, the frequency of calibration, and that the technique utilized with these instruments is providing accurate data.

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13.0 NONCONFORMANCE AND CORRECTIVE ACTION PROCEDURES

If QA/QC deficiencies are noted during an audit or during any phase of the study, or if unacceptable analysis results are obtained, the project manager will specify the corrective actions to be taken to ensure compliance with the QA/QC procedures of this document. The quality assurance officer is responsible for approving the corrective action.

Corrective action procedures that might be implemented from audit results indicating unacceptable data will be redeveloped on a case-by-case basis. Such actions usually relate to altering procedures in the field, laboratory, or office. Corrective actions could involve altering field procedures, using different sample containers, increasing calibration and maintenance schedules of field measurement instruments, requesting the laboratory to adopt additional QC measures, or re-analyzing samples. The project manager is responsible for initiating the corrective action.

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14.0 PROJECT RECORDS

The project manager has the responsibility for the overall document control program and is responsible for the maintenance of the document control system. Project personnel are responsible for project documents while working on the SI and SWAT. The following project records are anticipated to be used or generated during this effort. The Navy-approved document control/distribution program will be followed to provide proper distribution, inventory, custody, storage, and retrieval of all project documents.

Field Documents

Such documents include the following:

- Chain-of-Custody records
- Traffic Reports (hazardous samples)
- Analytical Services Request forms
- Custody seals
- Field data forms
- Field notebooks
- Maps
- Photographs
- Calculation briefs

It is the responsibility of field personnel and the project manager to see that these documents or equivalent documents are used appropriately, filed correctly, and distributed to the designated organizations.

Entries to the field notebook and field data forms shall be made legibly and completely. Each entry must include the sample location, field measurements taken, station number, and sample identification number. In situ measurements and field observations are to be recorded, with pertinent information necessary to explain and reconstruct field activities. Each page of a field notebook or field data form and calculation brief is to be dated and signed by all individuals making entries on that page.

The project manager and the field team on duty are responsible for ensuring that the field notebooks and data forms are used during monitoring activities and are stored safely. Any lost, damaged, or voided field notebooks or data forms will be reported to the project manager.

Photographs that show field activities and monitoring locations are numbered to correspond to field notebook or field data form entries. The names of the photographer and witness, date, time, site location, and site description are entered sequentially in the field notebook and on the field data form as photos are taken. Once developed, the photographic prints are labeled and stored safely.

Corrections to Field Documentation

Original data recorded in logbooks, field notebooks, calculation briefs, field data forms, Traffic Reports, custody records, and other data sheet entries will be written with waterproof ink. Errors discovered on an accountable document will be corrected by the person who made the entry and checked by another person. Corrections will be initialed and dated.

If a sample identification number is lost in shipment, or was never prepared for a sample(s), or a properly labeled sample was transferred without a formal COC record, a written statement is prepared detailing how the sample was collected, air-dispatched, or hand-transferred to the laboratory. The statement will include all pertinent information, such as entries in field notebooks regarding the sample and whether the sample was in the sample collector's physical possession or in a locked compartment until hand-transferred to the laboratory. Copies of the statement are distributed to the project manager and remedial project manager.

Laboratory Documents

Such documents include the following:

- Analysis reports
- Chain-of-Custody records
- QC/QA information
- Bench logbooks
- Refrigerator/storage logbooks

Before the release of a final analytical report, each laboratory assembles documents and cross-checks information on corresponding sample identification numbers, COC records, bench sheets, laboratory logbooks, and other logbooks to show that data pertaining to each particular sample are complete and consistent throughout the record. The project manager then cross-checks field documents to show that the information recorded corresponds with that of the laboratories and is consistent throughout the project record.

Materials that may not be used in field activities include project notebooks and project logbooks, calculation briefs, maps, diagrams, and office memoranda. Maintaining these and other documents, including reference materials and project reports are the responsibility of the project manager until the closed project file is assembled. The project manager will ensure that documents are labeled, filed, and stored in accordance with their classification.

15.0 PROJECT ORGANIZATION

Project organization for the SI and SWAT field work are described below.

Primary responsibility for the project quality review rests with the Project Manager (PjM). Independent quality assurance review is provided by the Quality Assurance Manager (QAM) and the QA auditors. The PjM will frequently review the financial, schedule, and technical status of the work assignment. The key people involved in interfacing with the PjM are the Remedial Project Manager (RPM) and the Technical Reviewer (TR).

The TR and the QA Review Team review all project deliverables. The TR and the PjM monitor the quality and delivery of the reviews and works with the QA Manager to mediate any differences. Where quality assurance problems or deficiencies requiring special action are uncovered, the PjM, Technical Reviewer(s), and QAM will identify the appropriate corrective action to be initiated by the PjM.

The following individuals are scheduled to work on the project:

Program Manager:	Phil Stassi
Project Manager:	Robert York
Project Controls Manager:	Norman Reeves
Remedial Project Manager:	Jeff Kidwell
Activity Point of Contract:	Arno Bernardo
Quality Assurance Manager:	Jim Graff

Technical Reviewers:	Walter Crone, Terry Foreman
Project Staff:	Robert Evangelista, John Lovenburg
Health and Safety Managers:	Carl Wilson, Lynn Laszewski
Contracts Manager:	Wilfred Sanchez

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15.0 PROJECT ORGANIZATION

Project organization for the SI and SWAT field work are described below.

Primary responsibility for the project quality review rests with the Project Manager (PjM). Independent quality assurance review is provided by the Quality Assurance Manager (QAM) and the QA auditors. The PjM will frequently review the financial, schedule, and technical status of the work assignment. The key people involved in interfacing with the PjM are the Remedial Project Manager (RPM) and the Technical Reviewer (TR).

The TR and the QA Review Team review all project deliverables. The TR and the PjM monitor the quality and delivery of the reviews and works with the QA Manager to mediate any differences. Where quality assurance problems or deficiencies requiring special action are uncovered, the PjM, Technical Reviewer(s), and QAM will identify the appropriate corrective action to be initiated by the PjM.

The following individuals are scheduled to work on the project:

Program Manager:	Phil Stassi
Project Manager:	Robert York
Project Controls Manager:	Norman Reeves
Remedial Project Manager:	Jeff Kidwell
Activity Point of Contract:	Arno Bernardo
Quality Assurance Manager:	Jim Graff

Technical Reviewers:	Walter Crone, Terry Foreman
Project Staff:	Robert Evangelista, John Lovenburg
Health and Safety Managers:	Carl Wilson, Lynn Laszewski
Contracts Manager:	Wilfred Sanchez

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Appendix B

HEALTH AND SAFETY PLAN

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APPENDIX B - HEALTH AND SAFETY PLAN Page

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SICTO4106

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1.0 GENERAL INFORMATION

CLIENT: Jacobs Engineering Group

JOB NO.: LAO30230.41.SI

PROJECT MANAGER: Robert York

SITE SAFETY COORDINATOR: Robert Evangelista

SITE NAME: Outlying Landing Field, Imperial Beach, California (CTO #0041, Activity 06)

SITE LOCATION: Outlying Landing Field, Imperial Beach, California (CTO #0041, Activity 06)

ACTIVITIES PLANNED: Conduct field contamination survey, drilling, soil sampling, well installation, well development, and well sampling.

DATES: 1990 and 1991

BACKGROUND INFORMATION AVAILABLE FROM: CH2M HILL, Santa Ana, California

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2.0 PLAN APPROVAL

PLAN PREPARED BY:	Robert Evangelista
DATE:	18 September 1990
APPROVED BY:	Lynn Laszewski, CH2M HILL; Terry Briggs, Jacobs
DATE:	25 September 1990

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3.0 SITE/WASTE CHARACTERISTICS

3.1 Facility Descriptions

The facility of concern is the Outlying Landing Field, Imperial Beach, California. The facility has four sites of concern: Site 6, Firefighting Training Area; Site 7, Rubble Disposal Area; Site 8, Oiled Areas; and Site 9, Fuel Farm Area.

Firefighting Training Area was used from the 1950s until the 1970s. Prior to 1970, an unlined pit was used and, reportedly, filled with any available combustible material. These combustibles included diesel, JP-5, gasoline, waste motor oils, hydraulic fluids, PD-680 solvent, kerosene, shop wastes, and transformer dielectric fluids, which may have included PCBs. These fluids were discharged into the pit 3 to 4 times per week up to 1,200 gallons and ignited once per month. Furans and dioxins may be present as products of incomplete combustion.

Rubble Disposal Areas were used for general refuse disposal. Prior to 10 to 15 years ago, disposal was reportedly random. However, since that time, disposal was limited to rubble and demolition debris. In addition, the area may contain waste motor oil, sandblast grit, oiled soil, and creosote pilings. It is possible that asbestos may be present in the rubble.

Oiled Areas consist of those locations on the base that were sprayed for dust and weed control. These locations were sprayed with mainly waste motor oil and hydraulic fluids. In addition, solvents and transformer fluids, whose estimated volume amounted to less than 5 percent of the entire volume, were also sprayed. It is possible that some of the hydraulic fluids may be corrosive.

The Fuel Farm Area and the adjacent helicopter washrack were used for fuel storage and helicopter maintenance, respectively. The potential contaminants believed to have leaked from the fuel area or to have been discharged from the helicopter washrack are: JP-5, gasoline, waste oils, PD-680, toluene, trichloroethylene, and isopropanol.

These sites are within the boundaries of the OLF. Utilities such as water, gas and/or oil, and high voltage electrical lines may be buried beneath asphalt and concrete surfaces. The approximate locations of these buried features can be determined from electrical, piping, and fire protection plans for the OLF. Locations of external buried utilities and verification of internal buried utility locations will be determined prior to drilling.

3.2 Waste Types

Liquid X Solid X Sludge__ Gas__

3.3 Characteristics

Corrosive___ Ignitable X Radioactive___ Volatile X Toxic X Reactive___ Unknown___ Other___

3.4 Hazard Evaluation

3.4.1 Chemical Hazards

Petroleum hydrocarbons (e.g., gasoline and diesel fuel) are the primary potential chemical hazards at the site. These chemical hazards associated with petroleum products are described below.

- **Diesel Fuel:** Diesel fuel is a complex petroleum mixture of paraffinic, olefinic, naphtenic, and aromatic hydrocarbons. The benzene content is typically less than 100 parts per million (ppm) in the source product. Excessive inhalation exposure may cause respiratory irritation, headache, dizziness, nausea, vomiting, and loss of coordination. Prolonged skin contact may lead to irritation of hair follicles and blockage of the sebaceous glands. Good personal hygiene will prevent this. Occupational Safety and Health Act (OSHA) has not determined a permissible exposure limit for diesel fuel.

- **Gasoline:** Gasoline is a variable mixture of paraffins, aromatics, and olefins. Acute toxicity includes anesthetic effects and mucus membrane irritation. Symptoms of acute exposure include headache, blurred vision, dizziness, and nausea. The major toxicity concern is benzene, a known human carcinogen through inhalation. Gasoline typically contains 0.7 to 1.0 percent benzene. The OSHA time weighted average (TWA) for benzene is currently 1 ppm.

  Gasoline also contains lead, which has adverse health effects if inhaled. The OSHA TWA for lead is 50 micrograms per cubic meter ($\mu g/m^3$); however, lead is not readily volatilized. The overall threshold limit value (TLV) for gasoline is 300 ppm, based largely upon assumptions about the hydrocarbon content of gasoline.

  Skin contact with gasoline can produce immediate or delayed symptoms of dryness or irritation. If skin comes in contact with gasoline, remove clothing from affected area and wash promptly with soap and water. Dry the skin carefully with a clean towel. If skin is inflamed, painful, or blistered, seek medical attention.

- **Kerosene (Includes Jet Engine Fuels):** Kerosene is a refined petroleum distillate consisting primarily of C_{10} to C_{16} hydrocarbons. Typical gas turbine (jet) engine fuels are derivatives of kerosene with various additives to improve performance or reduce smoke. Overexposure may cause headaches, dizziness, nausea, stupor, and respiratory tract and eye irritation. The primary health hazard is skin irritation and dermatitis from prolonged or repeated skin contact. Ingestion can be irritating to the mouth, throat, and digestive tract, with the hazard of aspiration into the lungs. The National Institute of Occupational Safety (NIOSH) REL is 100 milligrams per cubic meter (mg/m^3). If skin contact occurs, wash immediately with soap and water. If eye contact occurs, immediately flush the eye for 15 minutes with clean water and then seek medical attention.

- **Motor Oils, Insulating and Transformer Oils:** These oils may contain polynuclear aromatic hydrocarbons (PAHs) polychlorinated biphenyls (PCBs), lead, and other carcinogenic or mutagenic substances at relatively low concentrations. These constituents may be absorbed through the skin and, therefore, dermal protection and decontamination are important to protect against exposure. There are no OSHA PELs for these oils.

- **Chlorinated Solvents:** Possible low levels of chlorinated compounds may be encountered in water and soil samples. The primary avenue of exposure is inhalation and dermal contact. Some of these compounds act as central nervous system depressants that produce visual disturbances, mental confusion, fatigue, and nausea. The OSHA PELs for chlorinated solvents can be as low as 1 ppm, depending on the solvent.

- **Metals:** Heavy metals typically have a high affinity for soil particles, creating potential for both inhalation and dermal contact from dust created during drilling operations. Metals are absorbed in the bloodstream and produce fever, dizziness, mental confusion, and nausea. The OSHA PELs for several heavy metals are: arsenic 0.5 mg/m^3, cadmium 0.2 mg/m^3, lead 50 micrograms per cubic meter (ug/m^3), antimony 0.5 mg/m^3, and barium 0.5 mg/m^3.

- **PCBs:** Polychlorinated biphenyls (PCBs) are suspected human carcinogens. The OSHA PEL for chlorodiphenyl (54 percent chlorine) is 0.5 mg/m^3.

- **Organic Compounds and Solvents:** In general, the 'organic compounds' are water insoluble, nonpolar molecules, while various functional groups, such as amines, hydroxyls, halogens, carboxyls, etc., can be added to alter these two basic chemical properties, these properties result in two pharmacologic effects that provide the basis of their acute toxicities. Organic chemicals in general act as anesthetics (i.e., they depress the activity of the central nervous system) and are irritants to the eyes, respiratory system, and skin because they are good solvents for lipids (fat). Repeated and prolonged skin contact will dry and defat the skin, resulting in irritation, dermatitis, cell damage, and necrosis. Eye contact may cause irritation, tearing, and possibly permanent damage. Direct contact of liquid hydrocarbons with lung tissue (aspiration) can result in chemical pneumonitis, pulmonary edema, and hemorrhage. Both the anesthetic and irritant properties or organic alkane compounds are increased by halogenation and unsaturated double bonds. Most functional groups (e.g., amines, carboxylic acids, aldehydes, etc.) increase the ability of organic chemicals to cause tissue damage (corrosivity).

The chronic toxicity of organic chemicals varies widely with structure and the functional noncarbon groups that are attached. These chronic toxicities include kidney, liver, heart, and lung damage; methemoglobin formation in red blood cells and depression of blood cell formation; degenerative changes in the nervous system; sensitization and allergic reactions; and mutagenic, teratogenic, and carcinogenic effects.

Organic chemicals in general act as anesthetics and irritants to the eyes, respiratory system, and skin. Eye contact may cause irritation, dermatitis, cell damage, and necrosis. Chronic toxicities include kidney, liver, heart, and lung damage. The OSHA PELs for common solvents and paint constituents are: toluene 100 ppm, xylene 100 ppm, and benzene 1 ppm.

- **Petroleum Distillates (including PD-680 and mineral spirits):** Petroleum products represent different distillation fractions from petroleum refining and, as such, are actually complex mixtures of many different organic compounds. Gasoline alone contains over 400 different chemical constituents, some not yet positively identified by chemical structure. Kerosenes and diesel fuel contain even more constituents, and even less of these have been positively identified. Stoddard solvent is a mixture of aliphatic hydrocarbons, naphthenes, and benzene derivatives used extensively in degreasing operations and as a paint thinner. The major components of petroleum distillates are branched and straight chain alkanes and alkenes, cycloalkanes, and a variety of aromatics. Petroleum distillates are eye irritants and mildly toxic by inhalation. The OSHA PEL for Stoddard solvent is 500 ppm.

- **Alkylbenzenes (Toluene, Iethylbenzene, Xylene, etc.):** These chemicals are liquids with relatively low boiling points. They are primarily used as solvents. Because of their high affinity for lipids, these compounds are rapidly taken up by the central nervous system. With acute exposure, anesthesia is usually the primary problem, but high concentrations can lead to cardiac arrhythmia and are toxic to the kidneys. Still, because of the high exposures required, these compounds are relatively nontoxic.

  With chronic exposure, the harmful effects on the blood system seen with benzene do not occur. Chronic toluene exposure stimulates the metabolizing capacity of the liver and may increase the toxicity of other chemicals. Psychological tests of occupationally exposed workers have shown decreased performance in sensorimotor speed, psychomotor performance, and visual accuracy tests. Excessive chronic exposure to toluene, such as "glue sniffing," results in diffuse disorder of the cerebellar and cerebral functions of the brain, including a lack of coordination and emotional instability. The other compounds are similar in chemical structure and probably act similarly, but less data have been reported for them. These chemicals are not considered to be carcinogenic. TWA are as follows:

Ethylbenzene	100ppm
Toluene (toluol)	100ppm
Xylene (o-, m- and p-isomers)	100ppm

o **Benzene:** Benzene is a colorless, volatile liquid with a pleasant odor. It should be distinguished from benzine, a petroleum distillate containing mixed hydrocarbons (such as pentane and hexane) in uncertain proportions. Benzene is present to some extent in most gasolines (2 to 3 percent), and is a common ingredient of paint and varnish removers.

3.4.2 Physical Hazards

Explosions of petroleum vapor in confined spaces can be fatal, and workers must be attentive to this danger and guard against carelessness at all times. (Gasoline has a flashpoint of 50°F and diesel fuel has a flashpoint of 100°F.) The lower explosive limit (LEL) for gasoline is 1.3 percent, or 13,000 ppm. Because the vapors of petroleum fuel products are heavier than air, their explosivity and flammability hazard are increased. Vapors will tend to concentrate near the ground and in low lying areas, and will not be readily mixed or diluted with ambient air. When monitoring LEL, it is important to take measurements at ground level.

In order to prevent explosivity and flammability hazards, each team member must make sure that no spark sources, such as lighters, matches, unapproved flashlights, etc., are brought into the exclusion zone. The Site Safety Coordinator (SSC) must inspect the exclusion zone for spark sources including wiring, motors, etc., and enforce the requirements for fire prevention, including intrinsically safe electrical equipment, spark arrestors on vehicles, and exclusion of unauthorized personnel.

Drilling poses safety hazards to personnel in the immediate vicinity of the drill rig. To protect personnel from overhead falling objects (i.e., bolts, wrenches, pieces of pipe), hard hats must be worn in the immediate vicinity of the frill rig. Safety glasses are also required to protect against flying projectiles that could be caused by hammering fittings/ connections and driving casing. Drilling activities near overhead electrical lines will be avoided. The drill rig mast shall remain as far as practical from all overhead utility lines. Continuous monitoring with an explosion meter and HNu will be performed to identify potential fire/explosion and inhalation hazards.

Utility lines, both above ground and below ground, may pose a safety hazard for team members during drilling. The driller must maintain a safe clearance (at least 20 feet) between overhead utility lines and the drill-rig mast at all times during site operations. The location of utility lines must be determined prior to startup. This determination will be made via information gathered from several sources. First, a utility map must be obtained from the Naval Public Works Group in San Diego, California. Then, the utility must be contacted 72 hours prior to excavation or drilling by contacting. No drilling is to take place without identification of underground utility lines by a representative of the utility company(ies). Prior to drilling, two geophysical surveys will commence, a ground penetrating radar survey and a electromagnetic or a magnetometer survey.

Heat stress is a common type of stress which may affect field personnel during periods of warm (> 70°F) temperatures. The following are examples of heat-related stress that may be encountered:

Heat Rash: Caused by continuous exposure to heat and humid air, aggravated by chafing clothes. Symptoms include a decreased ability to tolerate heat and obvious signs of discomfort.

Heat Cramps: Caused by increased stress on various organs to meet increased demands to cool the body. Signs: muscle spasm and pain in the extremities and abdomen.

Heat Exhaustion: Caused by increase stress on various organs to meet increased demands to cool the body. Signs: shallow breathing, pale, cool, moist skin; produce sweating; dizziness and lassitude.

Heat Stroke: The most severe form of heat stress. The body must be cooled immediately to prevent severe injury and/or death. Signs and symptoms: red, hot, dry skin; no perspiration; nausea; dizziness and confusion; strong, rapid pulse; comma.

When temperatures exceed 70°F, remind team members of heat stress symptoms and treatment. Schedule a beverage break in a shaded area every 2 hours (observation, sampling). Above 80°F, schedule the drink break every 90 minutes (observation, sampling). At 85°F, take pulse measurements at each beverage break and take a 15-minute rest break (need full decontamination every other break). Above 90°F, schedule a 15-minute rest and beverage break every 30 minutes; take pulse reading at each break.

4.0 PROCEDURES

4.1 Team Organization

Team Members	Responsibility
Robert J. York, P.E.	Project Manager/Observer
Robert Evangelista	Project Engineer/Level C SSC
John Lovenburg	Hydrogeologist/Level D SSC

Observers must remain in clean areas and upwind of the exclusion zone. Observers will not conduct sampling activities. The project manager will check the medical and training status of team members prior to field work to assure that the requirements of 29 CFR 1910.120 are met.

FORM 533 will be completed by the SSC and returned to Ann West/WDC at the completion of field activities.

4.2 Personnel Safety Equipment

Level of Protection: A__ B__ C X D X

Polycoated Tyvek coveralls with nitrile outer gloves and latex inner gloves will be worn when splash protection is needed. Nitrile outer gloves and latex inner gloves will be worn during sampling and when handling samples. Safety glasses, hard hat, and neoprene steel toe/shank boots will be worn while onsite. A TLD badge must be worn if issued to employee.

Level C will include a full-face air purifying respirators (APR) with organic vapor cartridges (GMC-H).

Safety equipment and materials will include:

- First-aid kit
- Portable eyewash/shower
- A,B,C 20-lb fire extinguisher
- Blanket or stretcher
- Wind direction indicator
- Outdoor thermometer

4.3 Monitoring Equipment and Procedures

4.3.1 HNu With 10.2 eV Probe

Background readings will be obtained at an upwind location. Record HNu readings in the breathing zone upon initiating site work. Readings should be recorded at least every 1/2 hour during field activities. For an upgrade to be warranted, sustained readings in the breathing zone must be obtained. Spikes on the HNu above the action level do not call for an upgrade.

Action Levels: (Breathing Zone)

- Zero to 5 ppm above background--continue in Level D
- 5 ppm to 10 ppm above background--upgrade to Level C for the duration of operations at the specific borehole or monitoring well
- Greater than 10 ppm above background--discontinue operations and allow vapors to dissipate to below appropriate action level

4.3.2 Explosimeter/O_2 Meter

Continuous monitoring with the explosimeter is necessary in the breathing zone and at the borehole. Lead in gasoline will effect the O_2 sensor; therefore, a filter is required on the explosimeter.

Action Levels (measured at the borehole):

- Less than 5 percent LEL--Continue drilling.
- Greater than 5 to 20 percent LEL--Continue drilling with caution.
- Greater than 20 percent LEL--Shut down drilling operations and allow area to ventilate until LEL falls below 10 percent before resuming work. Mechanical ventilation (i.e., blower) may be required to reduce flammable vapors to below 20 percent. Do not place blower in atmospheres greater than 20 percent of the LEL.

- 0_2 less than 19.5 percent--shut down drilling operations and ventilate until 0_2 increases to above 19.5 percent.

4.4 Work Limitations

- No eating, drinking, or SMOKING onsite.
- No contact lenses to be worn onsite.
- No facial hair that would interfere with respirator fit.
- No spark sources within 50 feet of the excavation.

4.5 Site Entry

Locate emergency telephone numbers and route to hospital prior to starting work. Notify the facility of your presence at the site and your field plans. Prior to work onsite, the SSC must conduct a safety briefing with field personnel. This shall include informing them of the hazards associated with site work and the chemicals anticipated.

Set up decontamination area upwind of boring locations. The decontamination area should be a sufficient distance from the excavation or boring work so that the decon area will not become contaminated by splashing water or flying dirt. It is anticipated work will start in Level D, but be prepared to upgrade or leave the site.

4.6 Decontamination

Personnel Decontamination Procedures: Wash boots and outer gloves in TSP or appropriate detergent and water, rinse, and remove outer gloves; remove and bag coveralls; if cotton coveralls are used, bag in plastic bags and wash prior to rewearing; remove respirator, if worn; remove inner gloves and dispose in a plastic trash bag; wash hands and face; sanitize respirator nightly, if used; take a shower and wash hair as soon as possible after leaving the site.

Equipment Needed: Buckets, TSP or appropriate detergent, cleaner-sanitizer, brushes, garbage bags, hand soap, and paper towels.

For Sampling Equipment: The following procedure will be used following sampling activities:

- Wash sampling tool with laboratory grade detergent
- Rinse twice with potable water
- Rinse with 0.1N HNO_3
- Rinse with deionized water
- Dry
- Wrap with 0.1N HNO_3 - cleaned aluminum foil

For Heavy Equipment: Wash off the bucket of the backhoe or the drilling equipment with TSP or appropriate detergent and water; rinse in water. Use the HNu to monitor the backhoe or drilling equipment. If HNu readings are detected from the equipment, steam clean it prior to removing it from the site.

It is the responsibility of the SSC to make sure all pieces of equipment are properly decontaminated according to the procedures outlined above. Documentation of decontamination must be made in the field log notebook that will then become part of the permanent project file.

4.7 Disposal of Materials Generated Onsite

Contain in a secure area. Follow the client instructions for disposal of water and personnel protection equipment.

5.0 EMERGENCY INFORMATION

Form 311, Emergency Information, will be posted onsite.

If an injury occurs onsite, take the following action:

- o Stabilize injured person and follow decontamination procedures as much as practical.
- o Get medical attention for the injured person immediately.
- o Depending on the type and severity of the injury, notify the occupational physician for the injured person.
- o Notify Carl Wilson of JEG/Pasadena at 818/449-2171.
- o Fill out Form 306, CH2M HILL Accident Report (attached). Submit form to Beth Brown/ WDC and Marty Methamel/WDC.

5.1 Emergency Routes and Telephone Numbers (map to be posted)

o	Officer-In-Charge	619/437-9421
o	Police	911 or 619/565-5200 (offbase) 619/437-9428 (onbase)

o	Fire	**911** or 619/423-8222 (offbase) 619/437-9436 (onbase)
o	Ambulance	**911**
o	Client Contact	Jeff Kidwell, Navy RPM 619/532-3152
o	General Hospital	Paradise Valley Hospital 2400 East 4th Street National City, California 619/470-6311
	Directions to Hospital:	Exit Outlying Landing Field through main gate. Turn left (north) on 13th Street. Travel to Palm Avenue. Turn right (east) on Palm Avenue to Interstate 5. Travel north on Interstate 5 to Plaza Boulevard east, east on Plaza to Euclid Avenue, north on Euclid to hospital (see attached map).
o	CHEMTREC	800/424-9300
o	TSCA Hotline	202/554-1404
o	CDC	404/452-4100
o	National Response Center	800/424-8802

o	EPA ERT Emergency	201/321-6660
o	RCRA Hotline	800/424-9346
o	Bureau of Explosions	202/835-9500
o	Utilities	

Naval PWC Duty Desk:

7:00 a.m. to 3:30 p.m.	619/556-8189
3:30 p.m. to 11:30 p.m.	619/556-7341
11:30 p.m. to 7:00 a.m.	619/556-7349
San Diego Gas and Electric	619/239-7511

5.2 Emergency Contacts

Marty Methamel, Director of Health and Safety

Phone: 703/471-6405

Project Manager

Name: Robert York

Phone: 714/250-5500 x309

Workmen's Compensation

Name: Beth Brown, CH2M HILL/DEN

Phone: 303/771-0952

If an injury occurs onsite, please notify Beth Brown as soon as possible after obtaining medical attention for the injured. Notification must be made within 24 hours of the injury.

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SOURCE: MAP FROM THOMAS BROS. MAPS, 1987.

FIGURE B-1
HOSPITAL LOCATION
OUTLYING LANDING FIELD
IMPERIAL BEACH, CALIFORNIA

CH2M HILL

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6.0 HEALTH AND SAFETY SITE MEETING

We the undersigned have read this Site Safety Plan and fully understand its contents and will adhere to procedures set forth in this document.

Name	Affiliation	Title	Date

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Appendix C

JACOBS FIELD STANDARD OPERATING PROCEDURES

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STANDARD OPERATING PROCEDURE

Section No. 12.0

FIELD MEASUREMENT OF TEMPERATURE

By

JACOBS ENGINEERING GROUP INC.

SECTION 12.0

FIELD MEASUREMENT OF TEMPERATURE

INTRODUCTION

Temperature readings are used in the calculation of various forms of alkalinity, in studies of saturation and stability with respect to calcium carbonate, in the calculation of salinity, and in general laboratory operations.

EVALUATION

Normally, temperature measurements may be made with any good mercury-filled celsius thermometer. At a minimum, the thermometer should have a scale marked for every .1 degree celsius, with markings etched on the capillary glass. The thermometer should have a minimal thermal capacity to permit rapid equillibration. Periodically, check the thermometer against a precision thermometer certified by the National Bureau of Standards that is used with its certificate and correction chart. For field operations, use a thermometer having a metal case to prevent breakage.

CALIBRATION

Calibrate any temperature measurement devices with a National Bureau of Standards certified thermometer before field use. Make readings with the thermometer or device immersed in water long enough to permit complete equillibration. Report results to the nearest 0. 1 or 1 .0 degree celsius depending on need.

MEASUREMENT/SAMPLE PLAN

Measure temperature downhole or in a small flowthrough cell, if possible. Record measurements periodically throughout the time of pumping.

STANDARD OPERATING PROCEDURE

Section No. 13.0

FIELD MEASUREMENT OF pH

By

JACOBS ENGINEERING GROUP INC.

SECTION 13.0

FIELD MEASUREMENT OF pH

INTRODUCTION

Perhaps no water quality parameter is measured as frequently as pH. The measurement is so easily made that the attention given it is often inadequate. This is unfortunate since an accurate pH is critical for the prediction and interpretation of the reactions and migration of dissolved species. This procedure is designed to provide a useful pH measurement under most field situations. Conditions under which accurate measurements cannot be made are also described.

EVALUATION

Available Equipment

There are numerous adequate pH meters available. Meters used in remedial action programs should have temperature and slope adjustment and a repeatability of ±0.01. There is nothing to be gained by purchasing an instrument that exceeds this precision since that would also exceed the accuracy of the calibration.

pH meters for field use should be of rugged construction. A foam-lined carrying case is convenient both for travel and for use as a work table. Battery operation with easy replacement and/or recharge of batteries is required.

Combination pH electrodes are recommended for field use. Although more expensive than a simple glass and reference electrode pair, convenience of use easily outweighs the additional cost. Always carry a spare electrode and and keep both the spare and working electrode immersed in pH 4 or pH 7 buffer when not in use.

Measurement Problems

Temperature, atmospheric contamination, and ionic strength are factors that affect pH measurements; the presence of color, turbidity, or colloids will not affect pH measurements.

Temperature - The temperature compensation on a pH meter only permits adjustment of the electrode slope. It does not compensate for changes in the potential of the reference electrode, the asymmetry potential of the glass electrode, or the liquid junction potential. Nor does it compensate for changes in pH due to temperature. Figure 13-1 demonstrates this temperature effect on pH. Thus, the temperatue of the buffer and the unknown must be recorded at the time of measurement. Ideally, their temperature will be within 2°C.

Atmospheric Contamination - Atmospheric contamination can be a significant problem for groundwater samples. Dissolved oxygen and carbon dioxide can be evolved or dissolved when the sample is exposed to air. A considerable change in pH may result. For best results, a groundwater sample is pumped through a closed container in which pH and temperature probes are immersed. The measurements are not recorded until both temperature and pH have stabilized. The sampling pump should be stopped prior to recording the data because a streaming potential results with flowing samples.

Ionic Strength - Because of errors due to ionic strength (which are not worth correcting in the field), pH measurements should be accompanied by a measurement of the specific conductance. pH is a measure of the hydrogen ion activity. An ideal solution is assumed in which other ions do not affect the hydrogen activity. This assumption deteriorates if the ionic strength is too high. Some remedial action investigations include sampling waste ponds or other highly contaminated water. Since buffer solutions used in the field are not made with a similar concentration of dissolved ion the pH measurement will be inaccurate. Similarly, samples with very low ionic strength will cause difficulties because the resistance or the sample approaches that of the glass electrode. For best results, samples with very low ionic strength should be stirred for a few seconds prior to the reading. Even then, it may require several minutes for the reading to stabilize.

High sodium and alkalinity may also produce errors in the pH measurement. For pH >9 and a sodium concentration of 10 moles/liter, a special electrode is needed. One can be purchased from any of the principal electrode manufacturers. Similarly, any pH value that is less than 1 or greater than 9 will have a greater uncertainty associated with it because the electrode response is non-Nernstian in these regions.

APPARATUS

The following apparatus are recommended for the field measurement of pH:

- pH meter with repeatability of ±0.01
- Buffer solutions of pH 4.0, 7.0, 10.0
- Combination pH electrode
- Reference electrode filling solution
- Electrode holder
- Thermometer
- Distilled water and wash bottle
- Disposable beakers

CALIBRATION

Standards

Commercially prepared buffer solutions are used for calibration. Solutions traceable to the National Bureau of Standards can be purchased inexpensively from any major laboratory supply house. These solutions are certified with an accuracy of ±0.01 pH units at a specific temperature, usually 25°C.

Procedure

There are many adequate pH meters available. Since these use a variety of terms (balance, calibrate slope, standardize) to desribe the calibration process, it is not practical to list a detailed set of instructions that applies to each type of instrument. The user must be familiar with the manufacturer's instructions for the particular instrument. The following general guidelines should be followed for calibration of any pH meter:

1. Calibrate the meter with two buffer solutions. (The slope cannot be adjusted with a one-point calibration. The slope check is the best way to determine if the electrodes are in working order.
2. The two buffers used or calibration should bracket the anticipated pH of the unknown. For an anticipated pH of 6, calibrate with pH 4 and 7 buffers; for an anticipated pH of 8, calibrate with pH 7 and pH 10.
3. Ensure that the buffers are at the same temperature.

4. Adjust the instrument to read the pH 7 buffer accurately. Remember to take into account variations in pH caused by temperature. Adjust temperature compensator according to the manufacturer's instructions.
5. Read the second buffer. Adjust slope to obtain the correct reading. If the slope deviates greatly from its theoretical value, check for defective electrode or contaminated buffer solution.

Theoretically, buffer solutions are stable indefinitely. However, they are susceptible to contamination. Hence, old, partially full bottles are often contaminated and should be replaced.

MEASUREMENT/SAMPLE PLAN

Samples should not be filtered prior to analysis. A submersible pump or bladder pump is preferred for obtaining groundwater samples because degassing of the sample is minimized. The pH measurement must be made in the field.

Measurement Procedure

These steps should be followed for the field measurement of pH:

1. Calibrate the instrument according to the manufacturer's instructions and the guidelines provided in this S.O.P.
2. Set temperature compensation to the temperature of the sample.
3. Rinse electrode with deionized water and with the sample. Immerse electrode in the solution, and record the value. If the sample is being pumped through a closed container, wait for temperature and pH to stabilize. Stop sample flow to prevent the streaming potential and record the pH.

DATA REDUCTION

Field measurements of pH are ordinarily recorded to ±0.1 pH unit. The variety of possible errors makes more accurate measurements very difficult. All field measurements of pH should be recorded with the temperatures of the buffer and sample and the specific conductance of the sample. The pH measurement cannot be safely interpreted without this information.

MODELING CONSIDERATIONS

Extraordinary precautions may be needed if the data are to be used for modeling purposes. Langmuir (1971) states that "with proper care, pH may be determined with a reproducibility of about ±0.02 units and an accuracy of ±0.05 units in the feld." To accomplish this, the buffers should be bathed in water bath of the sample until the temperatures have equilibrated. This can be done with a flow-through cell. Test tubes containing buffer are placed in cell so that sample can flow around them. Once the buffers are at the sample temperature, proceed with the calibration and measurement procedures.

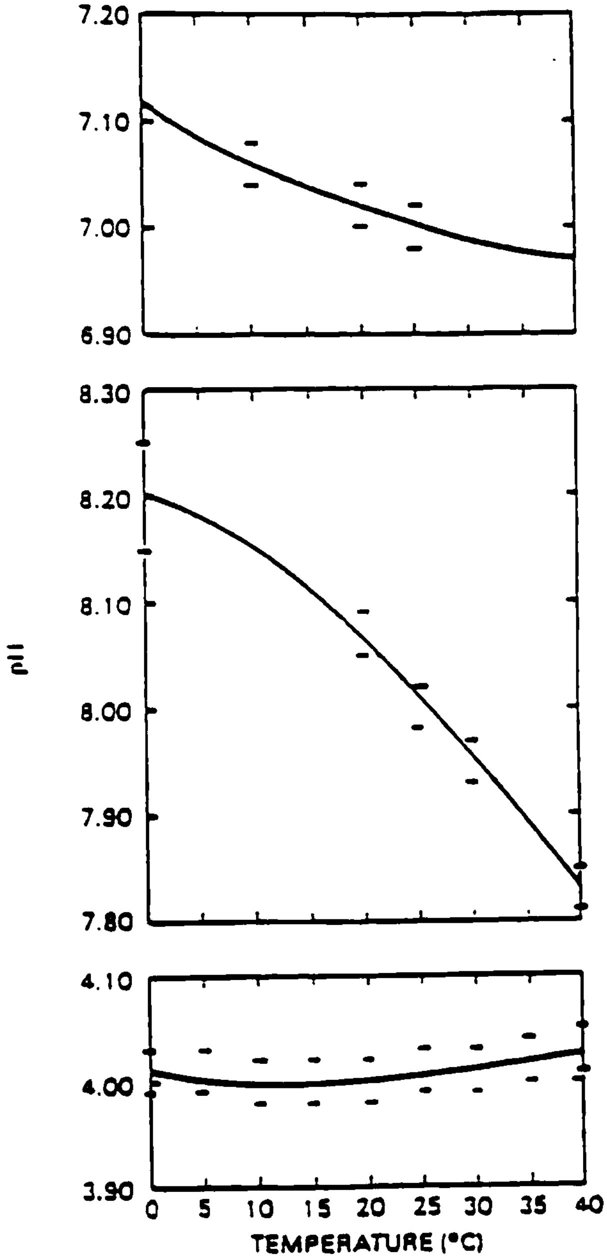
There are circumstances under which a measurement of ±0.02 repeatability and ±0.05 accuracy cannot be made. For example, the electrode response will not be stable for poorly buffered samples. In addition, if the ambient temperature is very different from the sample temperature, it will be difficult to maintain a constant temperature.

QUALITY ASSURANCE

The following information about the field measurement of pH must be logged for quality assurance documentation:

- Time when the two-buffer calibration was last performed. The two-buffer calibration should be performed at each sample site or once each hour.
- Buffer temperature at time of calibration.
- Sample temperature at time of measurement.
- Specific conductance of sample.
- Measurement conditions, i.e., in situ, open container, or air-exclusion container.

FIGURE 13-1
pH of Buffer Solutions as a Function of Temperature



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By

JACOBS ENGINEERING GROUP INC.

5. Large changes in the cell constant are generally an indication that the electrodes are dirty. Cleaning and replatinizing instructions can be found in the instrument manual or in the ASTM Annual Book of Standards.

6. Once the cell constant is checked, measurements can be made on unknown samples.

MEASUREMENT/SAMPLE PLAN

Samples should not be filtered prior to analysis. A submersible pump or bladder pump is preferred for obtaining groundwater samples because degassing of the sample is minimized. The specific conductance measurement must be made in the field.

MEASUREMENT PROCEDURE

Recommended measurement procedure steps are listed below:

1. Calibrate the instrument and check the cell constant according to the manufacturer's instructions and the guidelines provided in this S.O.P.

2. Measure and record temperature of sample.

3. Immerse probe into sample and record reading. (Note that probe should not be within several inches of large rocks because they can bias the reading.) Multiply sample reading by the cell constant to obtain the sample specific conductance. EC = (cell constant) (instrument reading in umhos).

DATA REDUCTION

The number of significant figures reported depends upon the range setting for the measurement. Usually only two significant figures are reported. For example, values of 760 or 1100 are appropriate, whereas 757 and 1130 are not.

QUALITY ASSURANCE

The following information about the field measurement of specific conductance must be logged for quality assurance documentation:

- Source of standard
- Preparation date of standard
- Time of analysis
- Time of last calibration check
- Standard temperature reading and cell constant
- Sample temperature and reading

STANDARD OPERATING PROCEDURE

Section No. 15.0

FIELD MEASUREMENT OF ORGANIC VAPORS

By

JACOBS ENGINEERING GROUP INC.

SECTION 14.0

FIELD MEASUREMENT OF SPECIFIC CONDUCTANCE

INTRODUCTION

Specific conductance is a widely used indicator of groundwater quality. It is a simple indicator of change within a system and provides useful information to lab analysts performing other measurements on the sample. The measurement is comprehensible even to the layman and is, therefore, a useful tool for studying water contamination.

EVALUATION

Available Equipment

There are numerous adequate specific conductance meters available. Any meter used in remedial action programs should also measure temperature, be equipped with temperature compensator, and read directly in umhos/cm corrected to 25°C. The probe-type unit, rather than the pipet type, is preferable for field use because it is more rugged. A relative accuracy of ±3 percent is adequate for the type of measurement being performed.

The meter should be of rugged construction. A foam-lined carrying case is essential. Battery operation with easy recharge and/or replacement of batteries is required.

Measurement Problems

The principal problem areas for specific conductance measurements are the temperature effect, determination of the cell constant, and allowance for very high ionic strengths. A change in temperature of 10°C can be assumed to cause an approximately 20 percent change in the measured specific conductance. Generally, reported data do not note whether the temperature correction has been applied. Some instruments perform the temperature compensation automatically, but this, too, is seldom noted in reported data. To ensure uniformity of readings, the data should be corrected to 25°C.

Field personnel are frequently not aware of the cell constant used in specific conductance measurements. A significant change in the cell constant indicates that the electrodes require cleaning or replatinizing. Thus, it is very important that the constant be checked with each calibration.

Specific conductance varies linearly with ion concentration up to a specific conductance of about 5,000 umhos/cm (National Handbook of Recommended Methods for Water Data Acquisition, 1977). Relative measurements are useful up to about 50,000 umhos/cm.Samples collected at remedial action program sites seldom have a specific conductance greater than 10,000 umhos/cm; most are less than 5,000 umhos/cm.

APPARATUS

The following apparatus are needed for the field measurement of specific conductance:

- Specific conductance meter with temperature measurement and compensation
- Distilled water and wash bottle
- Disposable beakers

CALIBRATION

Standards

Reagent-grade potassium chloride (KCl) is universally used for the standardization of specific conductance equipment. Purer grades of KCl are available but are not worth the additional expense because of the errors already inherent in the measurement.

Standard solutions are made up to O.OO1N, O.O1N, O.1N, or IN KCl. A concentration of O.O1N is used for most work because its specific conductance is closest to most natural samples.

Procedure

The instrument's measuring circuit is calibrated either by the manufacturer or with a calibrating resistor. The manufacturer's instructions should be followed for this step because they will be specific for the particular instrument.

The electrodes are calibrated by reading the specific conductance of standard KCl solutions. Individual manufacturers may use slightly different terminology, but the following general guidelines will always apply:

1. Prepare 0.01N KCl by dissolving 0.745 g of pure, dry KCl in 1 liter of deionized water.

2. Measure the temperature of the standard solution and the water used for the dilution. They should be at the same temperature.

3. Use Table 14-1 to determine the expected specific conductance or the 0.01N KCl at that temperature.

4. Measure the specific conductance of the water (C_2) and of the 0.01N KCl solutio (C_1) These readings can be used to check the cell constant that was specified by the manufacturer using the equation

$$K = \frac{C_T + C_2}{10^6 \times C_1} \qquad (14.1)$$

where C is the theoretical conductance of the standard solution (from Table 14.1).

Table 14-1. Relationship of Temperature and Specific Conductance for 0.01N Potassium Chloride

Temperature (°C)	Specific Conductance (umhos/cm)
15	1141.5
16	1161.5
17	1193.6
18	1219.9
19	1246.4
20	1273.0
21	1299.7
22	1326.6
23	1353.6
24	1380.8
25	1408.1
26	1436.5
27	1463.2
28	1490.9
29	1518.7
30	1546.7

SECTION 15.0

FIELD MEASUREMENT OF ORGANIC VAPORS

INTRODUCTION

The rapid detection of volatile organic compounds at hazardous waste sites during sampling, cleanup and remedial investigations allows onsite analytical screening of air, water, sediment, and soils. These measurements can then be used to set levels of protection, evaluate risk/exposure while performing site activities, and as a basis for setting health and safety levels of protection.

Field measurement of volatile organic vapors will be achieved using one or more of the following instruments:

- Hnu Photoionization Detector (PID), Model PI-101
  Photovac Tip (PID)
- Century Systems Organic Vapor Analyzer (OVA)
  (Flame Ionization Detector (FID))
- Combustible Gas Indicator
- Oxygen Meters
- Direct - Reading Colorimetric Indicator Tubes
- Photovac Gas Chromatograph
- Field - Operable Laboratory - Grade Gas Chromatograph

Each instrument listed above is briefly described below:

Photoionization Detector (PID)

There are numerous portable organic vapor meters currently available which utilize the principle of photoionization. Jacobs commonly utilizes an Hnu PID; Model PI-101, which is extremely easy to operate. Other instruments such as the Photovac Tip PID may also be used. Each of these instruments are portable, non-specific vapor/gas detectors employing the principle of photoionization to detect a wide variety of organic and inorganic chemical compounds.

<u>Hnu Photoionization Detector Measurement Problems/Instrument Limitations</u>

- The Hnu PID will provide performance to 95% relative humidity and to 40°C. The instrument is temperature-compensated so that a 20°C change in temperature corresponds to a change in reading of <2% full scale at maximum sensitivity. Elevated water vapor concentrations will fowl the PID and may result in a negative or erroneous reading.

- The instrument will operate in continuous use for up to 10 hours before requiring battery recharging.

- The Hnu is approved for Group I Division II, Class A,B,C and D operating environments (except when operated from an external power source or while using recorder).

- A small DC-operated fan is used to pull air through the photoionization sensor at a flow rate of 300 to 700 cm^3 per minute. The fan provides nearly instantaneous response times while consuming little power. However, characteristics of the fan are such that it cannot tolerate a significant pressure drop without affecting the flow rate and, therefore, either the instrument reading or response time. Because photoionization is essentially a nondestructive technique, changes in flow rate do not affect the signal but, if a large pressure drop is imposed at the inlet of the probe, the sample may not reach the sensor.

- The response to a gas or vapor may radically change when the gas or vapor is mixed with other materials. As an example, a Hnu calibrated to ammonia and analyzing an atmosphere containing 100 ppm would indicate 100 on the meter. Likewise, a unit calibrated to benzene would record 100 in an atmosphere containing 100 ppm concentration. However, in an atmosphere containing 100 ppm of each, the unit could indicate considerably less or more than 200 ppm, depending on how it was calibrated.

- The lamp window must be periodically cleaned to ensure ionization of the air containments.

- The instrument was designed to measure trace gases over a concentration range from less than 1 ppm to 2000 ppm. Higher levels of various gases (to percentage range) can be measured but the recommended procedure is to dilute the sample with clean air to a concentration of less than 500 ppm. This is generally within the linear range of the instrument and, if the concentration is multiplied by the dilution ratio, the correct concentration in the stream can be determined.

- If the probe is held close to AC power lines or power transformers, an error may be observed. For measurements made in close proximity to such items, their effect on measurements can be determined by the following procedure. Zero the instrument in an electrically quiet area, in the standby position, then move the instrument to the questionable area involved. If AC pickup is going to be a problem, the meter (in the standby position) will indicate the magnitude of the error.

Equipment

The following equipment is recommended for field measurement of volatile organic vapors using the Hnu:

- Hnu Model PI 101 photoionizer
- Hnu 10.2 eV probe assembly
- Span gas calibration standard (benzene)
- AC-battery recharging unit

Calibration

Standards

Commercially prepared standard span gases are available from HNU Systems, Inc. The choice of standards is dependent on the monitoring requirements for the actual chemical compounds at facility.

Procedures

Remove the top section of the instrument by opening the two fasteners on the cover. The inner panel of the top section can be removed by pulling out on the fasteners.

Before attaching the probe, check the function switch on the control panel to make sure it is in the "off" position. The 12-pin interface connector for the probe is located just below the span adjustment on the face of the instrument. Carefully, match the alignment key in the probe connector to the 12-pin connector on the control panel and then twist the probe connector until a distinct snap and lock is felt. Do not force it.

Turn the function switch to the "battery check" position. The needle on the meter should read within or above the green battery arc on the scaleplate. If the needle is in the lower portion of the battery arc, the instrument should be recharged before making any measurements. <u>If red LED comes on, the battery should be recharged.</u>

Turn the function switch to the "on" position. In this position the ultraviolet light source should be on. Look into the end of the probe to see the purple glow of the lamp.

To zero the instrument, turn the function switch to the "standby position" and rotate the zero potentiometer until the meter reads zero. Clockwise rotation of the zero potentiometer produces an upscale deflection while counterclockwise rotation yields a downscale deflection. No zero gas is needed because this is an electronic zero adjustment. If the span adjustment setting is changed after the zero is set, the zero should be rechecked and adjusted, if necessary. Wait 15 or 20 seconds to ensure that the zero reading is stable. If necessary, readjust the zero.

The instrument is now ready for calibration of measurement by switching the function switch to the proper measurement range. The instrument is calibrated to read directly in ppm (v/v) 0-20, 0-200, 0-2000 of benzene with the span position set at 9.8.

A rapid procedure for calibration involves bringing the probe and readout in close proximity to the calibration gas, cracking the valve on the tank, and checking the instrument reading. This provides a useful spot check for the instrument.

The recommended and most accurate procedure for calibration of the instrument from a pressurized container is to connect one side of a "T" to the pressurized container of calibration gas, another side of the "T" to a rotameter, and third side of the "T" directly to the 8" extension to the photoionization probe. Crack the valve of the pressurized container until a slight flow is indicated on the rotameter. The instrument draws in the volume of sample required for detection, and the flow in the rotameter indicates an excess of sample. Now adjust the span pot so that the instrument is reading the exact value of the calibration gas. (If the instrument span setting is changed, the instrument should be turned back to the standby position and the electronic zero should be readjusted, if necessary.)

Measurement/Operations

Instrument control functions for the Hnu PID are described below:

Control	Function	
Six-Position Switch	OFF	Shuts off all power and removes DC voltages.
	ON	In any other function position or measuring mode, the electronics are on.
	BATTERY	Indicates the condition of the battery. If needle position is in the lower portion of the green battery arc, the instrument should be recharged.
	STANDBY	UV lamp is off but electronics are on. This position will conserve power and extend the useful operating time between recharges of the battery. This position is also used to adjust the electronic zero.
	RANGES	0-20, 0-200, 0-2000 direct reading ranges available at minimum gain for benzene. More sensitivity is available by adjusting the span potentiometer.
Zero Potentiometer		A 10-turn potentiometer is used to adjust the zero electronically when the instrument is placed in the standby position with the probe attached. This eliminates the need for hydrocarbon-free gas.
Span Potentiometer		A 10-turn counting potentiometer is used for upscale setting of the meter or to calibrate gases. Counterclockwise rotation increases the sensitivity (about 10 times) and can increase the sensitivity to make the instrument give a direct reading for nearly any gas that the instrument responds to.

After performance of the calibration procedure (6.4.2) the Hnu is ready for operation.

For additional sensitivity, the span potentiometer is turned counterclockwise (smaller numbers) to increase the gain. By changing the span setting from 10 to 1, the sensitivity is increased approximately tenfold. Then, the 0-20, 0-200, and 0-2000 ppm scales become 0-2, 0-20, and 0-200 ppm fullscale.

This span control is also used to make the instrument scale read directly in ppm of the compound being measured (it is adjusted to match the value of a calibration gas to that same reading on the instrument scale). The span control can be used to calibrate nearly any compound measured by photoionization to be a direct reading on the 0-20 ppm range. For example, gain settings of 4.5 or 8.9 will provide direct reading capability of 0-20 and 0-200 ppm for vinyl chloride and trichloroethylene.

The Hnu is a good choice to determine the proper level of the protection in evaluating a hazardous waste site or spill. The need to properly interpret the Hnu's data cannot be overemphasized. Equally important is the need to understand the limitations of this instrument.

One particularly important limitation for on-site use is how the Hnu responds toward mixtures containing chemicals with very similar IP's. In a typical industrial plant, usually only one gas or vapor must be measured in a specific setting. This is relatively simple for the Hnu, and interferences and complications rarely exist. As a rule, the Hnu is more sensitive to complex compounds. Measured on a scale of 1 to 10, the Hnu responds to:

> Aromatics (e.g., benzene, toluene, xylene) and aliphatic amine hydrocarbons: 10
>
> Unsaturated chlorinated hydrocarbons (e.g., trichloroethylene, dichloroethylene): 5-9
>
> Unsaturated hydrocarbons (e.g., propylene): 3-5
>
> Paraffinic hydrocarbons with 5 to 7 carbons (e.g., hexane, heptane): 1-3
>
> Ammonian and paraffinic hydrocarbons with 1 to 4 carbons (e.g., ethane, propane): less than 1.

To compensate for this lack of sensitivity, the Hnu incorporates a span pot (potentiometer), which varies the gain on the amplifier. In the full clockwise (CW) position at level 9.8, the Hnu indicates the approximate air concentration of all chemicals with a sensitivity of 10 for example, aromatic hydrocarbons. In full counterclockwise (CCW) position at level 0, it indicates the approximate concentration of ammonia or paraffinic hydrocarbons. With the span pot positioned at any intermediate point, Hnu indicates the approximate air concentration of the chemical whose sensitivity corresponds to that level.

When the span pot is set at 0 (fully CCW) and the function switch to the 0-20 range, the scale on the meter face reads 0-2 ppm. This expansion, which is valid only for materials that have a relative sensitivity of 10, allows measurements in the parts-per-billion range (ppb).

In most circumstances, using the Hnu on the lowest setting (span pot 9.8, function switch 0-20) provides adequate data to select the proper protection (Levels A, B, C, D) for on-site workers. Unfortunately, several chemicals - for example, acrolein - exhibit medium to low sensitivity (0-5), while their toxicological effects place their threshold limit value (TLV) at a very low level. If these chemicals are indicated by the Hnu (on its lowest setting) response could select too low a protection level. Consider this scenario:

> The air in an unknown hazardous environment must be sampled. Response personnel survey the site with an Hnu, which indicates 2.0 ppm (instrument set to highest sensitivity). Level C protection may be worn based upon the instrument's data. Later, the air contaminant is found to be acrolein with a TLV of 0.1 ppm (100 ppb) and an immediate dangerous to life or health (IDLH) level of 5 ppm.

This total reliance to the Hnu data without regard for the chemical makeup of the sample can be a problem.

Quality Assurance

The following calibration and operation information must be logged in the field notebook for quality assurance documentation:

- Instrument model and serial number
- Date
- Calibration gas concentration
- Initial span setting

- Actual reading
- Comments, i.e. adjustments, cleaning requirements.

PHOTOVAC TIP I

The PHOTOVAC TIP I (TIP) is applicable to the detection of volatile organic compounds (VOC) to 0.1 ppm in vapor samples.

Soil gas VOC content is measured from the gas photoionization capacity. Air is continuously sampled by the TIP's air suction pump into the ionization chamber. Instrument readings provide overall volatile content.

Measurement Problems/Limitations

The TIP does not distinguish between different pollutants, but rather provides a composite of the total ionizables present, hence the instrument's T.I.P acronym. Instrument readings may be reported as equivalent to the specific compound used for calibration.

Equipment

The TIP packs all necessary components in a single flashlight-sized casing, weighing about three pounds, and including nozzle, filter, air pump, ionization chamber, UV lamp, electrometer, LCD window, zero/span controls, power switch, and battery pack with external connections to 12 volt DC power or recharge capability.

TIP accessories include a headset, 1/4-inch ID teflon tubing, a Tedlar bag, and a Span Gas tank. The Tedlar bag has a one-liter capacity and is fitted with a quick fill valve and septum sampling port. The Span Gas is isobutylene. Accessory items may be used for sample collection and analysis, or in the preparation of calibration standards.

Calibration

The TIP is used as a direct-reading instrument in conjunction with the Span Kit (Part No. TA103). Calibration of the instrument will proceed as follows:

- Press POWER switch to turn on the TIP.

- Unlock ZERO and SPAN controls by turning locking rings clockwise.
- Set SPAN control to 5.
- Allow the TIP to sample clean air.
- Adjust ZERO control until LCD reads 0.00.
- Connect bag of Span Gas to the TIP inlet.
- Adjust SPAN control until LCD indicates the Span Gas concentration (nominal -- 100 ppm isobutylene (2-methyl-1-propene)). Disconnect Span Gas bag.
- Sample clean air again and readjust ZERO control until LCD reads 0.00, if necessary.
- Lock SPAN control by turning locking ring counterclockwise. Disconnect Span Gas bag.
- Observe sample concentration changes on LCD. Concentration of total ionizables is displayed in Span Gas equivalent units.
- Do not allow the TIP to draw in any liquid.
- Press POWER switch after use to turn off the TIP.

Measurement/Operations

For the following steps refer to Figure 3.3 Pictorial Diagram in the TIP User's Manual for the position controls.

- Press POWER switch to turn on the TIP.
- Unlock ZERO and SPAN controls by turning the locking rings clockwise.
- Set SPAN control to 5.
- Lock SPAN control by turning locking ring counterclockwise.

- Allow the TIP sample clean air.
- Adjust ZERO control until liquid crystal display (LCD) reads 0.00.
- Lock ZERO control by turning locking ring <u>counterclockwise</u> - confirm that zero reading is unchanged.
- Connect the TIP nozzle to the probe with the Teflon tubing.
- Observe sample concentration changes on LCD display, or hear the changes in frequency using the headset connected to the TIP. Record concentration when stable readings are obtained.
- Do not allow TIP to draw in any liquid.
- Press POWER switch after use to turn off the TIP.

<u>Quality Assurance</u>

- Duplicate sample analyses are performed for each 10 sample analyses after a 5-minute minimum resting period. Results of duplicate analyses are properly recorded in the daily logs. A minimum of one duplicate analysis per day is required.
- Blank sample analyses are performed for each 10 sample analyses after a 5-minute minimum resting period. Results of blank sample analyses are properly recorded in the daily log. A minimum of one blank analysis per day is required.
- Instrument calibration is required three times a day: at the beginning of the work day, in the middle of the day, and at the end of the day.

Flame Ionization Detection (FID)

The FID uses ionization as the detection method, much the same as the PID, except that the ionization is caused by a hydrogen flame, rather than by a UV light. This flame has sufficient energy to ionize any organic species with an IP of 15.4 or less. The ions are then passed between two charged plates. The conductivity change is measured, the current charge is displayed and measured, the current charge is displayed on an external meter, and read in parts per million.

Century Systems Organic Vapor Analyzer (OVA)

Measurement Problems/Instrument Limitations

As with the PID, the OVA responds differently to different compounds. Below is a list, provided by the manufacturer of the relative sensitivities of the OVA to some common organic compounds. Since the instrument is factory calibrated to methane, all relative responses are given in percent, with methane at 100.

Compound	Relative Response (%)
Methane	100
Ethane	90
Propane	64
n-Butane	61
n-Pentane	100
Ethylene	85
Acetylene	200
Benzene	150
Toluene	120
Acetone	100
Methyl ethyl ketone	80
Methyl isobutyl ketone	100
Methanol	15
Ethanol	25
Isopropyl alcohol	65
Carbon tetrachloride	10
Chloroform	70
Trichloroethylene	72
Vinyl chloride	35

Equipment

The Century Systems OVA is a portable FID unit. This package consists of two major parts:

- A 9-pound package containing the sampling pump, battery pack, support electronics, flame ionization detector, hydrogen gas cylinder, and an optional gas chromatography (GC) column.
- A hand-held meter/sampling probe assembly.

Calibration

The OVA is typically calibrated using a methane gas standard of known concentration. Calibration gas standards are available from the manufacturer. Results of sample analysis are typically reported as methane equivalents or converted to specific compound concentrations based on a percent response basis as provided by tables supplied by the manufacturer.

If the OVA is operated in the GC mode, specific calibration gas standards are used. Identification and quantification of specific compounds is performed by direct comparison to specific calibration standards.

Measurement/Operations

The OVA can operate in two modes:

- Survey mode: A sample of ambient air is routed through the OVA into the detector, allowing all organic species to be ionized and detected at the same time. Based on the sensitivity of the instrument to various compounds, a concentration is displayed on the meter. The OVA is calibrated to methane.
- Gas chromatography mode: Gas chromatography (GC) is a technique for separating volatile substances by percolating a gas stream over a stationary phase. The components to be separated are carried through a column packed with an inert solid. A liquid is spread as a thin film over this solid and is the basis for separation. The different components of the sample migrate through the column at different rates. The component bands then leave the column and are measured by the detector. In this fashion, individual components of the ambient atmosphere may be analyzed. More complete instructions on the use of the Century Systems OVA can be found in the owner's manual.

Quality Assurance

Quality assurance for use of the OVA is similar to that of the Hnu and the Photovac Tip I. However, if the OVA is used in the chromatographic mode, calibration must be achieved using gas/vapor standards of known quality and as approved by the site QA officer. Certified gas/vapor standards may be obtained through certified or approved vendors as necessary for identification or quantification of specific VOCs.

Combustible Gas Indicator

A combustible gas indicator consists of three primary components; the sensor (hotwire, catalytic, solid state, etc.), signal processor and readout display. A sample is introduced to the sensor either by diffusion into a passive sensor or by pumping. The sensor produces a signal which is processed and displayed as the ratio of the combustible gas present to the total required to reach the lower explosion limit (LEL).

The lower explosive limit (also LFL, lower flammability limit) is defined as the lowest concentration of gas or vapor in air which can be ignited by an ignition source and cause an explosion or flame propagation. Conversely, the upper explosive limit or UEL (also UFL, upper flammability limit) is the concentration of gas in air above which there is insufficient oxygen available to support combustion, and an explosion is unlikely. A flame, however, may burn at the gas-air interface or, should additional air enter the mixture, a very explosive atmosphere develop. In general, the instruments respond in the following manner.

- The meter indicates 0.5 LEL (50 percent). This means that 50 percent of the concentration of combustible gas needed to reach an unstable combustible situation is present. If the LEL of the gas is 5 percent in air, then the instrument indicates a 2.5 percent mixture is present.
- The meter needle stays above 1.0 LEL (100 percent). This means that the concentration of combustible gas is greater than the LEL and less than the UEL and, therefore, immediately combustible and explosive.
- The meter needle rises above the 1.0 (100 percent) mark and then returns to zero. This indicates the ambient atmosphere has a combustible gas concentration greater than the UEL.

Measurement Problems/Instrument Limitation

Of the many instruments commercially available for detecting combustible or explosive gas, some are not certified safe for operation in the atmospheres they can detect. It is important to use only those monitors that are certified safe for use in atmospheres greater than 25 percent of the LEL.

Some combustible gas monitors provide readouts in units of percent LEL, some in percent combustible gasses by volume, and some have scales for both. Many situations may occur where the types of combustible gases to be encountered are unknown. In such instances the more explosive the calibration gas (the lower the LEL) the more sensitive the indication of explosivity and thus the greater the margin of safety. The operator should be familiar with the LEL concentrations for specific gases to effectively use instruments that provide data in percent combustible (by volume) only.

Calibration

Although monitors can be purchased that are factory calibrated using gases such as butane, pentane, natural gas, or petroleum vapors, methane calibration is the most common. The LEL of methane is 5 percent by volume in air, therefore, an air mixture containing 5 percent methane will be read as 100 percent LEL and will be explosive if a source of ignition is present. When combustible gases other than methane are sampled, the relative response of the detector for these other gases must be considered. Recalibration to other gases may be possible; see manufacturers recommendations. The relative sensitivity of the detector and the differences in LEL for different gases will produce varying meter responses equal concentrations of different gases. Actual correlation equations that will convert the percent LEL (based on methane) read by the unit to a percent LEL for another combustible gas can usually be found in the operating manual.

Many units also have alarm systems which can be adjusted for various LEL's and several are available that incorporate oxygen analyzers.

Measurement/Operation

In general, combustible gas detectors are used to determine the potential for combustion or explosion of unknown atmospheres. These instruments, in combination with oxygen detectors and radiation survey instrumentation, should be the first monitors used when entering a hazardous area. In this sense they provide a general indication of the degree of immediate hazard to personnel and can be used to assist the safety officer in making decisions on levels of protection required at the site. However, they provide little or no information about the presence of compounds hazardous or toxic at trace level concentrations.

1. Make sure instrument is clean and serviceable, especially sample lines and detector surfaces.

2. Check battery charge level. If in doubt, charge battery as described in operating manual. Some units have charge level meters, while others have only low charge alarms.

3. Turn unit to ON position, and allow instrument sufficient warmup time.

4. Verify that sample pump is operable (if so equipped) when analyzer is ON.

5. With the intake assembly is combustible gas-free ambient air, zero the meter by rotation the zero control until the meter reads 0 percent LEL.

6. Calibrate unit against known concentration of a calibration gas by rotating the calibration control (span or gain) until the meter reads the same concentration as the known standard. For those instruments with internal or nonadjustable span, a calibration curve should be prepared, using concentrations in the range expected to be encountered.

7. If necessary, adjust alarm setting to appropriate combustibility setting.

8. Position intake assembly or cell in close proximity to area in question to get accurate reading.

9. If alarm occurs, or if readings reach the action levels designated in the safety plan, personnel should evacuate area.

10. If instrument malfunction occurs, personnel should evacuate area.

11. Some important factors to keep in mind during use are:

- Slow sweeping motions of intake or cell assembly will help assure that problem atmospheres are not bypassed. Cover an area from floor (ground) to ceiling, or above breathing zone.
- Operation of unit in temperatures outside of recommended operating range may compromise accuracy of readings or damage the instrument.
- Platinum filament detectors may be poisoned (reduced in sensitivity) by gases such as leaded gasoline vapors (tetraethyl lead), sulphur compounds (mercaptan and hydrogen sulfide) and silicon compounds.
- Many combustible gas detectors are not designed for use in oxygen-enriched or depleted atmospheres. If this condition is encountered or suspected, personnel should evacuate the area. Specially designed units are available for operation in such atmospheres.
- An oxygen detector should always be used in conjunction with explosimeters.
- Accurate data depends on regular calibration and battery charging. See operating manual.
- More than any other factor, effective utilization of unit requires operator with full understanding of operating principles and procedures for the specific instrument in use.

SPECIFIC SURVEY INSTRUMENTS

Specific survey instruments are devices that measure a specific material. Oxygen meters and direct-reading colorimetric tubes are often used at incidents involving hazardous substances.

Oxygen Meters

The oxygen content in a confined space is of prime concern to anyone about to enter that space. Removal of oxygen by combustion, reduction reactions, or displacement by gases or vapors is a hazard that response personnel cannot detect. Consequently, remote measurements must be made before anyone enters any confined space.

Theory

An oxygen detector uses an electrochemical sensor to determine the oxygen concentration in air. The sensor consists of: two electrodes, a sensing and a counting electrode; a housing containing a basic electrolytic solution; and a semipermeable Teflon membrane.

Oxygen molecules (O_2) diffuse through the membrane into the solution. Reactions between the oxygen and the electrodes produce a minute electric current which is directly proportional to the sensor's oxygen content. The current passes through the electronic circuit. The resulting signal is shown as a needle deflection on a meter, which is usually calibrated to read 0-10%, 0-25%, or 0-100% oxygen

Limitations

The operation of oxygen meters depends on the absolute atmospheric pressure. The concentration of natural oxygen (to differentiate it from manufactured or generated oxygen) is a function of the atmospheric pressure at a given altitude.

At sea level, where the weight of the atmosphere above is the greatest, more O_2 molecules are compressed into a given volume than at higher elevations. As elevation increases, this compression decreases, resulting in fewer O_2 molecules being "squeezed" into a given volume. Consequently, an O_2 indicator calibrated at sea level and operated at an altitude of several thousand feet will falsely indicate an oxygen-deficient atmosphere (less than 19.5%).

High concentrations of carbon dioxide (CO_2) shorten the useful life of the oxygen detector cell. Therefore, the unit can be used in atmospheres greater than .05% CO_2 only with frequent replacing or rejuvenating of the oxygen detector cell.

Although several instruments can measure an oxygen-enriched atmosphere (O_2 greater than 21%), no testing or other work should ever be performed under such conditions because a spark, arc or flame could lead to fire or explosion. Oxygen measurements are most informative when paired with combustible gas measurements. Together, they provide response personnel with quick and reliable data on the hazards they may encounter.

Direct Reading Colorimetric Indicator Tubes

In evaluating hazardous waste sites, the need often arises to quickly measure a specific vapor or gas. Direct-reading colorimetric indicator tubes can successfully fill that need.

Theory

The interaction of two or more substances may result in chemical changes. This change may be as subtle as two clear liquids producing a third clear liquid, or as obvious as a colorless vapor and colored solid producing a differently colored substance. Indicator tubes use this latter phenomenon to estimate the concentration of gas or vapor in air.

Colorimetric indicator tubes consist of an impregnated glass tube with an indicating chemical. The tube is connected to a piston cylinder- or bellows-type pump. A known volume of contaminated air is pulled at the predetermined rate through the tube. The contaminant reacts with the indicator chemical in the tube, producing a stain whose length is proportional to the contaminant's concentration. A preconditioning filter may precede the substrate to:

- Remove contaminants (other than the one in question) that may interfere with the measurement.
- React with a contaminant to change it into a compound that reacts with the indicating chemical.
- Completely change a nonindicating contaminant into an indicating one.

Limitations

Several indicating chemicals may be able to measure the concentration of a particular gas or vapor, each operating on a different chemical principle and each affected in varying degrees by temperature, air volume pulled through the tube, and interfering gases or vapors. A "true" concentration versus the "measured" concentration may vary considerably among and between manufacturers. To limit these sources of error, control the numerous types and manufacturers of tubes, and provide a degree of confidence to users, the

National Institute of Occupational Safety and Health (NIDSH) tests and certifies indicator tubes. Certified tubes have an accuracy of ± 35% at 1/2 the TLV of the chemical and ± 25% at the TLV.

To improve performance on all tubes, they should be:

- Refrigerated prior to use to maintain shelf life of approximately 2 years.
- Calibrated and used at the same temperature.
- Calibrated with the pump prior to sampling (pressure test) and on a quarterly basis (volumetric test).

Undoubtedly the greatest source of error is how the operator "reads" the endpoint. The jagged edge where contaminant meets indicator chemical makes it difficult to get accurate results from this seemingly simple test. A diligent and experienced operator should be able to accurately read the endpoint.

CONCLUSION

Combined Instruments

Several instrument packages combine two or more detectors. For example, a combined hot wire detector for combustible gases and an oxygen sensor use a common pump, battery, and electronic circuit. Normally, each detector operated independently, thereby allowing one to be used even if the other is not working properly.

Combination units afford response personnel several advantages over single units, chiefly portability. Additionally, combined instruments may incorporate an adjustable alarm circuit that alerts the user to potentially hazardous conditions. This capacity frees the user of the need to take frequent meter readings and focuses attention on other hazards.

Other Useful Instruments

Several manufacturers of micro-miniature electronic circuits and fuel cells have entered the field of specific contaminant analysis. These devices analyze the ambient atmosphere for the more insidious gases and vapor, such as hydrogen sulfide and carbon monoxide. Although their use is limited, they may be useful in certain situations.

Photovac Gas Chromatograph

This instrument is applicable to the analysis of 10 to 10,000 parts per billion levels of halogenated or aromatic hydrocarbons in vapor/gas samples.

The Photovac is a portable GC/PID which uses direct injection of the vapor/gas samples. Quantitation is performed by the external standard technique; identification is based on retention time comparison to the standard material.

Measurement Problems/Limitations

- The minimum quantitation limit for TCE using a 0.8 second autoinjection (0.267 ml, calculated) is 10 ppb.
- The linear range of the method is 10 to 10,000 ppb; samples showing a TCE concentration greater than 10,000 ppb must be diluted and rerun to ensure proper quantitation.
- Any compound co-eluting with TCE will produce an erroneously high result or misidentification.
- Samples are collected in individual gas tight Tedlar bags.
- All samples are analyzed within 8 hours of collection.
- Drastic changes in temperature during collection, storage, and analysis need to be avoided to ensure sample integrity and analytical consistency.

Equipment

- Photovac model 10S50 portable gas chromatograph (GC), equipped with a photoionization detector (PID), strip chart recorder and electronic integrator.

- Analytical column - 6 inch Teflon pre-column plus 48 inch Teflon analytical column, both packed with 5% SE-30 on 100/120 mesh Chromosorb 6.
- Syringes - several, 50cc, all glass, gas tight, for preparation of standards.
- Tedlar bags - 1 liter for preparation of standards and blanks. Must have a quick fill valve and septum sampling port.
- Calibrated flow meter - for monitoring the carrier gas flow rate.

Sample Preparation

Allow standards and samples to equilibrate to room temperature prior to analysis.

Reagents

Standard(s) - certified specialty gas preparation of 9.979 ppm trichloroethylene in nitrogen, prepared by Scott Specialty Gas Company.

Calibration

- Daily Standards
  - High program standard - The certified standard (9.979 ppm) is used as-is.
  - Low program standard:

    A 200 ppb low standard is prepared fresh every other day by using an all glass syringe to add 20 ml of the certified standard to 980 ml of carrier gas in a 1 liter Tedlar bag.

    The standard is stored at room temperature. Loss during an 8 hour period is minimal, but the concentration will be lower on the second day of use. The actual concentration of the low standard is verified daily by calibration against the certified high level standard.
- Initial 3-point Calibration Standard

Program 1: Off
Program 2: On with set-up
Program 3: On with set-up

- Chart speed is set at 0.5 cm/min.

- Printer delay is set at 300 seconds.

- Analysis is 400 seconds.

- Cycle time is used with Program 1. It is set at 60 min. for overnight, 180 min. for weekends, and 12 min. for purging after contamination from a high level sample.

o Integration parameters are set up as follows:

Up-slope sensitivity	:	10 mv/sec
Down-slope sensitivity	:	15 mv/sec
Peak width @ 4 min.	:	4 sec
Window	:	± 20 sec
Minimum area	:	5 mv/sec

o Periodically check and adjust, if needed, the column flow, especially if a new column is installed.

o Replace the column as required when analytical performance deteriorates.

- The equation used to calculate the standard concentration is provided in the following example:

Where:

$$\text{ppb of TCE} = \frac{A \times B}{C + A}$$

A is the volume (ml) of certified or intermediate standard injected into the Tedlar bag.

B is the concentration of the certified or intermediate standard.

C is the volume (ml) of carrier gas used for dilution.

- Use all glass syringes to measure and inject both the standard gas and dilution gas into a clean Tedlar bag.

- The standards are prepared at the time of analysis as follows:

Concentration of Certified or Intermediate Standard (ppb)	Volume Used (ml)	Volume Dilution Gas (ml)	Final Concentration of Calibration Standard
10,000 (certified)	0	0	10,000
10,000 (certified)	100	100	5,000
10,000 (certified)	50	450	1,000*
10,000 (certified)	25	475	500*
10,000 (certified)	10	490	200
1,000 (intermediate)	20	180	100
1,000 (intermediate)	10	190	50
500 (intermediate)	10	240	20

*These standards are used as intermediate standards for makin the lower level calibration standards.

o The Photovac automatically zeros the detector and sets the baselin according to levels dictated in program set-up.

o A system blank is prepared by filling a Tedlar bag directly from the carrie gas supply line. An aliquot is auto-injected into the system for analysis.

A clean system blank in the RT window is required to continue. Th blank will be considered clean if no extraneous peak responses ar observed ≥ 10 ppm or 0.85 vs at a gain of 200.

If the first blank is not clean, the GC is cycled continuously throug Program 1 and blanks are re-run until satisfactory results are obtained.

o Initial Calibration:

At the start of project analysis a 3-point calibration curve is established for each of the 3 most commonly used sensitivity settings (gain) to confirm linearity of response under typical operating conditions. The 3-point curve is established as follows:

- The points are ploted as concentration versus volt seconds (vs).
- At a gain of 200 use TCE concentrations of 20 ppb, 50 ppb, 200 ppb.
- At a gain of 50 use TCE concentrations of 200 ppb, 500 ppb, 1,000 ppb.
- At a gain of 5 use TCE concentrations of 1,000 ppb, 5,000 ppb, 10,000 ppb.
- The initial 3-point calibration curve is considered acceptable if the correlation coefficient for the linear regression line is $\geq$ 0.980.
- If the initial calibration is not acceptable, it must be re-run until satisfactory results are obtained.

o Daily Calibration

- Establish the instruments high concentration calibration by running the certified high level standard using Program 2 at a gain of 5 and a 0.8 second auto-injection.
- At the end of the calibration run, enter the following data into the integrator:

  1) Chromatogram peak # for TCE
  2) Name the peak as follows:

     TCE-GA-B

     Where:

     A is the gain used during the calibration run of Program 2.

B is the concentration of the standard used for calibration of Program 2.

- Record the date, standard concentration, gain and RF (vs/ppm) in the daily standard log.

- Confirm data entry and instrumental analysis by re-running the high standard under the same conditions.

- Run a system blank to verify that no carry-over has occurred.

- Run the low level standard using Program 2, a gain of 50 and a second auto-injection.

- Calculate the actual concentration of the low level standard follows:

  $$\text{ppb of TCE} = \frac{A \times B}{C + A}$$

  Where:

  A is volume of certified standard injected into the Tedlar bag (in milliliters).

  B is the concentration of the certified standard in ppb.

  C is the volume of dilution air in the Tedlar bag (in milliliters).

- Confirm the actual concentration of the low level standard running the same analysis under the same conditions. The standard is considered accurate when two successive runs produce values that differ by no more than ±5%.

- Establish the instruments low concentration calibration by running the confirmed low standard using Program 3 at a gain of 200.

- At the end of the calibration run enter the following data into the integrator:

1) Chromatogram peak # for TCE

2) Name the peak as follows:

   TCE-GA-B

   Where:

   A is the gain used during the calibration run of Program 3.

   B is the concentration of the standard (ppm) used for calibration of Program 3.

- Record data in daily standard log.

- Confirm data entry and instrumental analysis by rerunning the low standard under the same conditions.

- Daily calibration acceptability is based upon the folowing criteria:

1) Comparability of the response factor (vs/conc) to previous calibration response factors as recorded in the daily standard log.

2) The resulting TCE concentrations for runs must agree within ±3% of the standard concentrations used for these runs.

If these acceptability criteria are not met, then:

a) The standards are re-run; if still unacceptable, continue with steps b-e as far as necessary.

b) Check to see if certified standard is still good.

c) Prepare or acquire fresh standard.

d) Repeat entire daily calibration procedure.

e) Run new initial 3-point calibration curve.

- When the integrator fails to recognize the TCE peak due to external changes (i.e., temperature), the system instrument must be re-programmed (i.e., re-calibrated) with both levels of standards. Also, previous calibration data is no longer valid and is erased from memory when this occurs.

Sample Analysis

o After acceptable daily calibration, run a blank air sample using Program 3 at a gain of 200. If the blank is clean, proceed with sample analysis. If the blank is not clean, use Program 1 with a cycle time of 12 minutes to purge the instrument until it meets the following criteria:

   a. The blank is clean.

   b. Three consecutive blank runs show contamination peak at the same vs or concentration.

o To analyze the sample, connect the Tedlar bag to the sample inlet, open the valve and set the Photovac up according to the following:

   a. If the concentration is expected to be between 10-200 ppb, use Program 3 at a gain of 200.

   b. If the concentration is expected to be between 200-1000 ppb, use Program 2 at a gain of 50.

   c. If the concentration is expected to be between 1000-10,000 ppm use Program 2 at a gain of 5.

   d. If the concentration is greater than 10,000 ppb, dilute and run with the appropriate program.

      - Push the start button and allow the program to run until the data printout is complete.

      - Remove the Tedlar bag from the sample inlet and repeat the analysis procedure for the next sample.

  - If the sample has concentration <2,000 ppb, run a blank to check for system contamination.

- o Raw Data Documentation:

  - Each run is identified on the strip chart with the following information:

    a. Sample ID (or "Blank," or "Standard")

    b. Run identification (i.e., "original" or 1st re-run")

    c. Data and time of analysis

    d. Gain and intrument temperature.

  - An analysis work sheet (Figure 15-1) is completed for each sample analyzed and all the sample chromatograms are stapled to it.

  - A daily standard log (Figure 15-2) is maintained by the analyst.

  - A continuous run log (Figure 15-3) is maintained by the analyst.

- o Calculation:

  - The integrator determines the area under the peaks in the retention time window in terms of volt seconds (vs).

  - Concentration of a sample is automatically calculated by the integrator according to the following equation:

    TCE in ppm = R_f x VS

    Where:

R_f is a constant automatically calculated by the integrator during calibration procedures by dividing standard concentration (in ppm) by the standards VS (i.e., ppm/VS,.

VS is the volt seconds of the sample peak as calculated by the integrator during that run.

- When the run is completed, the results for TCE are printed on the chromatogram in ppm.

Quality Assurance

- o A duplicate sample analysis is performed for every 10 sample analyses, or daily, whichever is more frequent and the relative percent difference is calculated.
- o A blank sample analysis is performed for every 10 sample analyses, or daily, whichever is more frequent.
- o Instrument calibration is performed using appropriate sample standards three times a day: at the beginning of the work day, in the middle of the work day, and at the end of the day. Percent recovery from standard analysis is recorded as instrument performance verification.

Data Storage

- o Daily a manila folder is labeled with the date for storage and filing of that day's analysis worksheets and chromatograms for all calibration standards, blanks and samples.
- o Results tabulations, the daily standard log, the analysis run log, and the sample log in sheets are accumulated chronologically in separate labeled files.

Field-Operable, Laboratory-Grade Gas Chromatograph

For selected field activities it may be advantageous to set up and use a full-scale, laboratory-grade gas chromatograph (GC) in the field for sample screening for volatile organic compounds and other selected constituents (e.g. pesticides and PCBs). The advantage of a field-operable laboratory-grade GC is that the instrument may be configured with various detectors and may be modified to allow direct aqueous injection of liquid samples. The previously described instruments do not allow direct aqueous injection.

Sample screening using a field-operable GC provides in-situ, real-time sample analyses results that may be used to guide and manage field activities. Since the exact configuration and operation of such a "custom" instrument is unknown, Standard Operating Procedures for use of a field-operable GC will be prepared prior to initiating such work at any specific site. Standard Operating Procedures will be custom-designed to meet analytical needs on a site-specific basis.

FIGURE 15-1
PHOTOVAC
FIELD ANALYSIS WORKSHEET

DATE ____________________

ANALYST ____________________

FIELD SAMPLE NO. ____________________

SAMPLE CONTAINER NO. ____________________

SAMPLE LOCATION ____________________

RUN #	GAIN	TIME	ul INJ.

	ON	OFF
EVENT 1		
EVENT 3		
EVENT 4		
EVENT 5		

FLOW ____________________ ML/MIN

RESULTS:

COMMENTS:

FIGURE 15-2
STANDARD DAILY LOG

Date	Actual Conc. (PPM)	Actual VS (Volt/Seconds)	Gain	Vs/PPM

FIGURE 15-3
DAILY PHOTOVAC ANALYTICAL FLOW SHEET

Analysis No.	Sample ID	Analysis Time	Gain	Date

VOL: III, SEC: 20
DATE: 8/87
EFFECTIVE: 11/87
SUPERCEDES:
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STANDARD OPERATING PROCEDURE

Section 20.0

SOILS

By

JACOBS ENGINEERING GROUP INC.

SECTION 20.0

SOILS

SOILS

Soil sampling is an important adjunct to groundwater monitoring. Sampling of the soil horizons above the groundwater table can detect contaminants before they migrate to the water table, and can help establish the amount of contamination sorbed on aquifer solids that have the potential of contributing to the groundwater contamination.

Soil conditions can vary considerably on the hazardous waste site. These variations, along with vegetation, can effect the rate of contaminant migration through the soil. It is important, therefore, that a detailed record be maintained during sampling operations, particularly of location, depth, and such characteristics as grain size, degree of rounding, clay content, color and odor, and/or readings obtained on a field monitoring equipment. All soils should be classified in the field by a geologist using the Unified Soil Classification System. Subsurface conditions are often stable on a daily basis and may demonstrate only slight seasonal variation especially with respect to temperature, available oxygen, and light penetration. Changes in any of these conditions can radically alter the rate of chemical reactions or the activity of associated microbiological community. As a result samples should be kept at their at-depth temperature or lower, protected from direct light, sealed tightly in glass bottles or stainless steel tubes, and analyzed as soon as possible.

The physical properties of the soil, its grain size, cohesiveness, associated moisture, and such factors as depth to bedrock and water table will limit the depth from which samples can be collected and the method required to collect them. Often this information on soil properties can be acquired from published soil surveys obtainable through the U.S. Geological Survey (USGS) and other government and farm agencies. A comprehensive listing of these offices and currently available soil surveys is included in the "NEIC Manual for Groundwater/Subsurface Investigations at Hazardous Waste Sites." Most of the methods employed for soil sampling at hazardous waste sites are adaptations of techniques long employed by foundation engineers and geologists. This section presents those methods which can be employed with a minimum of special training, equipment or cost. More detailed methods capable of sampling to greater depths in more difficult soil conditions, or that can simultaneously install groundwater monitor wells, usually require professional assistance. These techniques are discussed more fully in the "Manual for Ground-water Sampling Procedures."

Collection of samples from near the soil surface can be accomplished with tools such s spades, shovels, scoops and hand augers. With this type of readily available equipment the soil cover can be removed to the required depth; then a stainless steel scoop can be used to collect the sample. An undisturbed sample can be collected from this excavation by employing a thin wall tube sampler. This device is, as the name implies, a metal tube generally 2.5 to 7.5 cm in diameter and 30.5 to 61.0 cm long. The tube is forced into the soil, then extracted. Friction will usually hold the sample material in the tube during the extraction. The construction material is generally steel, and some samplers can utilize plastic liners and interchangeable cutting tips. The liners are useful for trace element sampling but are generally not suitable for organic analysis due to the possibility that materials in the liner will leach out and become incorporated as part of the sample. The liner tubes can further be capped off and used s sample containers for transport to the lab.

Interchangeable cutting tips facilitate smoother penetration with reduced sample disturbance. They are available in various styles and construction suitable for moist, dry, sandy or heavy-duty applications. The design of these cutting tips will further aid in maintaining the sample in the tube during sample extraction.

Augers are also very effective for soil sampling. Bucket type augers can be used directly for soil sample collection or to advance a borehole to the desired depth so then a thin wall can be employed.

Kits are available that include, in conjunction with the tube sampler and cutting tips, an auger point and a series of extension rods. These kits allow for hand augering a borehole. The auger can then be removed and a tube sampler lowered and forced into the soil at the completion depth. Though kits are available with sufficient tools to reach depths in excess of 7 meters, soil structure, impenetrable rock, and water levels usually prevent reaching such completion depths. Kits that include 1 meter of drill rod and the ability to order additional extensions will in practice prove satisfactory. The need for soil information at greater depths will normally require professional assistance. Consideration should be given to supplementing this information with groundwater monitoring since soil sampling can be conducted in conjunction with well completion.

For those wishing a more in-depth discussion of soils and soil sampling, refer to the <u>Preparation of Soil Sampling Protocol: Techniques and Strategies</u>, (EPA 600/4-83-020) by r. Benjamin J. Mason, prepared under contract to the U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory - Las Vegas, August 1983. This report discusses in detail the factors that influence the selection of a particular sampling scheme or the use of a particular sampling method with a strong emphasis on statistical design and data analysis. Another document, Soil Sampling Quality Assurance User's Guide, (EPA 600/4-84-043) by Dr. Delbert S. Barth and Dr. Benjamin J. Mason, prepared by the Environmental Research Center, University of Nevada - Las Vegas under a cooperative agreement with the Environmental Protection Agency (May 1984) will also be helpful.

SOIL SAMPLING WITH A SPADE AND SCOOP

Discussion

The simplest, most direct method of collecting soil samples for subsequent analysis is with the use of a spade and scoop. A normal lawn or garden spade can be utilized to remove the top cover of soil to the required depth and then a smaller stainless steel scoop can be used to collect the sample.

Uses

This method can be used in most soil types but is limited somewhat to sampling the near surface. Samples from depths greater than 50 cm become extremely labor intensive in most soil types. Very accurate, representative samples can be collected with this procedure depending on the care and precision demonstrated by the technician. The use of a flat, pointed mason trowel to cut a block of the desired soil will be of aid when undisturbed profiles are required. A stainless steel scoop or lab spoon will suffice in most other applications. Care should be exercised to avoid the use of devices plated with chrome or other materials. Plating is particularly common with garden implements such as potting trowels.

Procedures for Use

1. Carefully remove the top layer of soil to the desired sample depth with a precleaned spade.
2. Using a precleaned stainless steel scoop or trowel, remove and discard a thin layer of soil from the area which comes in contact with the shovel.
3. Transfer sample into an appropriate sample bottle with a stainless steel lab spoon or equivalent.

4. Check that a Teflon liner is present in the cap if required. Secure the cap tightly. The chemical preservation of solids is generally not recommended. Refrigeration is usually the best approach supplemented by a minimal holding time. For specific containerization and preservation requirements, consult Section 28.0.
5. Label the sample bottle with the appropriate sample tag. Be sure to label and tag carefully and clearly, addressing all the categories or parameters. Complete all chain-of-custody documents and record in the field log book.

6. Decontaminate equipment after use and between sample locations. For specific decontamination guidelines, consult Section 26.0

THIN WALL TUBE SAMPLER

Discussion

This system consists of an auger bit, a series of drill rods, a "T" handle, and a thin-wall tube corer (see Figure 20-1). The auger bit is used to bore a hole to the desired sampling depth and then withdrawn. The auger tip is then replaced with the tube corer, lowered down the borehole, and forced into the soil at the completion depth. The corer is then withdrawn and the sample collected.

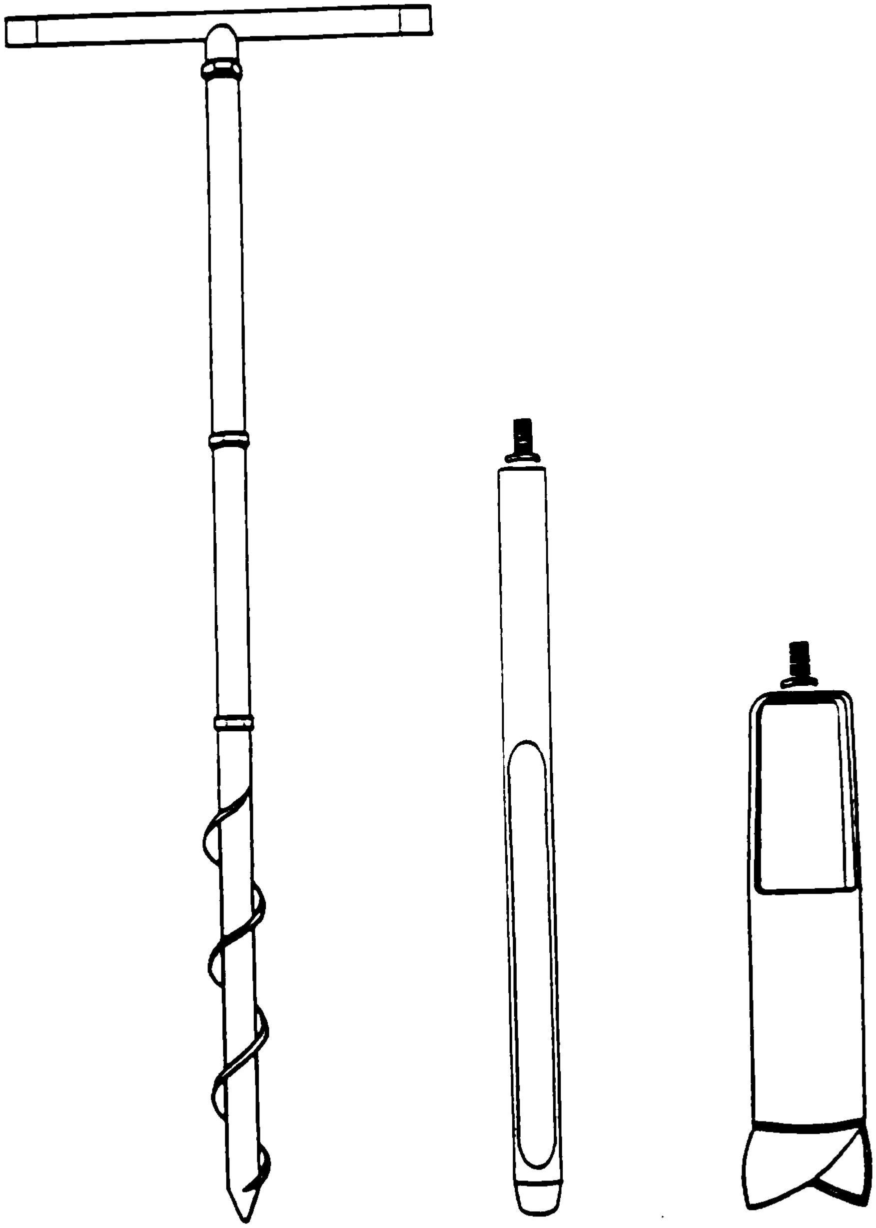
Alternately the sample can be recovered directly from the auger. This technique however, does not provide an "undisturbed" sample as would be collected with a thin tube sampler. In situations where the soil is rocky, it may not be possible to force a thin tube sampler through the soil or sample recovery may be poor. Sampling directly from the auger may be the only viable method. Several auger types are available which include Bucket type, continuous fligh (screw) and posthole augers. Bucket types are good for direct sample recovery and are fast and provide a large volume of sample. When continuous flight (screw) augers are utilized, the sample can be collected directly off the flights, however, this technique will provide a somewha unrepresentative sample as the exact sample depth will not be known. The continuous flights auger are, however, satisfactory for use when a composite of the entire soil column is desired. Posthole augers have limited utility for sample acquisition as they are designed more for thei ability to cut through fibrous, heavily rooted, swampy areas. In soils where the borehole will not remain open when the tool is removed, a temporary casing can be used until the desired sampling depth is reached.

Uses

This system can be used in a wide variety of soil conditions. It can be used to sample both from the surface, by simply driving the corer without preliminary boring, or to depths in excess of 6 meters. The presence of rock layers and the collapse of the borehole, however, usually

FIGURE 20-1

AUGERS AND THIN-WALL TUBE SAMPLER



prohibit sampling at depths in excess of 2 meters. Interchangeable cutting tips on the corer reduce the disturbance to the soil during sampling and aid in maintaining the core in the device during removal from the borehole.

Procedures for Use

1. Attach the auger bit to a drill rod extension and further attach the "T" handle to the drill rod.

2. Clear the area to be sampled of any surface debris (twigs, rocks, litter). It may be advisable to remove the first 8 to 15 cm of surface soil for an area approximately 15 cm in radius around the drilling location.

3. Begin drilling, periodically removing accumulated soils. This prevents accidentally brushing loose material back down the borehole when removing the auger or adding drill rods.

4. After reaching desired depth, slowly and carefully remove auger from boring. (Note: When sampling directly from auger, collect sample after auger is removed from boring and proceed to Step 10.)

5. Remove auger tip from drill rods and replace with a precleaned thin-wall tube sampler. Install proper cutting tip.

6. Carefully lower corer down borehole. Gradually force corer into soil. Care should be taken to avoid scraping the borehole sides. Hammering of the drill rods to facilitate coring should be avoided as the vibrations cause the boring walls to collapse.

7. Remove corer and unscrew drill rods.

8. Remove cutting tip and remove core from device.

9. Discard top of core (approximately 2.5 cm), which represents any material collected by the corer before penetration of the layer in question. Place remaining core into sample container.

10. Check that a Teflon liner is present in the cap if required. Secure the cap tightly. The chemical preservation of solids is generally not recommended. Refrigeration is usually the best approach supplemented by a minimal holding time.

11. Label the sample bottle with the appropriate sample tag. Be sure to label the tag carefully and clearly, addressing all of the categories or parameters. Complete all chain-of-custody documents and record in the field log book.

12. Decontaminate sampling equipment after use and between sampling locations. Refer to Section 26 for decontamination requirements.

Sources

deVera, E.R., Simmons, B.P., Stephens, R.D., and Storm, D.L. "Samplers and Sampling Procedures for Hazardous Waste Streams." EPA 600/2-80-018, January 1980.

STANDARD OPERATING PROCEDURE

Section No. 21.0

SLUDGES AND SEDIMENTS

By

JACOBS ENGINEERING GROUP INC.

SECTION 21.0

SLUDGES AND SEDIMENTS

SLUDGES AND SEDIMENTS

In general, and for the purpose of this manual, sludges will be defined as semi-dry materials ranging from dewatered solids to high viscosity liquids. Sediments are the deposited material underlying a body of water. On occasion they are exposed by evaporation, stream rerouting, or other means of water loss. In these instances they can be readily collected by soil or sludge collection methods.

Sludges can often be sampled by the use of a stainless steel scoop or trier. Frequently, sludges form as a result of settling of the higher density components of a liquid. In this instance the sludge may still have a liquid layer above it. When the liquid layer is sufficiently shallow, the sludge may be scooped up by a device such as the pond sampler described in Section 23.0, use of pond samplers for the collections of surface water samples, or preferable by using a thin-tube sampler as described in this section (see sampling sludge or sediments with a hand corer, this section). The latter is preferable as it results in less sample disturbance and will also collect an aliquot of the overlying liquid, thus preventing drying or excessive sample oxidation before analysis. Sludges which develop in 55-gallon drums can usually be collected by employing the glass tubes used for the liquid portion sample (see collection of liquid containerized wastes using glass tubes, Section 24.0) as a thin-tube sampler. The frictional forces which hold the sludge in the tube can be supplemented by maintaining a seal above the tube. When the overlying layer is deep, a small gravity corer such as those used in limnological studies will be useful. Gravity corers, such as Phlegers, are easier to preclean and decontaminate than piston type corers.

If the sludge layer is shallow, less than 30 centimeters, corer penetration may damage the container liner or bottom. In this instance a Ponar or Eckman grab may be applicable, as grab samplers are generally capable of only a few centimeters of penetration. Of the two, Ponar grab samplers are applicable to a wider range of sediments and sludges. They penetrate deeper and seal better than the spring-activated Eckman dredges, especially in granular substrates.

In many instances sediments and sludges can be collected with a peristaltic pump as described in Section 23.0. This method is limited to slurried samples less than approximately 20 percent solid. The weight of the material will also greatly reduce the lift capacity of the pump, however, it may still be useful in extending the reach of the sampler laterally toward the center of a vessel. In slurries not fully agitated, a bias may also be introduced toward the liquid portion of the material.

Sediments can be collected in much the same manner as described above for sludges; however, a number of additional factors may be considered. Streams, lakes, and impoundments, for instance, will likely demonstrate significant variations in sediment composition with respect to distance from inflows, discharges, or other disturbances. It is important, therefore, to document exact sampling location by means of triangulation with stable references on the banks of the stream or lake. In addition, the presence of rocks, debris, and organic material may complicate sampling and preclude the use of or require modification to some devices. Sampling of sediments should therefore be conducted to reflect these and other variants.

COLLECTION OF SLUDGE OR SEDIMENT SAMPLES WITH A SCOOP

Discussion

Sludge and sediment samples are collected using the simple laboratory scoop or garden type trowel specified in Section 20.0. This method is more applicable to sludges but it can be used for sediments provided the water depth is very shallow (a few centimeters). It should be noted, however, that this method can be disruptive to the water/sediment interface and might cause substantial alteration.

Uses

This method provides for a simple, quick, and easy means of collecting a disturbed sample of a sludge or sediment.

Procedures for Use

1. Sketch the sample area or note recognizable features for future reference.

2. Insert scoop or trowel into material and remove sample. In the case of sludges exposed to air, it may be desirable to remove the first 1-2 cm of material prior to collecting sample.

3. If compositing a series of grab samples, use a stainless steel mixing bowl or Teflon tray for mixing.

4. Transfer sample into an appropriate sample bottle with a stainless steel lab spoon or equivalent.

5. Check that a Teflon liner is present in cap if required. Secure the cap tightly. The chemical preservation of solids is generally not recommended. Refrigeration is usually the best approach supplemented by a minimal holding time. Containerization and preservation requirements are detailed in Sections 28.0 and 29.0.

6. Label the sample bottle with the appropriate sample tag. Be sure to label the tag carefully and clearly, addressing all the categories or parameters. Complete all chain-of-custody documents and record in the field log book.

7. Decontaminate sampling equipment after use and between sample locations according to the guidelines presented in Section 26.0.

SAMPLING SLUDGE OR SEDIMENTS WITH A HAND CORER

Discussion

This device is essentially the same type of thin-wall corer described for collecting soil samples (Section 20.0). It is modified by the addition of a handle to facilitate driving the corer (see Figure 21-1) and a check valve on top to prevent washout during retrieval through an overlying water layer.

Uses

Hand corers are applicable to the same situations and materials as the scoop described previously. It has the advantage of collecting an undisturbed sample which can profile any stratification in the sample as a result of changes in the deposition.

Some hand corers can be fitted with extension handles which will allow the collection of samples underlying a shallow layer of liquid. Most corers can also be adapted to hold liners generally available in brass, polycarbonate plastic or Teflon. Care should be taken to choose a material which will not compromise the intended analytical procedures.

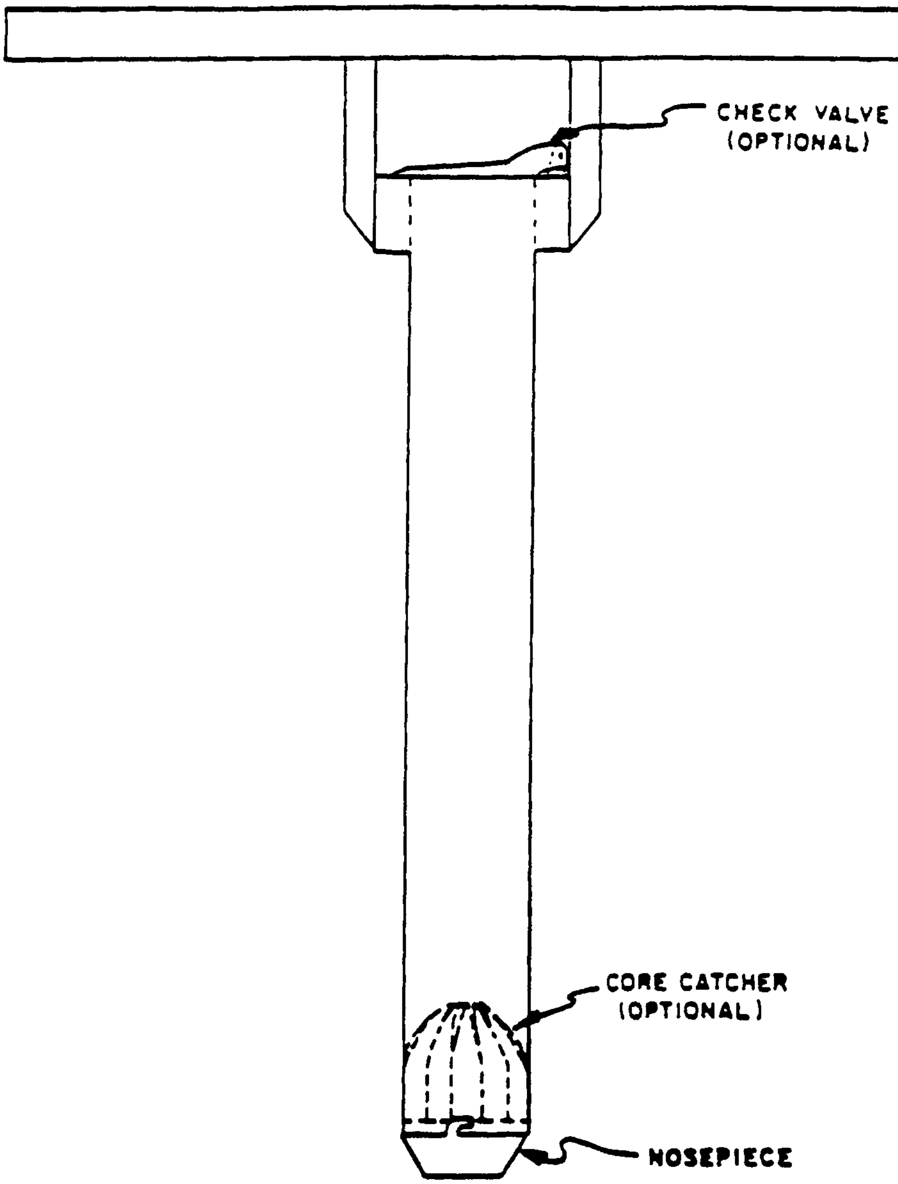
Procedures for Use

1. Inspect the corer for proper precleaning, and select sample location.

2. Force corer in with smooth continuous motion.

FIGURE 21-1

HAND CORER



3. Twist corer then withdraw in a single smooth motion.

4. Remove nosepiece and withdraw sample into a stainless steel or Teflon tray.

5. Transfer sample into an appropriate sample bottle with a stainless steel lab spoon or equivalent.

6. Check that a Teflon liner is present in cap if required. Secure the cap tightly. The chemical preservation of solids is generally not recommended. Refrigeration is usually the best approach supplemented by a minimal holding time. Sample Containerization (Section 28.0) and Preservation (Section 29.0) should be consulted for specific requirements.

7. Label the sample bottle with the appropriate sample tag. Be sure to label the tag carefully and clearly, addressing all the categories or parameters. Complete all chain-of-custody documents and record in the field log book.

8. Decontaminate sampling equipment after use and between sample locations as required by procedures in Section 26.0, Decontamination.

SAMPLING BOTTOM SLUDGES OR SEDIMENTS WITH A GRAVITY CORER

Discussion

A gravity corer is a metal tube with a replacement tapered nosepiece on the bottom and a ball or other type of check valve on the top. The check valve allows water to pas through the corer on descent but prevents a washout during recovery. The tapered nosepiece facilitates cutting and reduces core disturbance during penetration.

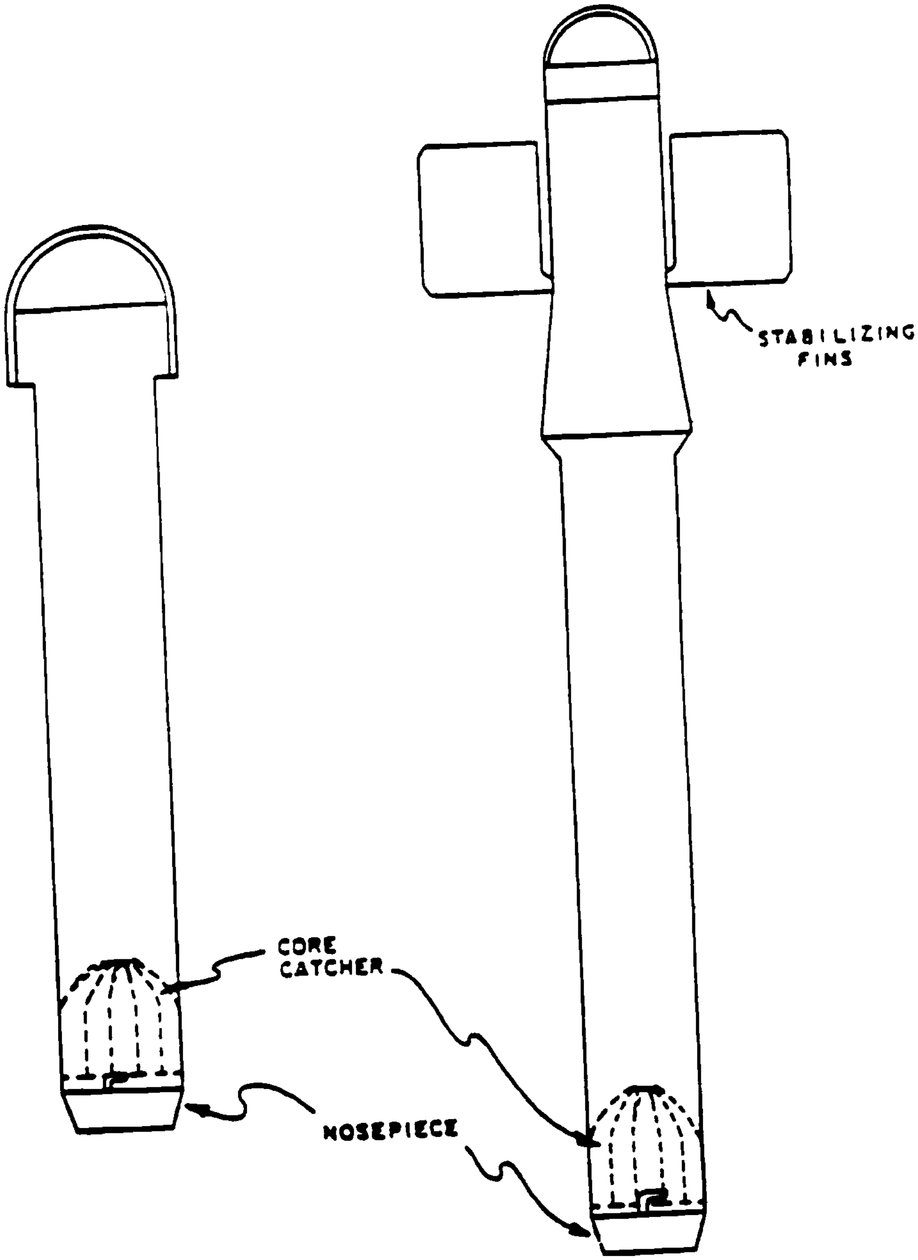
Most corers are constructed of brass or steel and many can accept plastic liners and additional weights (see Figure 21-2).

Uses

Corers are capable of collecting samples of most sludges and sediments. They collect essentially undisturbed samples which represent the profile of strata which may develop in sediments and sludges during variations in the deposition process. Depending on the density of the substrate and the weight of the corer, penetration to depths of 75 cm (30 inches) can be attained.

FIGURE 21-2

GRAVITY CORERS



Care should be exercised when using gravity corers in vessels or lagoons that have liners because penetration depths could exceed that of the substrate and result in damage to the liner material.

Procedures for Use

1. Attach a precleaned corer to the required length of sample line. Solid braided 5 mm (3/16 inch) nylon line is sufficient; 20 mm (3/4 inch) nylon, however, is easier to grasp during hand hoisting.
2. Secure the free end of the line to a fixed support to prevent accidental loss of the corer.
3. Allow corer to free fall through liquid to bottom.
4. Retrieve corer with a smooth, continuous lifting motion. Do not bump corer as this may result in some sample loss.
5. Remove nosepiece from corer and slide sample out of corer into stainless steel or Teflon pan.
6. Transfer sample into appropriate sample bottle with a stainless steel lab spoon or equivalent.
7. Check that a Teflon liner is present in cap if required. Secure the cap tightly. The chemical preservation of solids is generally not recommended. Refrigeration is usually the best approach supplemented by a minimal holding time. Refer to Sections 28.0 and 29.0 for sample containerization and preservation guidelines.
8. Label the sample bottle with the appropriate sample tag. Be sure to label the tag carefully and clearly, addressing all the categories or parameters. Complete all chain-of-custody documents and record in the field log book.
9. Consult Section 26.0 for decontamination requirements and decontaminate sampling equipment after sue and between sampling locations.

Sources

American Public Health Association. "Standard Methods for the Examination of Water and Wastewater" 14th Edition, Washington, D.C. 1975.

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STANDARD OPERATING PROCEDURE

Section No. 22.0

BULK MATERIALS

By

JACOBS ENGINEERING GROUP INC.

SECTION 22.0

BULK MATERIALS

BULK MATERIALS

Unlike soils which are heterogeneous associations of earthen and manufactured substances, bulk materials are generally a homogeneous collection of a single identifiable product. They are usually contained in bags, drums, or hoppers although on occasion large amounts of the material may be piled directly on the ground, either deliberately or as the result of a spill.

Those surfaces exposed to the atmosphere may undergo some chemical alteration or degradation and should be avoided during sample collection. Since the process producing the bulk material may demonstrate some variation with respect to time, it is advisable to collect a series of samples as one composite to represent the material.

Bulk materials in an unconsolidated state may be readily collected by a stainless steel scoop. When the amount of the material is large, a composite can be collected by the use of a grain thief (see Figure 22-1). This device is essentially a long hollow tube with evenly spaced openings along its length. This tube is placed inside an outer sleeve with similar openings and forced into the material. The inner sleeve is then further rotated sealing the openings, the device is withdrawn, and the sample recovered.

Grain thief are available in many materials including brass and various plastics. As with other sampling devices, care should be taken to choose a construction material which will not compromise the desired analytical results.

A more detailed treatment of this subject (Bulk Materials) can be found in The Sampling of Bulk Materials by R. Smith and G. V. James, The Royal Society of Chemistry, London (1981). Although this book does not deal specifically with hazardous waste sampling, the concepts discussed, especially on the subject of the establishment of a sampling scheme, are readily applicable.

SAMPLING OF BULK MATERIAL WITH A SCOOP OR TRIER

Discussion

A typical sampling trier (Figure 22-2) is a long tube with a slot that extends almost its entire length. The tip and edges of the tube slot are sharpened to allow the trier to cut a core of the material to be sampled when rotated after insertion into the material. Sampling triers are usually made of stainless steel with wooden handles. They are about 6l to 100 cm long and 1.27 to 2.54 cm in diameter. They can be purchased readily from laboratory supply houses.

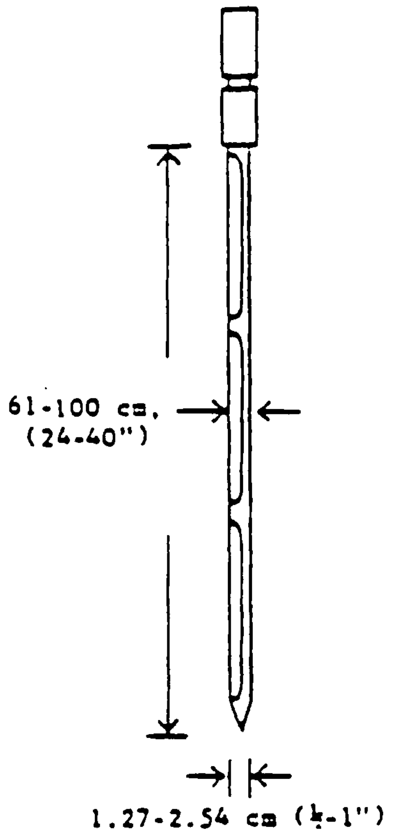
A laboratory scoop or garden variety trowel can also be used to sample bulk material. The trowel looks like a small shovel. The blade is usually about 7 by l3 cm with a sharp tip. A laboratory scoop is similar to the trowel, but the blade is usually more curved and as a closed upper end to permit the containment of material. Scoops come in different sizes and shapes. Stainless steel or polypropylene scoops with 7 by 13 cm blades are preferred. A trowel can be bought from hardware stores; the scoop can be bought from laboratory supply houses.

The use of the trier is similar to that of the grain sampler discussed later in this section. It is preferred over the grain sampler when the powdered or granular material to be sampled is moist or sticky. The trowel or lab scoop can be used in some cases for sampling dry, granular or powdered material in bins or other shallow containers. The lab scoop is a superior choice since it is usually made of materials less subject to corrosion or chemical reactions.

Procedures for Use

1. Insert the precleaned trier into the waste material at a 0 to 45° angle from horizontal. This orientation minimizes the spillage of sample from the sampler. Extraction of amples might require tilting of the containers.
2. Rotate the trier once or twice to cut a core of material.
3. Slowly withdraw the trier, making sure that the slot is facing upward.
4. Transfer the sample into a suitable container with the aid of a spatula and/or brush.
5. If composite sampling is desired, repeat the sampling at different points two or more times and combine the samples in the same sample container.
6. Check that a Teflon liner is present in the cap if required. Secure the cap tightly the chemical preservation of solids is generally not recommended. Refrigeratior is usually the best approach supplemented by a minimal holding time.

FIGURE 22-1
GRAIN THIEF



7. Label the sample bottle with the appropriate sample tag. Be sure to label the tag carefully and clearly, addressing all the categories or parameters. Complete all chain-of-custody documents and record in the field logbook.

8. Clean and decontaminate sampler after use and between sampling locations as per guidelines presented in Section 26.0 Field Decontamination Procedures.

Sources

deVera, E.R., Simmon B.P., Stephens, R.D., and Storm, D.L."Samplers and Sampling Procedures for Hazardous Waste Streams." EPA-600/2 80-018. January 1980.

SAMPLING BULK MATERIALS WITH A GRAIN THIEF

Discussion

The grain thief (Figure 22-1) consists of two slotted telescoping tubes, usually made of brass or stainless steel. The outer tube has a conical, pointed tip on one end that permits the sampler to penetrate the material being sampled. The sampler is opened and closed by rotating the inner tube. Grain thieves are generally 61 to 100 cm long by 1.27 to 2.54 cm in diameter, and they are commercially available at laboratory supply houses.

Uses

The grain thief is used for sampling powdered or granular wastes or materials in bags, fiberdrums, sacks or similar containers. This sample is most useful when the solids are no greater than 0.6 cm in diameter.

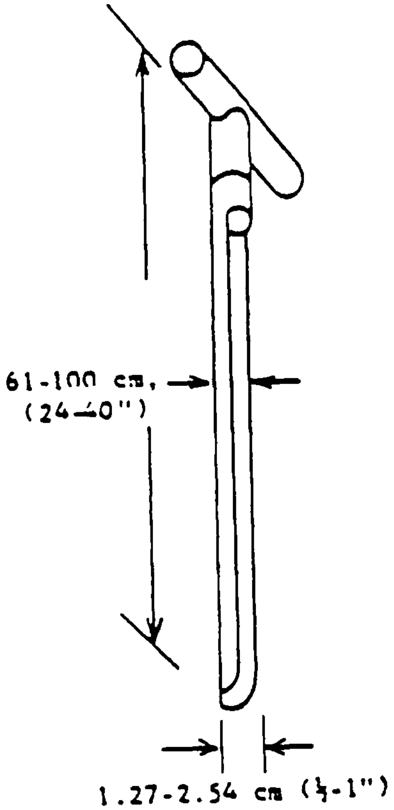
Procedures for Use

1. While the precleaned sampler is in the closed position, insert is into the granular or powdered material or waste being sampled from a point near a top edge or corner, through the center, and to a point diagonally opposite the point of entry.

2. Rotate the inner tube of the sampler into the open position.

3. Wiggle the sampler a few times to allow materials to enter the open slots.

FIGURE 22-2
SAMPLING TIER



4. Place the sampler in the closed position and withdraw from the material bein sampled.

5. Place the sampler in a horizontal position with the slots facing upward.

6. Rotate and slice away the outer tube from the inner tube.

7. Transfer the collected sample in the inner tube into a suitable sample container.

8. If composite sampling is desired, collect two or more core samples at differe points, and combine the samples in the same container.

9. Check that a Teflon liner is present in the cap if required. Secure the cap tightl The chemical preservation of solids is generally not recommended. Refrigeration is usually the best approach supplemented by a minimal holding time.

10. Label the sample bottle with the appropriate sample tag. Be sure to label the tag carefully and clearly, addressing all the categories or parameters. Complete all chain-of-custody documents and record in the field logbook.

11. Decontaminate equipment after use and between sampling locations using recommended techniques of provided in Section 26.0.

Sources

deVera, E.R., Simmon B.P., Stephens, R.D., and Storm, D.L."Samplers and Sampling Procedures for Hazardous Waste Streams." EPA-600/2-80-018. January 1980.

Horwitz, W., Sensel, A., Reynolds, H., and Parks, D.L., editors. Animal Feed: Sampling Procedure. In: Official Methods of Analysis. The Association of Official Analytical Chemists. 12th Edition. Washington, D.C. 1979.

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STANDARD OPERATING PROCEDURE

Section No. 23.0

SURFACE WATERS

By

JACOBS ENGINEERING GROUP

SECTION 23.0

SURFACE WATERS

SURFACE WATERS

The choice of sample locations in surface waters is an important consideration which must be addressed prior to sample acquisition, since it will often affect the selection of sampling equipment. Selection of representative locations will depend on many factors including stream dimensions, shape, flow rate (velocity), inputs and discharges.

The selection of sample locations will be detailed in the sampling plan, however samplers should anticipate accommodating infield adjustment. Most often depth integrated and/or cross-sectional composite samples are preferable to single-point grabs. In practice safe access and handling as well as other physical limitations will be influential factors during sample acquisition at hazardous waste contaminated sites.

Samples from shallow depths can be readily collected by merely submerging the sample container. The method is advantageous when the sample might be significantly altered during transfer from a collection vessel into another container. This is the case with samples collected for oil and grease analysis since considerable material may adhere to the sample transfer container and as a result produce inaccurately low analytical results. Similarly the transfer of a liquid into a small sample container for volatile organic analysis, if not done carefully, could result in significant aeration and resultant loss of volatile species. Though simple, representative, and generally free from substantial material disturbances, it has significant shortcomings when applied to hazardous waste, since the external surface of each container would then need to be decontaminated. Submerging the sample container to collect a surface water sample cannot be done if preservatives are added to the container prior to sample collection.

In general the use of a sampling device, either disposable or constructed of a nonreactive material such as glass, stainless steel, or Teflon, is the most prudent method. The device should have a capacity of at least 500 ml, if possible, to minimize the number of times the liquid must be disturbed, thus reducing agitation of any sediment layers.

A 1-liter stainless steel or glass beaker with pour spout and handle works well. It is easily cleaned and considerably less expensive than Teflon. Though still more expensive than other plastics it is more durably and generally more inert under field conditions. Also useful are large stainless steel ice scoops and ladles available from commercial kitchen and laboratory supply houses.

It is often necessary to collect liquid samples at some distance from shore or the edge of the containment. In this instance an adaptation which extends the reach of the technician is advantageous. Such a device is the pond sampler. It incorporates a telescoping heavy-duty aluminum pole with an adjustable beaker clamp attached to the end (see use of pond sampler for the collection of surface water samples, this Section). The beaker previously described, a disposable glass or plastic container, or the actual sample container itself, can be fitted into the clamp. In situations where cross contamination is of concern, use of a disposable container or the actual container is always advantageous. The cost of properly cleaning usually outweighs the cost of disposal of otherwise reusable glassware or bottles. This is especially true when the cleanup must be done in the field and the decontaminate rinsate must be contained and disposed. The potential contamination of samples for volatile organic analysis by the mere presence of organic solvents necessary for proper field cleaning is usually too great to risk.

Another method of extending the reach of sampling efforts is the use of a small peristaltic pump (see peristaltic pump for sampling surface water bodies, this Section). In this method the sample is drawn in through heavy-wall Teflon tubing and pumped directly into the sample container. This system allows the operator to reach out into the liquid body, sample from depth, or sweep the width of narrow streams.

If a medical grade silicone tubing is used in the peristaltic pump, the system is suitable for sampling almost any parameter including most organics. Some volatile stripping, however, may occur and though the system may have a high flow rate, some material may be lost on the tubing. Therefore, pumping methods should be avoided for sampling volatile organics or oil and grease. Battery-operated pumps of this type are available and can be easily hand-carried or carried with a shoulder sling. It is necessary in most situations to change both the Teflon suction line as well as the silicon pump tubing between sample locations to avoid cross-contamination. This requires maintaining a sufficiently large stock of material to avoid having to clean the tubing in the field.

These tubings are quite expensive but their relatively inert nature makes thorough decontamination in the lab both practical and simple thus allowing reuse. It should be noted that the Teflon suction tubing is an effective substitute for that supplied with the sophisticated automatic liquid waste samplers such as the ISCO Model 2100 and Manning Models S-3000 and S-4000.

When medical grade silicon tubing is not available the analytical requirements are particularly strict, the system can be altered as described by Figure 23-3, in the discussion on peristaltic pumps. In this configuration the sample volume accumulates in the vacuum flask and does not enter the pump. The integrity of the collection system can now be maintained with only the most nonreactive material contacting the sample. Some loss in lift ability will result since the pump is now moving air, a compressible gas rather than an essentially noncompressible liquid.

It may on occasion be necessary to sample large bodies of water where a near surface sample will not sufficiently characterize the body as a whole. In this instance again the above-mentioned pump is quite serviceable. It is capable of lifting water from depths in excess of 6 meters. Since the lift capacity is actually measured as the distance above the hydrostatic surface, it is possible to withdraw samples from depths significantly below the water surface. It should be noted that this lift ability decreases somewhat with higher density fluids and with increased wear on the silicone pump tubing. Similarly increases in altitude will decrease the pumps ability to lift from depth. When sampling a liquid stream which exhibits a considerable flow rate, it may be necessary to weight the bottom of the suction line. The stainless steel strainer suction weight supplied with the ISCO and Manning samplers usually works well. A heavier weight can be constructed by filling a short (7.5 cm to 10 cm) length of Teflon tubing with lead and plugging both ends with tight-fitting Teflon plugs. This weight can then be clamped with stainless steel band clamps to the suction tubing.

Situations may still arise where a sample must be collected from depths beyond the capabilities of a peristaltic pump. In this instance an at-depth sampler may be required, such as a Kemmerer, ASTM Bomb (Bacon Bomb) or Van Dorn sampler. These devices work well; however, care must be utilized in selecting devices that are made of materials that will not contaminate the sample. Van Dorn samplers are not generally recommended for organics as they are clamped with stainless steel band clamps to the suction tubing.

Kemmerer samplers are available on special order or adaptable for sample collection for organic analysis by substituting Teflon for the rubber or plastic stoppers. If the device is further ordered with stainless steel metallic parts in addition to Teflon stoppers it becomes a very versatile sampler.

The submersible pumps discussed in conjunction with groundwater sampling (Section 25.0) may also be useful in this application.

SAMPLING SURFACE WATERS USING A DIPPER OR OTHER TRANSFER DEVICE

Discussion

A dipper or other container constructed of inert material, such as stainless steel or Teflon, can be used to transfer liquid wastes from their source to a sample bottle. This prevents unnecessary contamination of the outer surface of the sample bottle that would otherwise resu from direct immersion in the liquid. Use of this device also prevents the technician from having to physically contact the waste stream. Depending upon the sampling application, the transfe vessel can be either disposed of or reused. If reused, the vessel should be thoroughly rinse and/or decontaminated prior to sampling a different source. It should also be noted that preservatives must be added following sample collection if the sample is collected b submerging the container.

Uses

A transfer device can be utilized in most sampling situations except where aeration must be eliminated (samples for volatile organic analysis) or where significant material may be lost du to adhesion to the transfer container.

Procedures for Use

1. Submerge a precleaned stainless steel dipper or other suitable device with minimal surface disturbance.
2. Allow the device to fill slowly and continuously.
3. Retrieve the dipper/device from the surface water with minimal disturbance.
4. Remove the cap from the sample bottle and slightly tilt the mouth of the bottle below the dipper/device edge.
5. Empty the dipper/device slowly, allowing the sample stream to flow gently down the side of the bottle with minimal entry turbulence.
6. Continue delivery of the sample until the bottle is almost completely filled. Leave adequate space to allow for expansion.
7. Select appropriate bottles and preserve the sample if necessary as per guidelines in Section 28.0.
8. Check that a Teflon liner is present in the cap if required. Secure the cap tightly.
9. Label the sample bottle with an appropriate sample tag. Be sure to label the tag carefully and clearly, addressing all the categories or parameters. Record the information in the field logbook and complete the chain-of-custody form.

10. Properly clean and decontaminate the equipment prior to reuse or storage (Section 26.0).

Sources

GCA Corporation, "Quality Assurance Plan, Love Canal Study - Appendix A, Sampling Procedures," EPA Contract 68-02-3168.

USE OF POND SAMPLER FOR THE COLLECTION OF SURFACE WATER SAMPLES

Discussion

The pond sampler consists of an adjustable clamp attached to the end of a two- or three-piece telescoping aluminum tube that serves as the handle. The clamp is used to secure a sampling beaker (see Figure 23-1). The sampler is not commercially available, but it is easily and inexpensively fabricated. The tubes can be readily purchased from most hardware or swimming pool supply stores. The adjustable clamp and sampling beaker can be obtained from most stores. The adjustable clamp and sampling beaker can be obtained from most laboratory supply houses.

Uses

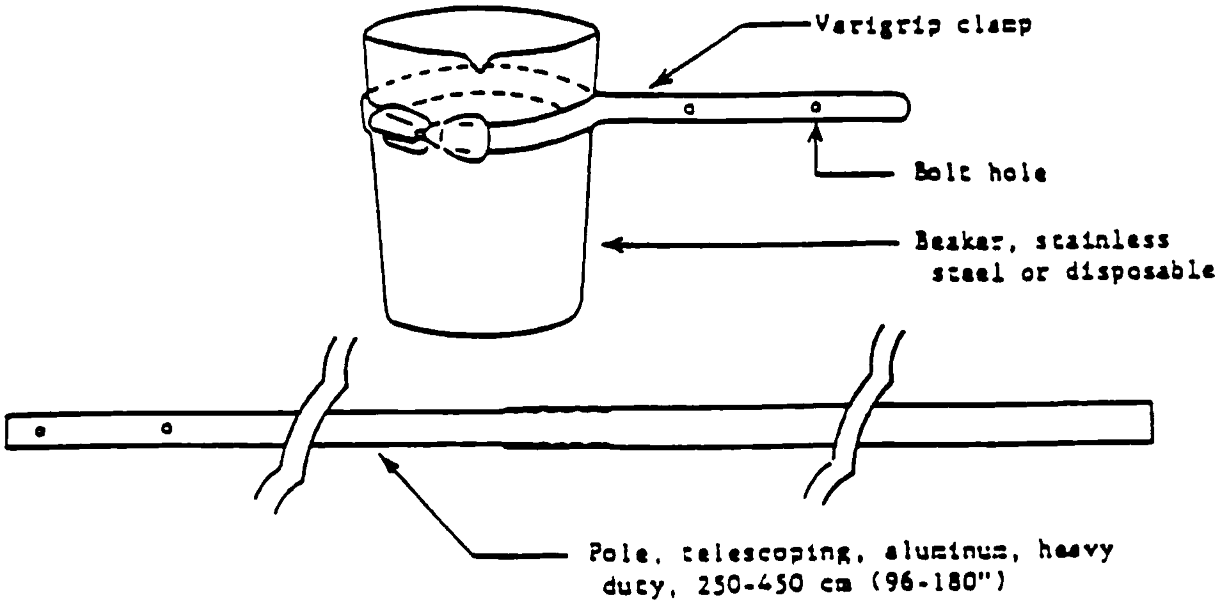
The pond sampler is used to collect liquid waste samples from disposal ponds, pits, lagoons, and similar reservoirs. Grab samples can be obtained at distances as far as 3.5 m from the edge of the ponds. The tubular aluminum handle may bow when sampling very viscous liquids if sampling is not done slowly.

Procedures for Use

1. Assemble the pond sampler. Make sure that the sampling beaker and the bolts and nuts that secure the clamp to the pole are tightened properly.
2. With proper protective garment and gear, take grab samples by slowly submerging the precleaned beaker with minimal surface disturbance.
3. Retrieve the pond sampler form the surface water with minimal disturbance.
4. Remove the cap from the sample bottle and slightly tilt the mouth of the bottle below the dipper/device edge.

FIGURE 23-1

POND SAMPLER



5. Empty the sampler slowly, allowing the sample stream to flow gently down the side of the bottle with minimal entry turbulence.

6. Continue delivery of the sample until the bottle is almost completely filled.

7. Select appropriate sample bottles and preserve the sample if necessary as per guidelines in Section 28.0.

8. Check that a Teflon liner is present in the cap is required. Secure the cap tightly.

9. Label the sample bottle with an appropriate sample tag. Be sure to label the tag carefully and clearly, addressing all the categories and parameters. Record the information in the field logbook and complete the chain-of-custody documents

10. Properly clean and decontaminate the equipment prior to reuse or storage using recommended guidelines of Section 26.0.

Sources

de Vera, E.R., Simmons, B.P., Stephens, R.D., and Storm, D.L. "Samplers and Sampling Procedures for Hazardous WAste Streams," EPA-600/2-80-018, January 1980.

GCA Corporation, "Quality Assurance Plan, Love Canal Study - Appendix A, Sampling Procedures," EPA Contract 68-01-3168

PERISTALTIC PUMP FOR SAMPLING SURFACE WATER BODIES

Discussion

This collection system consists of a peristaltic pump capable of achieving a pump rate of 1 to 3 gpm, and an assortment of Teflon tubing for extending the suction intake. A battery operated pump is preferable as it eliminates the need for DC generators or AC inverters.

Uses

The system, as shown in Figures 23-2 and 23-3, is highly versatile. It is portable and the sample collection is conducted through essentially chemically nonreactive material. It is practical for a wide range of applications including streams, ponds, and containers. This procedure can both extend the lateral reach of the sampler and allow sampling from depth. Likewise, it can function both as a well purge and a sample collection system. The chief disadvantage of this method is the limited lift capacity of the pump, approximately 8 meters.

Procedures for Use

1. Install clean, medical-grade silicone tubing in the pump head, as per the manufacturer's instruction. Allow sufficient tubing on discharge side to facilitate convenient dispensation of liquid into sample bottles and only enough on the suction end for attachment to the intake line. This practice will minimize sample contact with the silicone pump tubing.

2. Select the length of suction intake tubing necessary to reach the required sample depth and attach to intake side of pump tubing. Heavy-wall Teflon, of a diameter equal to the required pump tubing, suits most applications. (Heavier wall will allow for a slightly greater lateral reach.)

3. If possible, allow several liters of sample to pass through system, before actual sample collection. Collect this purge volume and then return to source after the sample aliquot has been withdrawn.

4. Fill necessary sample bottles by allowing pump discharge to flow gently down the side of bottle with minimal entry turbulence. Cap each bottle as filled.

5. Select appropriate bottles and preserve the sample if necessary as per guidelines in Section 28.0.

6. Check that a Teflon liner is present in the cap is required. Secure the cap tightly.

7. Label the sample bottle with an appropriate tag. Be sure to complete the tag with all necessary information. Record the information in the field logbook and complete the chain-of-custody documents.

8. Allow system to drain, then disassemble. Return tubing to lab for decontamination (if feasible). See Section 26.0 for general decontamination procedures.

Sources

U.S. Environmental Protection Agency. "Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities." EPA-530/SW-611. August 1977.

FIGURE 23-2

PERISTALTIC PUMP FOR LIQUID SAMPLING

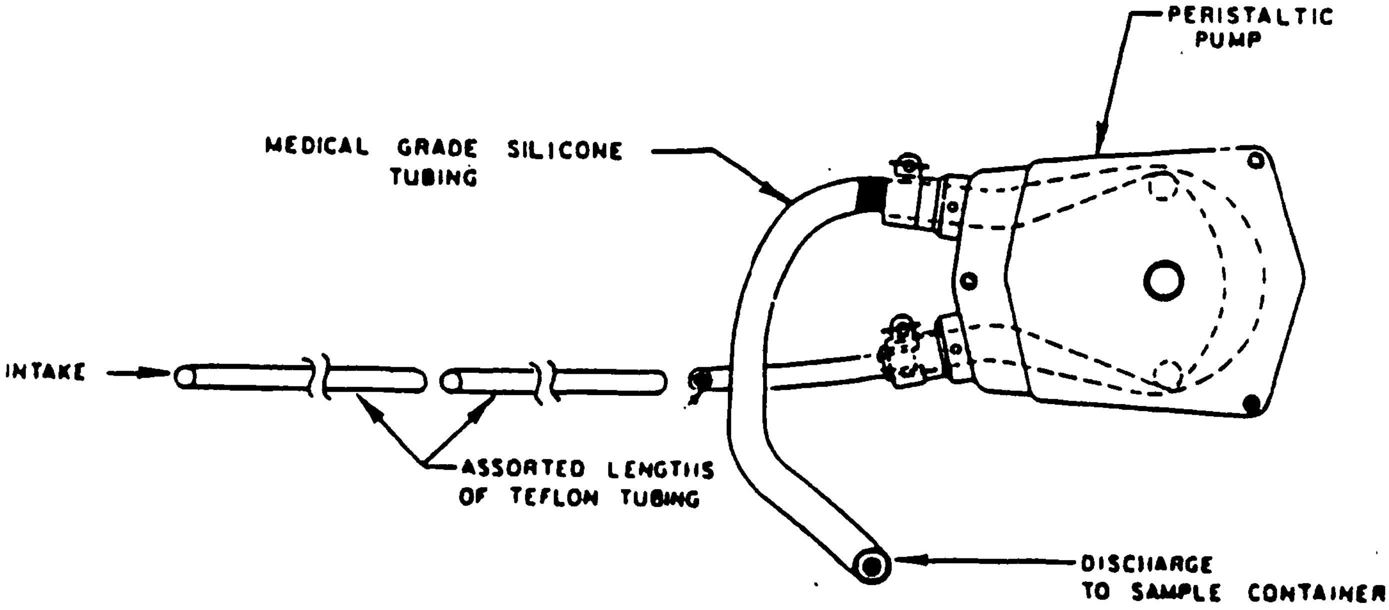
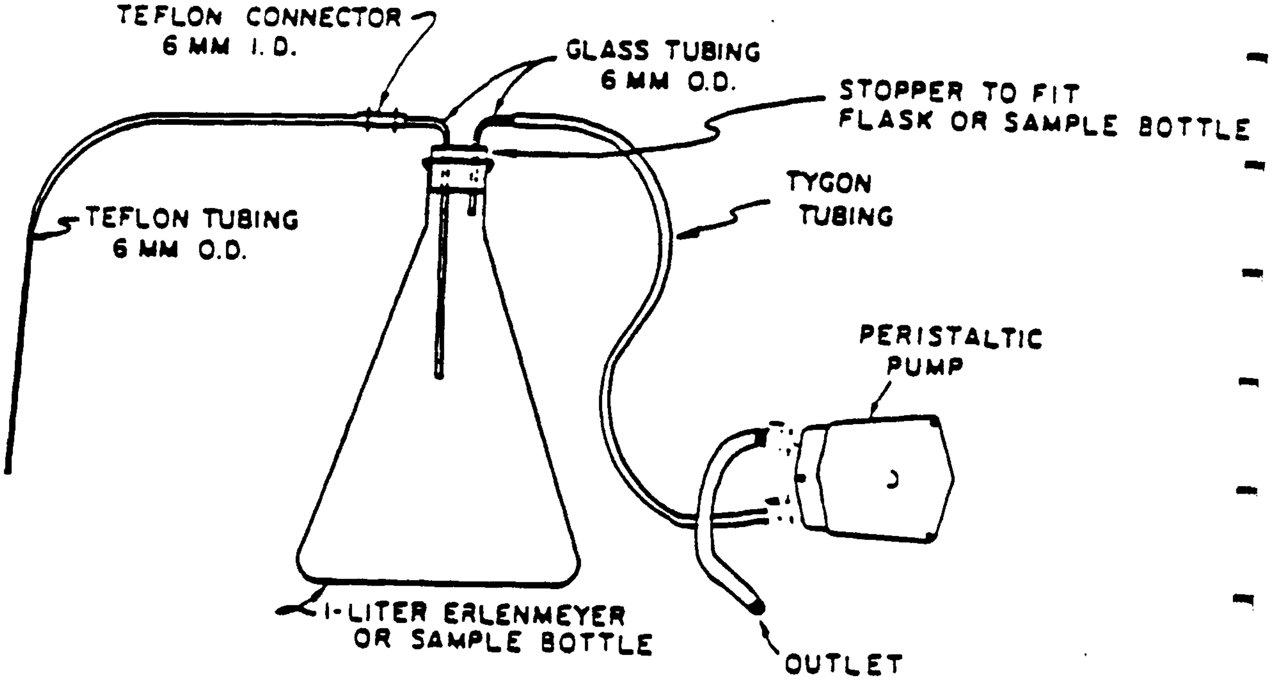


FIGURE 23-3

PERISTALTIC PUMP FOR LIQUID SAMPLING (MODIFIED)



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STANDARD OPERATING PROCEDURE

Section No. 24.0

CONTAINERIZED LIQUIDS

By

JACOBS ENGINEERING GROUP INC.

SECTION 24.0

CONTAINERIZED LIQUIDS

CONTAINERIZED LIQUIDS

The sampling of tanks, containers, and drums present unique problems not associated with natural water bodies. Containers of this sort are generally closed except for small access ports, manways, or hatches on the larger vessels or taps and bungs on smaller drums. The physical size, shape, construction material, and location of access will limit the types of equipment and methods of collection.

When liquids are contained in sealed vessels, gas vapor pressures build up, sludges settle out, and density layerings develop. The potential for explosive reactions or the release of noxious gases when containers are opened requires considerable safeguards. The vessels should be opened with extreme caution. Preliminary sampling of any headspace gases may be warranted. As a minimum, a preliminary check with an organic vapor analyzer may help determine needed levels of personnel protection and may be of aid in selecting a sampling method.

In most cases it is impossible to observe the contents of these sealed or partially sealed vessels. Since some layering or stratification is likely in any solution left undisturbed over time, a sample must be taken that represents the entire depth of the vessel.

Agitation to disrupt the layers and rehomogenize the sample is physically difficult and almost always undesirable. In vessels greater than 1 meter in depth the method of choice is to slowly, in known increments of length, lower the suction line from a peristaltic pump. Discrete samples can be collected from various depths then combined or analyzed separately. If the depth of the vessel is greater than the lift capacity of the pump, an at-depth water sampler, such as the Kemmerer type discussed in Section 23.0, or the ASTM Bomb (Bacon Bomb) may be required. In situations where the reactive nature of the contents are known, a small submersible pump may be used.

When sampling a previously sealed vessel, a check should be made for the presence of a bottom sludge. This is easily accomplished by measuring the depth to apparent bottom then comparing it to the known interior depth. Methods for sampling a bottom sludge are found in Section 21.0.

The most widely used method of sampling drums for hazardous liquid waste is a glass tube, 6 mm to 16 mm I.D., that is lowered into the drum. The top of the tube is sealed with a stopper or the thumb and the tube withdrawn. The bottom of the tube is then placed over a glass jar, the stopper removed from the top and the contents drained into the containers. Aft collection of sufficient sample the tube is then broken up into the drum. This method is simple, relatively inexpensive, and quick and collects a sample without having to decontaminat equipment. It does, however, have serious drawbacks. Most low density fluids do not hol well in the glass tubes. A great deal of the potential sample flows out of the bottom of the tube as it is raised from the drum, thereby reducing the representativeness of collected materi Many variations to this technique have been reported. These include the incorporation of small suction device (i.e., pipette bulb) to the top of the tube as well as the sue of various tube sizes. Some success has been reported with tubes that have been heated at one end the drawn to form a much smaller orifice. This allows the use of larger diameter tubing, therefor a greater volume of sampler per attempt, while reducing the material loss from the tube bottom normally associated with larger diameter tubes.

It should be noted that in some instances disposal of the tube by breaking it into the drum may interfere with eventual plans for the removal of its contents. The use of this technique shoul therefore be cleared with the Project Manager, or other disposal techniques evaluated.

In many instances a drum containing waste material will have a sludge layer on the botto (Section 21.0). Slow insertion of the sample tube down into this layer and then a gradu withdrawal will allow the sludge to act as a bottom plug to maintain the fluid in the tube. The plug can be gently removed and placed into the sample container by the use of a stainles Steel lab spoon. These spoons are relatively inexpensive and can be disposed of in th original waste container with the glass transfer tube.

Designs exist for equipment that will collect a sample form the full depth of a drum an maintain it in the transfer tube until delivery to the sample bottle. These designs include primarily the Composite Liquid Waste Sampler (COLIWASA) and modifications thereof. Th COLIWASA is difficult to properly decontaminate in the field; its applicability is therefore limite to those cases when a sample of the full depth of the drum is absolutely necessary. The COLIWASA can be somewhat modified for this task by making the lift rod of stainless steel, th bottom stopper of Teflon, and the body of glass tubing. In this configuration the glass tub can be broken into the drum leaving only the center rod and the stopper to be decontaminated. In a preliminary investigation where the total number of drums to be sample is small, an equal number of both the center rods and bottom stoppers could be made advance thus eliminating the time involved for onsite cleanup. Heat shrinkable Teflon tubing or other types of Teflon coating can also be used to cover the stainless steel rod if contact the stainless steel with the waste is undesirable.

COLLECTION OF LIQUID CONTAINERIZED WASTES USING GLASS TUBES

Description

Liquid samples from opened containers (55-gallon drums) are collected using lengths of glass tubing. The glass tubes are normally 122 cm in length and 6 to 16 mm inside diameter. Larger diameter tubes may be used for more viscous fluids if sampling with the small diameter tube is not adequate. The tubing is broken up and discarded in the container after the sample has been collected, eliminating difficult cleanup and disposal problems. This method should not be attempted with less than a two-man sampling team.

Uses

This method provides for a quick, relatively inexpensive means of collecting concentrated containerized wastes. The major disadvantage is from potential sample loss which is especially prevalent when sampling less viscous fluids. Splashing can also be a problem and proper protective clothing (e.g., butyl rubber apron, face shields, boot covers) should always be worn.

Procedures for Use

1. Remove cover from sample container opening.
2. Insert glass tubing slowly to almost the bottom of the container. Try to keep at least 30 cm of tubing above the top of the container.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Cap the top of the tube with a safety-gloved thumb or a rubber stopper.
5. Carefully remove the capped tube from the drum and insert the uncapped end in the sample container.
6. Release the thumb or stopper on the tube and allow the sample container to fill to approximately 90 percent of its capacity.
7. Repeat steps 2 through 6 if more volume is needed to fill the sample container.
8. Remove the tube from the sample container and replace the tube in drum.

9. Cap the sample container tightly with a Teflon-lined cap and affix the sample identification tag.

10. Break the glass sampling tube in such a way that all parts of it are discarded inside the drum. (Note: see the initial discussion to this section for exceptions.)

11. Replace the bung or place plastic over the drum.

12. Place sample container in a Ziplock plastic bag (one per bag).

13. Place each bagged container in a 1-gallon metal paint can (or appropriate sized container) and pack in vermiculite packing material. Place lid on the can.

14. Mark the sample identification number on the outside of each paint can and complete chain-of-custody log and the field logbook.

Optional Method (If sample of bottom sludge is desired)

1. Remove cover from container opening.

2. Insert glass tubing slowly almost to the bottom of the container. Try to keep at least 30 cm of tubing above the top of the container.

3. Allow the waste in the drum to reach its natural level in the tube.

4. Gently push the tube towards the bottom of the drum into the sludge layer. Do not force it.

5. Cap the top of the tube with a safety-gloved thumb or rubber stopper.

6. Carefully remove the capped tube from the drum and insert the uncapped end in the sample container.

7. Release the thumb or stopper on the tube and allow the sample container to fill to approximately 90 percent of its capacity. If necessary, the sludge plug in the bottom of the tube can be dislodged with the aid of a stainless steel laboratory spatula.

8. Repeat if more volume is needed to fill sample container and recap the tube.

9. Proceed as in Steps 9 through 14 above.

Note:

1. If a reaction is observed when the glass tube is inserted (violent agitation, smoke, light, heat, etc.) the investigator should leave the area immediately.

2. If the glass tube becomes cloudy or smokey after insertion into the drum, the present of hydrofluoric acid is indicated and a comparable length of rigid plastic tubing should be used to collect the sample.

3. When a solid is encountered in a drum (either layer or bottom sludge) the optional method described above may be used to collect a core of the material, or the material amy be collected with a disposable scoop attached to a length of wooden or plastic rod.

4. If analysis is to be performed onsite, packing Steps 12 and 13 may be deleted. These steps are necessary for transporting and/or shipping samples.

Sources

American Society for Testing and Materials. "Standard Recommended Practices for Sampling Industrial Chemicals, " ASTM E-300-73.

U.S. Environmental Protection Agency, "Technical Methods for Investigating Sites Containing Hazardous Substances, Technical Monograph 1-29, Draft," Ecology and the Environment, June 1981.

SAMPLING CONTAINERIZED WASTES USING THE COMPOSITE LIQUID WASTE SAMPLER (COLIWASA)

Discussion

The COLIWASA is a much cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized wastes. The sampler is commercially available or can be easily fabricated from a variety of materials including PVC, glass, or Teflon. In its usual configuration it consists of a 152 cm by 4 cm (inside diameter) section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper. A current recommended model of the COLIWASA is shown in Figure 24-1; however, the design can be modified and/or adapted somewhat to meet the needs of the sampler.

Uses

The COLIWASA is primarily used to sample most containerized liquids. The plastic COLIWASA is reported to be able to sample most containerized liquid wastes except for those containing ketone, nitrobenzene, dimethylforamide, mesityloxide and tetrahydrofuran. A glass COLIWASA is able to handle all wastes unable to be sampled with the plastic unit except strong alkali and hydrofluoric acid solution. Due to the unknown nature of most containerized waste, it would therefore be advisable to eliminate the use of PVC materials and use samplers composed of glass or Teflon.

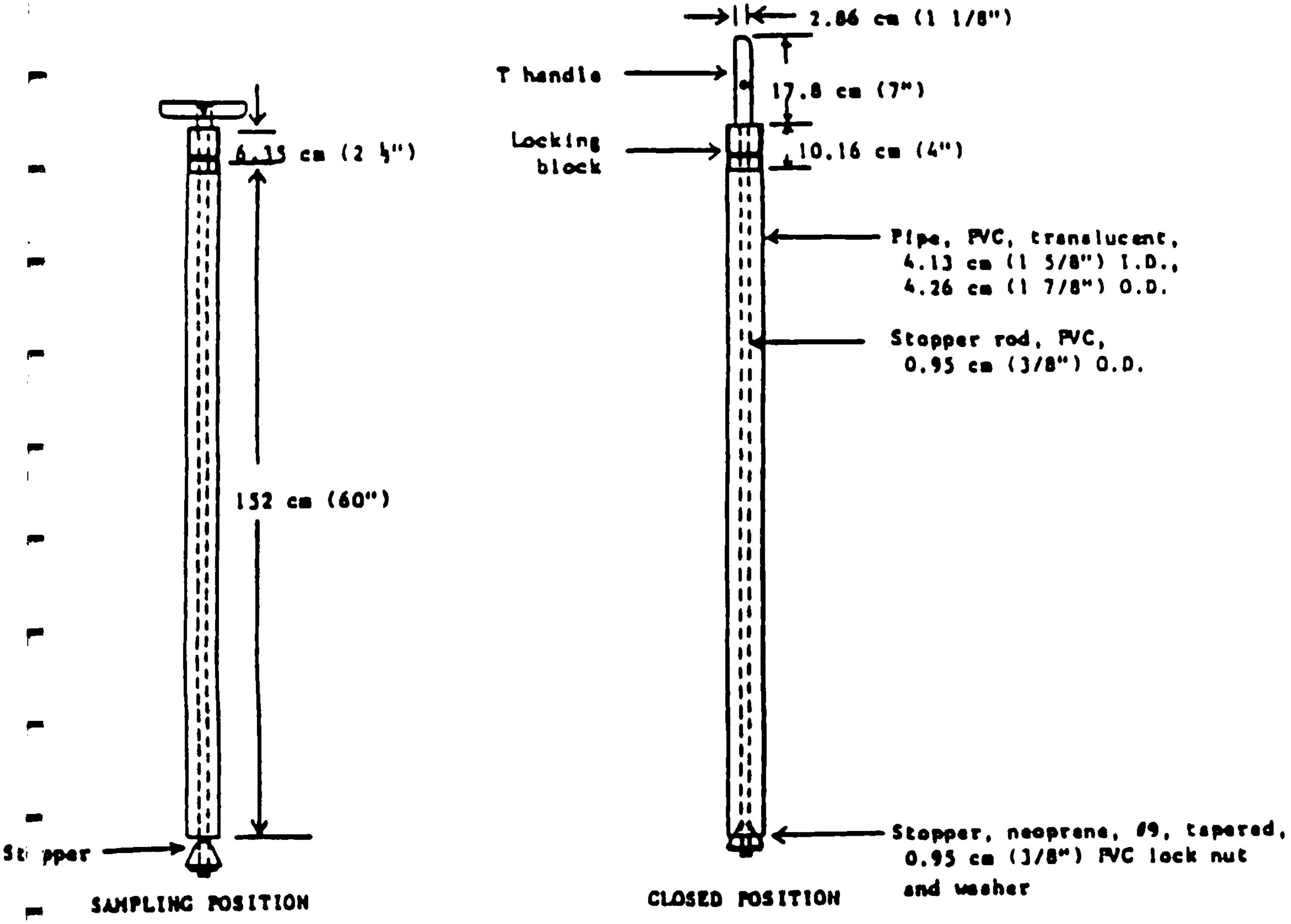
The major drawbacks associated with using a COLIWASA concern decontamination and costs. The sampler is difficult if not impossible to decontaminate in the field and its high cost in relation to alternative procedures (glass tubes) make it an impractical throwaway item. It stil has applications, however, especially in instances where a true representation of a multiphase waste is absolutely necessary. For this reason, the procedure for its use is included.

Procedures for Use

1. Choose the material to be used to fabricate the COLIWASA and assemble the sampler as shown in Figure 24-1.
2. Make sure that the sampler is clean.
3. Check to make sure the sampler is functioning properly. Adjust the locking mechanism if necessary to make sure the neoprene rubber stopper provides a tight closure.
4. Wear necessary protective clothing and gear and observe required sampling precautions.
5. Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.

FIGURE 24-1

COMPOSITE LIQUID WASTE SAMPLER



6. Slowly lower the sampler into the liquid waste. (Lower the sampler at a rate tha permits the levels of the liquid inside and outside the sampler to be about the same. If the level of the liquid in the sample tube is lower than that outside th sampler, the sampling rate is too fast and will result in a nonrepresentativ sample.)

7. When the sampler stopper hits the bottom of the waste container, push th sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T handle until it is upright and on end rests tightly on the locking block.

8. Slowly withdraw the sampler from the waste container with one hand while wipin the sampler tube with a disposable cloth or rag with the other hand.

9. Carefully discharge the sample into a suitable sample container by slowly pullin the lower end of the T handle away from the locking block while the lower en of the sampler is positioned in a sample container.

10. Cap the sample container with a Teflon-lined cap; attach label and seal; recor in field logbook; and complete sample analysis request sheet and chain-of-custody record.

11. Unscrew the T handle of the sampler and disengage the locking block. Clea sampler onsite or store the contaminated parts of the sampler in a plastic storag tube for subsequent cleaning. Store used rags in plastic bags for subsequen disposal.

Sources

de Vera, E.R., Simmons, B.P., Stephens, R.D., and Storm, D.L. "Samplers and Samplin Procedures for Hazardous Waste Streams." EPA 600/2-80-018, January 1980.

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Section No. 25.0

GROUNDWATER SAMPLING

BY

JACOBS ENGINEERING GROUP INC.

SECTION 25.0

GROUNDWATER SAMPLING

GROUNDWATER SAMPLING

Groundwater sampling, as discussed in this Section, involves the collection of groundwater samples from seeps and springs; the collection of groundwater samples from groundwater wells and the collection of groundwater samples during drilling activities. A discussion of surface water sample collection techniques is provided in Section 23.0 of this document. Standard operating procedures for the installation and development of groundwater monitoring wells are provided in Sections 36.0 and 37.0, respectively. Field measurements of static water levels and the total depth of groundwater wells are discussed in Section 38.0.

Sampling of Seeps and Springs

Seeps are generally areas where the surface contour intersects the water table. These areas usually have well established microbiological populations evidenced by extensive moss and algal growths. These microbiological populations usually extend for some distance into the water-bearing formation (aquifer) and are generally more populous and of different species than those associated with the bulk of the aquifer. Their effect on the oxygen content, pH, nutrient and metals concentrations in the groundwater can be extensive. The water, therefore, that seeps from these areas may be substantially altered, and not representative of the conditions deeper in the subsurface. They can, however, yield some information if properly interpreted. If the area in question is without developed wells they are certainly worth consideration, especially for the ease with which they can be sampled.

A stainless steel scoop of the type found in ice machines is ideal for collecting samples from seeps. The flat bottom can be pressed against the bank and the water will flow with very little additional disturbance into the scoop, for transfer to the sample bottles. It is important to collect the sample as close to the actual seep as possible to reduce contact time with the atmosphere and potential for surface contamination.

Sampling of Groundwater Wells

For the purposes of this document, groundwater monitoring via wells will include only sampling of existing wells. The methods and techniques for placement, construction, and development of wells for groundwater monitoring are discussed in Section 36.0. The "Manual for Groundwater Sampling Procedures" (Fenn et.al., 1977), the "NEIC Manual for Groundwater/Subsurfac Investigations at Hazardous Waste Sites" (Sisk et.al., 1981) and the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (EPA, 1986) provide considerabl information for establishing a full groundwater monitoring program including the completion o monitoring wells. When sampling groundwater wells it is necessary to know the well depth. diameter, construction material, type and size of the well screen if used, vertical position of th well screen or slotted section of casing, and type of annular packing if any. This informatio will aid in evaluating the suitability of the well for sampling for a particular analysis. For instance, if the well has a galvanized steel casing with a brass well screen, it would not b suitable for trace metal analysis. Similarly, if the well is located in a swampy area, the type an amount of grout or fill around the well casing would determine the degree of surface water inflow to the well that might be expected. Information concerning site-specific subsurfac geology and well construction may be available from the well driller's or the field geologist' borehole log. However, the actual well depth may be less than the completion depth listed on the log as a result of aquifer invasion through the screen or open-hole sloughing below th casing. This may be particularly noticeable in wells that have had only sporadic use or hav been idle long. It is recommended that actual well depth be checked by field measurement whenever possible.

The water within a well casing and in close proximity to the well is probably not representative of the overall groundwater quality in the aquifer surrounding the well. This is due to th possible presence of contaminants introduced to the well during drilling and because importan environmental conditions such as the oxidation-reduction potential may differ in and near the well from the conditions in the surrounding water-bearing materials. For these reasons it i highly desirable that a well be pumped or bailed until the well is thoroughly flushed of standin water and contains water representative of the aquifer. The recommended amount of purging before sampling is dependent on many factors including the construction characteristics of th well, the hydrogeological nature of the aquifer, the type of sampling equipment being used, an the parameters being sampled. A common procedure is to pump or bail the well until a minimum of three (3) to five (5) bore-volumes have been removed. Borehole-volumes may b calculated using the borehole radius and field measurements of total well depth and static wate level (as discussed in Section 38.0). One borehole-volume (BV) in cubic feet (ft^3) may be calculated as follows:

$$BV = \pi r^2 \times h$$

where: r = Radius of the borehole in feet
h = height of water column in well as calculated by subtracting the depth to groundwater (from measurement of static wate level) from the total depth of the well.

Removing all water from the well bore is only possible if the well is pumped dry. Two alternative approaches are recommended: (a) monitor the water level in the well while pumping. When the water level has "stabilized" most if not all of the water being pumped is coming from the aquifer. (b) monitor the temperature, conductivity, or pH of the water while pumping. When these parameters "stabilize" it is probable that little or no water from casing storage is being pumped (Gibb et. al. 1981).

The use of an indicating analysis such as pH, temperature, redox potential, or, most commonly, conductivity, may be the most accurate and reliable method of assuring complete well purging. This also reduces the technique likelihood of overpurging. The technique is easily implemented in the field and provides a rapid and positive indication of changes in the well bore water. This change in the water character and subsequent stabilization can normally be interpreted as evidence that sufficient purging has occurred. Methods used for field measurement of temperature, pH, and specific conductance are provided in Sections 12.0, 13.0, and 14.0, respectively. The sensitivity of these parameters to changes as a result of exposure of groundwater to surface level conditions (i.e., changes in the partial pressure of dissolved gases or conditions of the purging system) make in-situ monitoring desirable. An alternative to this technique is to conduct these measurements in a closed cell attached to the discharge side of the well pump system.

Other factors which will influence the amount of purging required before sampling include the pumping rate and the placement of the pumping equipment within the column of water in the well bore. For example, if a pump is lowered immediately to the bottom of a well before pumping, it may take some time for the column of water above it to be exchanged if the transmissivity of the aquifer is high and the well screen is at the bottom of the casing. In such cases the pump will be drawing water primarily from the aquifer.

Because of the potential for further environmental contamination, planning for purge water disposal is a necessary part of well monitoring. Alternatives range from dumping it on the ground (not back down the well) to full containment, treatment, and disposal. If the well is believed to be contaminated, the best practice is to contain the purge water and store it until the water samples have been analyzed. Once the contaminants are identified, appropriate treatment requirements can be determined.

Sample Collection Procedures

Monitoring wells with submersible pumps, production wells with dedicated pumps (either on- or off-line), and wells without pumps may be sampled during remedial investigations activities. Wells without pumps will be purged and/or sampled using a peristaltic pump, a gas pressure displacement pump, stainless steel or teflon ball-valve bailer, or portable submersible pump. Procedures for groundwater sample collection are provided below.

Before Entering the Field

- Prepare Field Sampling Plan specifying sampling locations, analytical parameters, and time of sampling. The plan will be submitted for review and approval by appropriate agencies if necessary.
- Collect appropriate sampling and safety equipment to be used in the field.
- Advise appropriate analytical laboratory regarding samples to be collected and arrange for appropriate sample containers.
- Evaluate access availability to the well. If the well is locked or access is on private land, make arrangements to obtain keys or gain access.
- The diameter of the well should be known. This will aid in determining size of bailers to be used when sampling. The diameter of the well is also used in the calculation of the borehole water volume for determining minimum volume to be pumped prior to sampling.
- Determine the depth to the perforated interval of the well. This indicates the depth at which groundwater will be entering the well.
- Determine the total depth of the well. This will enable calculation of the well water volume.
- Identify the type of casing material, i.e., PVC or steel.
- For production wells, obtain information on the pumping rates, latest "dynamic" and pumping water levels, pump intake depths, and length of time the pump has been on or off.
- Determine the location of the sampling point from the owner/agency (this will be described in the Sampling Plan).
- Identify production wells within 1/2 mile from well to be sampled (as described in the Sampling Plan).

In the Field

Sampling of a monitoring well may be divided into three parts: 1) measurement of borehole volume and water level, 2) evacuation of borehole water, and 3) obtaining the sample. Information pertinent to sampling such as the well designation, the time the pump is turned on and off, the time of sampling, and volume of water pumped will be recorded in the field notebook. Photographs should be taken of each sampling location.

1. If the well to be sampled has a permanent pump and the well is currently in operation, (and has pumped long enough to evacuate a minimum of 3 borehole volumes) collect a sample directly from the discharge point into the appropriate sample container. The sampling procedure to be used is as follows:

   o Sample containers will be rinsed (except when collecting samples for extractable organic compounds and pesticide/PCBs) with sample water a minimum of three times to ensure that possible contaminants in the sample bottle are removed unless pre-preserved containers are used.

   o When sampling for volatile organic compounds (VOAs) the 40 ml sample vials will have no headspace. To avoid aeration, the glass sampler will be held at an angle so that the stream of water flows down the side. Fill the vial until it overflows to eliminate any air bubbles and replace the teflon-lined cap. A stainless steel cup may be used to fill the vial, if necessary. Two or three vials will be collected for each sample.

   o Turn the vial upside-down and tap it to check for air bubbles. If there are any bubbles, refill the vial and check for air bubbles again. Repeat this procedure until an acceptable sample is obtained.

     For other samples, such as inorganic compounds or other organic compounds, follow the descriptions of sample containers and preservation methods described in Sections 28.0 and 29.0.

   o Package the sample according to standard procedures described in Section 31.0.

   o Put samples on ice and ship to appropriate analytical laboratory using shipping procedures described in Section 31.0.

2. If the well to be sampled has a dedicated installed pump, but the well is not in operation at the time of sampling, a pre-sampling water level measurement will be taken, the pump

will be turned on and three borehole volumes will be evacuated. In addition, physical parameters (pH, conductivity, temperature) will be monitored until stable (±10 percent). If stabilization is not reached within 30 minutes after the three borehole volume evacuation, then the well will be sampled without stabilization. Prior to turning the pump on, measure the water level. The sampling procedure to be used is as follows:

- Take a water level measurement. The Sampling Plan will specify the applicable method for a specific well.
- Calculate the borehole water volume for well evacuation purposes (or use a previously prepared table or graph).
- Turn on the pump, evacuate a minimum of three borehole volumes, and monitor parameters for stabilization as described above.
- Collect water sample in appropriate sample container from the discharge valve at the wellhead after evacuation and stabilization.
- Turn off the pump.
- Measure recovery water levels as specified in Sampling Plan; this will only be implemented at the first sampling event of that well, and only if pumping tests have not occurred previously at that particular well.

3. If the well to be sampled does not have any downhole equipment in it, a portable pump will be used for well evacuation of at least three to five borehole volumes and parameters will be monitored for stabilization as described above. The sampling procedure to be used is as follows:

- Calculate the well water volume.
- Measure discharge rate from the pump, using the appropriate method, and calculate the time required for evacuation of three borehole volumes.
- Collect water sample directly from the pump discharge tubing into appropriate sample containers.
- Remove pump from well and decontaminate the pump by steam-cleaning.

- Measure recovery water levels as specified in the Sampling Plan. Recovery measurements will only be taken during the first sampling event of a well.

4. Wells which do not have downhole pumping equipment or are not large enough for a submersible pump (or do not yield much water) will be sampled with a stainless steel or teflon bailer, field conditions permitting. The bailer has a teflon ball-valve check system which enables sampling from a discrete depth within the well. The sampling procedure to be used is as follows:

   - Take a water level measurement prior to bailing. The method for a specific well will be determined in the Sampling Plan.

   - Attach the bailer to a nylon rope and raise and lower by hand. Different ropes will be used for each well so that there will be no cross-contamination between wells. All sample collection bailers will be decontaminated prior to use and between well samplings using procedures described in Section 26.0.

Sampling Equipment

There are many methods and equipment items available for well purging. In some cases bailing will suffice, however it can become tedious and labor intensive in deep or large diameter wells. In some situations, an inflatable packer can be utilized above and/or below the pump to reduce the casing volume requiring purging. This technique is particularly adaptable to wells with more than one screened internal to isolate the aquifer of interest. The size and weight of a pump and packer assembly usually require tripods/derricks and hoist equipment which are not easily implemented. Additionally the packer may be constructed of rubber material which may effect some analysis although viton packers are feasible.

Gas pressure lift systems are useful in many instances. They are usually light, easy to install, and can be powered by several different pressure systems, usually compressed nitrogen or air. The effect of the contact between the pressure gas and the groundwater usually results in changes in the dissolved gas content. As a result pH, conductivity, or other analysis used to determine purge completion must be conducted down hole.

Peristaltic pumps are widely used for purging of wells with water levels close to the surface (less than 8 meters). They are reasonably portable, light, and easily adaptable to ground level monitoring of purge indicator parameters by attaching a flow-through cell. These pumps require a minimum of down hole equipment and can easily be cleaned in the field; or the entire tubing assembly can be changed for each well.

Several manufacturers are marketing submersible pumps specifically designed for groundwater monitoring. Most of these pumps have effective depth limitations of less than 150 feet. Although some can operate to depths in excess of 300 ft., they usually have substantially reduced discharge flows and significant power consumption. All electrically powered equipment should be checked for electrical safety certification (UL, FM, NFPA, NEC).

Three basic designs are currently available:

- Educators - A pump is used to circulate water through a venturi, the resultant pressure drop across the venturi is used to draw sample into the recirculating stream. A split stream is drawn off the recirculating stream equal to the flow at the intake. These systems require priming water and must be run long enough to insure complete removal of the priming water from the recirculation loop. They readily fit into a 2-inch diameter well and will recover samples from as deep as 100 ft or 50 ft in a 1-1/2 inch ID well.
- Submersible Motor - A small submersible electric motor is used to drive a common stator/rotor pump. They will fit inside a 2-inch ID well and operate at depths to approximately 150 ft. The discharge flow varies with depth from 1.2 gpm at 10 ft to 0.6 gpm at 125 ft.
- Bladder Compression - A flexible bladder with check valve at either end is suspended inside a rigid chamber. Hydrostatic pressure forces water into the bladder. The chamber is then pressurized which squeezes the bladder and forces the water out the other check valve and into the discharge tubing. This cycle is then repeated until the sample is recovered.

  The pump is operated by a compressed air source, either bottled gas or a small DC powered compressor. Pumps are available that can sample from depths of 250 ft. Flow rates vary with models but range from about 2.0 gpm at 25 ft. to 0.5 gpm at 150 ft. (At least one model is capable of 0.78 gpm at 250 ft.)

Once the well has been sufficiently purged, the actual sampling should begin as soon as the water level begins to approach its pre-purge level. Sampling for volatile organic compounds may begin even sooner, before substantial volatilization begins. If recovery is very slow, it may be necessary to wait several hours or even until the following day before sufficient volume is available for all the necessary analyses. In this instance a volatile organic compound sample may be collected soon after completion of the purging process and a second set with the remaining samples. When a pump is used for sample collection, its rate should be controlled. if possible to closely match the transmissivity of the formation. Excessive drawdown of the water level in the well during sampling may result in non representative samples due to changes in groundwater flow.

Bailers are probably the simplest means of collecting groundwater samples. They result in a minimum of sample disturbance if carefully handled. They can be constructed of noncontaminating materials, and their low relative cost makes the use of a separate device for each well practical, thus eliminating in-field cleaning and cross contamination. Peristaltic pumps can be used for sampling in most shallow wells. They require a minimum of down-hole equipment and cross contamination can be eliminated by replacement of the suction tubing between wells. Gibb et. al., 1981, as well as NCASI, 1982, found little difference between samples withdrawn by a peristaltic pump and those taken by a bailer. These pumps however may not be suitable for the collection of volatile organic compounds due to possible gas stripping; therefore, their use should be supplemented by a bailer when sampling includes volatile organic species.

The use of submersible pumps as described previously for sample collection is possible provided they are constructed of suitably noncontaminating materials and pumped at a moderate flowrate. They can operate at depths beyond the capabilities of peristaltic pumps and at which depths bailing becomes tedious. The chief drawback, however, is the difficulty of avoiding cross contamination between wells. These systems are generally too expensive to allow for several separate units. Though some units can be easily disassembled and allow for replacement of most sample contacted surfaces, field decontamination still may be difficult and should properly require solvents that may lead to sample contamination. Their use therefore, in multiple well programs, should be carefully considered against bailers.

In general, gas pressure displacement systems where gas interfaces with the liquid should not be used for sample collection as they have been shown to cause considerable changes in the groundwater character.

PURGING WITH A PERISTALTIC PUMP

Discussion

The peristaltic pump as described in Section 23.0 can be implemented for the presample purging of groundwater monitor wells.

Uses

The use of peristaltic pumps for well purging is particularly advantageous since the sam system can later be used for sample collection. The application, however, is limited to well with a depth of less than approximately 8 meters, due to the limited lift capabilities of peristaltic action.

Procedures for Use

1. Using clean equipment, sound well for total depth and water level, then calculate the fluid volume in the casing ("casing volume").
2. Determine depth from casing top to mid-point of screen or well section open to aquifer. (Consult drillers log, or sound for bottom).
3. If depth to mid-point of screen is in excess of 8 meters, choose alternate system.
4. Lower intake into the well to a short distance below the water level and begin wate removal. Collect or dispose of purged water in an acceptable manner. Lower suction intake, as required, to maintain submergence.
5. Measure rate of discharge frequently. A bucket and stopwatch are most commonl used.
6. Purge a minimum of three to five borehole volumes or until discharge, pH, temperatur, or conductivity stabilize. See discussion of field measurements in Sections 12.0, 13.0, and 14.0.
7. After pumping, monitor water level recovery. Recovery rate may be useful in determinin sample rate.

PURGING WITH A GAS PRESSURE DISPLACEMENT PUMP SYSTEM

Discussion

A gas pressure displacement pump system (bladder pump) consists of a chamber equippe with a gas inlet line, a water discharge line and two check valves (see Figure 25-1). When the chamber is lowered into the casing, water floods it from the bottom through the chec valve. Once full, a gas (i.e., nitrogen or air) is forced into the top of the chamber sufficient to result in the upward displacement of the water out the discharge tube. The check valve in the bottom prevents water from being forced back into the casing, and the upper check valve prevents water from flowing back into the chamber when the gas pressure is released. This cycle can be repeated as necessary until purging is complete.

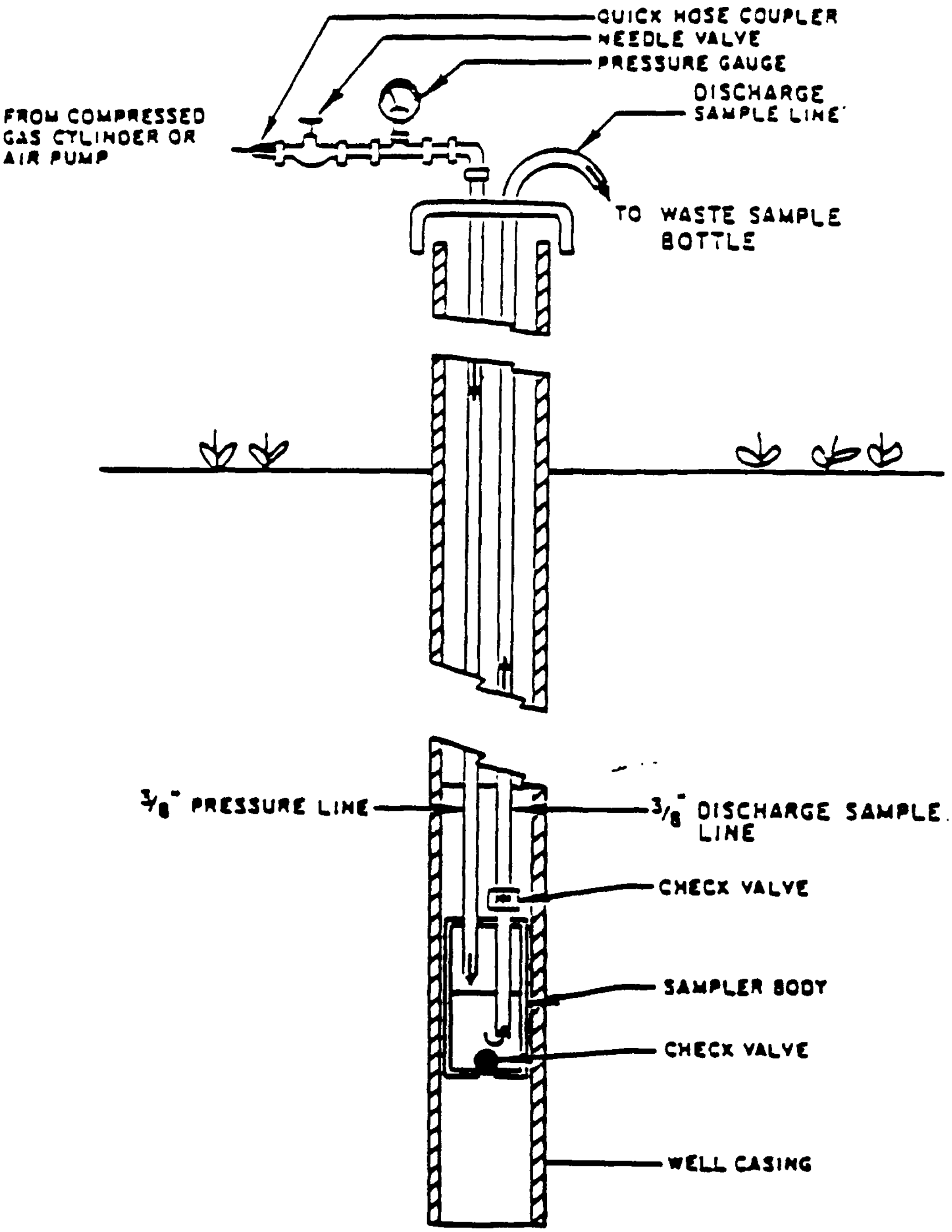
Uses

The pressure lift system is particularly useful when the well depth is beyond the capability of a peristaltic pump. The water is displaced up the discharge tube by the increased gas pressure above the water level. The potential for increased gas diffusion into the water makes this system unsuitable for sampling for volatile organic compounds or most pH critical parameters.

Procedures for Use

1. Using clean noncontaminating equipment, i.e., an electronic level indicator (avoid indicating pastes) determine the water level in the well, then calculate the fluid volume in the casing.
2. Determine depth to midpoint of screen or well section open to aquifer (consult drillers log).
3. Lower displacement chamber until top is just below water level.
4. Attach gas supply line to pressure adjustment valve on cap..
5. Gradually increase gas pressure to maintain discharge flow rate.
6. Measure rate of discharge frequently. A bucket and stopwatch are usually sufficient.
7. Purge a minimum of three to five borehole volumes or until discharge characteristics stabilize. See discussion on field measurements in Sections 12.0, 13.0 and 14.0.
8. After pumping, monitor water level recovery. Recovery rate may be useful in determining sample rate.

FIGURE 25-1
GAS PRESSURE DISPLACEMENT SYSTEM



SAMPLING WITH A BUCKET TYPE BAILER

Discussion

Bucket type bailers are tall narrow buckets equipped with a check valve on the bottom. This valve allows water to enter from the bottom as the bailer is lowered, then prevents its release as the bailer is raised (see Figure 25-2). Top filling bailers are also available and may be useful for well purging but generally result in increased sample turbulence and are not recommended for sample acquisition.

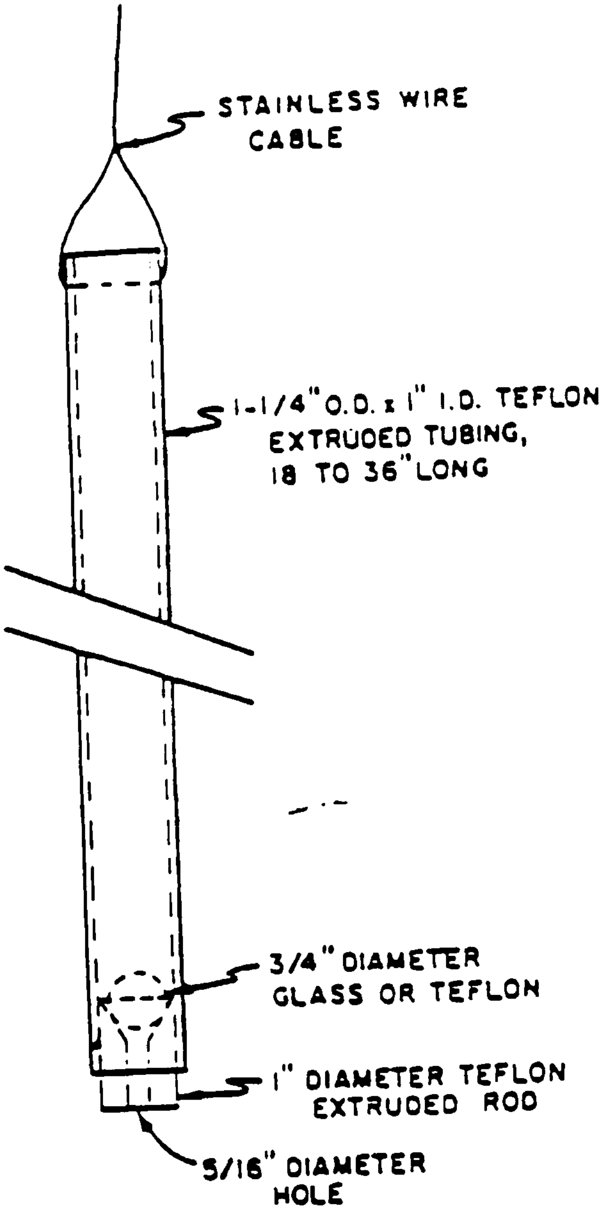
Uses

This device is particularly useful when samples must be recovered from depths greater than the range (or capability) of suction lift pumps, when volatile stripping is of concern, or when well casing diameters are too narrow to accept submersible pumps. It is the method of choice for the collection of samples which are susceptible to volatile component stripping or degradation due to the aeration associated with most other recovery systems. Samples can be recovered with a minimum of aeration if care is taken to gradually lower the bailer until it contacts the water surface and is then allowed to sink as it fills. Teflon is generally the best construction material but other materials (PVC, stainless steel, etc.) are acceptable if compatible with designated sample analysis. The primary disadvantages of bailers are their limited sample volume and inability to collect discrete samples from a depth below the water surface.

Procedures for Use

1. Using clean, noncontaminating equipment, i.e., an electronic level indicator (avoid indicating paste), determine the water level in the well, then calculate the fluid volume in the casing.
2. Purge a minimum of three to five borehole volumes or until discharge characteristics stabilize. See discussion on field measurements in Sections 12.0, 13.0 and 14.0.
3. Attach precleaned bailer to cable or line for lowering.
4. Lower bailer slowly until it contacts water surface.
5. Allow bailer to sink and fill with a minimum of surface disturbance.
6. Slowly raise bailer to surface. Do not allow bailer line to contact ground.

FIGURE 25-2
BAILER



7. Tip bailer to allow slow discharge from top to flow gently down the side of the sample bottle with minimum entry turbulence.

8. Repeat steps 2-5 as needed to acquire sufficient volume.

9. Select sample bottles and preserve the sample, if necessary, according to the guidelines in Section 28.0.

10. Check that a Teflon-liner is present in cap if required. Secure the cap tightly.

11. Label the sample bottle with an appropriate tag. Be sure to complete the tag with all necessary information. Record the information in the field logbook and complete all chain-of-custody documents.

12. Thoroughly decontaminate the bailer after each use according to specific laboratory instructions, or the general guidelines in Section 26.0. In some cases, especially where trace analysis is desired, it may be prudent to use a separate bailer for each well.

SAMPLING WITH A PERISTALTIC PUMP

Discussion

A pump system is considerably advantageous when analytical requirements demand sample volumes in excess of several liters. The major drawback of a pump system is the potential for increased volatile component stripping as a result of the required lift vacuum. Samples for volatile organic analysis should be collected with a bailer as described previously and should precede any sample collection which may further disturb the well bore content.

Uses

The peristaltic pump system can be used for monitoring well sampling whenever the lift requirements do not exceed 8 meters. It becomes particularly important to use a heavy wall tubing in this application in order to prevent tubing collapse under the high vacuums needed for lifting from depth.

Procedures for Use

1. Using clean, noncontaminating equipment, i.e., an electronic level indicator (avoi indicating paste), determine the water level in the well, then calculate the fluid volume in the casing.

2. Purge a minimum of three to five borehole volumes or until discharge characteristic stabilize. See discussion on field measurements in sections 12.0, 13.0 and 14.0.

3. If soundings show sufficient level of recovery, prepare pump system. If insufficien recovery is noted allow additional time to collect samples on a periodic schedule which will allow recovery between samplings.

4. Collect volatile organic analysis samples if required with bucket type bailer.

5. Install clean medical grade silicon tubing in peristaltic pump head.

6. Attach pump to required length of precleaned Teflon suction line and lower to midpoin of well screen if known or slightly below existing water level.

7. Consider the first liter of liquid collected as a system purge/rinse. NOTE: If well yiel is insufficient for required analysis this purge volume may be suitable for some les critical analysis.

8. Fill necessary sample bottles by allowing pump discharge to flow gently down the sid of bottle with minimal entry turbulence. Cap each bottle as filled.

9. Select sample bottles and preserve the sample, if necessary, according to the guideline in Section 28.0.

10. Check that a Teflon-liner is present in cap if required. Secure the cap tightly.

11. Label the sample bottle with an appropriate tag. Be sure to complete the tag with a necessary information. Complete all chain-of-custody documents and field logbook.

12. Allow system to drain then disassemble. Return tubing to lab for decontamination. See Section 26.0 for decontamination procedures.

SAMPLING MONITORING WELLS WITH A SUBMERSIBLE PUMP

Discussion

Several types of submersible pumps are available for groundwater monitoring and offer considerable advantages over other systems. They are able to operate from depths beyond the capabilities of peristaltic pumps and save significant time and effort relative to hand bailing. Further, if constructed of suitable materials and properly used, they can both purge and adequately sample the well.

Uses

Submersible pumps generally use one of two types of power supplies, either electric or compressed gas. Electric powered pumps generally run off a 12 VDC rechargeable battery from an automotive electrical system. Those units powered by compressed gas normally use a small electric compressor which also needs 12 VDC power. They may also utilize compressed gas from bottles or even high performance hand pumps.

These pumps are generally constructed of noncontaminating material suitable for priority pollutant sampling. They often contain plastics, rubber or metal parts which may contribute or otherwise effect the analysis of samples for certain trace components. Investigations requiring samples for a wide range of trace analysis may preclude their use for sample acquisition; however, they may still be useful for purging. In any case, when doubt remains, bailers are the best choice for actual sample acquisition.

Procedures for Use

1. Using clean, noncontaminating equipment, i.e., an electronic level indicator (avoid indicating paste), determine the water level in the well, then calculate the fluid volume in the casing.

2. Lower the precleaned pump to just below the water level and begin pumping. Collect or dispose of purged water in an acceptable manner. Lower the pump as required to maintain submergence.

3. Measure rate of discharge frequently. A bucket and stopwatch are commonly used.

4. Purge a minimum of three to five borehole volumes or until discharge pH, conductivity, or temperature stabilize. (Note: If the pump is constructed of materials compatible with the required sample analysis and if the well has recovered sufficiently (resound water

level) sample acquisition can proceed as follows. It should be cautioned that all down hole and potentially wetted surfaces must also be noncontaminating/noncontributing. This includes power and suspension cables and compressed gas or sample tubing.)

5. Fill necessary sample bottles by allowing pump discharge to flow gently down the side of bottle with minimal entry turbulence. Cap each bottle as filled.

6. Select sample bottles and preserve the sample, if necessary, according to the guidelines in Section 28.0.

7. Check that a Teflon-liner is present in cap if required. Secure the cap tightly.

8. Label the sample bottle with an appropriate tag. Be sure to complete the tag with all necessary information. Complete all chain-of-custody documents and field logbook.

9. Allow system to drain then disassemble. Return tubing to lab for decontamination. See Section 26.0 for Field Decontamination Procedures for equipment used in groundwater data collection.

ADVANTAGES AND DISADVANTAGES OF MONITORING WELL SAMPLING EQUIPMENT

<u>Type</u>	<u>Advantages</u>	<u>Disadvantages</u>
A. Bailer	Can be constructed in a wide variety of diameters	Time consuming sampling; sometimes impractical to properly evacuate casing before taking actual samples
	Can be constructed from a wide variety of materials	Transfer of water to sample bottle may result in aeration
	No external power source required	
	Extremely portable	
	Low surface area to volume ratio, resulting in a very small amount of outgassing of volatile organics while sample is contained in bailer	
<u>Type</u>	<u>Advantages</u>	<u>Disadvantages</u>

		Easy to clean Readily available Inexpensive	
B.	Suction Lift Pump	Relatively portable Readily available Inexpensive	Sampling is limited to situations where water levels are within about 20 ft from ground surface Vacuum effect can cause the water to lose some dissolved gas and volatile organics In some cased not constructed with materials compatible with sampling certain constituents
C.	Gas Lift Samplers	Relatively portable Readily available Inexpensive Very suitable for well development	Generally not considered appropriate method for acquisition of water samples for detailed chemical studies owing to degassing Regardless of the gas utilized, changes in CO$_2$ concentrations make this method unsuitable for sampling for pH sensitive parameters Aeration of water remaining in well frequently make method unsuitable for well evacuation

Type	Advantages	Disadvantages
		If air is used, oxygenation is impossible to avoid unless elaborate precautions are taken (only a very small amount of oxygen is required to cause a water sample to attain saturation with respect to oxygen)
D. Submersible Pumps	Wide range in diameters Various materials are available	Conventional units are unable to pump sediment-laden water without incurring damage to the pump
	Fairly portable	Relatively expensive
	Depending upon size of pump and pumping depths, relatively large pumping rates are possible	
	Positive displacement minimizes loss of volatiles during pumping	
	Readily available	
E. Gas-operated Squeeze Pump	Can be constructed in diameters as small as one inch	Gas source required
		Large gas volumes and long cycles are necessary for deep operation
	Can be constructed from a wide variety of materials	Pumping rates are not as great as with suction or jet pumps
	Relatively portable	

Type	Advantages	Disadvantages
	Fair range in pumping rates are	Commercial units are relatively expensive possible - pumps cost around $300.00, while central gas unit cost around $15.00
	Driving gas does not contact water sample, eliminating possible contamination or gas stripping	
	Positive displacement minimizes loss of volatiles	
F. Gas Driven Piston Pump	Isolates the sample from the operating gas	Relatively expensive; in excess of $3,000 operating gas for the continuously operating unit
	Requires no electrical power source	Particulate material may damage or inactivate pump unless the suction line is filtered over extended periods of time
	Operates continuously and reliably over extended periods of time	
		Low pumping rates
	Uses compressed gas economically	
	Can be operated at pumping heads in excess of 500m	
	Positive displacement minimizes loss of volatiles	
G. Jet Pumps	Capable of producing high yields	Requires priming and mixing sample with water circulating in pump, greatly limiting any use in monitoring well applications
	Commonly used in shallow domestic wells	

Type	Advantages	Disadvantages
	Available for relatively small diameter wells	Use of venturi may result in stripping of volatiles

Groundwater Sampling During Drilling

At times it may be advantageous to collect groundwater samples during drilling activities. Several drilling methods allow for the detection and sampling of perched water liquids in the borehole during drilling and prior to well installation. For example, hollow-stem auger, air-rotary/casing drive, air-hammer/casing drive, and dual-tube/air hammer drilling methods allow for groundwater identification and sampling, if desired. However, methods such as mud-rotary drilling do not allow for groundwater sampling during drilling due to the use of drilling mud in the borehole.

Typically a stainless steel or teflon bailer will be used for groundwater sample collection during drilling. If sufficient groundwater/liquid is available, a down-hole pump (e.g. peristaltic, gas-pressure displacement, or submersible pump) may be used to evacuate water/liquid from the borehole prior to sample collection. Samples collected during drilling may provide data that is not representative of the actual aquifer water chemistry. Laboratory data for samples collected during drilling may aid in identifying potential contaminant migration pathways however, these should be confirmed with samples collected from a properly constructed and developed groundwater monitoring well.

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STANDARD OPERATING PROCEDURE

Section No. 26.0

FIELD DECONTAMINATION PROCEDURES FOR EQUIPMENT USED IN GROUNDWATER DATA COLLECTION

By

JACOBS ENGINEERING GROUP INC.

SECTION 26.0

FIELD DECONTAMINATION PROCEDURES FOR EQUIPMENT USED IN GROUNDWATER DATA COLLECTION

INTRODUCTION

Decontamination procedures are required for all well monitoring equipment which comes in contact with ground water during groundwater data collection. These procedures are designed to ensure that the introduction and transfer of contamination from equipment to the groundwater, or between wells, is minimized. The procedures also ensure that the groundwater analytical parameters collected from a monitoring well are accurate and valid.

EVALUATION

Available Equipment

There are numerous decontamination procedures and solutions available. Their use is dependent on the type of equipment to be decontaminated, the type of contaminant(s) present, and the extent of contamination.

Problem

The primary problems involving decontamination procedures include the selection of specific decontamination agents for specific types of contamination, and the use of cleaning solvents and rinsates (e.g. acetone, hydrochloric acid, nitric acid, hexane) which will not interfere with the types of analyses to be performed. Some agents may require special handling and disposal procedures.

Apparatus

The items listed below are generally required for proper equipment decontamination:

- o Concrete-or synthetic material-lined decontamination pad
- o Stainless steel bucket(s)
- o Wooden-handled scrub brushes
- o Laboratory-grade, non-phosphate detergent (Liquinox)
- o Sodium carbonate

- Sump or collection system for contaminated liquid
- Calcium hypochlorite
- Hydrochloric acid
- Distilled water
- De-ionized water
- Laboratory rinse bottles
- High Pressure Liquid Chorotography(HPLC)-grade water
- Laboratory rinse bottles.

Procedures

Four general decontamination solutions and their preparation procedures are presented in Table 26-1. Other contaminant-specific solutions may be required, due to the presence of mixed contaminant types and/or the need to use specific decontamination solutions for specific sampling requirements.

Decontamination Plan

Decontamination will be required on all equipment that comes into contact with groundwater. This equipment includes, but is not limited to, pH and specific conductance meters, water level instruments, pumps, bailers, beakers, drilling equipment, etc.

Equipment

Recommended decontamination procedures for equipment and instruments are listed below:

- Step 1: Lay-out a clean plastic sheet proximate to the well.
- Step 2: Mix the appropriate decontamination solution outlined in Table 26-1 in a stainless steel bucket.
- Step 3: Empty distilled water into another stainless bucket and have de-ionized water available in wash bottles.
- Step 4: Wash contaminated equipment in the decontamination solution followed by a distilled water de-ionized water rinse and finally by an HPLC water rinse.
- Step 5: Place equipment on plastic to air dry.

Drilling equipment and down-hole testing and sampling equipment will be decontaminated using a high pressure steam cleaner. The following general procedures will be used:

- Step 1: Equipment is placed on the decontamination pad.
- Step 2: Equipment is steam-cleaned until all soil waste and foreign matter is removed from all surfaces.
- Step 3: Equipment is then placed on plastic and allowed to air dry.
- Step 4: Decontaminate rinsate is collected and contained for appropriate treatment or disposal.

Instruments

- Step 1: Instrument cells (pH meter and specific conductance meter) will be thoroughly washed with distilled water, then rinsed with de-ionized water. Use laboratory rinse bottles to direct the spray so an not to allow moisture near the electronic components of the instrument. Specific procedures for decontamination of the barrel filter unit can be found in Jacob's SOP No. 22 (Field Filtration of Groundwater Samples for Dissolved Metal Analysis)

QUALITY ASSURANCE

The following quality assurance information must be logged into a field notebook

- Decontamination solution used
- Unusual problems or conditions
- pH and specific conductance readings for both distilledand HPLC water.

The following QA information must be submitted to the laboratory:

- A rinsate sample, as required for analytical QA/QC, which will be collected after performance of the decontamination procedures to determine the adequacy of the procedure. The collection and handling of this sample will follow identical sampling procedures for all other samples collected onsite.

TABLE 26-1

GENERAL PURPOSE DECONTAMINATION SOLUTIONS

Solution	Preparation	Contamination
Solution A	Solution containing 5% sodium carbonate (NA_2CO_3) and 5% trisodium phosphate (NA_3PO_4). To ten gallons water add four pounds NA_2CO_3 and four pounds NA_3PO_4. Stir until evenly mixed.	Inorganic acids; processing wastes; heavy metals.
Solution B	Solution containing 10% calcium hypochlorite [Ca(CIO$_2$)]. To ten gallons water, add eight pounds Ca(CIO)$_2$. Stir until evenly mixed.	Pesticides, fungici chlorinated pheno dioxins; cyanides ammonia; non-acidic inorganics.
Solution C	Solution containing 5% trisodium phosphate (NA_3PO_4). To ten gallons water, add four pounds NA_3PO_4. Stir until evenly mixed.	Solvents; organic compounds; PBBs, PC oily, greasy wastes
Solution D	A dilute solution of hydrochloric acid (HCL). To ten gallons water, add one pint HCL. Stir to mix.	Inorganic bases; alkali and caustic wastes.

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STANDARD OPERATING PROCEDURE

Section No. 27.0

FIELD FILTRATION OF GROUNDWATER SAMPLES FOR DISSOLVED METALS ANALYSIS

By

JACOBS ENGINEERING GROUP INC.

SECTION 27.0

FIELD FILTRATION OF GROUNDWATER SAMPLES FOR DISSOLVED METALS ANALYSIS

INTRODUCTION

Filtration of groundwater samples is used to separate suspended particulate matter from the substances which are held in the solution. This procedure is designed to provide a groundwater sample that may be analyzed for dissolved metals. Generally, the filtered (dissolved metal) sample analysis is compared to an unfiltered total metal analysis from a duplicate groundwater sample. From this comparison, the difference in concentrations between total versus dissolved metals may be attributed to the original metal content of the suspended particles.

EVALUATION

Available Equipment

There are numerous types of filtration systems available. Of the available units, careful consideration should be given to: the volume of liquid the unit will hold as compared to the volume needed for analysis; the time it takes to filter the sample; the ease at which the unit can be decontaminated; how readily filtration can be re-started when clogging occurs; and how the system may produce any changes in sample quality.

Of equal importance, the system should be of rugged construction and should be easy to use in the field. Jacobs utilizes a 2.4-liter, Geotech pressure barrel filter. The unit consists of four sections: a bottom flange and filter support screen; a 2.4 liter sample reservoir; and a cover. Filtration pressure may be supplied by an air pump or nitrogen gas filter.

Measurement Problems/Instrument Limitation

The primary problem involving field filtration is the possible clogging of filters when filtering extremely turbid samples. Clogging can be partially avoided by the use of pre-filters.

APPARATUS

The items listed below are generally required for proper use of the barrel filter in the field:

- 2.4 liter, barrel filter apparatus
- Schleicher and Schuell, BA85, 102mm, .45 cm cellulose acetate membranes or equivalent
- Schleicher and Schuell, #30, 90mm glass prefilters or equivalent
- Pressure bulb, air pump, or nitrogen bottle
- Decontamination equipment
  - Non-phosphate detergent
  - Small diameter test tube brushes
  - De-ionized water
  - Distilled water

PROCEDURES

Filtration Procedures

Recommended procedures or field filtration of groundwater samples are listed below:

1) Groundwater samples for which metal analysis will be performed must be split into tw aliquots. One portion should be filtered for dissolved metal analysis and the remaining portion should be transferred to a sample bottle for total metal analysis.

2) Prior to filtration thoroughly decontaminate the filtration unit (see procedures below) and purge with well water prior to filling the sample reservoir.

3) Turn unit upside down, unscrew swing-away nuts and take bottom plate off.

4) With unit still upside down, pour the sample aliquot to be filtered into the reservoir, being careful to pour directly into the filter reservoir and not around the lip where 0-ring and filter paper rest.

5) The unit should be reassembled in the follow order:

- #30, 90mm prefilter
- .45 um, 120 m cellulose acetate filter
- Filter support screen
- Replace bottom plate
- Assemble swing -a-way nuts.

6) Turn the unit right side up and connect a pressure bulb, air pump, or nitrogen bottle.

7) Place sample bottle under the unit.

8) Slowly increase pressure as needed not to exceed 10-15 psi. Although the unit is rated to 30 psi, 10-15 psi is considered safe so as not to cause micro-fractures in the .45 um filter.

Procedures For Unclogging A Clogged Unit

Repeat procedures 3-8, but replace the pre-filter with a new filter and assemble according to procedure 5. Always release air pressure from unit before disassembly. This can be done through the pressure release valve on top of the unit.

Decontamination Procedures

The decontamination procedures outlined in Jacobs' S.O.P. No. 26.0 will be utilized for the filtration unit, paying close attention to the following:

o Remove and wash O-ring sealing reservoir from bottom plate.

o Wash filter support screen

o Remove and wash pop out center.

o Observe and replace pressure tubing if clogged and replace pre-filters.

Pay careful attention in rinsing the pressure relief valve and the spout from the reservoir t sample bottle.

QUALITY ASSURANCE

The following quality assurance information must be recorded in the field notebook:

- Well location
- Quality of sample collected (i.e., turbidity, color, etc.)
- Type of filter(s) used (i.e., material and pore size)
- Problems encountered in the field.

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STANDARD OPERATING PROCEDURE

Section No. 28.0

SAMPLE PRESERVATION AND ANALYSES METHODS

By

JACOBS ENGINEERING GROUP INC.

TABLE 28-1
SAMPLE VOLUMES, CONTAINERS, AND PRESERVATIVES FOR SOIL SAMPLES*

Analysis	Container/Volume	Preservation	Maximum Holding Time
Total Petroleum Hydrocarbons	2 120-ml glass jars	Cool to 4°C	Laboratory Protocol
Total Fuel Hydrocarbons	2 120-ml glass jars	Cool to 4°C	Laboratory Protocols
Volatile Organic Compounds	2 120-ml glass jars	Cool to 4°C	Laboratory Protocol
Semivolatile Organic Compounds	2 4-oz. glass jars	Cool to 4°C	Laboratory Protocol
Inorganic Compounds	1 8-oz. glass jar	None	Laboratory Protocol

* Containers supplied by laboratory. Preparation according to laboratory and method specifications.

TABLE 28-2
SAMPLE VOLUMES, CONTAINERS, AND PRESERVATIVES FOR WATER SAMPLES

Analysis	Container/Volume	Preservation	Maximum Holding Time
Volatile Organic Compounds	2 40-ml vials[b] (no head space)	Cool to 4°C Add 2 drops of 1:1 HCl	Laboratory protocol
Total Petroleum Hydrocarbons	4 1-liter glass bottles	Cool to 4°C	Laboratory Protocol
Total Fuel Hydrocarbons	4 1-liter glass bottles	Cool to 4°C	Laboratory Protocols
Semivolatile Organic Compounds	4 1-liter amber glass bottles	Cool to 4°C	Laboratory Protocol
Pesticides/PCBs	1 2.5-liter amber glass bottles	Cool to 4°C	Laboratory Protocol
Metals	1 1-liter polyethylene bottle	Filter Nitric acid to pH < 2	Laboratory Protocol
Cyanides	1 1-liter polyethylene bottle	Sodium hydroxide to pH ≥ 12	Laboratory Protocol
Sulfide	1 1-liter polyethylene bottle	Zinc acetate and sodium hydroxide to pH > 9	7 days[c]
Suspended solids	3 1-liter polyethylene bottles	Cool to 4°C	7 cays
Total Solids			7 days
Sulfate			28 days
Alkalinity			48 hours[c,d]
Fluoride			28 days
Chloride			—

TABLE 28-2
SAMPLE VOLUMES, CONTAINERS, AND PRESERVATIVES FOR WATER SAMPLES (CONTINUED)

Analysis	Container/Volume	Preservation	Maximum Holding Time
Total Phosphorus Chemical Oxygen Demand (COD) Nitrate and Nitrite	1 1-liter polyethylene bottle	Sulfuric acid to pH < 2, cool to 4°C	28 days 28 days 48 hours
Biochemical Oxygen Demand (BOD)	1 1-liter polyethylene bottle	Cool to 4°C	48 hours
Oil and Grease	4 1-liter glass bottles	Sulfuric acid to pH < 2	28 days
Total Organic Carbon	1 500-ml amber glass bottle	Sulfuric acid pH ≤ 2, cool to 4°C	48 hours
Specific Conductance (E.C.)	3 1-liter polyethylene bottles	Cool to 4°C No headspace	24 hours
pH	3 1-liter polyethylene bottles	Cool to 4°C No headspace	24 hours

---

[a] Containers supplied by laboratory. Preparation according to laboratory and method specifications.

[b] If detection limits lower than laboratory standard protocol are requested, three vials will be supplied.

[c] See the method.

[d] Minimize atmospheric exposure before analysis.

TABLE 28-3
LABORATORY METHODS FOR SOILS AND SEDIMENT

Parameters	Analytical Method[a]
Metals	STLC/TTLC[b]
Arsenic	7061[a]
Barium	7080
Cadmium	7130
Chromium	7190
Copper	7210
Lead	7420
Manganese	7460
Mercury	7471
Nickel	7520
Zinc	7950
Physical and Chemical Soil Properties	
Total Organic Carbon	EPA 3-73[c]
Soil pH	9040[a]
Percent Moisture	ASA No. 9
Organic Compounds	
Purgeable Organic Compounds	8240[a]
Volatile Halogenated Organic Compounds	8010
Total Petroleum Hydrocarbons	418.1
Total Fuel Hydrocarbons	8015
Volatile Aromatic Organic Compounds	8020
Semivolatile Organic Compounds	8270
Organochlorine Pesticides and PCBs	8080

---

[a] Method source unless otherwise indicated: U.S. Environmental Protection Agency, 1982. Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods, SW-846, Revised November 1986.

[b] Title 22, California Administrative Code, Section 66700. "Waste Extraction Test" (WET).

[c] U.S. Environmental Protection Agency, 1981. Procedures for Handling and Chemical Analysis of Sediment and Water Samples. Contract No. EPA-4805572010.

[d] American Society of Agronomy, Number 9, Part 1, 1982. Methods of Soil Analysis: Physical and Mineralogical Methods. 2nd Edition, 7-2.2.2, 13-2.2.1.

TABLE 28-4
LABORATORY METHODS FOR WATER SAMPLES

Parameters	Analytical Method	Source
INORGANIC COMPOUNDS		
Arsenic	206.2/7060	a/b
Barium	208.2/7080	a/b
Cadmium	213.2/6010	a/b
Calcium	215.1	a
Total Chromium	218.2/6010	a/b
Hexavalent Chromium	218.5/7175	a/b
Copper	220.2/6010	a/b
Iron	236.2	a
Lead	239.2/6010	a/b
Magnesium	242.2/6010	a/b
Manganese	243.2	a
Mercury	245.2/7471	a/b
Nickel	249.2/6010	a/b
Potassium	258.1	a
Selenium	270.2/7740	a/b
Silver	272.2/7760	a/b
Sodium	273.1	a
Zinc	289.2/6010	a/b
Cyanide	335.2	a
Major Anions		
Bicarbonate	Std. Method 403	c
Carbonate	Std. Method 403	c
Chloride	325.3	a
Sulfate	375.4	a
Sulfide	376.1	a
Fluoride	340.2	a
Nitrate-Nitrite	353.3	a
GENERAL CHEMICAL PARAMETERS		
pH	150.1/9040	a/b
Alkalinity	310.1	a
Electrical Conductivity (specific conductance)	120.1	a

TABLE 28-4
LABORATORY METHODS FOR WATER SAMPLES (CONTINUED)

Parameters	Analytical Method	Source
Total Dissolved Solids	160.1	a
Total Suspended Solids	160.2	a
Total Kjeldahl Nitrogen	351.4	a
Chemical Oxygen Demand (COD)	410.1, 410.2	a
Biochemical Oxygen Demand (BOD), Five Day, 20°C	405.1/507	a/c
ORGANIC COMPOUNDS		
Purgeable Organic Compounds	624[d]	a
Volatile Halogenated Organic Compounds	601	a
Total Petroleum Hydrocarbons	418.1	a
Total Fuel Hydrocarbons	8015	b
Volatile Aromatic Organic Compounds	602	a
Semivolatile Organic Compounds	625	a
Pesticides and PCBs	608	b
Total Organic Carbon (TOC)	9060	b
Total Organic Halogens (TOX)	9020	b
Total Recoverable Oil and Grease	413.2	a

---

[a] U.S. Environmental Protection Agency. Revised March 1983.

[b] U.S. EPA, November 1986.

[c] APHA, AWWA, WPCF, 1985.

[d] U.S. EPA, October 26, 1984.

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STANDARD OPERATING PROCEDURE

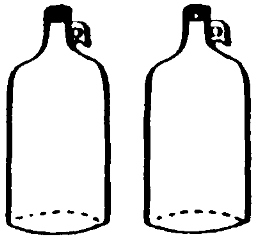
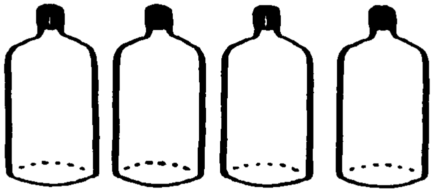
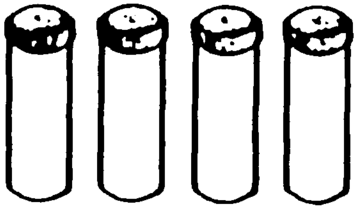
Section No. 29. 0

CLP SAMPLE CONTAINER REQUIREMENTS

By

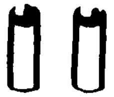
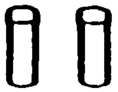
JACOBS ENGINEERING GROUP INC.

ORGANIC SAMPLE COLLECTION REQUIREMENTS

WATER SAMPLES	REQUIRED VOLUME		CONTAINER TYPE
EXTRACTABLE ANALYSIS (LOW LEVEL)	1 GALLON		2 X 1/2-GAL. AMBER GLASS BOTTLES
			OR 4 X 1-LITER AMBER GLASS BOTTLES
EXTRACTABLE ANALYSIS (MEDIUM LEVEL*)	1 GALLON		4 X 32-OZ. WIDE-MOUTH GLASS JARS
VOLATILE ANALYSIS (LOW OR MEDIUM LEVEL*)	80 ML		2 X 40-ML GLASS VIALS

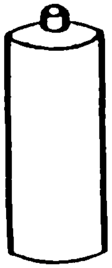
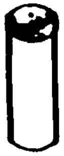
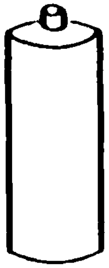
*ALL MEDIUM LEVEL SAMPLES TO BE SEALED IN METAL PAINT CAN FOR SHIPMENT

ORGANIC SAMPLE COLLECTION REQUIREMENTS

SOIL/SEDIMENT SAMPLES	REQUIRED VOLUME		CONTAINER TYPE
EXTRACTABLE ANALYSIS (LOW OR MEDIUM LEVEL*)	6 OZ.		1 X 8-OZ. WIDE-MOUTH GLASS JAR
			OR
			2 X 4-OZ. WIDE-MOUTH GLASS JARS
VOLATILE ANALYSIS (LOW OR MEDIUM LEVEL*)	240 ML		2 X 120-ML WIDE-MOUTH GLASS VIALS

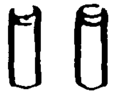
*ALL MEDIUM LEVEL SAMPLES TO BE SEALED IN METAL PAINT CAN FOR SHIPMENT

INORGANIC SAMPLE COLLECTION REQUIREMENTS

WATER SAMPLES	REQUIRED VOLUME		CONTAINER TYPE
METALS ANALYSIS (LOW LEVEL)	1 LITER		1 X 1-LITER POLYETHYLENE BOTTLE
METALS ANALYSIS (MEDIUM LEVEL*)	16 OZ.		1 X 16-OZ. WIDE-MOUTH GLASS JAR
CYANIDE (CN^-) ANALYSIS (LOW LEVEL)	1 LITER		1 X 1-LITER POLYETHYLENE BOTTLE
CYANIDE (CN^-) ANALYSIS (MEDIUM LEVEL*)	16 OZ.		1 X 16-OZ. WIDE-MOUTH GLASS JAR

*ALL MEDIUM LEVEL SAMPLES TO BE SEALED IN METAL PAINT CAN FOR SHIPMENT

INORGANIC SAMPLE COLLECTION REQUIREMENTS

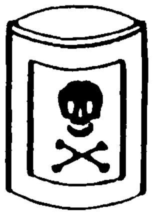
SOIL/SEDIMENT SAMPLES	REQUIRED VOLUME		CONTAINER TYPE
METALS AND CYANIDE (CN^-) ANALYSIS (LOW OR MEDIUM LEVEL*)	6 OZ.		1 X 8-OZ. WIDE-MOUTH GLASS JAR
			OR
			2 X 4-OZ. WIDE-MOUTH GLASS JARS

*ALL MEDIUM LEVEL SAMPLES TO BE SEALED IN METAL PAINT CAN FOR SHIPMENT

HIGH HAZARD SAMPLE COLLECTION REQUIREMENTS

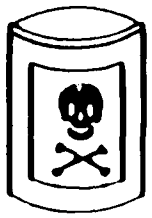
	REQUIRED VOLUME		CONTAINER TYPE
LIQUID SAMPLES			
ORGANIC AND INORGANIC ANALYSIS	6 OZ.		1 X 8-OZ. WIDE-MOUTH GLASS JAR
SOLID SAMPLES			
ORGANIC AND INORGANIC ANALYSIS	6 OZ.		1 X 8-OZ. WIDE-MOUTH GLASS JAR

*ALL MEDIUM LEVEL SAMPLES TO BE SEALED IN METAL PAINT CAN FOR SHIPMENT



DIOXIN SAMPLE COLLECTION REQUIREMENTS

SOIL/SEDIMENT SAMPLES	REQUIRED VOLUME		CONTAINER TYPE
2.3.7.8-TCDD (DIOXIN) ANALYSIS	4 OZ.		1 X 4-OZ. WIDE-MOUTH GLASS JAR
			OR
			1 X 8-OZ. WIDE-MOUTH GLASS JAR



*ALL MEDIUM LEVEL SAMPLES TO BE SEALED IN METAL PAINT CAN FOR SHIPMENT

STANDARD OPERATING PROCEDURE

Section No. 30.0

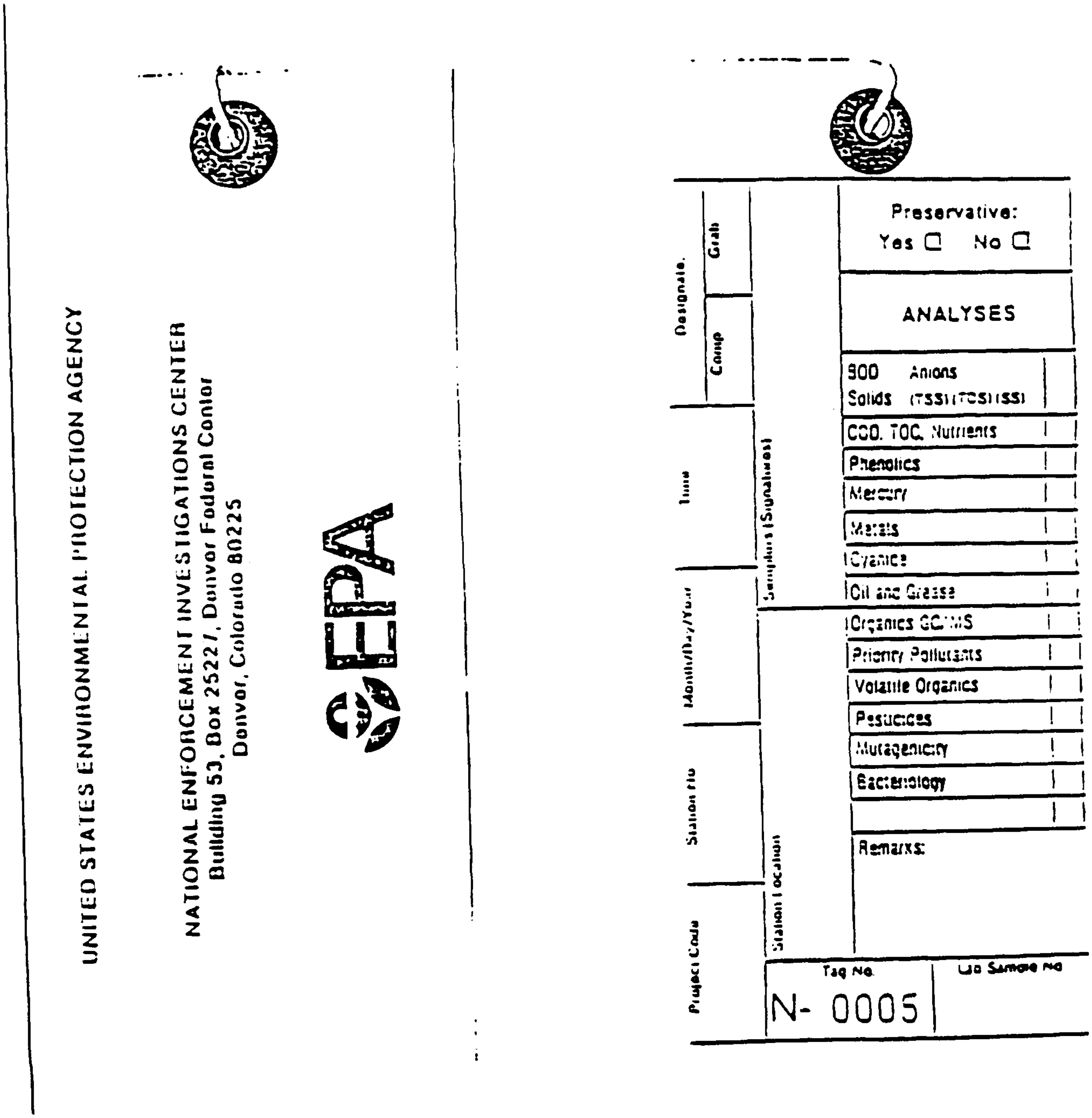
SAMPLE DOCUMENTATION

By

JACOBS ENGINEERING GROUP INC.

FIGURE 30-1

SAMPLE IDENTIFICATION TAG



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

NATIONAL ENFORCEMENT INVESTIGATIONS CENTER
Building 53, Box 25227, Denver Federal Center
Denver, Colorado 80225

EPA

Project Code
Station No.
Month/Day/Year
Time
Designate: Comp Grab
Samplers (Signatures)
Station Location

Preservative:
Yes ☐ No ☐

ANALYSES

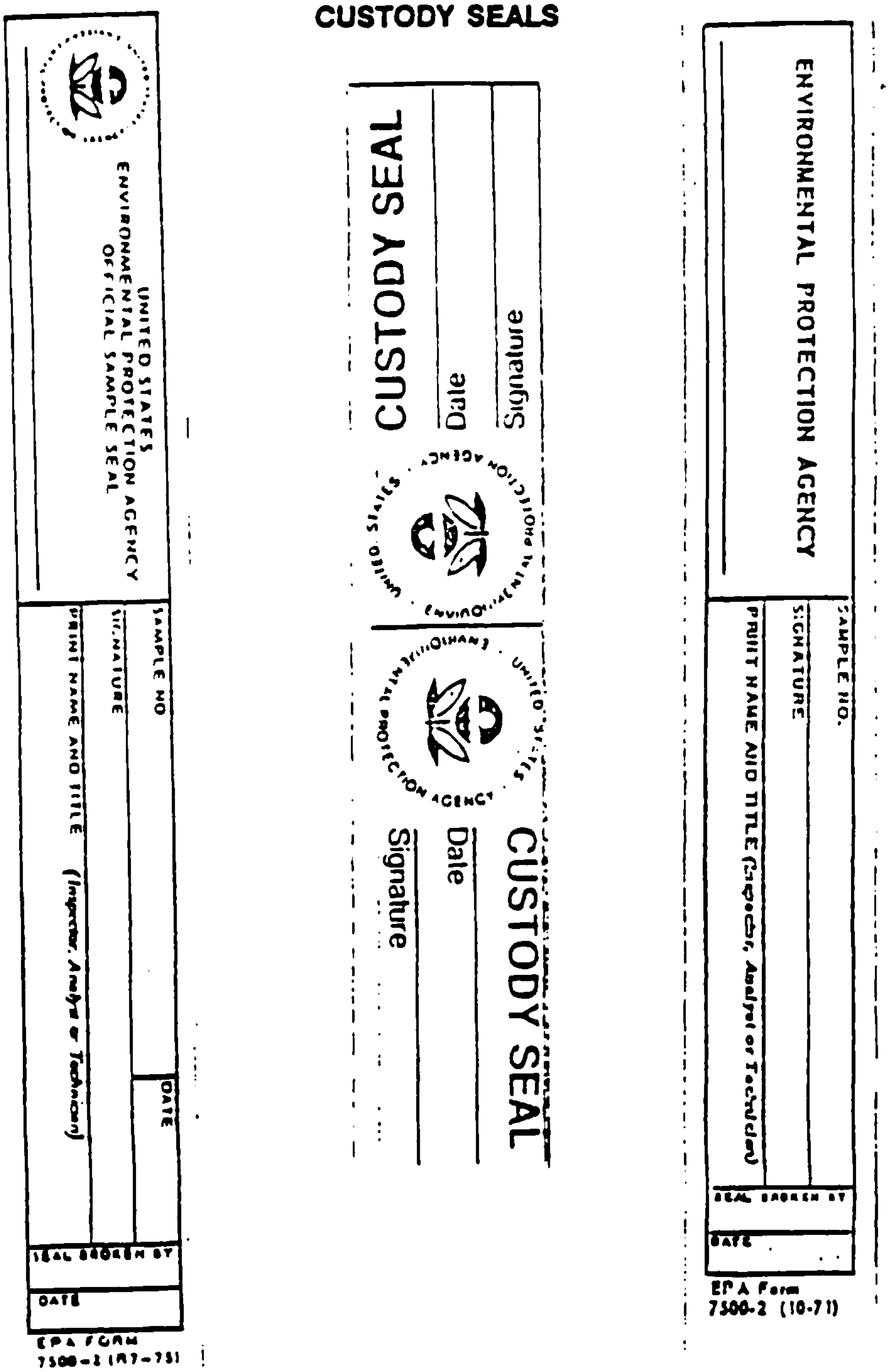
- BOD Anions
- Solids (TSS)(TDS)(SS)
- COD, TOC, Nutrients
- Phenolics
- Mercury
- Metals
- Cyanide
- Oil and Grease
- Organics GC/MS
- Priority Pollutants
- Volatile Organics
- Pesticides
- Mutagenicity
- Bacteriology

Remarks:

Tag No.	Lab Sample No.
N- 0005	

FIGURE 30-2

CUSTODY SEALS



UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
OFFICIAL SAMPLE SEAL

SAMPLE NO	DATE
SIGNATURE	
PRINT NAME AND TITLE (Inspector, Analyst or Technician)	
SEAL BROKEN BY	
DATE	

EPA FORM
7500-2 (R7-75)

CUSTODY SEAL
Date
Signature

CUSTODY SEAL
Date
Signature

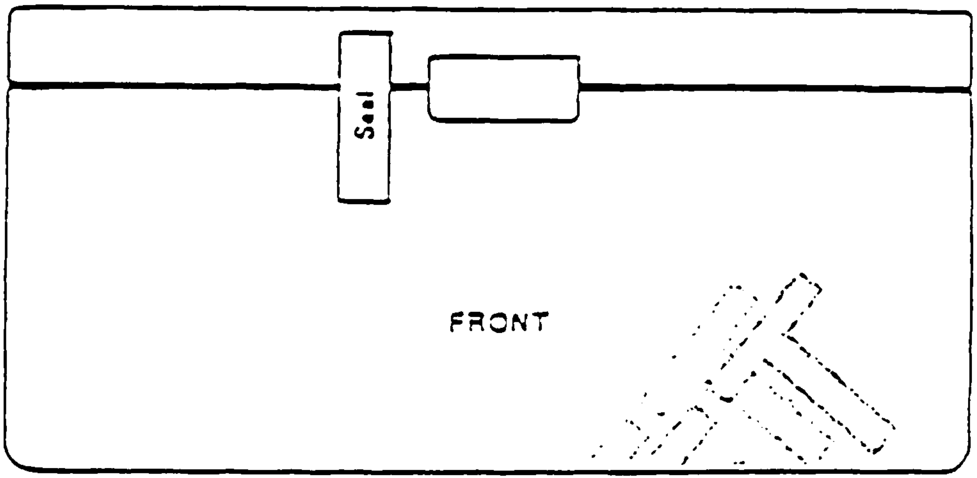
ENVIRONMENTAL PROTECTION AGENCY

SAMPLE NO.
SIGNATURE
PRINT NAME AND TITLE (Inspector, Analyst or Technician)
SEAL BROKEN BY
DATE

EPA Form
7500-2 (10-71)

FIGURE 30-3

PLACEMENT OF SECURITY SEALS



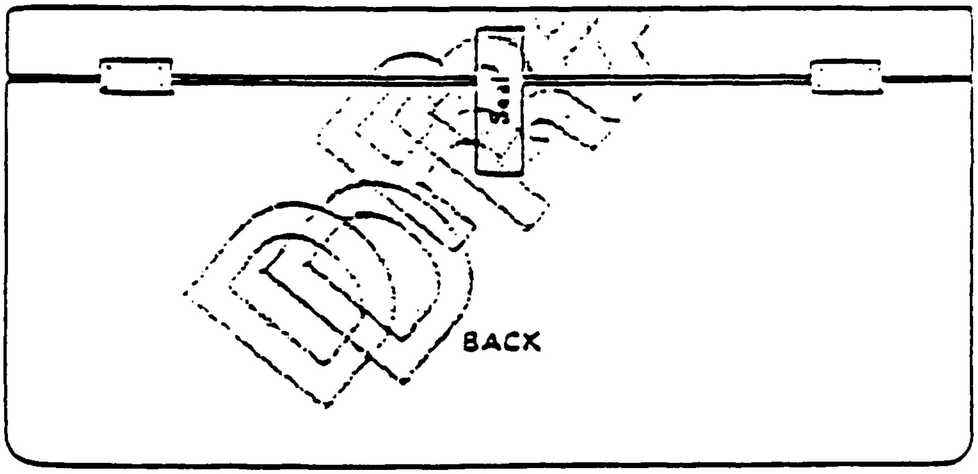
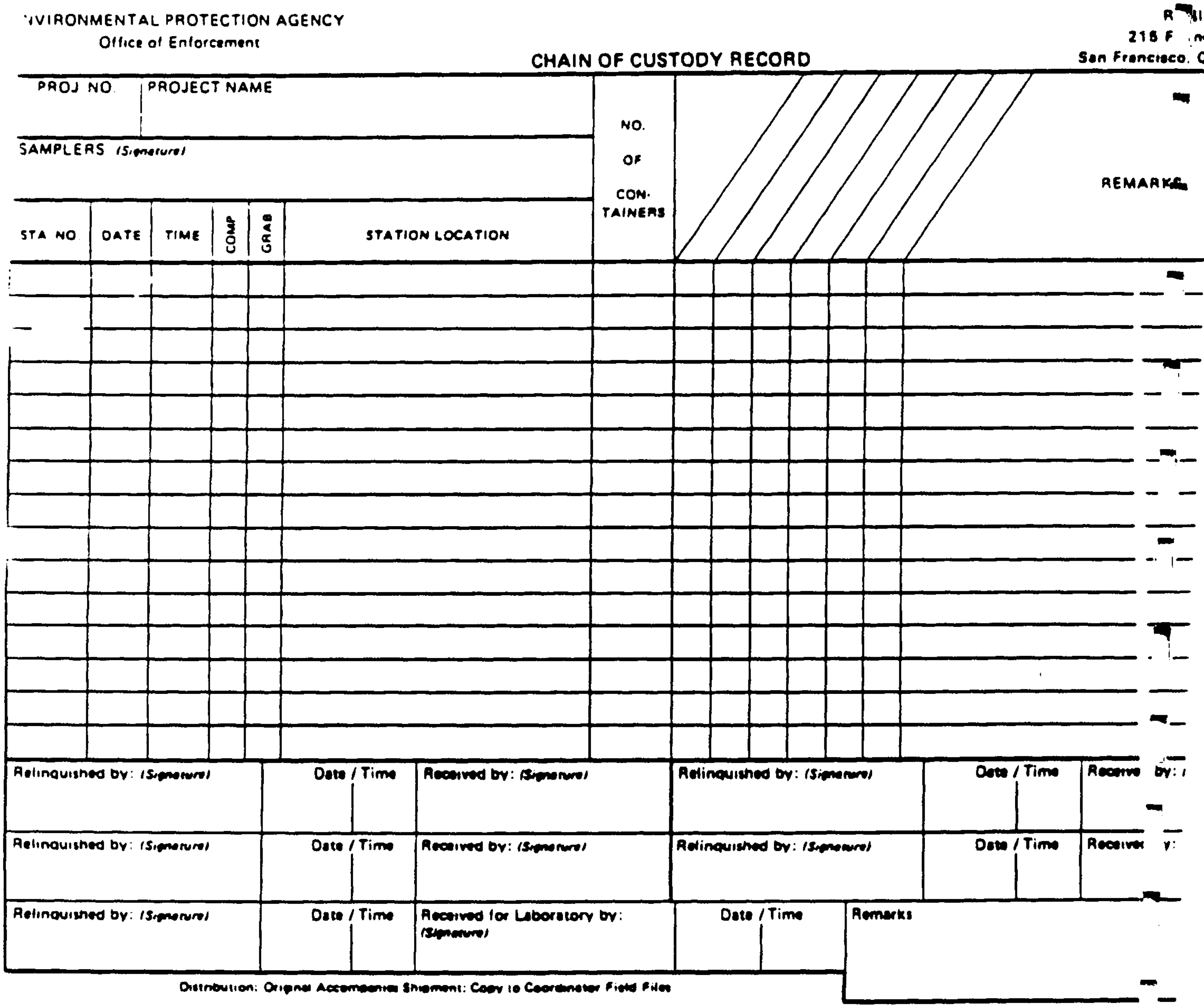


FIGURE 30-4

CHAIN OF CUSTODY RECORD



'IVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

R
215 F
San Francisco, C

CHAIN OF CUSTODY RECORD

PROJ NO.

PROJECT NAME

SAMPLERS *(Signature)*

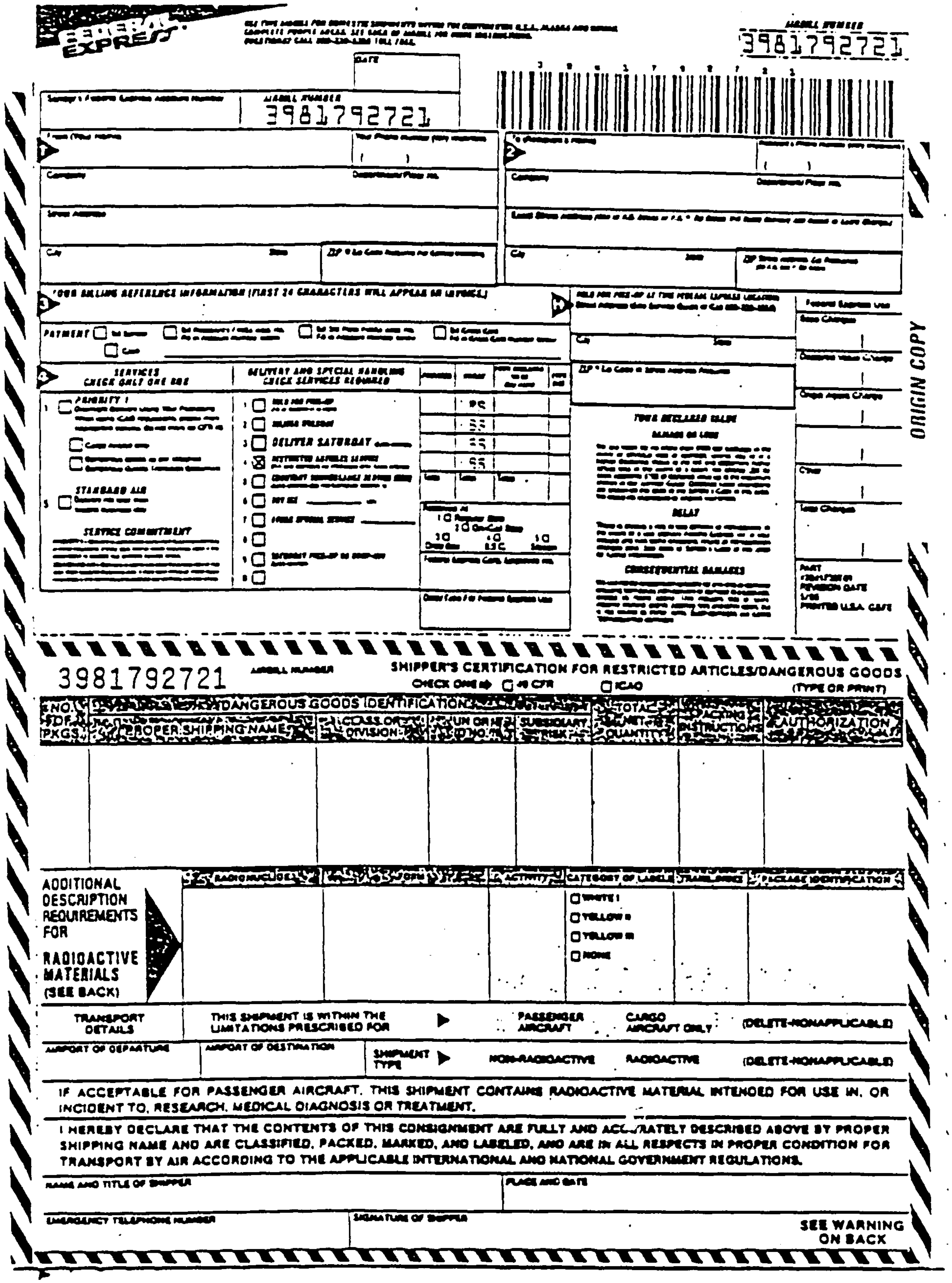
STA NO	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CONTAINERS							REMARKS

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Receive by:
Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Receive y:
Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks	

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

FIGURE 30-5

SHIPPING FORM



EXPRESS

3981792721

ORIGIN COPY

YOUR BILLING REFERENCE INFORMATION (FIRST 24 CHARACTERS WILL APPEAR ON INVOICE)

PAYMENT ☐ ☐ ☐ ☐ ☐

SERVICES CHECK ONLY ONE BOX

DELIVERY AND SPECIAL HANDLING CHECK SERVICES REQUIRED

1 ☐ PRIORITY 1

☐

☐

5 ☐ STANDARD AIR

SERVICE COMMITMENT

1 ☐

2 ☐

3 ☐ DELIVER SATURDAY

4 ☒

5 ☐

6 ☐

7 ☐

8 ☐

9 ☐

0 ☐

3981792721

SHIPPER'S CERTIFICATION FOR RESTRICTED ARTICLES/DANGEROUS GOODS

CHECK ONE ☐ 49 CFR ☐ ICAO (TYPE OR PRINT)

NO. OF PKGS.	DANGEROUS GOODS IDENTIFICATION PROPER SHIPPING NAME	CLASS OR DIVISION	UN OR ID NO.	SUBSIDIARY RISK	TOTAL NET QUANTITY	PACKING INSTRUCTIONS	AUTHORIZATION

ADDITIONAL DESCRIPTION REQUIREMENTS FOR RADIOACTIVE MATERIALS (SEE BACK)

RADIONUCLIDES	FORM	ACTIVITY	CATEGORY OF LABEL	TRANSPORT INDEX	PACKAGE IDENTIFICATION
			☐ WHITE I ☐ YELLOW II ☐ YELLOW III ☐ NONE		

TRANSPORT DETAILS — THIS SHIPMENT IS WITHIN THE LIMITATIONS PRESCRIBED FOR ▶ PASSENGER AIRCRAFT CARGO AIRCRAFT ONLY (DELETE-NONAPPLICABLE)

AIRPORT OF DEPARTURE

AIRPORT OF DESTINATION

SHIPMENT TYPE ▶ NON-RADIOACTIVE RADIOACTIVE (DELETE-NONAPPLICABLE)

IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS OR TREATMENT.

I HEREBY DECLARE THAT THE CONTENTS OF THIS CONSIGNMENT ARE FULLY AND ACCURATELY DESCRIBED ABOVE BY PROPER SHIPPING NAME AND ARE CLASSIFIED, PACKED, MARKED, AND LABELED, AND ARE IN ALL RESPECTS IN PROPER CONDITION FOR TRANSPORT BY AIR ACCORDING TO THE APPLICABLE INTERNATIONAL AND NATIONAL GOVERNMENT REGULATIONS.

NAME AND TITLE OF SHIPPER

PLACE AND DATE

EMERGENCY TELEPHONE NUMBER

SIGNATURE OF SHIPPER

SEE WARNING ON BACK

FIGURE A - 6. RESTRICTED ARTICLES AIRBILL

FIGURE 30-6

ORGANIC TRAFFIC REPORT FORM

U.S. ENVIRONMENTAL PROTECTION AGENCY HWI Sample Management Office

ORGANICS TRAFFIC REPORT

Sample Number
YB 195

ase Number:

Sample Site Name/Code:

② SAMPLE CONCENTRATION
(Check One)

____ Low Concentration
____ Medium Concentration

③ SAMPLE MATRIX
(Check One)

____ Water
____ Soil/Sediment

④ Ship To:

Attn:

Transfer
Ship To:

Regional Office: ________

ampling Personnel:

(Name)

(Phone)

ampling Date:

(Begin) (End)

hipping Information

Name of Carrier

Date Shipped:

Airbill Number:

⑥ For each sample collected specify number of containers used and mark volume level on each bottle.

	Number of Containers	Approximate Total Volume
Water (Extractable)		
Water (VOA)		
Soil/Sediment (Extractable)		
Soil/Sediment (VOA)		
Other		

[redacted]

⑧ Sample Description

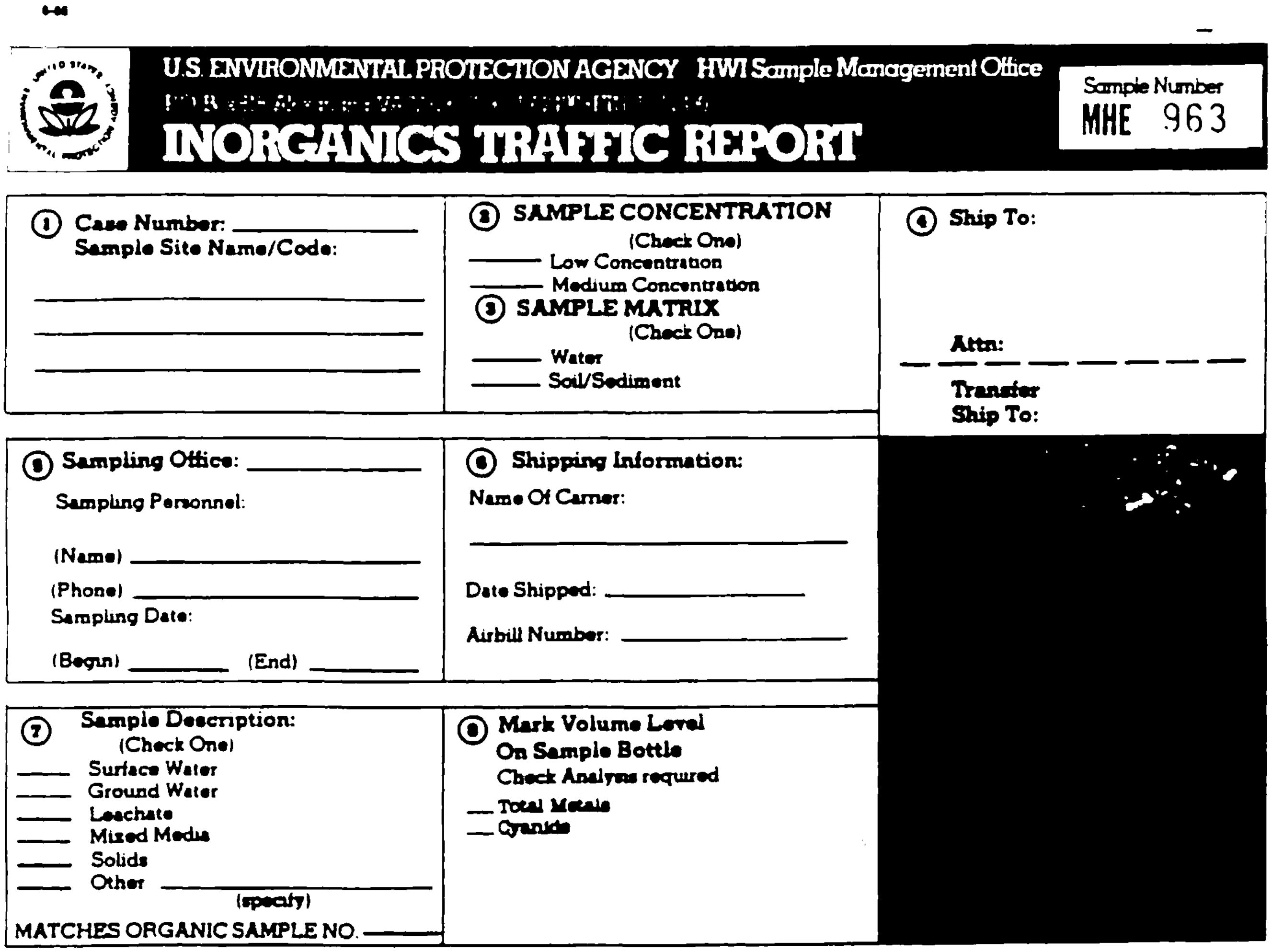
____ Surface Water
____ Ground Water
____ Leachate
____ Mixed Media
____ Solids
____ Other (specify) ________

⑨ Sample Location

Special Handling Instructions:
(e.g., safety precautions, hazardous nature)

FIGURE 30-7

INORGANIC TRAFFIC REPORT FORM



8-86

U.S. ENVIRONMENTAL PROTECTION AGENCY HWI Sample Management Office
[illegible]
INORGANICS TRAFFIC REPORT

Sample Number
MHE 963

① **Case Number:** ____________
Sample Site Name/Code:
____
____
____

② **SAMPLE CONCENTRATION**
(Check One)
_____ Low Concentration
_____ Medium Concentration

③ **SAMPLE MATRIX**
(Check One)
_____ Water
_____ Soil/Sediment

④ **Ship To:**

Attn: ____________

Transfer
Ship To:

⑤ **Sampling Office:** ____________
Sampling Personnel:
(Name) ____________
(Phone) ____________
Sampling Date:
(Begin) ________ (End) ________

⑥ **Shipping Information:**
Name Of Carrier:
____
Date Shipped: ____________
Airbill Number: ____________

⑦ **Sample Description:**
(Check One)
_____ Surface Water
_____ Ground Water
_____ Leachate
_____ Mixed Media
_____ Solids
_____ Other ____________
(specify)
MATCHES ORGANIC SAMPLE NO. ______

⑧ **Mark Volume Level**
On Sample Bottle
Check Analyses required
__ **Total Metals**
__ **Cyanide**

SMO COPY

STANDARD OPERATING PROCEDURE

Section No. 31.0

SAMPLE PACKAGING AND SHIPMENT

By

JACOBS ENGINEERING GROUP INC.

SECTION 31.0

SAMPLE PACKAGING AND SHIPMENT

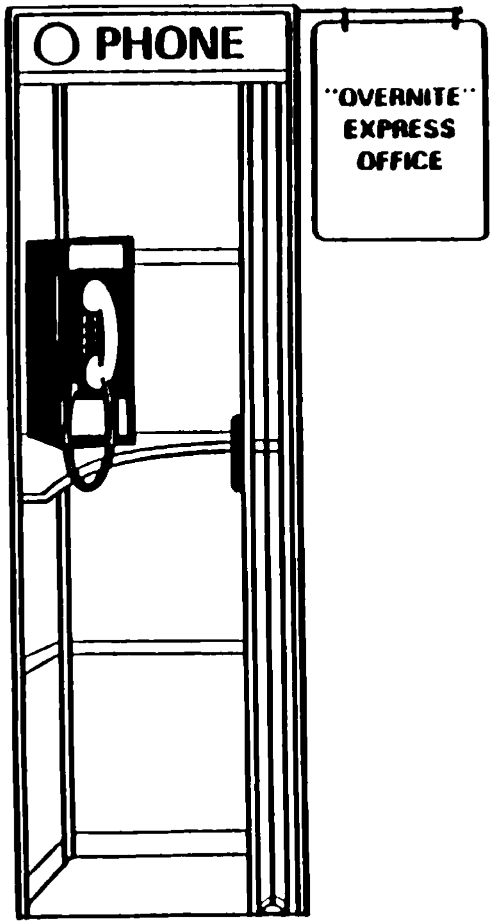
Shipping of Samples. Samples will be delivered to an approved laboratory for analysis as soon as practicable after the number of samples and number of coolers is sufficient to comprise a shipment, normally the same day in which the samples were taken. The sample must be accompanied by the Chain-of-Custody Record and by traffic reports, if applicable.

Procedures for Packing Soil and/or Groundwater Samples. Most samples collected during the QA/QC audits are assumed to contain low concentrations (less than 10 ppm) of organic and inorganic chemical compounds and will, therefore, be considered environmental samples. Procedures for packing samples for transport to the certified laboratory will be as follows:

- If using an express mail carrier, determine maximum weight allowed per package from shipper (70 lbs for Federal Express shipment).
- Secure sample bottle lids (for liquids) or plastic caps on brass tubes (for soils) with strapping tape or evidence tape.
- Mark volume level on liquid containers with grease pencil.
- Place about 3 inches of inert cushioning material, such as foam, vermiculite or zonolite, in bottom of cooler or install a cooler liner.
- Labels/sample tags will be numbered and used on all sample containers. The organic/inorganic traffic report number labels must appear on the bottles to be sent to an approved laboratory. Cover the labels with clear plastic tape.
- Place containers in cooler in such a way that they do not touch or more around inside cooler.
- Pack containers in inert cushioning material.
- Fill cooler with either inert cushioning material or foam and frozen blue ice if sample refrigeration is required. Do not use dry ice if liquid samples are being handled, or if package is being transported by air.

- Tape cooler drain shut.
- After acceptance by Federal Express or shipper, wrap cooler completely with strapping tape at two locations. Secure lid by taping. Do not cover any labels.
- Place lab address on top of cooler.
- Put "this side up" labels on all four sides and "fragile" labels on at least two sides.
- Affix numbered custody seals on front right and back left of cooler. Cover seals with wide, clear tape.

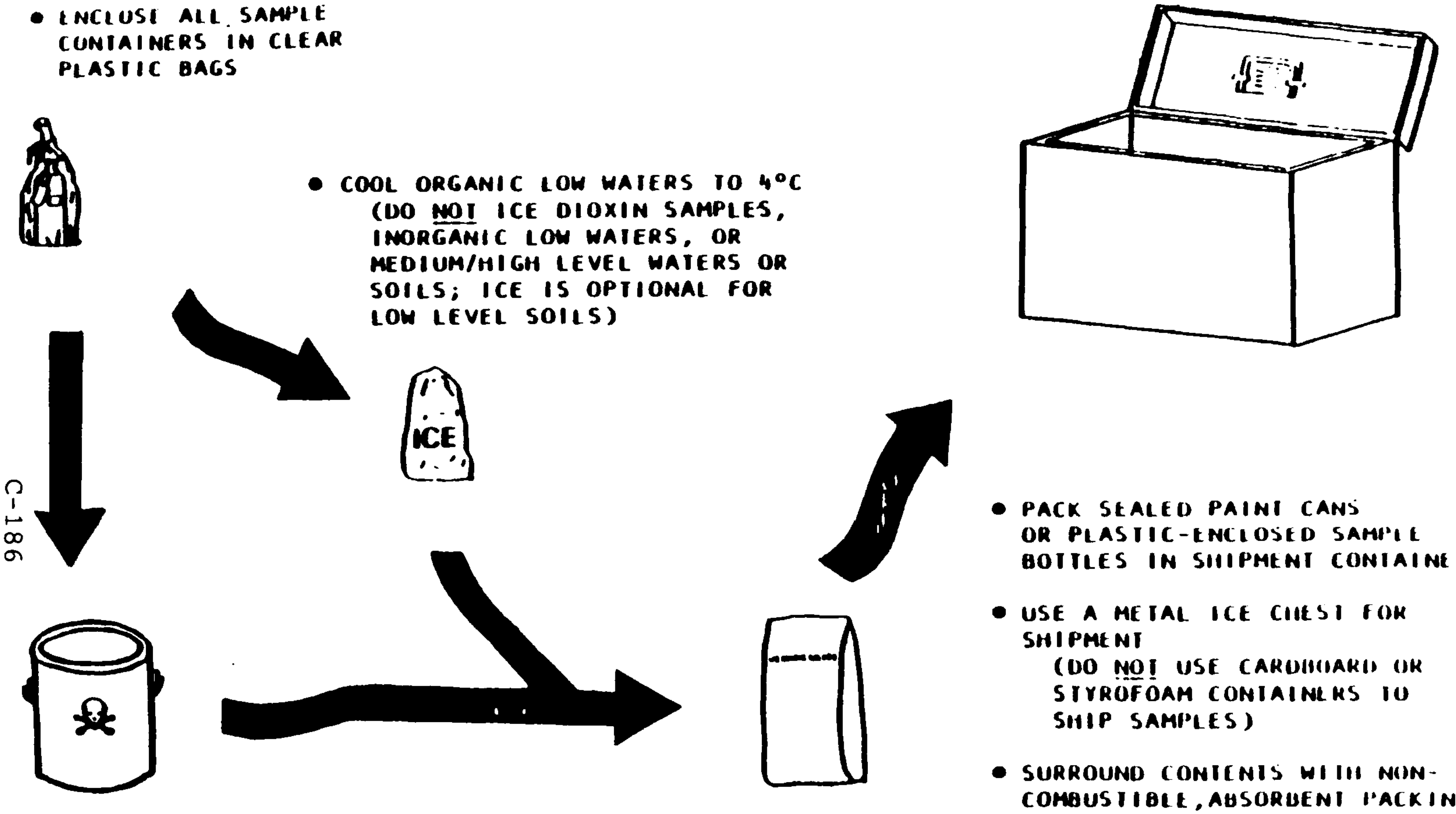
SAMPLE SHIPMENT COORDINATION CHECKLIST



__IMMEDIATELY__ UPON SHIPMENT OF SAMPLES, SAMPLERS CALL SMO WITH THE FOLLOWING INFORMATION:

- CASE OR SAS NUMBER
- NAME OF LABORATORY
- DATE OF SHIPMENT
- CARRIER, AIRBILL (SHIPMENT) NUMBERS AND TYPE OF SERVICE
- NUMBER AND MATRICES OF SAMPLES SHIPPED
- INFORMATION ON CHANGES, DELAYS, CONTINUATIONS, ETC., PERTINENT TO THE CASE
- SMO __MUST__ BE NOTIFIED BY 3:00 PM ON FRIDAY FOR SAMPLES INTENDED FOR SATURDAY DELIVERY/PICKUP

SAMPLE PACKAGING SUMMARY



- ENCLOSE ALL SAMPLE CONTAINERS IN CLEAR PLASTIC BAGS

- COOL ORGANIC LOW WATERS TO 4°C
  (DO <u>NOT</u> ICE DIOXIN SAMPLES, INORGANIC LOW WATERS, OR MEDIUM/HIGH LEVEL WATERS OR SOILS; ICE IS OPTIONAL FOR LOW LEVEL SOILS)

- PACK ALL MEDIUM AND HIGH LEVEL WATER AND SOIL SAMPLES IN METAL PAINT CANS

- SURROUND CONTENTS OF CAN WITH NON-COMBUSTIBLE, ABSORBENT PACKING MATERIAL

- PACK SEALED PAINT CANS OR PLASTIC-ENCLOSED SAMPLE BOTTLES IN SHIPMENT CONTAINER

- USE A METAL ICE CHEST FOR SHIPMENT
  (DO <u>NOT</u> USE CARDBOARD OR STYROFOAM CONTAINERS TO SHIP SAMPLES)

- SURROUND CONTENTS WITH NON-COMBUSTIBLE, ABSORBENT PACKING MATERIAL
  (DO <u>NOT</u> USE EARTH OR ICE PACKING MATERIALS)

- TAPE PAPERWORK IN PLASTIC BAGS UNDER COOLER LID

- CLOSE COOLER AND SEAL WITH CUSTODY SEALS

POTENTIAL PROBLEMS WITH SHIPMENT AND ANALYSIS

- Non-homogeneous/multi-phase water or soil samples
- Matrices other than water or soil
  (i.e., Rocks, leaves, sticks, oil, etc.)
- Insufficient volume for analysis requested
- Broken or leaking samples
- Incorrect or incomplete paperwork
- Laboratory receipt of incorrect samples
- Laboratory accidents involving samples
- Analytical problems with samples

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STANDARD OPERATING PROCEDURE

Section No. 36.0

MONITORING WELL INSTALLATION

By

JACOBS ENGINEERING GROUP INC.

SECTION 36.0

MONITORING WELL INSTALLATION

PURPOSE

To assure quality control on monitoring well installation, the following standard operating procedures have been set forth to successfully complete a field drilling investigation oriented toward obtaining hydrogeological and future water quality information.

Scope

Outlined herein are the minimum requirements for monitoring well installation. As attachments to this section are the following:

Figure 36-l, Well Completion Record.

Figure 36-2, Borehole/Well Construction Log.

Figure 36-3, Typical Monitoring Well Construction.

All field measurement and comments shall be recorded in the field logbook and on the appropriate forms. All lines on the forms shall be completed. The letter designation "NA" for not applicable or "NK" for not known shall be used in all blank spaces as appropriate. If some steps or procedures were not performed as described herein, the reason must be stated as is practicable on the appropriate form or submitted as an attachment thereto.

Procedures

Centralizers shall be used, to assure the uniform and complete annular filling of filter pack, annular seal, and grout materials. Centralizers shall be fastened to the well casing by mechanical fasteners, and radially spaced about the casing at 120 degree or 90 degree intervals. On the Borehole/Well Construction Log, a description of the fastening device and centralizer including their locations will be provided.

A filter pack shall be placed in the annulus of the well between the borehole wall and the screened or slotted casing to prevent formation material from entering into the well and to ensure continuous fluid flow from the formation to the well. Filter pack materials shall be described in terms of lithology, grain size distribution, and source. Th materials used to construct the filter pack should be chemically inert (e.g., clean quart sand, silica, or glass beads), well rounded and dimensionally stable. The filter pack should extend no more than two feet above the screened interval in order to ensur discrete sampling. The filter pack shall be emplaced in the monitoring well as follow

a) Filter pack materials should be well sorted (poorly graded) to assure goo permeability and hydraulic conductivity of the materials near the screen. Th average grain size of the filter pack shall be based on the expected grain size distribution in the screened formation and on the size of the predesigned wel screened openings. A filter pack is chosen to retain most of the formatio material. The well screen opening should be capable of retaining at least 90% of the filter pack after well development.

b) Depending on the boring method, the filter pack shall usually be emplaced using a tremie pipe. A slurry (using potable water) shall be pumped through the tremi pipe into the annulus throughout the entire screened interval and over the tc of the screen.

c) It is necessary to pump sufficient slurry to compensate for settlement of the filt pack after placement.

d) The depth of the top of the sand shall be ascertained using the tremie pipe, th verifying the thickness of the sand pack.

e) Under no circumstances shall the sand pack extend into any aquifer other th the one to be monitored. In most cases, the well design can be modified to allow for a sufficient sand pack without threat of cross-flow between producin zones through the sand pack.

An annular sealant shall be emplaced between the filter pack and cement and bentonite grout. The permeability of the sealant should generally be one to two orders magnitude less than the surrounding formation. The materials used to seal the annula space must prevent the migration of contaminants to the sampling zone from the surface or intermediate zones and prevent cross contamination between strata. In addition, th materials should be chemically compatible with the anticipated wastes. They shou also be chemically inert so they do not affect the quality of the groundwater samples. In special circumstances, an open borehole may be drilled to a depth below that which the screen will be set. If grout is used to seal off a lower aquifer or as backfill up to the proper level, an annular seal must be emplaced above the grout before casing, screen, and filter pack are introduced. The grout should be allowed to set up prior to placing the seal. The annular seal shall be placed in the monitoring well as follows:

a) The annulus between water-tight well casing and borehole shall be filled with an annular seal at least two (2) feet thick (vertically), above the filter pack and prior to the addition of the grout.

b) If construction of the annular seal is in the saturated zone, bentonite pellets shall be used because they will penetrate the column of water to create an effective seal. The pellets shall have a minimum purity of 90 percent montmorillonite clay and a minimum dry bulk density of 75 lb/cu ft for 1/2-inch pellets, as provided by American Colloid, or equal. A five (5) gallon bucket of pellets shall be poured directly down the annulus, if feasible. Otherwise, the tremie method shall be used. Care must be taken to avoid introducing pellets into the well bore. Thus a cap should be placed over the top of the well casing before pouring from the bucket. The pellets should be poured from different points around the casing to ensure even application. A tremie pipe may be used to redistribute and level out the top of the seal.

c) For wells of sufficient depth, the annular seal may either be poured as pellets or, if necessary, introduced as a slurry.

The method of emplacement shall be determined after evaluating the condition of the well and borehole wall.

d) If a slurry is used as an annular seal, the slurry shall be prepared by mixing powdered or granular bentonite with potable water. In some instances when chlorinated organics are being sampled, non-chlorinated water may be required. The slurry must be of sufficiently high specific gravity and viscosity to prevent its displacement by the grout that will be emplaced above. As a precaution, regardless of depth and depending on fluid viscosity, a few handfuls of bentonite pellets may be added to solidify the surface of the bentonite slurry.

e) Before placing the annular seal, check that the filter pack has ceased settling b measuring the depth to the top of the sand with the tremie pipe. The filter pac must provide an adequate cover over the screen.

f) Visually check the condition of the slurry by pumping into a bucket or onto th ground. Retract the tremie pipe three (3) feet and commence pumping.

g) In all situations, the annular seal should be a minimum of 2 feet thick. The to of the seal shall be tagged by tremie pipe to verify that the proper thickness of seal has been placed in the annulus.

h) Repeat application and verification as necessary until the specified quantity of annular sealant has been placed in the well annulus.

Only Type II cement without accelerator additives may be used in the cement and bentonite mixture (grout). The addition of bentonite to the cement should generally be in the amount of 2 to 5 percent by weight of cement content. This will aid in reducin shrinkage and control time of setting. In most cases sodium bentonite is appropriate. Calcium bentonite may be more appropriate in calcic sediments or soils due to reduced exchange potential. The bentonite should be pure and free of any additives that coul affect groundwater quality. The grout shall be placed in the monitoring well as follows:

a) The annulus between the well casing and borehole wall shall be filled with grou

b) The grout shall be implaced by a tremie pipe, located just above the top of the annular seal. Allow 20 minutes for the annular seal to set before groutin commences.

c) The tremie pipe should normally consist of 1.25 inch PVC or steel pipe. One (1 inch rolled thin-walled poly-pipe has been used with success in some cases.

d) The grout shall be pumped through this pipe to the bottom of the open annulu until undiluted grout flows from the annulus at the ground surface.

e) The grout shall consist of a bentonite and cement mix with four (4) pounds (commercial bentonite and approximately 7.5 gallons of water added per 9 pound bag of cement. Only grout mixed with approved water shall be used.

f) Any drill casing or hollow-stem auger shall be left in the hole during the grouting to the extent practical.

g) During grouting, the drill casing or hollow-stem auger may be removed as the grout level rises above the contact.

h) The grout should not extend above the frost line.

i) Allow the grout to set (about 48 hours) prior to emplacement of the expanding cement seal.

The remaining annular space should be sealed with expanding cement to provide for security and an adequate surface seal. Locating the interface between the cement and bentonite-cement mixture (grout) below the frost line serves to protect the well from damage due to frost heaving. The cement should be placed in the borehole using the tremie method.

Upon completion of the well, a suitable cap or compression seal should be properly placed to prevent either tampering with the well or the entrance of foreign material into it. A one-quarter inch vent hole should be put in the pipe to provide an avenue for the escape of gas.

Protective casing shall be installed around all monitor wells. Exceptions shall be on a case-by-case basis. Minimum elements in the protection design include:

a) A concrete well apron shall be placed around the protective casing. Minimum dimensions include 1) a radius of three (3) feet and 2) a thickness of at least four (4) inches, sloping away from the protective casing. The well apron shall be constructed using expanding cement.

b) A well cover shall be used to keep precipitation out of the protective casing and shall be secured to the casing by means of a padlock. It is generally advantageous if all padlocks can be opened by the same key. The numbers on the locks shall be noted and then removed from the locks if site security is a special concern.

c) Protective casing is to be painted either red or fluorescent orange.

d) The protective casing may also require a gas vent tube.

e) Well protection posts shall be placed around wells in any area where vehicular traffic is present. In general, posts shall be four (4) inch by four (4) inch wood three (3) inch diameter steel, or tee-bar driven steel posts. Posts should b placed about two (2) feet below ground, should rise a minimum of four (4) feet above ground. If the well is located in a livestock area, a three strand barbed wire livestock guard shall be strung on four (4) posts around the well.

A sketch of any well installation shall be recorded on the Well Completion Record Log and shall show, by depth from surface grade, the bottom of the boring, sump, scree location, coupling design and location, filter pack annular seals, grout, cave-in, centralizers, and height of riser above the ground surface. Materials used for casing and screen and the actual composition of the grout, seals, and granular backfill sha also be recorded on each Well Completion Record Log. Also include the casing and screen diameter (in inches), screen slot size (in inches), slot configuration, total open area per foot of screen, and screen manufacturer.Any use of PVC solvents, glues, soa or cleaners is prohibited below grade unless otherwise stated in the specifications. Where it is used, such material shall be described, to include manufacturer and type (specification). Well sketches shall also include the protective casing detail.

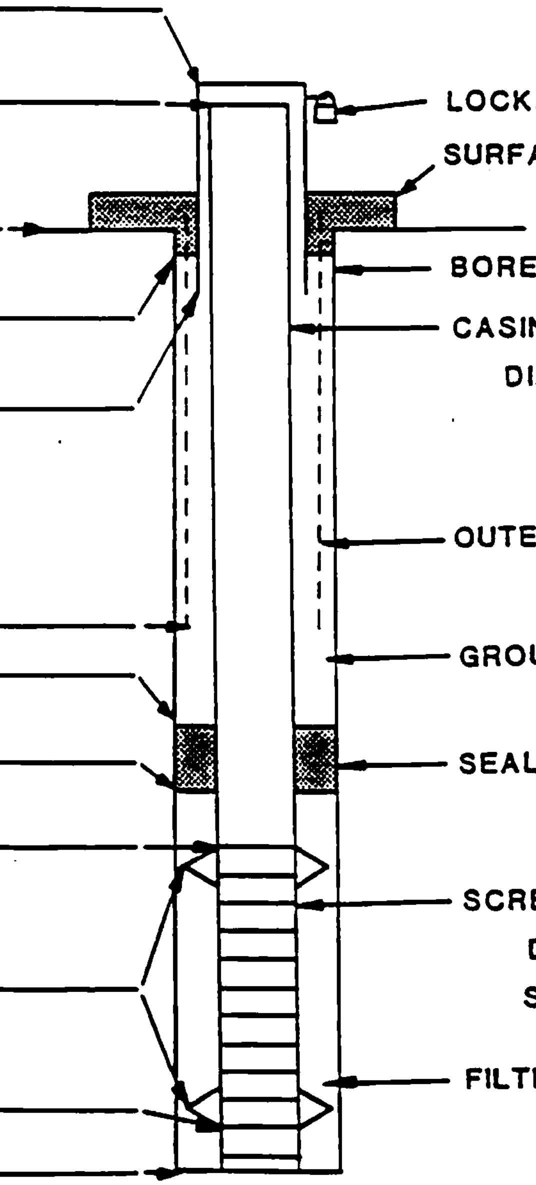
Figure 36-3 depicts typical monitoring well construction. In some cases, specific contract requirements may alter some of the components and/or values shown. Whe installed as a piezometer or well point (for water levels only), the well configuration may significantly vary from these figures, however, it may not vary from the design specifications. The water level in the well and date of measurement, after we development is complete, should be indicated on the well construction diagram.

FIGURE 36-1

WELL COMPLETION RECORD

WELL NUMBER ____________________ DATE INSTALLED ____________________

PMC REPRESENTATIVE ____________________ DRILLER ____________________



TOP OF PROTECTIVE CASING ____________

TOP OF CASING ____________

GROUND SURFACE ____________

TOP OF GROUT ____________

BOTTOM OF PROTECTIVE CASING ____________

BOTTOM OF OUTER CASING ____________

TOP OF SEAL ____________

TOP OF FILTER PACK ____________

TOP OF SCREEN ____________

CENTRALIZER DEPTHS ____________

BOTTOM OF SCREEN ____________

TOTAL DEPTH ____________

LOCKED-DATE ____________

SURFACE SEAL TYPE ____________

THICKNESS ____________

BOREHOLE DIAMETER ____________

CASING TYPE ____________

DIAMETER ____________

OUTER CASING TYPE ____________

DIAMETER ____________

GROUT TYPE ____________

SEAL TYPE ____________

SCREEN TYPE ____________

DIAMETER ____________

SLOT SIZE ____________

FILTER PACK TYPE ____________

COMMENTS ____

____

____

____

REPRESENTATIVE SIGNATURE ____________________ DATE ____________

FIGURE 36-2

BOREHOLE LOG

PAGE ____ OF ____

SITE ID: ________ LOCATION ID: ________
SITE COORDINATES (FT.): ________
N ________ E ________
GROUND ELEVATION (FT. MSL): ________
DRILLING METHOD: ________
DRILLING CONTR.: ________
DATE STARTED: ________
DATE COMPLETED: ________
FIELD GEOLOGIST/ENGINEER: ________

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (FT.)

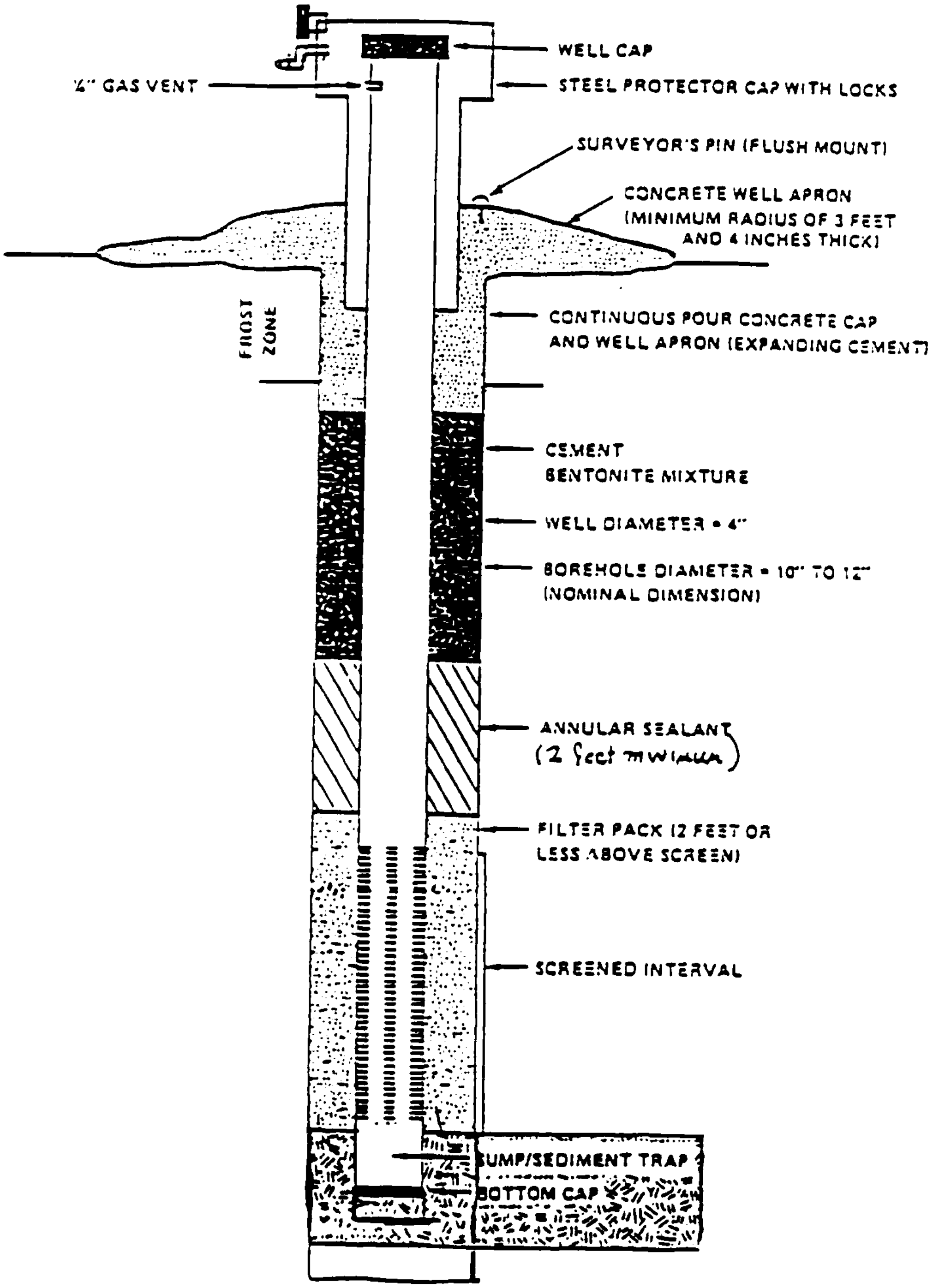
LOCATION DESCRIPTION ________
____
SITE CONDITION ________
____

DEPTH	SAMPLE INTERV.	SAMPLE RECOV.	CPM (OPT.)	BLOWS PER 6 IN.	N VALUE	VISUAL CLASSIFICATION

COMMENTS: ________
____
____
____

FIGURE 36-3

TYPICAL MONITORING WELL CONSTRUCTION



STANDARD OPERATING PROCEDURE

Section No. 37.0

WELL DEVELOPMENT

By

JACOBS ENGINEERING GROUP INC.

SECTION 37.0

WELL DEVELOPMENT

PURPOSE

To restore the natural hydrulic conductivity of the formation and to remove all foreign sediment. To define the procedures to be followed while developing a well in order to obtain water samples for future water-quality testing.

SCOPE

The following procedures shall be implemented after the installation of an observation monitoring well.

As attachments to this section is the following:

Figure 37-1, Borehole/Well Construction Log.

All field measurements and comments shall be recorded in the field logbook. If some steps or procedures were not performed as described herein, the reason must be state as is practicable on the appropriate form or submitted as an attachment thereto.

PROCEDURES

The development shall be performed as soon as practical after well installation, but no sooner than 48 hours after grouting is completed. In addition, development is to be completed at least two weeks before well sampling occurs.

A variety of techniques are available for developing a well. To be effective, they require reversals or surges in flow to avoid bridging by particles. A combination of techniques may also be successful. Some techniques include, but not limited to the following:

a) Overpumping - The simplest method of removing fines. This technique involves pumping at a higher rate than the well will be pumped when put into service. This technique, by itself, does not provide for flow reversals.

b) Backwashing - A surging action consists of alternately lifting a column of water a significant distance above the pumping water level and letting the water fall back into the well. This process is called rawhiding.

FIGURE 37-1

BOREHOLE LOG

PAGE ____ OF ____

SITE ID: ________ LOCATION ID: ________
SITE COORDINATES (FT.): ________
N ________ E ________
GROUND ELEVATION (FT. MSL): ________
DRILLING METHOD: ________
DRILLING CONTR.: ________
DATE STARTED: ________
DATE COMPLETED: ________
FIELD GEOLOGIST/ENGINEER: ________

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (FT.)

LOCATION DESCRIPTION ________
____
SITE CONDITION ________
____

DEPTH	SAMPLE INTERV.	SAMPLE RECOV.	CPM (OPT.)	BLOWS PER 6 IN.	N VALUE	VISUAL CLASSIFICATION

COMMENTS: ________
____
____
____

c) Mechanical Surging - Water is forced to flow into and out of a screen by operating a plunger up and down in the casing. The tool normally used is called a surge block, surge plunger or swab. A heavy bailer may also be used to produce the surging action.

d) Air Development by Surging and Pumping - Air is injected int the well to lift the water to the surface, and then allowed to fall by stopping the air supply. Air-lift pumping is used to pump the well periodically to remove sediment from the screen or borehole. Introducing air into a well is not recomended by EPA.

e) High-Velocity Jetting - Development by this method may be done with either water or air. The procedure consists of operating a horizontal jet inside the well screen so that high-velocity streams of fluid shoot out through the screen openings.

Development shall continue until the well water is clear and sediment within the well is removed to the fullest extent practical.

a) For those wells where the boring was made without the use of drilling fluid (mud, and /or water); remove five (5) times the standing water volume in the well (well screen and casing plus saturated annulus). Should recharge be so slow that five (5) volumes could not be removed in one (l) day, or the water remains discolored or contains greater than one (1) percent total particulates after this five (5) volume removal, the PMC shall direct an alternate procedure based on the subjective judgment of the TR.

b) For those wells where the boring was made or enlarged with the use of drilling fluid (mud, and/or water) remove five (5) times the measured amount of total fluids lost while drilling plus five (5) time the standing water volume as above (in paragraph a.). The same procedure also applies here as above for cases of slow recharge, discolored, or particulate-laden water.

c) All development equipment shall be decontaminated prior to l) its initial use and 2) in between subsequent use.

Nothing should be introduced into the well which might affect future wate quality analyses, such as dispersing agents, acids or disinfectants.

No water shall be added to the well to assist development without prior PMC/TR approval. Formation water should generally be used for surging the well. If a well cannot be cleaned of mud to produce formation water because the aquifer yields insufficient water (e.g., one (l) gal on per minute or less), small amounts of potable water may need to be injected to complete well development. This may be done by dumping in buckets of water which have been previously analyze. When most of the drilling mud is out, continue development with formation water only. It is essential that at least five (5) times the amount of water injected must be produced back from the well in order to assure that all injected water is removed from the formation. When most of the drilling mud is out, continue development with formation water only.

During development, the effort shall be made to remove the standing water from points near the bottom of the well screen as well as from the top of the water column.

To evaluate initial water quality, the FTR shall conduct pH and specific conductivity tests during development. The detection of abnormal readings should be relayed to the MC/TR prior to completion of development.

If problems are encountered during development, the Project Manager shall be notified within one (l) working day after problem detection.

The following data shall be recorded on the Borehole/Well Construction Log.

a) Well designation (location ID).
b) Date(s) of wel installation.
c) Date(s) and time of well development.
d) Static water level before and after development.
e) Quantity of water removed & time of removal.
f) Depth of open hole inside well before and after development
g) Physical character of removed water, to include changes during development in clarity, color, particulate and odor.
h) Quantity an physical character of removed sediments, to include lithology and grain size.
i) Type and size/capacity of pump and/or bailer used.
j) Description of surge techniques, if used.

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STANDARD OPERATING PROCEDURE

Section No. 38.0

FIELD MEASUREMENT OF STATIC WATER LEVELS AND TOTAL DEPTH IN GROUNDWATER MONITORING WELLS

By

JACOBS ENGINEERING GROUP INC.

SECTION 38.0

FIELD MEASUREMENT OF STATIC WATER LEVELS AND TOTAL DEPTH IN GROUNDWATER MONITORING WELLS

INTRODUCTION

Static water level and total depth measurements in groundwater monitoring wells enable the scientist or engineer to accurately determine the hydraulic gradient of a groundwater aquifer. The measurements are also useful guides that allow for monitoring of physical changes in an aquifer over time.

EVALUATIONS

Available Equipment

There is a variety of methods and devices available for recording static water levels and total depths in groundwater monitoring wells.

These methods and devices range from completely manual to fully automated. The most commonly employed instruments combine both manual and automatic features in an instrument ruggedly built for field operation. This type of instrument usually employs a battery powered probe assembly attached to a cable which is lowered into the well casing. When the probe makes contact with the water surface an electrical impulse is transmitted in the cable to either a meter or sound amplifier housed in the body of the instrument. The instrument is often equipped with a sensitivity adjustment switch that enables the operator to discern between actual and false readings due to the presence of saline, immiscible components on top of the groundwater.

The primary consideration in selection of the appropriate instrument should be the ability of the instrument to withstand rugged treatment.

Measurement Problems

The primary problem encountered during measurement of static water level and total depth in groundwater monitoring wells is properly recording the measurement at a common reference point. Common reference points are those points where the elevation is known with respect to mean sea level.

When measuring static water levels and total depths in groundwater monitoring wells, the measurement is taken at the top of the well casing which may be marked for future use.

APPARATUS

Water Level Measurement

The following apparatus are needed for the field measurement of static water level:

- Water level indicator equipped with a probe assembly capable of detecting static water levels at undetermined depths;
- Small (pocket) measuring tape capable of providing measurements to the 0.010 inch increment.

Total Depth Measurement

The following apparatus are needed for the measurement of total depth in groundwater monitoring wells:

- Measuring tape of sufficient length to provide measurements to 0.010 inch at undetermined lengths,
- Teflon-coated stainless steel line to be used as a plumb line,
- Stainless steel plumb for detecting bottom of groundwater monitoring wells.

MEASUREMENT PROCEDURE

Static Water Level

Recommended measurement procedures are outlined below:

- With the water level indicator sensitivity switch set at its full setting position, lower the probe until it contacts the water surface as indicated by audible alarm or dial needle reaction.
- Raise the probe out of the water until the indicator or alarm turns off. Repeat raising and lowering probe by hand until precise level is obtained.

- Record the increment reading at the designated reference point (for example, to adjacent ground surface, or to top of casing) to the nearest 0.10 feet.

- Following measurement of static water level, turn meter to the off position to conserve battery life.

Total Well Depth

Recommended measurement procedures are outlined below:

- Reel out the anticipated length of measuring tape on the ground surface.

- Attach stainless steel plumb to a plumb line and lower into well until the plumb encounters the base of the well.

- Record the position of the plumb line at the designated reference point

- Remove plumb line and plumb from well casing and place parallel to the measuring tape. Record total depth of groundwater monitoring well at the position where the measuring tape coincides with the measured reference point

- Decontaminate plumb and line.

QUALITY ASSURANCE

The following field measurement reference information must be recorded for quality assurance documentation:

- Designated reference point

- Elevation of designated reference point.

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STANDARD OPERATING PROCEDURES

Section No. 39.0

FIELD MEASUREMENT OF IMMISCIBLE COMPONENTS IN GROUNDWATER MONITORING WELLS

By

JACOBS ENGINEERING GROUP INC.

SECTION 39.0

FIELD MEASUREMENT OF IMMISCIBLE COMPONENTS IN GROUNDWATER MONITORING WELLS

INTRODUCTION

Immiscible components that are either less dense or more dense than water are occasionally encountered in groundwater wells. An accumulation of light immiscible components on the water table will depress the water level in a well because of the buoyancy effect of a less dense fluid floating on a fluid of greater density. Thus measurement of the water level surface with compensation for the deflection of the water table will yield erroneous results. The presence of light immiscible components on the water table may indicate migration of hazardous constituents along the water table surface.

An accumulation of heavy immiscible components would not affect the static water level measurement for the monitoring well, but they are a concern, as identification of heavy immiscible component may indicate migration of hazardous constituents along lower confining layers within the aquifer system.

EVALUATION

Available Equipment

There are numerous methods of identifying immiscible components in a monitoring well system. These include the use of an interface probe that can be used to identify the air/water, air/light immiscible, light immiscible/water, and water/heavy immiscible interfaces. An interface probe yields good quantitative results.

Water and gasoline level indicator pastes are available to identify the presence of water in oil or gasoline storage tanks. If used properly, this method may also yield good quantitative results, but because of the potential contamination risks of using these organic based pastes in groundwater monitoring wells, this technique is not discussed further in this SOP.

Measurement of the immiscible components in a monitoring well can be accomplished by the use of an electronic water level indicator. This method, when used in conjunction with a photoionization detector that will monitor the air quality in the headspace of the well, will provide good qualitative results (presence and approximate thickness) rather than quantitative results (accurate thickness). Qualitative results are acceptable for the measurement of thickness of immiscible components because small differences in the thickness of the immiscible components do not dramatically affect water level calculations.

Measurement Problems

There are numerous measurement problems that are encountered when measuring the thickness of immiscible components in a monitoring well. One of the major problems encountered is recognizing or identifying the presence of the immiscibles, either due to their thickness in the well casing, or because of similarities between the immiscibles and the groundwater (for example, similar color, viscosity, etc.). Another problem is that some of the immiscible components may have some degree of electrical conductivity that may interfere with the identification of the immiscible/water interface. A saltwater/freshwater interface is an example of a lower, relatively immiscible layer (under the right conditions) that will exhibit a conductivity greater than that of the upper layer. This SOP is directed primarily for the identification of measuring of accumulations of hydrocarbon immiscible components.

The investigator should be acutely aware of the types and characteristics of raw, intermediate, final and waste products at the site in order to anticipate the possibility of immiscible components, and to have an approximate idea how they may be identified in the monitoring well system.

A water level indicator or slope indicator can be used to measure the thickness of the immiscible components because the instrument interacts differently with the immiscible components than it does water. Water level indicators are generally some form of conductivity measuring device, and immiscible components such as hydrocarbons should have dramatically lower conductivities than does the ground water.

APPARATUS

The following materials and equipment will be needed for the measurement of immiscible components in the monitoring well:

- Water level indicator or water level probe
- Photoionization detector
- Hexane in wash bottle
- De-ionized water in wash bottle
- Paper towels

PROCEDURE

Jacobs' health and safety procedures require monitoring of the headspace of the well during well entry (removal of cap for any open-hole activities). If organic vapors are identified with a photoionization meter that is inserted into the well casing as soon as the casing is opened, the possibility of immiscible components should be considered.

Light Immiscible Components

Once the casing is opened and the headspace is analyzed, a clean water level indicator probe is inserted into the well casing. The probe is lowered into the well casing until it indicates (by light, buzzer, or meter) that the probe is in contact with water. Carefully measure the depth to the water level surface in the nearest 0.01 feet. Allow the probe to rest at the water surface for a few seconds, and then retrieve the probe to the surface. The presence of light immiscible components should either be visible on the probe or probe cord upon visual examination, or it can be identified by wiping the probe on a white paper towel (this assumes the immiscible component is not water white). If light immiscible components are identified, decontaminate the probe, first with a hexane rinse, and finally with deionized water.

Reinsert the probe into the hole and carefully lower the probe to the depth previously recorded water level. Wait a few moments, then retrieve the probe a second time. The purpose of this method is to provide an air/immiscible interface mark on the probe cord that is as accurate as possible. Retrieve the probe and carefully measure the distance (to the nearest 0.01 feet) from the probe sensor to the interface mark. Record the distance as the thickness of the light immiscible layer.

Heavy Immiscible Components

Heavy immiscible components can be detected with the use of the water level indicator or probe. The probe is lowered into the borehole until the bottom of the hole can be "felt" by the investigator. With the probe at the bottom of the hole, check the water level instrument reading (light, buzzer, or meter) to determine if the conductivity diminishes at the bottom of the well. If the conductivity diminishes, the presence of heavy immiscible components should be suspected. Record the depth to the bottom of the well, and very slowly retrieve the probe until the instrument reading provides a reading similar to that in the water layer. This will be the approximate interface between the water and the heavy immiscible component phase. Record this depth. The distance between the base of the well and the interface will be the approximate thickness of the heavy immiscible component in the well.

Retrieve the probe and decontaminate the probe and the cord, first by washing them in hexane, and finally with a rinse in deionized water before testing the next well.

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STANDARD OPERATING PROCEDURE

Section No. 40.0

AQUIFER PUMPING TESTS

By

JACOBS ENGINEERING GROUP INC.

SECTION 40.0

AQUIFER PUMPING TESTS

PURPOSE

The purpose of this Section is to briefly outline the procedures for conducting aquifer pumping tests to evaluate aquifer characteristics. Aquifer pumping tests, commonly referred to as pump tests, are used to evaluate hydraulic characteristics and properties of water-bearing zones. Pumping tests provide results that are usually more representative of the aquifer's characteristics than slug tests or laboratory "Permeability" tests.

Aquifer characteristics which may be obtained from pumping tests include specific capacity (S_c) hydraulic conductivity (K), transmissivity (T) and specific yield (S_y) for unconfined aquifers and storage coefficient (S) for confined aquifers.

Equipment, personnel and time commitments needed to conduct pumping tests are greater than those required for slug tests. Briefly, a pumping test consists of pumping one well and simultaneously recording the drawdown in the pumping well and, when possible, in other nearby observation wells.

There are advantages and disadvantages to pumping tests. Some of these are listed below.

Advantages of pumping test:

- A greater portion of the aquifer is tested and the results obtained are typically more reliable and representative of the aquifer characteristics than from slug tests.
- Coefficient of storage and specific yield values can be estimated.

Disadvantages of pumping test:

- In low permeability aquifers long-term pumping may be required to complete the test and obtain reliable aquifer characteristics.
- Disposal of discharged water may require special provisions if the ground water is contaminated.
- Test may be very expensive when compared to slug tests.

There are several types of pumping tests. The most common type is the constant rate discharge test (Todd, 1980). Variable rate tests are also employed under some conditions. Although the analysis is more complicated, any sort of temporal variations in flow rate can be accounted for by assuming the law of superposition holds. Usually this is a good assumption. The most widely used variable rate tests are the step-drawdown test, the constant head test and the air-lift pump test (Kruseman and DeRidder, 1976).

SCOPE

Pumping tests will be performed to estimate the hydrogeologic characteristics of subsurface water-bearing geologic material. The equipment used in the test will depend on the rate of flow of fluid encountered and drill hole stability conditions. Because of the great variety of hydrogeologic conditions that are likely to be encountered during drilling and testing, several different test tool arrangements are planned in order to be able to perform the pumping test.

PROCEDURES

Equipment Needed

The amount of equipment necessary to perform a constant-rate pumping test is greater than that used in a slug test. This is part of the reason why the aquifer pumping test is considerably more expensive. Equipment needed for a pumping test includes:

- Pumping well and pump. Pumps are commonly of the submersible or turbine type. The pumping well should be properly developed prior to testing.
- One or more observations wells hydraulically connected to the pumped aquifer and completed to the proper specifications for the particular test.
- An orifice weir, flow meter, calibrated container or other type of water measuring device to accurately measure and monitor the discharge from the pumping well.
- Sufficient pipe to transport the discharge from the pumping well away from the area to prevent infiltration in the area of influence of the pumped zone
- Gate valve on the discharge pipe to control the pumping rate.
- Outlet near well head for water quality determinations and sampling.

- Depth-to-water measuring device for each observation well and the pumping well (this may include steel tapes, electric sounding probes, Stevens Recorders, or pressure transducers).
- A thermometer and other necessary water quality monitoring equipment.
- Watches capable of reading to the nearest second for all observers or a stopwatch.
- 3-cycle or 5 cycle log and 5-cycle semi-log graph paper.
- Indelible pens or pencils and forms for recording times and drawdown measurements at each well.
- Appropriate references and calculator for determinations in the field.
- A barometer or recording barograph (for tests conducted in confined aquifers).

Pump Well Design

Design of the pump well is an important consideration in aquifer testing. In some cases an existing well will be used for pumping. When sufficient funds and conditions permit, a pumping well can be designed and constructed specifically for the test. The pumping well should be screened throughout the thickness of the aquifer to be tested. The well should be gravel packed, if necessary, to minimize sand production in unconsolidated fine-grained aquifers. The slot size of the well sceen and the gravel pack should be selected based on a grain size analysis of the native geologic materials. Standard well construction techniques are discussed in Driscoll (1986). The well should be properly plugged from overlying and underlying units that are not to be directly pumped so that leakage down the well annulus cannot occur which may interfere with the interpretation of the test. The completed pumping well should be developed by the appropriate methods to remove drilling fluid from the well and to wash and grade the grain size of the gravel pack and surrounding aquifer materials. Proper development of the well may prevent an unexpected variation in the pumping rate during the constant discharge test which, if the variation occurred, could lead to inconsistent drawdown data from the pumping well.

Observation Well Siting

The location and number of observation wells depends on several factors:

- Whether the aquifer unit to be tested is confined or unconfined
- The thickness of the aquifer
- The anisotropy of the aquifer
- Location of the screened interval of the pumping well relative to the total aquifer thickness.
- Location of aquifer boundaries, whether positive (lake or stream) or negative (impermeable boundaries)
- Practical and economic considerations
- The hydraulic conductivity and heterogeneity of the aquifer

Any number of observation wells may be considered. Often, four wells are desirable, three on a line passing through the center of the pumped well and one on a line normal to that line and also passing through the pumping well. A number of guidelines for location of observation well are presented in the Ground Water Manual prepared by he U.S. Department of Interior (1977) and Kruseman and DeRidder (1976).

Pump Test Procedure

A) All data generated in the conduct of a pumping test will be entered on the Aquifer Test Data Form (Figure 40-1)

B) The data obtained during the test, regardless of method or equipment, shall include:

   a) Static water level
   b) Water discharge rate
   c) Water level or pressure versus time data for each gauge
   d) Water temperature and specific conductivity
   e) Depth of water intake
   f) Depth of pressure sensor, if pressure device is used
   g) Whether or not a flowmeter/trace ejector survey was performed.
   h) Elevation of the top of each casing or point from which depth to water measurement are taken (datum).

C) A diagram of the equipment actually used in each pumping test shall be prepared. The diagram will show the tubing dimensions, the depth of water intake, and the location of gauges and packers. This diagram shall become part of the data records of each test.

D) All gauges and flowmeters used in the pump-out testing procedures shall be calibrated before arrival on site. Copies of the documentation of instrument calibration shall be obtained from the instrument or testing service company by the hydrologist. The calibration records shall consist of laboratory measurements and, if performed, an on-site zero adjustment and/or calibration.

E) Water pumped from the well during the pumping test shall be disposed of in such a manner so that no adverse impacts are created on surface water quality or on the quality of the drawdown data from observation wells.

F) In cases where a weir or an orifice are used to measure flow volumes or rates, these devices will be checked on site using a bucket or drum of known volume and a stopwatch and their accuracy documented before testing proceeds.

Data Analysis

Numerous technique of analysis have been developed by researchers to evaluate water level data collected from constant discharge aquifer pumping tests. Many of the analyses use the graphical "curve matching" technique which involves the matching of theoretical "type" curves to plots of log-drawdown versus log-time from the observation wells. Other analyses rely on other graphical techniques such as application of a straight line to plots of drawdown versus log-time. Common methods include Theis (1935), Cooper and Jacob (1946), Hantush (1955, 1956), Neuman (1972, 1974, 1975) and Boulton (1954, 1963). In addition, Kruseman and DeRidder (1976) have detailed descriptions of most of the analysis and valuation methods for pumping test data.

It is generally a good idea for field personnel to conduct preliminary analysis of the data in the field. (This preliminary analysis can be used to evaluate, for example:)

- If the data are producing reasonable results,
- If the data are reducing to "type" curves or straight lines,
- If the test should be repeated,
- If the length of the test should be extended.

Only the Project Manager can authorize repetition or extension of a pump test. One reason that it is important to immediately evaluate the data is so that it can be decided to release or retain the field personnel and equipment. It is not uncommon for a pump

to fail for a brief period of time or for the pump to be stopped for refueling.
preliminary analysis can evaluate the significance of the pump failure.

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ATTACHMENT 40-1

AQUIFER TEST DATA FORM

SITE ID: ______________________
LOCATION ID: ______________________
SITE ELEVATION: ______________________
END TEST: DATE ______________________
START TEST: DATE ______________________
TIME ______________________
TIME ______________________
AVERAGE PUMPING RATE (GAL/MIN): ______________________
DATUM : ______________________
STATIC WATER LEVEL:
METHOD: ______________________
INITIAL (AT t_0) ______________________
WELL DEPTH (FT): ______________________
FINAL ______________________
CASING DIAMETER (IN.) ______________________

WATER LEVEL MEASUREMENT METHOD: ______________________
DISTANCE FROM PUMPED WELL, r(FT): ______________________
DATA ADJUSTED FOR REGIONAL WATER LEVEL CHANGES ? ______________________
FIELD REP(S): ______________________
COMMENTS: ______________________

PUMP TEST			RECOVERY TEST	
ELAPSED TIME (MIN)	DEPTH TO WATER BELOW DATUM	PUMPING RATE (GAL/MIN)	ELAPSED TIME (MIN.)	RESIDUAL DRAWDOWN (FT)