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FINAL RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION
COMPREHENSIVE SAMPLING AND ANALYSIS PLAN VOLUME II PAGE CHANGES
REVISION 2 CNC CHARLESTON SC
7/30/1996
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**COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY
NAVAL BASE CHARLESTON
CHARLESTON, SOUTH CAROLINA
CTO-029**

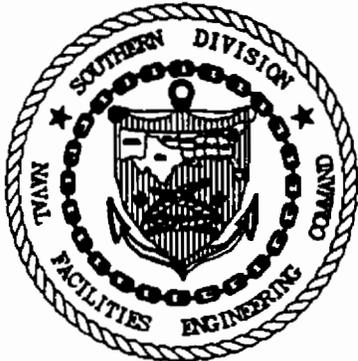


**FINAL
COMPREHENSIVE SAMPLING AND ANALYSIS PLAN
RCRA FACILITY INVESTIGATION
PAGE CHANGES, REVISION NO: 02**

Prepared for:

**DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON, SOUTH CAROLINA**

SOUTHDIV CONTRACT NUMBER: N62467-89-D-0318



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July 30 1996

Release of this document requires the prior notification of the Commanding Officer of the Naval Base Charleston, Charleston, South Carolina.

VOLUME II

ACRONYM LIST

AASHTO	American Association of State Highway and Transportation Officials
AOC	Area of Concern
ASTM	American Society of Testing and Materials
AWQC	Ambient Water Quality Criteria
bls	below land surface
CAMU	Corrective Action Management Unit
CFR	Code of Federal Regulations
CHASP	Health and Safety Plan
CLEAN	Comprehensive Long-term Environmental Action Navy
CLP	Contract Laboratory Program
cm	centimeter
CNSY	Charleston Naval Shipyard
COC	Contaminant of Concern
COLIWASA	composite liquid waste sampler
CSAP	Comprehensive Sampling and Analysis Plan
CTO	Control Task Order
CWA	Clean Water Act
°C	degrees Centigrade
DE	disposable equipment
DMP	Data Management Plan
DOT	Department of Transportation
DPT	Direct Push Technology
DQO	Data Quality Objective
DRMO	Defense Reutilization and Marketing Office
DS3	Datasonde 3
E/A&H	EnSafe/Allen & Hoshall
EIC	Engineer in Charge
EM	Electromagnetic
EPROM	Erasable Programmable Read Only Memory
ESDLOPQCM	USEPA Environmental Services Division <i>Laboratory Operations and Quality Control Manual</i> (1990)
ESDSOPQAM	USEPA Environmental Services Division <i>Standard Operating Procedures and Quality Assurance Manual</i> (1991)
FID	Flame Ionization Detector
ft ³	cubic feet

ACRONYM LIST (Continued)

GC	Gas Chromatograph
GIS	Geographic Information System
gpm	gallons per minute
GPS	Global Positioning System
HAZWOPER	Hazardous Waste Operations and Emergency Response
HCl	Hydrochloric Acid
HSWA	Hazardous and Solid Waste Amendment
IATA	International Air Transport Association
ID	Inner Diameter
IDL	Instrument Detection Limit
IDW	Investigation-Derived Waste
IRP	Installation Restoration Program
KI	Potassium Iodide
LCD	Liquid Crystal Display
LDR	Land Disposal Restrictions
LQAC	Laboratory Quality Assurance Coordinator
ml	Milliliter
MS	Matrix Spike
MSD	Matrix Spike Duplicate
msl	Mean Sea Level
MTR	Minimum Technical Requirements
NAD	North American Datum
NaI	Sodium Iodide
NaOH	Sodium Hydroxide
NAVBASE	Naval Base Charleston
NBS	National Bureau of Standards
NCP	National Oil and Hazardous Substances Contingency Plan
NCR	NEESA Contract Representative
NEESA	Naval Energy and Environmental Support Activity
NIST	National Institute of Standards and Technology
NPDES	National Pollution Discharge Elimination System
NSF	National Sanitary Foundation
NTU	Nephelometric Turbidity Unit

ACRONYM LIST (Continued)

OD	Outer Diameter
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OVA	Organic Vapor Analyzer
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PCP	Pentachlorophenol
PID	Photoionization Detector
PMP	Project Management Plan
POTW	Publicly Owned Treatment Works
PPE	Personal Protective Equipment
ppm	parts per million
PVC	polyvinyl chloride
QA	Quality Assurance
QAP	Quality Assurance Plan
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RAM	Random Access Memory
RCRA	Resource Conservation and Recovery Act
redox	oxidation/reduction potential
RI/FS	Remedial Investigation/Feasibility Study
RFI	RCRA Facility Investigation
RPD	Relative Percent Difference
RT	Regulatory Threshold
SAP	Sample and Analysis Plan
SCDHEC	South Carolina Department of Health and Environmental Control
SOUTHNAVFACENGCOM	Southern Division Naval Facilities Engineering Command
SVOC	Semivolatile Organic Compound
SW-846	USEPA <i>Test Methods for Evaluating Solid Waste</i> , 3rd. ed. (1986)
SWMU	Solid Waste Management Unit
TCLP	Toxicity Characteristic Leaching Procedure
TD-MS	Thermal Desorption-Mass Spectrometry
TD-GC/MS	Thermal Desorption-Gas Chromatograph/Mass Spectrometry
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TSCA	Toxic Substances Control Act

ACRONYM LIST (Continued)

TSDf	Treatment, Storage, and Disposal Facility
TU	Temporary Unit
USCS	Unified Soil Classification Scheme
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound

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1.0 INTRODUCTION

This document is intended to function as the Comprehensive Sampling and Analysis Plan (CSAP) portion of the Resource Recovery and Conservation Act (RCRA) Facility Investigation (RFI) Work Plan. This document outlines all monitoring procedures to be performed during the investigation to characterize the environmental setting, source, and releases of hazardous constituents. In addition, the CSAP includes the Quality Assurance Plan (QAP) and Data Management Plan (DMP) to ensure that all information and data are valid and properly documented. Unless otherwise noted, the sampling strategy and procedures will be performed in accordance with the United States Environmental Protection Agency (USEPA) Environmental Services Division *Standard Operating Procedures and Quality Assurance Manual*, February 1, 1991 (ESDSOPQAM), included in Volume V of the RFI Work Plan. A copy of the ESDSOPQAM will be kept onsite to supplement the CSAP during all field operations. Sample analyses will be conducted in accordance with the guidance in USEPA *Test Methods for Evaluating Solid Waste, SW-846, 3rd ed.*, Office of Solid Waste and Emergency Response (SW-846) and in the USEPA Environmental Services Division *Laboratory Operations and Quality Control Manual* (ESDLOPQCM) (included in Volume V of this RFI Work Plan).

Due to the number and diversity of Solid Waste Management Units (SWMUs) and Areas of Concern (AOC) to be investigated at Naval Base Charleston (NAVBASE), the CSAP does not address site specific sampling strategies. Instead, this information will be presented in a series of zone-specific Sampling and Analysis Plans (SAPs) to be used in conjunction with the CSAP. Each zone-specific SAP will document any deviations from the CSAP. The zone based investigative rationale is described in greater detail in the Project Management Plan (PMP). The intent of this approach is to develop a work plan that is independent of the number of investigation sites, and therefore will not require iterative revisions as new sites are discovered.

The investigations will consist of various activities depending upon the nature of the subject site and the work previously completed by Navy contractors. Tasks will likely include but may not be limited to physical surveys, field sampling, and laboratory analysis. The physical surveys

are screening tools and may consist of a preliminary air survey, habitat/biota survey, soil gas survey, aerial photograph reconnaissance, a contaminant source survey, and Dextsil™ Cl- or immunoassay screening. In addition, direct push technology (DPT) may be used as a screening tool to obtain groundwater, soil and soil vapor samples. At a minimum, physical surveys will be conducted at USEPA Data Quality Objective (DQO) Level II protocol. Field sampling, as well as the DPT screening efforts, will be used to delineate the extent, nature, and/or magnitude of contamination in the selected media. Media to be sampled and analyzed includes ambient air, surface water, sediment, soil, groundwater, and biota. The laboratories to be used are Naval Energy and Environmental Support Activity (NEESA)-approved and the QAPs of potential contract laboratories are included in Volume V of the RFI Work Plan for USEPA approval. With the exception of laboratory screening procedures performed at USEPA DQO Level II, sample analysis and data collection efforts will satisfy USEPA DQO Level III protocol. A minimum of 5 percent of the samples will be analyzed at USEPA DQO Level IV for confirmation purposes.

A report will be submitted to the Navy, USEPA, and South Carolina Department of Health and Environmental Control (SCDHEC) upon completion of the investigative work within each zone. The report will include laboratory analyses, a summary of the field activities, and the results and conclusions of the investigations. The results will provide a basis for a human health risk assessment and/or an ecological risk assessment to be completed at the subject sites. Information contained within the zone specific RFI reports will be summarized in a final report submittal that addresses NAVBASE as a whole.

1.1 Topography

NAVBASE is in the lower South Carolina Coastal Plain Physiographic Province, on the Cooper River side of the Charleston Peninsula. The Charleston Peninsula is formed by the confluence of the Cooper and Ashley Rivers. Topography in the area is typical of the South Carolina lower coastal plain, having low relief plains broken only by the meandering courses of sluggish streams and rivers which flow toward the coast past occasional marine terrace escarpments. Topography

at NAVBASE is essentially flat. Elevations range from just over 20 feet above mean sea level (msl) in the northwest part of the base to sea level at the Cooper River. Most of the original topography at NAVBASE has been modified by man's activities. The southern end was originally tidal marsh drained by Shipyard Creek and its tributaries, and originally, the other portions of the facility were only slightly higher in elevation. The land surface at NAVBASE has been filled with both solid wastes and dredged spoil (primarily the latter) in increments over the last 93 years. Nonetheless, most of NAVBASE remains within the 100-year flood zone, that is, less than ten feet above msl.

1.2 Geology

Geology of the Charleston area is typical of the southern Atlantic Coastal Plain. Cretaceous and younger sediments thicken seaward and are underlain by older igneous and metamorphic basement rock (Figure 1-1). Surface exposures at NAVBASE, in the limited areas which remain undisturbed, consist of recent and/or Pleistocene sands, silts, and clays of high organic content. NAVBASE is underlain by a plastic calcareous clay known as the Cooper Marl. The Cooper Marl is, in turn, underlain by the Santee limestone and sequentially older rocks.

1.3 Soil Characteristics

Surface soils at NAVBASE have been extensively disturbed. Native soils were the fine-grained silts, silty sands, and clay, typical of terrigenous tidal marsh environments. Sand lenses are present in localized areas; however, these are generally only several feet thick. Much of the material, particularly in the southern portion of the base, has been filled using dredged spoil from the Cooper River and Shipyard Creek. The spoils are an unsorted mixture of sands, silts, and clays. Most of the remainder of the base has been either filled or reworked.

1.4 Surface Hydrology

Parts of the southern portion of NAVBASE are drained by Shipyard Creek while some northern areas are drained by Noisette Creek. Both creeks are tributary to the Cooper River. Surface

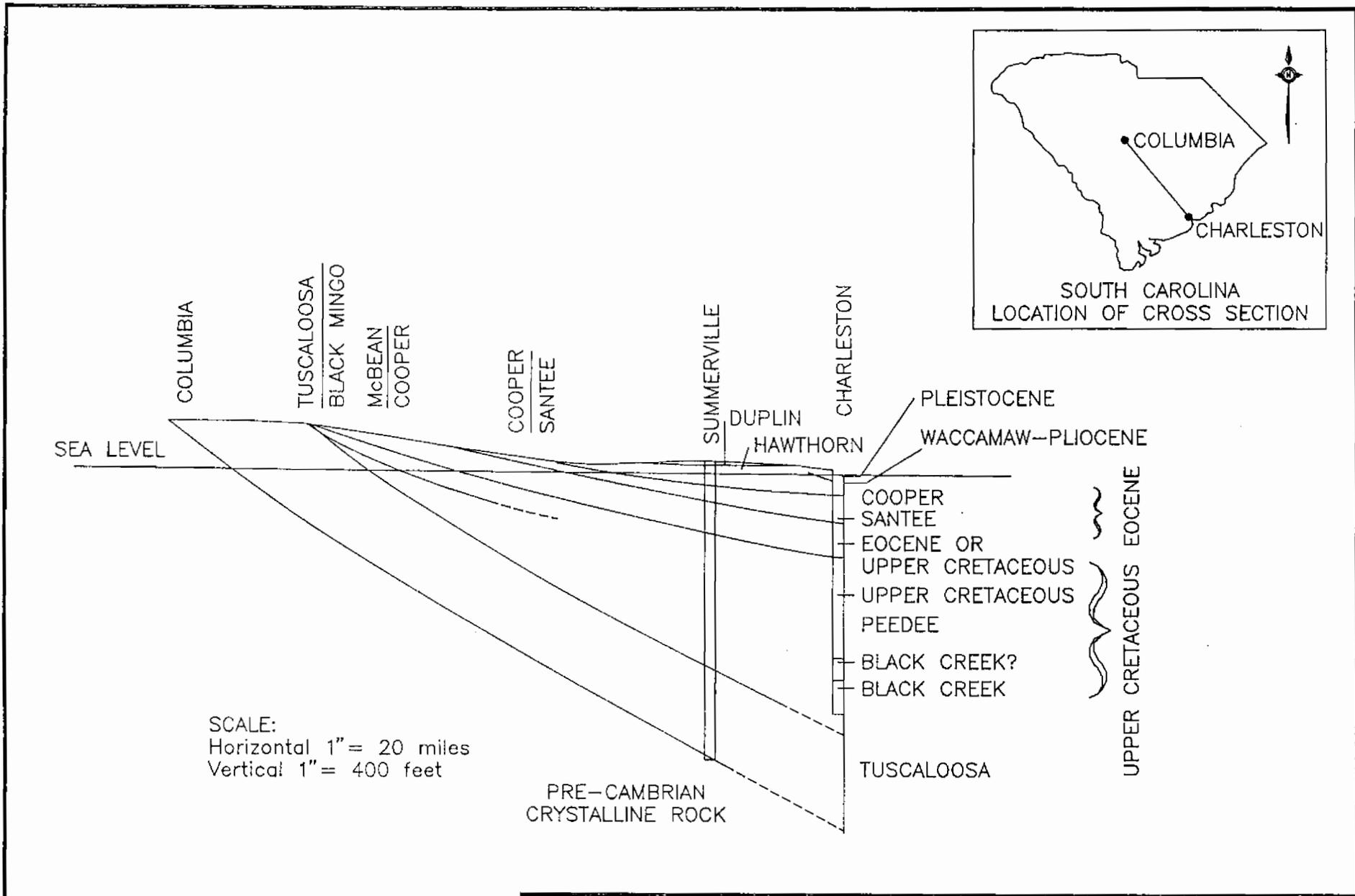
drainage over the remainder of NAVBASE flows directly into the Cooper River. The Cooper discharges into Charleston Harbor.

Shipyard Creek is a small tidal tributary, about two miles in length, which flows to the southeast along the southwestern boundary of NAVBASE to its confluence with the Cooper River, opposite the southern tip of Daniel Island. Docking facilities are located along the western shore of the lower mile of the channel, while the entire length of the eastern shore is bounded by tidal marshland.

Noisette Creek, which transects the northern portion of NAVBASE, is a tidal tributary approximately 2.5 miles long. The creek flows nearly due east from its headwaters in the City of North Charleston and empties into the Cooper River.

1.5 Hydrogeology

Two distinct aquifers exist beneath the NAVBASE site, a deep confined aquifer located within the Santee Limestone, and a shallow water table aquifer located within the near surface sediments. Both the shallow aquifer and the Santee Limestone function as potable aquifers in other locations. The shallow aquifer is not significantly developed in the NAVBASE area and is not developed at all at NAVBASE. A survey of groundwater users within a 7-mile radius of the NAVBASE was provided by the South Carolina Water Resources Commission to ascertain the extent, if any, of shallow groundwater usage in the vicinity of the NAVBASE. The survey indicated there are no wells screened in the surficial aquifer being utilized as a source for drinking water within a 4-mile radius of the NAVBASE. Currently, there is no evidence of groundwater being used as a potable water source at NAVBASE, apparently due to total dissolved solids (TDS) concentrations ranging from 1,000 to 1,500 parts per million (ppm) in the Santee. Even so, as outlined by the *Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy*, Final Draft, December 1986, the shallow groundwater is classified as Class IIB, Potential Source of Drinking Water. In addition, the groundwater



FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 1-1
GEOLOGIC CROSS SECTION
FROM COLUMBIA TO CHARLESTON

SOURCE: NAVFAC, 1976 & ESE, 1981.

DWG DATE: 08/08/94 | DWG NAME: 029EWCRS

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relating to the site has been classified as an underground source of drinking water (Class GB) by SCDHEC (*Water Classifications and Standards*, R.61-68).

The Cooper Marl, in the Charleston area, is a well documented confining layer for the Santee Limestone. The top of the Santee Limestone, which occurs at about 250 feet below msl in the NAVBASE area, has a groundwater potentiometric elevation of approximately 15 feet above msl. The hydraulic gradient is generally towards the southeast. Some wells in the vicinity of NAVBASE are pumping from the Santee for industrial purposes. In July 1981, the water level of a deep water well in the Santee Limestone beneath NAVBASE measured 15 feet below msl, indicating that the gradient across the confining Cooper Marl is artesian. Specifically, water from the confined aquifer of the Santee Limestone formation has an upward potential through the Cooper Marl.

Groundwater in the shallow aquifer beneath NAVBASE flows north-northeast into the Cooper River and south-southeast into Shipyard Creek due to the gently sloping topography away from the center of NAVBASE. Groundwaters in the immediate vicinity of Noisette Creek flow into it. The water table is within 3 to 7 feet of the ground surface. The shallow groundwater table continually but slowly discharges to the Cooper River and Shipyard Creek and, to a lesser extent, into Noisette Creek. **Figures 1-2 and 1-3 indicate the location of pre-RFI well installations.**

1.6 Climatology

The climate of the Charleston Harbor area is relatively mild compared to other areas further inland. The mountains of the northern portion of the state serve as a barrier to cold air masses from the northwest, and the Bermuda high pressure system limits the progress of cold fronts into the area. These conditions produce relatively mild temperate winters. Summers are hot and humid, but relatively moderate with regard to temperature extremes, largely due to the influence on the Gulf Stream (S. C. SEA Grant Consortium, 1992).

1.6.1 Temperatures

The average monthly air temperatures for the Charleston area are presented in Table 1.1. The temperatures are generally moderated by marine influences and are often 2-3 °C lower in the summer and 3-8 °C higher in the winter than those areas further inland from the harbor. Temperatures higher than 38 °C and lower than -6.5 °C are unusual for the area (S. C. SEA Grant Consortium, 1992).

1.6.2 Winds

The wind direction and velocity in the Charleston area are highly variable, and rather evenly distributed in all directions. The inland portions of the region are subjected to a southwest-northeast wind regime. The prevailing winds are northerly in the fall and winter, and southerly in spring and summer. The monthly average wind velocities and directions for the area range from a low of 12.1 kph in May to a high of 16.7 kph in March. The average monthly wind speeds and prevailing wind directions are presented in Table 1.1 (S. C. SEA Grant Consortium, 1992).

1.6.3 Rainfall

The Charleston area receives an annual average precipitation of 124.9 cm which is almost exclusively rainfall. Very little precipitation is recorded as snow, sleet, or hail. The greatest mean monthly precipitation is normally received in July while the smallest amount normally occurs in November (Table 1.2) (S. C. SEA Grant Consortium, 1992).

1.6.4 Humidity

Relative humidity in the Charleston Harbor area is normally very high and fluctuates greatly. Generally, it is higher during the summer months than other times of the year, and the coastal areas exhibit a lower relative humidity than inland portions of the area. The monthly mean relative humidity for four different times of day are presented in Table 1.2 (S. C. SEA Grant Consortium, 1992).

Table 1.1 Monthly and Annual Mean Temperature and Wind Data for Charleston Harbor between 1970 and 1985 (NOAA 1972, 1985)*				
Month	Daily Max	Daily Min	Mean Speed km/hr	Prevailing Direction
January	16.4	3.1	14.8	SW
February	16.8	4.5	16.6	NNE
March	20.0	7.3	16.7	SSW
April	24.9	11.5	16.1	SSW
May	28.8	16.6	14.3	S
June	31.6	20.6	13.7	S
July	31.6	22.2	13.0	SW
August	31.5	21.4	12.1	SW
September	29.2	18.8	13.0	NNE
October	25.1	12.7	13.2	NNE
November	19.9	6.6	13.2	N
December	16.1	3.5	14.0	NNE
Annual	24.3	12.4	14.2	NNE

1.6.5 Cloud Cover

Cloud cover varies widely for Charleston, with annual averages of 101 clear days, 115 partly cloudy days, and 149 cloudy days. The mean monthly clear, partly cloudy, and cloudy days for the area are presented in Table 1.2 (S. C. SEA Grant Consortium, 1992).

1.6.6 Climate Extremes

The primary concern as far as climate extremes are concerned is the occurrence of tropical cyclones or hurricanes. Hurricanes frequent the east coast of the United States, and almost always have some effect on the weather around Charleston Harbor. Hurricanes normally occur between August and December. The last hurricane to make landfall in the Charleston area was hurricane Hugo a class IV hurricane which struck Charleston in September 1989 causing sever

Table 1.2 Table II-3. Monthly and Annual Mean Precipitation, Relative Humidity, and Cloud Cover for Charleston Harbor between 1960 and 1985 (Based on NOAA 1972, 1985)*								
Month	Precipitation (cm)	Relative Humidity by Time				Cloud Cover % Number of Days		
		0100	0700	1300	1900	Clear	Partly	Cloudy
January	6.45	82	84	55	73	8	8	15
February	8.36	79	82	52	68	9	6	13
March	9.98	81	83	50	67	9	9	13
April	7.32	84	84	50	67	11	8	11
May	9.17	88	84	54	72	8	12	11
June	12.65	90	86	59	75	6	12	12
July	19.58	91	88	64	79	4	13	14
August	16.79	92	91	63	80	5	14	12
September	14.81	91	91	63	82	7	11	12
October	7.21	88	89	56	80	12	8	11
November	5.31	85	87	51	77	13	6	11
December	7.24	82	84	54	74	9	8	14
Annual	124.87	86	86	56	75	101	115	149

Note:

* (S.C. SEA Grant Consortium, 1992)

damage. Tornadoes are extremely rare in the vicinity but have occurred in the inland portions of Charleston county (S. C. SEA Grant Consortium, 1992).

1.7 Ecological Setting

A survey of available documents regarding natural resources was conducted at NAVBASE. The survey was conducted in order to make a preliminary identification of local flora and fauna, and any potential biological receptors such as sensitive environments. The following sections addresses the communities and sensitive environments identified during the survey.

1.7.1 Sensitive Environments

A tributary of the lower Cooper River, Shipyard Creek, forms part of the eastern property boundary of NAVBASE. Shipyard Creek is a navigable water body maintained to an Army Corps of Engineers authorized depth of 38 feet below mean low water. The periodic dredging of sediment in this river affects communities of benthic organisms. The river contains numerous wetlands including estuarine intertidal emergent, estuarine intertidal unconsolidated shore, and estuarine subtidal unconsolidated bottom. A significant wetland community exists in the intertidal emergent zone along Shipyard Creek. Vegetation consists primarily of *Spartina* spp. "Demersal fish species which are typically associated with the lower water column and substrate of Charleston Harbor include star drum (*Stellifer lanceolatus*), croaker (*Micropogon undulatus*), bay anchovy (*Anchoa mitchilli*), Atlantic menhaden (*Brevoortia tyrannus*), spotted hake (*Urophycis requis*), weakfish (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), blueback herring (*Alosa aestivalis*), white catfish (*Ictalurus catus*), and silver perch (*Bairdiella chrysura*). Other fish species commonly found in Charleston Harbor of primary interest to recreational and commercial fisherman include flounder (*Paralichthys* spp.), redfish (*Sciaenops ocellata*), spotted seatrout (*Cynoscion nebulosus*), bluefish (*Pomatomus saltatrix*), black drum (*Pogonias cromis*), and striped mullet (*Mugil cephalus*). Four anadromous fish species including shad and herring (*Aolsa* spp.), and striped bass (*Morone saxatilis*) and one catadromous species, American eel (*Anquilla rostrata*) also utilize Charleston Harbor and its tributaries as migration routes and spawning areas. Additionally, the endangered shortnose sturgeon (*Acipenser brevirostrum*), has been documented as occurring within Charleston Harbor (Eudaly et al, 1991).

A second tributary to the lower Cooper River, Noisette Creek, transects the northern portion of NAVBASE. Little information regarding Noisette Creek's physical attributes, such as mean depth, was discovered during this preliminary survey. The biota of Noisette Creek is anticipated to be similar to that of Shipyard River due to the propinquity of these bodies, with the exception of benthics as Noisette Creek is not dredged.

The Clouter Creek Dredge Area is located on the eastern shore of the Cooper River. Clouter Creek branches and rejoins the Cooper River to form an island reserved by the U.S. Navy for dredge disposal. A 1993 United States Geologic Survey (U.S.G.S.) Geology of the Cainhoy, Charleston, Fort Moultrie, and North Charleston Quadrangles, Charleston and Berkeley Counties, South Carolina map characterizes Clouter Creek Dredge Area as artificial fill surrounded by salt marsh. Extensive wetlands are indicated on the map including Broad Creek, which transects the island. The biota of this site is anticipated to be similar to biota of analogous wetland locations in the area. This may include nesting sites for migratory and resident wading and shore birds.

The majority of NAVBASE is characterized as disturbed material, primarily dredge spoil used for fill and material used in the upkeep of NAVBASE such as run of crusher (ROC) gravel, asphalt and concrete parking areas, buildings, laydown yards, and improved roads.

The wetland at the southwestern section of the Base is identified on Survey of Charleston Naval Base, Drawing h696-268, Map of Charleston Naval Shipyard, Naval Station, and Contiguous Activities Existing and Planned — as Modified by U.S. Army Corps of Engineers, Charleston District 2. February 1988. In summary, they include estuarine subtidal unconsolidated bottom and estuarine intertidal emergent zones along Shipyard Creek. An unimproved road transects the wetland inland from these zones and to the east of the road is primarily salt marsh with irregular topography which allows for zones in which non-hydrophytic vegetation exists. No other significant wetlands are known to exist at NAVBASE.

1.7.2 Threatened and Endangered Species

Information concerning threatened and endangered species was obtained from the South Carolina Heritage Trust of the South Carolina Wildlife and Marine Resources Department. Table 1.3 identifies species of concern listed for Charleston County and reports the status of these species.

Table 1.3 Endangered and Threatened Species in Charleston County, South Carolina		
SPECIES NAME	COMMON NAME	STATUS
Flora		
<i>Amaranthus pumilus</i>	Sea-beach amaranth	T
<i>Oxypolis canbyi</i>	Canby's dropwort	E
<i>Lindera melissifolia</i>	Pondberry	E
<i>Schwalbea americana</i>	Chaff-seed	E
<i>Myotis austroriparius</i>	Southeastern myotis	C2
<i>Agrimonia incisa</i>	Incised groovebur	C2
<i>Asplenium heteroresiliens</i>	Wagner's spleenwort	C2
<i>Aster georgianus</i>	Georgia aster	C2
<i>Dionaea muscipula</i>	Venus' fly-trap	C2
<i>Ilex amelanchier</i>	Sarvis holly	C2
<i>Litsea aestivalis</i>	Pondspice	C2
<i>Lobelia boykinii</i>	Boykin's lobelia	C2
<i>Pteroglossaspis ecristata</i>	Eulophia	C2
Fauna		
<i>Trichechus manatus</i>	West Indian manatee	E
<i>Falco peregrinus tundrius</i>	Arctic peregrine falcon	T
<i>Haliaeetus leucocephalus</i>	Bald eagle	E
<i>Vermivora bachmanii</i>	Bachman's warbler	E
<i>Mycteria americana</i>	Wood stork	E
<i>Picoides borealis</i>	Red-cockaded woodpecker	E
<i>Charadrius melodus</i>	Piping plover	T
<i>Lepidochelys kempii</i>	Kemp's ridley sea turtle	E
<i>Dermochelys coriacea</i>	Leatherback sea turtle	T
<i>Caretta caretta</i>	Loggerhead sea turtle	T
<i>Chelonia mydas</i>	Green sea turtle	T

Table 1.3 Endangered and Threatened Species in Charleston County, South Carolina		
SPECIES NAME	COMMON NAME	STATUS
Fauna (continued)		
<i>Acipenser brevirostrum</i>	Shortnose sturgeon	E*
<i>Odocoileus virginianus</i>	Bull's Island white-tailed deer	C2
<i>Plecotus rafinesquii</i>	Fafinesque's big-eared bat	C2
<i>Aimophila aestivalis</i>	Bachman's sparrow	C2
<i>Lateralis jamaicensis</i>	Black rail	C2
<i>Lanius ludovicianus</i>	Loggerhead shrike	C2
<i>Ophisaurus compressus</i>	Island glass lizard	C2
<i>Rana areolata capito</i>	Gopher frog	C2
<i>Ambystoma cingulatum</i>	Flatwoods salamander	C2

2.0 GENERAL REQUIREMENTS

2.1 Sampling Strategy

Before any sampling is conducted, a sampling strategy will be developed. The sampling strategy will take into consideration:

- The environmental quality of the Base as a whole.
- The possible impacts of one SWMU/AOC on another.
- The benefit to be gained at one SWMU/AOC by sampling at another.
- The possibility of environmental contamination migrating onto an/or off of the Base.
- Specific data needs for various potential presumptive remedies; this is needed to know how to design the Corrective Measures Study (CMS), and when to end the RFI and begin the CMS.
- Data needs of other related activities such as the Baseline Risk Assessment.
- The specific need for each piece of data, and.
- A minimum of mobilizations.

2.2 Orientation Meeting

Before performing any field activities at the NAVBASE, sampling personnel will attend an orientation meeting summarizing general and site-specific requirements for sampling and documentation at NAVBASE. General topics to be discussed will include the base location, the locations of the site office trailer, subject site, decontamination area within the base; and the Comprehensive Health and Safety Plan (CHASP). Sampling requirements to be discussed will include general sampling protocol, the Unified Soil Classification System (USCS), use of the stainless-steel sampling sleeves if applicable, the sample numbering system, quality assurance/quality control (QA/QC) sampling requirements, and sample packaging. Documentation requirements to be discussed will include the use of field forms, field logbooks, and documentation of photographs. A checklist of requirements and an acceptance form indicating the above items have been reviewed by sampling personnel are provided in Appendix A.

2.3 General Sampling Requirements

General procedures for field personnel to follow when collecting environmental samples are included in this section. Detailed sampling procedures are discussed in Sections 4, 6, 7, 8, and 9. These general procedures are designed to prevent cross-contamination of samples.

General Sampling Procedures:

- Field sampling teams will have at least two people. One person will collect the sample as the other ensures adherence to the sampling procedures, records any difficulties encountered, and documents other information pertinent to the investigation. When sampling using the peristaltic pump/vacuum jug technique (often the preferred method for shallow wells where turbidity is of concern), the recommended order of collection is metals, cyanide, pesticides/PCBs, volatiles.
- All sampling activities in each medium will proceed from the area of least contamination to greatest contamination, if possible. If free product or contaminant-saturated media are encountered, collect grab samples there.
- The preferred order of sample collection in all media will be as follows (on a parameter basis): volatile organic analysis (VOA), total organic carbon (TOC), semivolatile organic analysis (SVOA), pesticides, herbicides, polychlorinated biphenyls (PCB), total metals, dissolved metals, cyanide, inorganics, and turbidity.
- The sampler will don a clean pair of protective gloves before collecting each sample.
- Samples for chemical analysis will be collected with either disposable sampling devices or decontaminated, stainless-steel or Teflon™ devices. When composite samples are required, they will be homogenized in stainless-steel bowls. All sampling equipment will be decontaminated in accordance with the procedures outlined in Section 15 of this plan.
- Disposable sample equipment will be constructed of Teflon™. The device will be decontaminated by the manufacturer before shipment to the site. An equipment rinsate blank will be collected before use.

- Fill all sample bottles, except for VOA bottles, to the shoulder to compensate for temperature and pressure changes during transport. If the container is filled below the shoulder, mark the level with a permanent marker or grease pencil. VOA bottles will be filled until there is zero headspace.
- Samples collected for VOA analysis will not be homogenized.
- All samples requiring chemical preservation shall be preserved immediately after field collection or the bottles may be preserved before sample collection.
- After collection, samples exhibiting obvious visual or olfactory contamination will be separated from the samples not exhibiting such evidence of contamination.
- Precleaned sample containers will be provided by the analytical laboratory except for the stainless-steel sleeves used for soil sampling, which will be decontaminated onsite. All data relative to sample container integrity shall be documented in the site log.
- Heterotrophic plate count samples will be collected with sterile containers and scoops provided by the laboratory.

Sample Processing:

Some of the analyses to be performed on selected samples require them to be preserved immediately after collection to maintain their integrity, as per the following procedures:

- Clearly identify the chemical preservative on the sample label.
- Chill all samples to 4 degrees centigrade (°C) immediately after collection and during shipment to the laboratory. In each cooler, include a 40-milliliter (ml) vial of tap water as a temperature blank or place a temperature strip on a sample bottle to measure its temperature at the time of receipt. If possible, samples from different sites will not be placed in the same cooler.
- Handle the samples as infrequently as possible. Use extreme care to ensure samples are not cross-contaminated. Use sealable plastic bags to protect samples from cross-contamination.

- A trip blank, prepared by the laboratory, will be shipped with each set of samples to be analyzed for VOA. It is not necessary to refrigerate trip blanks before use; store in a dust-free, organic-free environment away from fuels, solvents, and volatile compounds. Discard any trip blanks with bubbles larger than a pinhead.
- Avoid headspace (bubbles) in all VOA samples. VOA samples effervescing due to dissolved gases or high carbonate content will not be preserved with hydrochloric acid (HCl). Document unpreserved VOA samples on the chain-of-custody form and notify the laboratory before shipment.
- Identify and fully document all samples in the field logbook, on the chain-of-custody forms, and on the sample labels. Refer to the specific instructions for completing sample labels and chain-of-custody forms in Sections 11.3, 11.4, and 11.5 of this plan. Document all samples in accordance with the DMP.
- Follow chain-of-custody procedures to assure sample custody is maintained in a reliable manner and to assure each step in transportation to the laboratory is documented. This process will be initiated in the field and followed throughout the sampling process. Document chain-of-custody in accordance with the procedures described in Section 11.5 of this plan.
- Every effort will be made to ship all samples overnight to the laboratory on the day of collection via express air courier. Refer to Section 11.3 for sample shipment procedures. Record airbill numbers on the chain-of-custody forms.
- The laboratory will be notified in advance of sample shipment.

3.0 PHYSICAL SURVEYS

3.1 Well Inventory

Before beginning any field activities, all existing monitoring wells at the NAVBASE will be inventoried to ensure the validity and accessibility of groundwater sampling locations. A well integrity checklist is provided in Figure 3-1.

Before the Well Inventory

Before beginning the well inventory, the following information will be recorded on the well integrity checklist from previous reports.

- Well number and SCDHEC well permit number
- Reported dimensions of the monitoring wells including:
 - Diameter
 - Total well depth
 - Last available depth to water
 - Screened interval
 - Suspected contaminant

A site map will be included with the well inventory checklist for locating the monitoring wells.

During the Well Inventory

The condition of all monitoring wells will be checked and recorded on the well integrity checklist. Conditions to be checked will include:

- Legible labeling of the monitoring well (if the labeling is illegible, the wells will be relabeled during the inventory).
- Presence of a protective casing and the presence of weep holes.
- Presence of yellow bumper posts.
- Condition of the cement surface seal.
- Presence of a well cap and lock. (Damaged locks will be replaced during the well inventory.) All Installation Restoration Program (IRP)-related locks will be keyed alike.

Presence of odor or ionizable organic vapors using an photoionization detector (PID) or flame ionization detector (FID).

- Construction of the well including:
 - Construction material
 - Diameter
 - Depth to water and depth to bottom.

After the Well Inventory

Monitoring wells no longer needed will also be abandoned. All damaged wells (unable to be sampled) will be abandoned in accordance with SCDHEC standards and regulations. If additional monitoring wells are needed to replace the abandoned ones, they will be installed during the site-specific investigation. Damaged surface seals will be removed and replaced, bumper posts will be installed and/or painted, and protective casings will be repaired or replaced as necessary during the site-specific investigation.

3.2 Geophysical Surveys

3.2.1 Magnetometer Survey

A magnetometer survey identifies areas of buried metallic objects and geologic anomalies (magnetic mineral formations) contrasting with the surrounding rock or subsurface soil. The magnetic field strength, measured by the detector as a magnetic signal intensity, varies between $1/r$ and $1/r^3$ (r being the distance from the sensor to the buried object), depending upon the type of object. Metal location and depth of burial is indicated by the shape and width of the anomaly. The accuracy of this method is within 40 percent of the interpreted value. Total field and vertical gradient measurements are two types of magnetic surveys. Setup procedures apply to both types.

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Setup Procedures:

1. Review past disposal practices to identify target and non-target areas.
2. Determine the minimum size of target to be identified.
3. Reconnoiter the site to identify areas of potential magnetic interference (e.g., metal fences, metal buildings, and power lines).
4. Review the site geology to determine if any geologic anomalies might interfere with target detection.
5. If anomalies are expected, estimate their intensity.

Establishing a Grid System:

6. A South Carolina-registered surveyor or EnSafe/Allen & Hoshall (E/A&H) personnel will define the two baselines (x and y axes) and record the baselines and other key elements of the grid on report maps. If possible, establish the grid so the lines are perpendicular to the target axes. If not possible, align the grid north to south or anchor it to a permanent site feature.
7. The baselines will be flagged at regular intervals, in accordance with the site-specific SAP. The distance between sampling points depends on the resolution required for a particular site. The closer the sampling points are to each other, the greater the resolution.
8. The internal grid points then will be established using a Brunton compass and measuring tape. Use a non-metallic marker, such as a wooden stake, to identify stations.
9. Check the calibration date of the magnetometer. If the magnetometer has been calibrated more than one year ago, return it for recalibration.

Total Field Measurement Survey

The total field measurement is a scalar measurement of the total magnetic field intensity. The person operating the magnetometer must be free of any magnetic material (e.g., steel-toe boots).

Survey Procedures:

1. Place the magnetometer at a station, properly orient the sensors, and collect the reading in accordance with the manufacturer's operating manual.
2. Hold the magnetometer approximately 0.5 meters above the ground surface to obtain a reading. At subsequent grid nodes, the magnetometer must be held at the same height. A 0.5-meter mark on a staff may be used to estimate this height.
3. Record the magnetometer reading, measurement time, grid node identification, and applicable comments in the field logbook.

Vertical-Gradient Field Measurements

The vertical gradient field measurement consists of two or more total field measurements taken at different sensor heights. This helps quantify regionally pervasive magnetic effects from nearby building or ubiquitous bedrock magnetization.

Survey Procedures:

1. At each grid node, collect total field measurement at 0.5 meters above the ground surface.
2. Collect a second reading with the sensor approximately 1 to 2 meters above the point where the first reading was taken. A staff will be designed to hold the two sensors so separation can remain constant.
3. Record the second value and the distance between the readings.
4. Record any additional comments in the field logbook.
5. Collect readings at the remaining grid nodes with the same distance between the first and second readings.

In most cases it will be necessary to correct for drift and sudden fluctuation in the earth's magnetic field intensity. This can be done in one of two ways. Method 1 uses a "tie base station" and repeats the measurements there at least once every hour. The data obtained between

repeats at the base station can then be corrected by a linear interpolation. Method 2 uses a second magnetometer to continuously monitor the magnetic field. The data are then corrected manually or by software in digital magnetometers. Method 2 is more costly but more accurate, and is sometimes necessary due to prevailing conditions.

3.2.2 Electromagnetic Induction Survey

This section describes the procedures for conducting an electromagnetic (EM) survey with an EM-31 terrain conductivity meter. Survey procedures are detailed below.

Induction Survey Setup Procedures:

1. Review past disposal practices at the site in order to identify buried targeted and non-targeted metallic objects.
2. Review the site geology for variable geologic conditions or features, possibly causing spurious anomalies affecting target detection.
3. If anomalies are expected, estimate their intensities.
4. The EM survey can be completed with horizontal and/or vertical dipoles, and with conductivity with/without in-phase component.
5. The intervals of the grid system will be defined in the site-specific SAP.
6. Tie the grid system to existing permanent features (i.e., roads and buildings) so the grid may be used for locating and mapping physical site features, such as monitoring wells, and tracing contaminant plumes.
7. Mark the grid system origin and key axes using a Brunton compass and tape to ensure accurate instrument placement.

EM Instrument Calibration

EM instruments are calibrated by the manufacturer. Instrument calibration checks will be performed before use each day in accordance with manufacturer's specifications.

If site activities are expected to last more than one day, select a local standard site in the field to provide a reference base station. The instrument will be calibrated daily at the base station to check for drift in the instrument's performance.

EM Instrument Field Check Procedures:

1. Select a reference base station without nearby conductors and obtain a reading with the EM instrument.
2. Record the site location, orientation of each coil (e.g., east-west versus north-south), coil spacing, and the EM reading in the field logbook.
3. At the beginning of each subsequent day, obtain a reading at the test site with the same coil spacing and orientation as before. Variation should be less than ± 5 percent.
4. Record the reading and location in the field logbook, and compare with the initial reading to cross-check for instrument drift.

Data may be obtained using horizontal or vertical dipoles. For an EM-31, the horizontal dipoles are selected when the instrument is placed with the meter facing up; vertical dipoles are selected when the meter faces the horizon. In both cases, the long boom is held parallel to the ground at a fixed height. Horizontal dipoles are usually used since they provide the deepest penetration (about 12 meters). Vertical dipoles are only useful in certain applications (i.e., when better resolution at shallower depths is required.)

In addition, one can choose conductivity mode and/or in-phase mode. Always use at least conductivity mode. In-phase can be run in addition to conductivity to help better define buried metals.

3.3 Cadastral Survey/Geodetic Survey

When the field investigation is complete, a survey will be conducted to locate all sampling locations, both horizontally and vertically. The vertical elevations will be surveyed to an

accuracy of ± 0.01 foot. The horizontal locations will be supplied in latitude and longitude, in accordance with North American Datum (NAD) 83. In addition, locate all utilities, above-ground structures, and surface improvements (e.g., pavement). Geodetic surveys will be conducted using a differential global positioning system (GPS). The cadastral survey will be conducted by vendor-registered land surveyors in South Carolina.

4.0 SOIL SAMPLING

Soil sampling locations will be positioned in accordance with the site-specific SAP. Techniques for sample collection depend on the soil type, depth of the sample, and DQO parameter requirements. Surface soil sampling will be conducted in accordance with Section 4.11 of the ESDSOPQAM found in Volume V of the RFI Work Plan. Surface samples are defined as 0 to 1 foot below land surface (bls) exclusive of rocks, twigs, leaves, and vegetation. Surface soil samples may be collected manually with hand augers. Power devices such as drill rigs, backhoes, or DPT probing equipment frequently are used for deeper subsurface samples, depending on the depth of the sample to be collected and the soil type. Samples collected using a drill rig or probing equipment may include steel split-barrel samplers with stainless-steel, plastic, or teflon liners, steel split-barrel samplers without liners, or Shelby tubes (Shelby tubes will only be used to collect samples to be analyzed or tested for physical parameters). If stainless-steel liners are used, all samples (except for VOA) will be homogenized in the field.

Each soil sampling team will have at least two members. One person will collect the sample as the other documents information in the field logbook regarding adherence to sampling procedures, difficulties encountered, and other pertinent information.

4.1 Designating Soil Collection Locations

Soil boring, surface soil sample collection locations, and test trenches will be designated in compliance with the sample identification system outlined in Section 11.4 of this CSAP to facilitate sample data management. Soil borings, surface soil sample collection locations, and test trenches will be labeled by site (first three digits), media sampled (one matrix digit), and unique number (four digits). For example, if soil boring 28 was advanced at SWMU #36, the boring designation would be "036S0028." Another example: if a surface soil sample was collected at location 12 at SWMU 30, the designation should be "030S0012." Different identification numbers must be designated for surface soil collection locations and soil borings. For example, if a surface soil sample is to be collected at location 01 at SWMU 33 and a soil

boring designated "01" also was advanced at SWMU 33, the identification numbers would be the same (033S0001). These errors are easily avoided with careful planning. Previously existing borings, surface sampling locations, and trench identifications will be modified to correlate with this labeling system. For example, the soil boring at location 04 of SWMU 9, currently labeled "S09-B04" would become "009S0004."

4.2 Soil Description

Samples will be described by a qualified geologist using the USCS on a soil boring log. A USCS summary and sample boring log are included as Figures 4-1 and 4-2, respectively. If trenching is used to uncover subsurface soil, soil characteristics should be described in the field logbook. Descriptions will include color, texture, grain size, staining, and odor. In accordance with the American Society for Testing and Materials (ASTM) standards for Description and Identification of Soils using the USCS (Visual-Manual Procedure) (ASTM D2488-90).

4.3 Soil Screening Techniques

4.3.1 Dexsil™ Cl⁻ Screening

Dexsil™ Cl⁻ screening is an effective tool for pesticide/PCB screening and is useful for establishing soil sampling locations. This survey requires establishing a grid system across the site. This may be done using the grid establishment procedures provided in Section 3.2. Soil samples may be collected from the designated intervals using any of the procedures provided in this section. Procedures for using the Dexsil™ equipment are provided below.

Before Sampling

1. Attach power supply.
2. Fill the electrode with filling solution provided by the manufacturer.
3. Empty the electrode by pressing down on the white cap.
4. Refill the electrode with the filling solution to the hole.
5. Fill one 40-ml VOA vial with rinse solution provided by the manufacturer.
6. Place the electrode in the rinse solution.

Unified Soil Classification System

Compiled by B. W. Pipkin, University of Southern California

MAJOR DIVISIONS		GROUP SYMBOLS	TYPICAL NAMES
COARSE-GRAINED SOILS More than half of material is larger than no. 200 sieve size.	GRAVELS More than half of coarse fraction is larger than no. 4 sieve size.	Clean gravels	GW Well-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GP Poorly graded gravels, gravel-sand mixtures, little or no fines.
			GM Silty gravels, gravel-sand-silt mixtures.
		Clean sands	GC Clayey gravels, gravel-sand-clay mixtures.
			SW Well-graded sands, gravelly sands, little or no fines.
		SANDS More than half of coarse fraction is smaller than no. 4 sieve size.	SP Poorly graded sands, gravelly sands, little or no fines.
	Sands with fines		SM Silty sands, sand-silt mixtures.
			SC Clayey sands, sand-clay mixtures.
	FINE-GRAINED SOILS More than half of material is smaller than no. 200 sieve size.		Low liquid limit
		CL Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	
OL Organic silts and organic silty clays of low plasticity.			
High liquid limit		MH Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	
		CH Inorganic clays of high plasticity, fat clays.	
		OH Organic clays of medium to high plasticity, organic silts.	
		Highly organic soils	PI Peat and other highly organic silts.

NOTES:

1. Boundary Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example, GW-GC, well-graded gravel-sand mixture with clay binder.
2. All sieve sizes on this chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus no. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (next page), and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. For a complete description of the Unified Soil Classification System, see "Technical Memorandum No. 3-357," prepared for Office, Chief of Engineers, by Waterways Experiment Station, Vicksburg, Mississippi, March 1953. (See also Data Sheet 29.)

SOURCE: AGI DATA SHEETS 3rd ed. 1989



FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4-1
UNIFIED SOIL
CLASSIFICATION SYSTEM

DWG DATE: 08/08/94

DWG NAME: BOARD

FIGURE 4-2 BORING LOG

 <p>NAVY CLEAN ENSAFE/ALLEN & HOGHALL (901) 383-9115</p>		JOB NO.	CLIENT		LOCATION																																																																																																																																																																																																																																											
		DRILLING METHOD:				BORING NO.																																																																																																																																																																																																																																										
LOCATION OF BORING		SAMPLING METHOD:				SHEET OF																																																																																																																																																																																																																																										
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Calibration

7. Turn power on.
8. Fill one 40-ml VOA vial with calibration solution.
9. Remove the electrode from the rinse solution and wipe with Kemwipe™.
10. Place electrode in calibration fluid and swirl for a few seconds.
11. Move selector knob to "CAL."
12. Press "Start."
13. When "READ" light comes on, adjust to "50."
14. Remove electrode from calibration solution, wipe with Kemwipe™, and place in rinse solution.

Sample Preparation

15. Tear a white-capped tube removing the cap provided by the manufacturer.
16. Weigh 10 grams of soil in tube.
17. Empty contents of one extract solution into tube.
18. Shake for one minute. Let settle for two minutes.
19. Setup drying tube/syringe apparatus. Place apparatus in black-capped tube.
20. Use polyethylene pipette to remove at least 7 ml of extraction solvent from top of soil. Place solvent in open syringe.
21. Apply pressure to syringe to force the solvent through drying column at a rate of two to three drops per second.
22. Fill black-capped tube to the 5-ml line. Replace black cap tightly.
23. Break the bottom clear ampule. Shake for 10 seconds.
24. Break the top gray ampule. Shake for 10 seconds. Continue to shake intermittently for 60 seconds.
25. Add 5 ml of extract solution (using 5-ml pipette). Shake for 10 seconds. Vent cap (turn 1/2 turn), squeeze tube, and cap tightly. Shake vigorously for 20 seconds.
26. Allow tube to settle upside down for two minutes.

27. Filter bottom phase through polyethylene filter funnel into analytical vial (small white vial). Stop filtering when first drop of yellow liquid hits the filter.
28. Allow extracted fluid to cool for five minutes.

Analysis

29. Remove electrode from rinse solution. Wipe dry with Kemwipe™.
30. Place electrode in extracted solution.
31. Press "start."
32. Read and record results.

After Analysis

33. Place all investigation-derived wastes (IDW) in 55-gallon drums for future disposal by the Navy in accordance with Section 16 of this CSAP.

4.3.2 Immunoassay Screening

Immunoassay screening is effective for petroleum hydrocarbon, polyaromatic hydrocarbons (PAH), pentachlorophenol (PCP), and PCB screening and is useful for establishing soil sampling locations. This survey may require establishing a grid system across the site using the procedures in Section 3.2. Soil samples may be collected from the designated intervals using procedures provided in this section. Procedures for using immunoassay screening equipment varies between manufacturers and are provided in each test kit. Procedures for use will be detailed in the site-specific SAP.

4.3.3 Soil Sample Screening using DPT

DPT consists of vehicle mounted probing equipment which applies both static force and hydraulically powered percussion hammers for probe placement. To obtain a soil sample at a desired depth, a sample collection device is attached to the leading end of the probing rod and driven into the subsurface. The size of the sample collection device is dependent upon the

manufacturer and the volume of sample required. This screening method may be used for sampling where DQO Level II criteria is permitted.

The procedures outlined below are applicable to equipment used by a majority of DPT venders. However, if the DPT sampling approach by the selected vender differs from the outlined procedures, the deviations will be outlined and submitted as an amendment to the zone specific work plan. At a minimum the following procedures will be adhered to.

1. Stake the location(s) to be sampled. A utility contractor will be required to ensure an underground utility is not obstructing the pathway of the probing rod; or to determine the location of the utility (i.e. fuel, sanitary sewer or storm sewer line) to be investigated.
2. Don personal protective clothing and equipment as required by the site-specific CHASP.
3. Position DPT equipment/vehicle at desired probing location.
4. Shift the vehicle transmission to park; shut off ignition; and activate parking brake.
5. If the desired probing location is beneath an asphaltic or concrete surface, the surface pavement will be cored. If the DPT equipment does not contain coring equipment, the core shall be completed prior Step 3. The coring hole shall be of sufficient diameter to allow the probing rod adequate clearance, and sufficient depth to access underlying soil material.
6. Ensure probing equipment and rods are vertically positioned.
7. Drive the closed sample collection device using static force or hydraulically powered percussion hammers to the top of the desired sampling depth. Once at this depth, the sampler is opened, then is advanced the full length of the sampler tube.
8. The sampler assembly is then retracted from the hole, and the liner containing the soil sample is removed.
9. If additional samples are required at the same location but at differing elevations, a clean new liner is inserted and the probe is placed into the same borehole and advanced to the next sampling interval. Repeat Steps 7 and 8 until all required samples are obtained from the borehole.

10. Refer to Section 4.6.1 Step 16 for processing samples collected with or without stainless-steel liners.
11. Label the samples in accordance with Section 11 of this CSAP.
12. Upon completion of the sample recovery, the hole will be grouted from bottom to top.
13. All sampling equipment is decontaminated in accordance with Section 15 of this CSAP before use and between each sample collection point.
14. Complete the field logbook entry and soil boring log for the site.

4.4 Surface Soil Sample Collection

Before Surface Soil Sampling:

1. Don personal protective clothing and equipment as required by the site-specific CHASP.
2. Stake the location(s) to be sampled.
3. Clear vegetation and other debris from the surface around the boring location.
4. Place clean plastic sheeting on the surface near the sample collection location to hold decontaminated sampling equipment.
5. Set up a decontamination area for sampling equipment, if required.

During Surface Soil Sampling:

6. Remove surface debris from the sample location.
7. With a stainless-steel device, scrape the sample collection location to obtain a previously unexposed surface.
8. Use a decontaminated stainless-steel or Teflon™-lined sampling device (e.g., spoon, spatula) to collect the volume needed to fill the sample container(s).
9. For Grab samples:
 - Completely fill the sample containers directly from the sampling device, avoiding twigs, large rocks, and grass. Collect the VOA samples first.
 - Be sure to have zero headspace in the VOA sample container.

- Place the remainder of the sample in the mixing bowl and thoroughly homogenize. Place the homogenized mixture into the appropriate sample containers.

For Composite samples:

- Empty contents of the sampling device into a decontaminated stainless-steel or Teflon™-lined bowl. Collect enough to fill all the containers.
- Mix sample in accordance with ESDSOPQAM procedures using a decontaminated stainless-steel or Teflon™-lined spoon or spatula. *Do not mix samples for VOA analysis.*
- Place the homogenized mixture into the appropriate sample containers.

For Toxicity samples:

- Empty contents of sampling device into appropriate sample container.
- Toxicity samples will not be composited.

10. Secure container with Teflon™-lined cap.
11. Label each sample container and preserve to 4°C.

After Surface Soil Sampling:

12. Backfill the borehole with any excess soil.
13. Record pertinent information in the field logbook.
14. Clean site. Place contaminated disposable materials in the designated drum for disposal by the Navy.

4.5 Hand-Augering Sample Collection

Before Augering:

1. Don personal protective clothing and equipment as required by the site-specific CHASP.
2. Stake the location(s) to be sampled. The survey will include horizontal location and elevation relative to msl or other specified reference data. Horizontal and vertical surveying may occur before or after the sampling event, as applicable.

3. Clear vegetation and other debris from the surface around the boring location.
4. Place clean plastic sheeting on the surface near the sample collection location to hold decontaminated sampling equipment.
5. Set up a decontamination area for sampling equipment, if required.

During Augering:

6. Begin augering to the depth required for sampling.
7. Make detailed notes about geologic features of the soil or sediments on a field boring log.
8. Stop drilling at the top of the specified or selected sampling depth. Remove the contaminated auger bucket and replace with a decontaminated bucket.
9. Collect sample.
 - Without homogenizing, collect VOA samples from auger bucket and immediately place into the appropriate container. Fill the container so there is zero headspace.
 - Place the remaining sample volume into a stainless-steel bowl. Mix the sample in accordance with ESDSOPQAM procedures until thoroughly homogenized and place into the appropriate containers. Label the samples and preserve to 4° C.
 - Record the sample identification number, sample collection depth, and analyses required in the field logbook and/or on the appropriate field forms.
10. Proceed with additional sampling, as the site-specific work plan requires.

After Augering:

11. Backfill the borehole with excess cuttings, neat cement grout, or hole plug as the site-specific work plan stipulates.
12. Decontaminate all equipment in accordance with Section 15 of this CSAP.
13. Place used plastic sheeting and other disposable sampling equipment in the designated drum for disposal by the Navy.
14. Complete the field logbook entry and soil boring log for the site.

4.6 Sample Collection by Drill Rig/Backhoe

Soil borings advanced by a drill rig will use hollow-stem augers as outlined in Appendix E.2.1 of the ESDSOPQAM. During borehole advancement, a PID or FID will be used to monitor the breathing zone for volatile organic vapors. The augers will be advanced without a center plug to facilitate split-barrel or Shelby tube sample collection. To improve recovery in sandy soil, continuous split-spoon sampling may be completed using a Central Mine Equipment continuous coring system in some areas. Soil boring locations will be determined based on the site-specific SAP. After soil samples are obtained to the proper depth, the borings will be abandoned with neat cement grout or completed with monitoring wells. Soil samples also may be collected from test trenches. Specific sampling procedures are provided below.

4.6.1 Split-Barrel

Before Split-Barrel Sampling:

1. Don personal protective clothing and equipment as required by the site-specific CHASP.
2. Stake the location(s) to be sampled.
3. Clear vegetation and debris from the surface.
4. Prepare the site by placing plastic sheeting around the borehole and over the sampling table.
5. Align the derrick of the drill rig at the sampling location.
6. Set up a decontamination area for sampling equipment, if required.
7. Install four decontaminated, 6-inch, stainless-steel liners in the steel split-barrel sampler, if required.

During Sampling:

8. Install a decontaminated steel split-barrel sampler on the center rod(s) and insert into the hollow-stem auger. Connect the hammer assembly and lightly tap the rods to seat the drive shoe at the ground surface.
9. If blow counts are needed, mark the center rods in 6-inch increments from the top of the auger flight(s).

10. Drive the sampler using the hammer. Use a full 30-inch drop as specified by ASTM Method D-1586. Record the number of blows required to drive the sampler through each 6-inch increment.
11. If blow counts are not needed, push the sampler using the drill rig's hydraulics.
12. Cease driving or pushing when the full length of the sampler has been driven or upon sampler refusal. Refusal occurs when little (<1 inch) or no progress is made after 50 blows of the hammer.
13. Pull the sampler free by using upswings of the hammer to loosen it, or using the drill rig's winch. Pull out the center rod and sampler.
14. Unscrew the split-barrel assembly from the center rod and place it on the sampling table.
15. Remove the drive shoe and head assembly. If necessary, tap the split-barrel sampler assembly with a decontaminated hammer to loosen threaded couplings.
16. Processing for samples collected *with stainless-steel liners*:
 - a. With the drive-shoe and head-assembly off, split the sampler and remove the liners without disturbing the contents.
 - b. Screen sample with PID or FID, and select two samples with highest readings for laboratory analysis. If there are no headspace readings, submit the two bottom liners for laboratory analysis.
 - c. Immediately install a Teflon™ septa over the ends of the selected liners and cap and seal the VOA samples with PVC caps. The remainder of the sample material will be placed in a stainless steel mixing bowl and thoroughly homogenized prior to containerization.
 - d. If additional samples are needed for quality control (e.g., duplicates, matrix spike (MS) samples, matrix spike duplicate (MSD) samples) the other two liners will be covered and capped.

NOTE: *If the recovery is not complete (< 2 feet), submit the two sleeves with the most complete recovery.*

Processing for samples collected *without stainless-steel liners*:

- a. With the drive shoe and head assembly off, split the sampler and expose the contents.
 - b. Screen sample with PID or FID.
 - c. Immediately containerize samples for VOA analysis with zero headspace. Place the remaining sample into a stainless-steel bowl for mixing. After homogenizing in accordance with ESDSOPQAM procedures, containerize the sample.
17. Label the samples in accordance with Section 11 of this CSAP.
 18. Preserve the samples at 4°C.
 19. Decontaminate sampling equipment as needed in accordance with Section 15 of this CSAP.
 20. Attach the hollow-stem auger with the cutting head and center rod(s).
 21. Proceed to the next sampling depth.
 22. Slightly raise the auger flight(s) to disengage the cutting head and rotate without advancement to clean cuttings from the bottom of the hole.
 23. Collect samples as outlined above by inserting the steel split-barrel sampler into the hollow-stem auger.
 24. Describe sample lithology on soil boring logs based on observations of the auger cuttings, the bottom end of the sample in the liner, or the sample inside the split-barrel sampler (when liners are not used).

After Split-Barrel Sampling:

25. Backfill the borehole with neat cement grout or hole plug as stipulated by the site-specific work plan stipulates.
26. Remove the drill rig to the heavy-equipment decontamination area.
27. Place used plastic sheeting and other disposable sampling equipment in the designated drum for disposal by the Navy in accordance with Section 16 of this CSAP.
28. Record all relevant information in the field logbook before leaving the site.

4.6.2 Shelby Tube

Before Shelby Tube Sampling:

1. Don personal protective clothing and equipment as required by the site-specific CHASP.
2. Stake the location(s) to be sampled.
3. Clear vegetation and debris from the ground surface.
4. Prepare the site by placing plastic around the borehole and over the sampling table.
5. Align the decontaminated drill rig to the sampling location.
6. Set up a decontamination area for sampling equipment if required.

During Sampling:

7. Advance augers to the desired sample depth.
8. Attach a head-assembly to a decontaminated Shelby tube. Attach the Shelby tube to the center rods.
9. Lower the Shelby tube and center rods into the hollow-stem augers until seated at the bottom.
10. Use the rig's hydraulics to push the Shelby tube to its full length or until refusal. Attach a hoisting plug to the upper end of the center rod, twist to break off the sample, and pull it out of the borehole with the rig winch.
11. Retrieve the Shelby tube to the surface, detach it from the center rod, and remove the head assembly.
NOTE: Shelby tubes may not retain loose, sandy soil.
12. If the Shelby tube does not have a full recovery, pack the remaining space with paraffin to prevent soil movement within the tube.
13. Seal the ends of the Shelby tube immediately. Mark the top end of the tube for transport to the laboratory.

After Shelby Tube Sampling:

14. If drilling is complete, abandon the borehole with neat cement grout or hole plug as site-specific work plan stipulates.
15. Remove the drill rig for decontamination.
16. Place used plastic sheeting and any other disposable equipment in the appropriate drum for disposal by the Navy.
17. Record relevant information in the field logbook before leaving the site.

4.6.3 Test Trenching

Test pits and trenches are open excavations used to determine the shallow subsurface conditions at the site. Test pits and trenches can be excavated manually or mechanically with a backhoe or bulldozer.

Before Trenching:

1. Don personal protective equipment as the site-specific CHASP requires.
2. Collect surface soil samples if the site-specific work plan requires.

During Trenching:

3. Carefully excavate soil in 1-foot increments and stockpile in a designated area on plastic sheeting.
4. Collect subsurface soil samples as required in the site-specific work plan. Avoid entering the test trenches. Use sampling devices, such as a hand auger with extension handles/rods, to collect samples after removing smeared materials with a decontaminated spoon or other scraping device. If necessary, collect samples from the center of the decontaminated backhoe bucket from a previously unexposed surface. Conduct sampling in accordance with Sections 4.4 or 4.5 of this CSAP.

5. If the test trench is deeper than 3 feet and personnel entry is required, walls must be stabilized according to Occupational Safety and Health Administration (OSHA) requirements.
6. Water or other liquids removed from the excavation must be considered contaminated. Contain the liquid until it can be returned to the excavation properly disposed of by the Navy in accordance with Section 16 of this CSAP.
7. Sample liquids in a test trench according to surface water sampling procedures presented in Section 7 of this CSAP or sample using a decontaminated stainless-steel well screen and decontaminated bailer.
8. Photograph all significant features in the test trench. Record all pertinent information in the field logbook as listed in Section 4.2.

After Trenching:

9. As required, collect samples of the stockpiled soil for Toxicity Characteristic Leaching Procedure (TCLP) analyses.
10. Backfill the trench with clean material or stockpiled soil to the surface after all samples have been collected in accordance with the site-specific work plan.
11. Place all used plastic sheeting and other disposable equipment in the designated drum for disposal by the Navy in accordance with Section 16 of this CSAP.
12. If stockpiled soil is contaminated, dispose of it in accordance with applicable state and federal regulations.

4.6.4 Continuous Core Sampling Using Rotasonic Drilling Methods

Boreholes drilled to depths greater than 20 feet BGS may be installed using a rotasonic drilling technique that will allow a continuous soil core sample to be collected. This method employs the use of high frequency vibration and rotation to rapidly advance drill casings. Section 5.5 gives a detailed description of the rotasonic drilling and sampling method.

5.0 INSTALLING AND DEVELOPING MONITORING WELLS

The following section provides procedures for installing temporary monitoring wells, installing permanent monitoring wells in unconfined and confined aquifers, and developing those wells. The installation of temporary wells (i.e., a well installed for a one-time sampling event) is not anticipated; however, the method is presented as a viable alternative to Hydropunch sampling for collecting screening level data for sample analyses that require greater than 500 ml of sample volume should it become necessary.

5.1 Monitoring Well Permitting

Before beginning drilling activities, a well permit must be obtained from SCDHEC for all monitoring well installations in accordance with the *South Carolina Well Standards and Regulations (R.61-71)*. Approval for the installation of all monitoring wells, including permanent, temporary and/or non-standard wells (Hydrocone™, Hydropunch™, etc.) will be obtained from the SCDHEC prior to installation. Specific items to be included in the request are listed below.

- Proposed monitoring well designation number.
- Site map showing proposed locations of the monitoring wells.
- Proposed monitoring well construction details including materials of construction, depth of monitoring well, and depth of screened interval.
- Proposed monitoring well construction procedures including hydration time for bentonite pellets and cure time for bentonite grout.
- Justification for installing flush-mount monitoring wells, as necessary, and a list of monitoring wells to be flush-mounted.

The request for monitoring well installation approval should be submitted at least three weeks before beginning drilling activities.

5.2 Monitoring Well Designations

Monitoring wells will be designated as part of the sample identification system to facilitate sample data management. Shallow monitoring wells will be designated according to the Naval facility name (first three digits), investigative zone (one digit), the SWMU/AOC number (three digits), and the unique well number (three digits). For example, if monitoring well 23 is installed at SWMU 9 in Zone H at Naval Base Charleston, the groundwater monitoring well designation would be "NBCH009023". Supplemental grid based monitoring wells will require a slight variation to the identification system. The first two digits of the SWMU/AOC field described above will be replaced with the characters "GD" to indicate the well is grid based. The third digit will be replaced with the corresponding investigative zone. An example would be grid based well 1 installed in Zone H at Naval Base Charleston. The designation would be "NBCHGDH001". The identification of deep monitoring wells will adhere to the same system with the addition of the letter "D" (to indicate deep) being added to the end of the character string. Pre-existing wells will be designated by modifying the well name to correlate with this monitoring well designation system. A unique number must be assigned to all wells. The well inventory will be consulted before assigning a number to a new or existing monitoring well to prevent duplication.

5.3 Drilling Methods

For a *permanent* monitoring well, boreholes will generally be advanced using hollow-stem augers with PVC plugs, as outlined in Appendix E.2.1 of the ESDSOPQAM (included as Volume V of the RFI Work Plan), if no soil is to be sampled. The PVC plug may be needed to keep the augers clear while drilling in saturated media. If soil must be sampled, the borehole will be advanced and sampled in accordance with Section 4 of this CSAP using hollow stem augers. If hollow stem augers are used in flowing sand conditions, water may be added to the augers to keep them clear of sand. Rotasonic will be the preferred method for drilling in saturated media to depths greater than 20 feet. The rotasonic method can maintain a head of water that can be pressurized to push back flowing sand as the sample tube is extracted.

Section 5.5 gives a detailed description of the rotasonic drilling and sampling method. In the unlikely event both of these methods fail, water rotary methods will be attempted. Mud rotary drilling techniques will be attempted only as a last resort. Pure bentonite drilling mud will be used in these instances.

For a *temporary* monitoring well, soil borings will be advanced using manual (hand) auger drilling methods or hollow-stem auger.

5.4 Monitoring Well Construction

All monitoring wells will be constructed in accordance with the SCDHEC regulations and as outlined in Appendix E.4.1 and E.4.2 of the ESDSOPQAM with the following modifications.

- A tremie pipe will be used to place well construction materials if the total depth of the borehole is 20 feet or greater.
- The PVC well construction materials will meet National Sanitation Foundation (NSF) Standard 14wc, in addition to ASTM Schedule 40. Refer to Figures 5-1 and 5-2, respectively, for typical monitoring well construction diagrams in unconfined and confined aquifers. Detailed monitoring well construction procedures are outlined below.
- If hollow-stem auger drilling methods are used, the auger will act as a tremie pipe during well installation at depths of 20 feet or less.
- The grain size of the sand pack and monitoring well screen slot size will be determined by the results of one or more (more will be necessary when distinct changes in lithology are observed) grain size analyses conducted for each SWMU or zone. The procedure for determining the appropriate filter pack size is presented in Section 5.4.1 below.
- If the well casing arrives onsite with printing and/or writing on it, remove the printing with Emery cloth or sand paper before being cleaned. *No* solvents or hot water may be used to clean the PVC materials.
- After installing the monitoring well, notch the top of the inner casing. This point will be the reference mark for elevation measurement.

- All monitoring wells will be labeled with an identification plate constructed of a durable material affixed to the casing or the surface pad where it is readily visible. The plate shall provide monitoring well identification number, date of construction, static water level, and driller name and state certification number.
- To reduce the cross-contamination risk, the outer protective casings of the monitoring wells will not be painted onsite. Monitoring well construction in an unconfined aquifer and a confined aquifer will be documented in the field logbook or on monitoring well construction logs provided in Figures 5-3 and 5-4, respectively. Detailed monitoring well construction procedures are provided below.

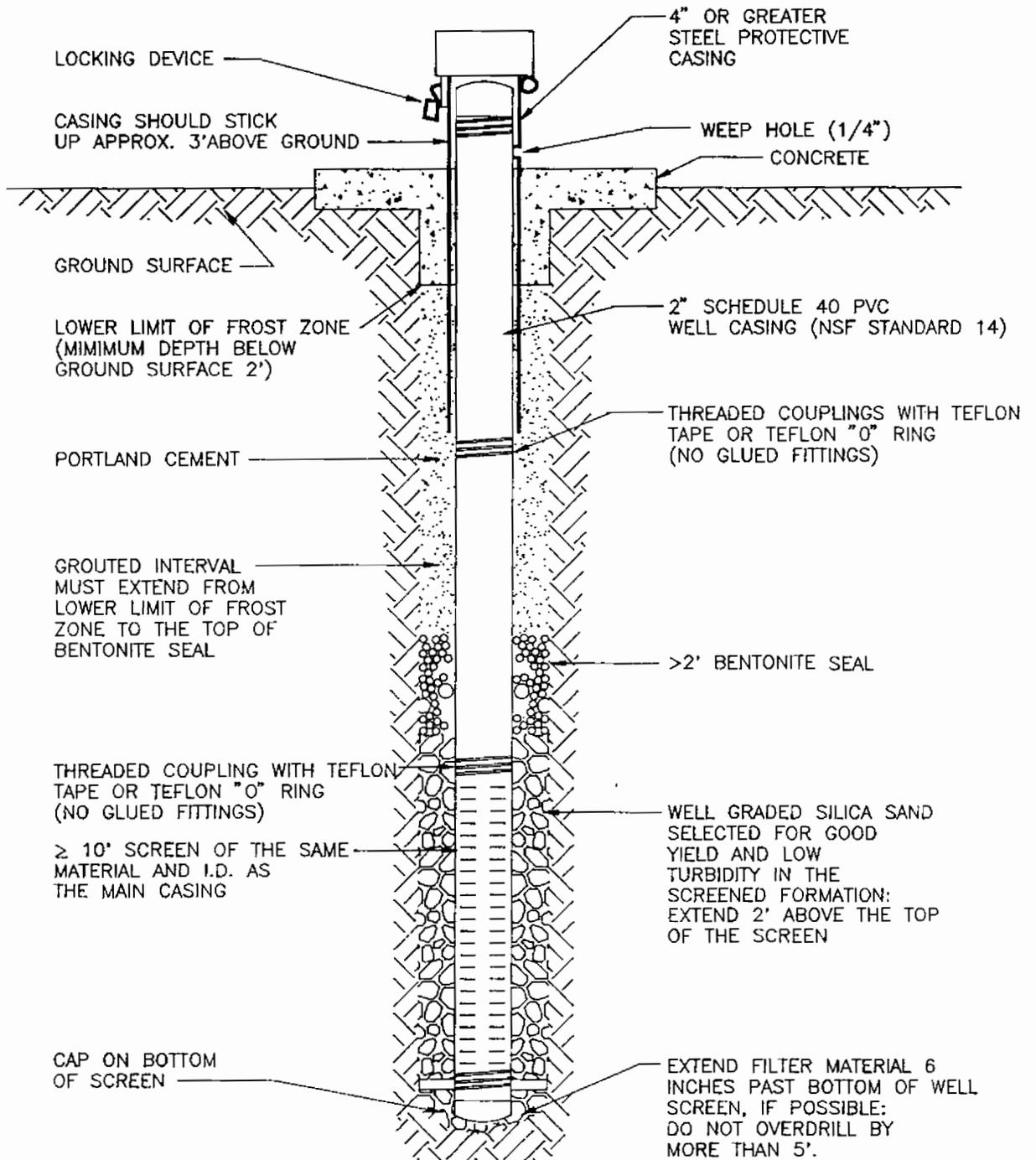
5.4.1 Filter Pack Material and Screen Slot Size Design

The filter pack materials shall consist of well-rounded to rounded, clean, silica sand. Filter pack material of varying grain sizes will not be used. As a general rule, the material must have a uniformity coefficient of 2.5 or less.

When installing the first well in a given zone, a representative sample of the aquifer matrix from within the screened interval (both shallow and deep wells) will be collected for grain size analysis using ASTM D-2434 or similar method. Grain size will continue to be analyzed at each well location within a given zone where the screened interval is within a previously uncharacterized lithology. To determine an appropriate filter pack size to limit the entrance of formation materials into the well and minimize head loss, the following procedures will be followed.

- A grain size distribution curve will be constructed on a grain size distribution graph using the results of a sieve analysis performed on the aquifer material;
- Multiply the D50 (50 percent passing) size by a factor of 2;
- Plot this point on the D30 (30 percent passing) abscissa of a grain size distribution graph and draw a smooth curve with uniformity coefficient of approximately 2.5. This represents the grain size distribution of an appropriate filter pack size.

TYPICAL ILLUSTRATION OF MINIMUM SPECIFICATIONS
FOR MONITORING WELL CONSTRUCTION



FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

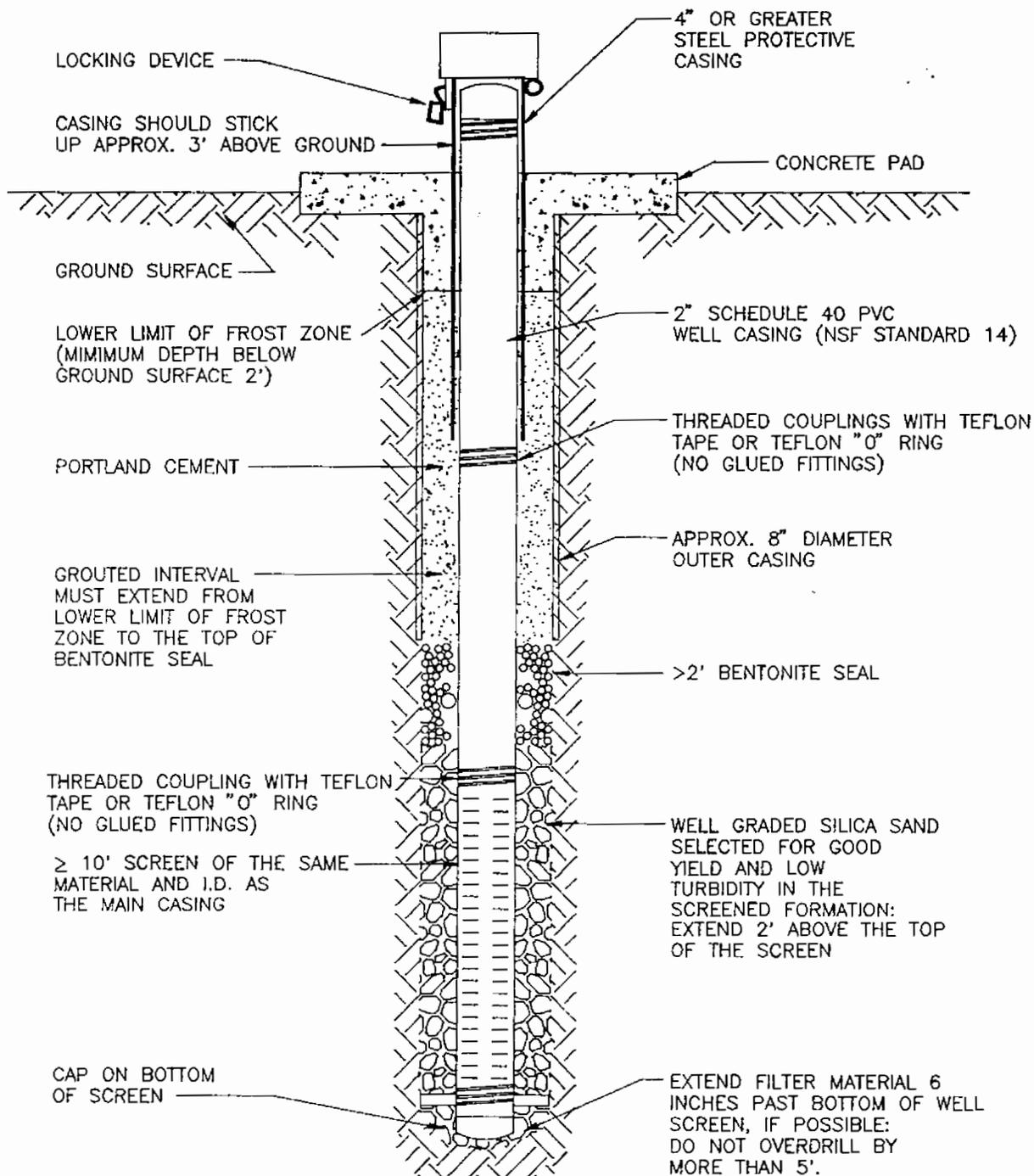
FIGURE 5--1
UNCONFINED AQUIFER
MONITORING WELL DESIGN

DWG DATE: 08/08/94

DWG NAME: 029TYPE2

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TYPICAL ILLUSTRATION OF MINIMUM SPECIFICATIONS
FOR MONITORING WELL CONSTRUCTION



FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 5-2
CONFINED AQUIFER
MONITORING WELL DESIGN

DWG DATE: 08/08/94

DWG NAME: 029MGWEL

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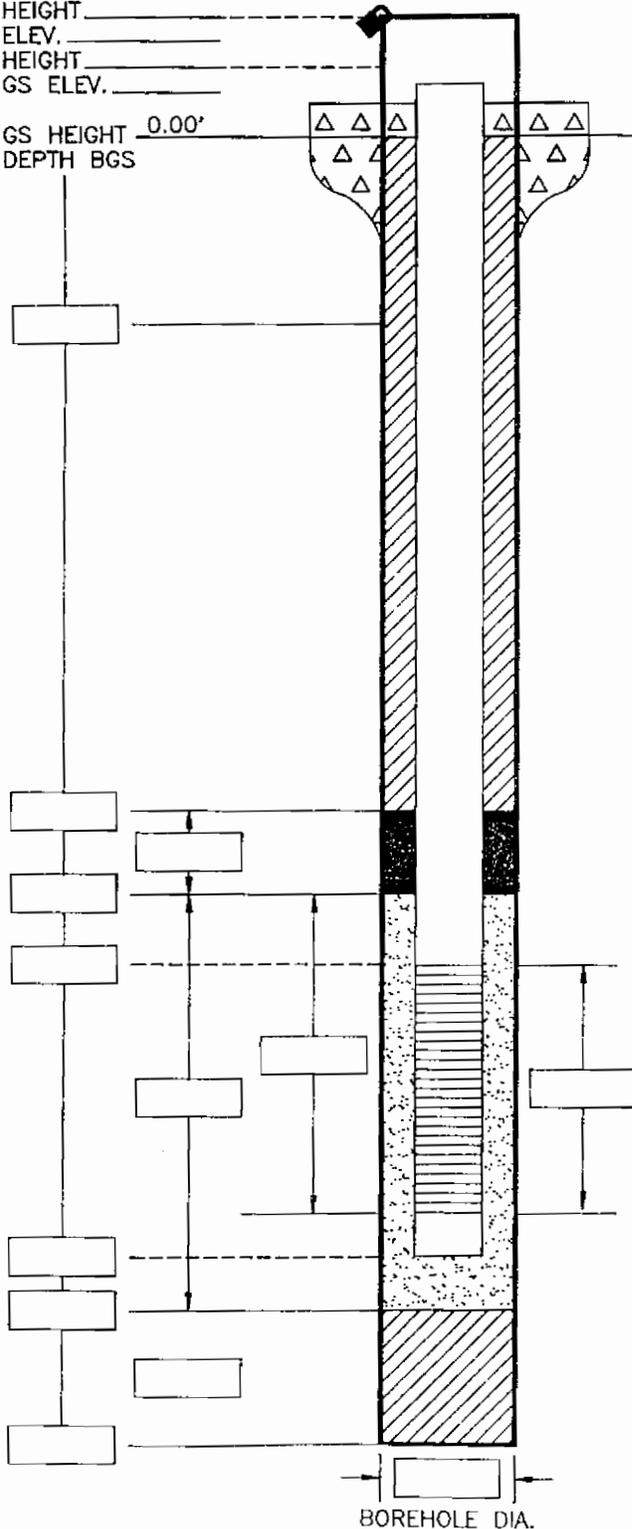
FIGURE 5-3

MONITORING WELL CONSTRUCTION LOG - STANDARD

WELL NO.:	INSTALLATION:	SITE:
PROJECT NO.:	CLIENT/PROJECT:	
CLEAN CONTRACTOR:	DRIG. CONTRACTOR:	
COMP. START: (_____ m)	COMP. END: (_____ m)	
BUILT BY:	WELL COORD.:	

ELEV. _____
 HEIGHT _____
 ELEV. _____
 HEIGHT _____
 GS ELEV. _____

GS HEIGHT 0.00'
 DEPTH BGS _____



PROTECTIVE CASING
 MATERIAL/TYPE _____
 DIAMETER _____
 DEPTH BGS _____ WEEP HOLE(Y/N) _____

GUARD POSTS (Y/N)
 NO. _____ TYPE _____

SURFACE PAD
 COMPOSITION & SIZE _____

RISER PIPE
 TYPE _____
 DIAMETER _____
 TOTAL LENGTH(TOC to TOS) _____
 VENTILATED CAP (Y/N) _____

GROUT
 COMPOSITION & PROPORTIONS _____

TREMIED (Y/N) _____
 INTERVAL BGS _____

CENTRALIZERS (Y/N)
 DEPTH(s) _____

SEAL
 TYPE _____
 SOURCE _____
 SETUP/HYDRATION TIME _____
 VOL. FLUID ADDED _____
 TREMIED (Y/N) _____

FILTER PACK
 TYPE _____
 AMT. USED _____
 TREMIED (Y/N) _____
 SOURCE _____
 GR. SIZE DIST. _____

SCREEN
 TYPE _____
 DIAMETER _____
 SLOT SIZE & TYPE _____
 INTERVAL BGS _____

SUMP (Y/N)
 INTERVAL BGS _____ LENGTH _____
 BOTTOM CAP (Y/N) _____

BACKFILL PLUG
 MATERIAL _____
 SETUP/HYDRATION TIME _____
 TREMIED (Y/N) _____

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MONITORING WELL CONSTRUCTION LOG — CONFINED AQUIFER		
WELL NO.:	INSTALLATION:	SITE:
PROJECT NO.:	CLIENT/PROJECT:	
DRILLER:		
GEOLOGIST:		

ELEV. _____
HEIGHT _____
ELEV. _____
HEIGHT _____
GS ELEV. _____

GS HEIGHT 0.00'
DEPTH BGS _____

BOREHOLE DIA.

PROTECTIVE CASING
MATERIAL/TYPE _____
DIAMETER _____
DEPTH BGS _____ WEEP HOLE(Y/N) _____

GUARD POSTS (Y/N)
NO. _____ TYPE _____

SURFACE PAD
COMPOSITION & SIZE _____

OUTER CASING
TYPE _____
DIAMETER _____ TOTAL LENGTH _____

RISER PIPE
TYPE _____
DIAMETER _____
TOTAL LENGTH(TOC to TOS) _____
VENTILATED CAP (Y/N) _____

GROUT SETUP/HYDRATION TIME _____
AMOUNT _____

TREMIED (Y/N) _____
INTERVAL BGS _____

CENTRALIZERS (Y/N)
DEPTH(s) _____

SEAL
TYPE _____
MFR. _____
SETUP/HYDRATION TIME _____
VOL FLUID ADDED _____
TREMIED (Y/N) _____

FILTER PACK
TYPE _____
AMT. USED _____
TREMIED (Y/N) _____
MFR. _____
GR. SIZE DIST. _____

SCREEN
TYPE _____
DIAMETER _____
SLOT SIZE & TYPE _____

SUMP (Y/N)
INTERVAL BGS _____ LENGTH _____
BOTTOM CAP (Y/N) _____

BACKFILL PLUG
MATERIAL _____
SETUP/HYDRATION TIME _____
TREMIED (Y/N) _____

48MWCLG1



FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 5-4
MONITORING WELL CONSTRUCTION
LOG — CONFINED AQUIFER

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- Select the slot size openings for a well screen that will retain a minimum of 90 percent of the filter pack material.

5.4.2 Monitoring Well Installation (Unconfined Aquifers)

Before Installation:

1. Make sure area is clear of all underground and overhead utilities using Public Works Department utility maps. Clear vegetation and debris from monitoring well site.
2. Place plastic sheeting on ground near the area to hold decontaminated equipment. Stake the location(s) to be sampled. Make sure area is clear of all underground and overhead utilities using Public Works Department utility maps. Clear vegetation and debris from monitoring well site. The drilling area will then be positively cleared using electro-magnetic techniques. In highly developed areas a 5-foot pilot hole will be advanced manually prior to drilling.

During Installation:

Drill the Hole

3. For boreholes requiring soil sampling to the completion depth:
 - Advance the boring and conduct sampling in accordance with Section 4 of this CSAP until the borehole completion depth is encountered. The borehole should be at least 4 inches larger in diameter than the well casing. Drill the hole slightly deeper — approximately 6 inches more than required for the combined length of casing and screen. Sound the final completion depth with a decontaminated, weighted tape before continuing.

For boreholes not requiring soil sampling to the completion depth:

- Advance the borehole to the required depth using a bit or auger flight with PVC plug. The borehole should be at least 4 inches larger in diameter than the casing. Drill the hole slightly deeper — approximately 6 inches more than required for the combined

length of casing and screen. Sound the final completion depth with a decontaminated, weighted tape before continuing.

4. Condition the borehole by circulating drilling fluids (mud, water, or air), or by rotating augers without advancing them until the hole is cleaned of cuttings. Remove cuttings from the area around the auger.

Prepare the Well Casing

5. Prepare the casing and screen for installation. Decontaminate the casing and screen in accordance with Section 15 of this CSAP. *Do not* clean the PVC casing and screen with hot water or solvent rinse.
6. Withdraw the drill rods and bit **if a conventional water or mud rotary method is used.** Check depth of hole with a weighted surveyor's tape. **If hollow stem augers or rotasonic is used it is not necessary to remove the drill string at this point since the well will be constructed through the center of either the augers or the casing.**
7. Hang the casing string, screen down, over or in the top of the borehole. Lower the casing string down to the bottom of the well.

Set the Well Casing

8. **Prepare the dry sand or sand slurry for the filter pack.**
9. When the casing string is set to the desired depth, hang the centered casing in place. There should be 2 to 3 feet of stickup once the well has been lowered to its final position, unless the wellhead is flush-mounted because of its location.

Install the Filter Pack

10. If the well is greater than 20 feet, install the filter pack through the tremie pipe. Six inches or more of filter pack material must be spotted at the bottom of the hole, under the screen. Withdraw the augers slowly so the filter pack is placed evenly around the

screen without bridging. Conditions permitting, the filter pack will be installed to a depth of approximately 2 feet above the top of the screened interval.

11. Check depth to top of filter pack with a weighted tape.

Install Bentonite Seal

12. If well is deeper than 20 feet, tremie bentonite pellets (not powder) on top of the filter pack. Use pellets if the seal is to be seated below the water table. Granular, flake, or slurried bentonite may be used above the water table. Slowly withdraw the auger as the bentonite is added to ensure even placement of the seal around the annulus. Check the depth with a weighted tape. If possible, there should be at least 2 feet of bentonite above the screen.
13. Hydrate according to manufacturer's specifications or eight hours, whichever is greater.

Grout the Annular Space

14. Mix high solids bentonite and water (approximately 6 gallons to each 94 pound [lb] bag of cement) to make a pumpable slurry.
15. If well is deeper than 20 feet, the grout should be tremied into the annulus using a side discharge tremie pipe. Slowly withdraw the auger as the annulus fills. Grout the well to within 2 to 4 feet of the surface. Note the amount of grout used in the field logbook.
16. After installing grout, dismantle and decontaminate equipment. Allow adequate cure time (~24 hours) for the grout before developing the well.

Construct Wellhead Pad

17. Mix and pour concrete for the wellhead pad. Concrete must extend to the top of the grout. Each well will be surrounded by a 3 feet x 3 feet x 6 inches elevated, outwardly sloping pad. The pad will extend 6 inches below the ground surface. It may be convenient to first fill the annulus to the bottom of the pad form and then set the locking

- well cover or locking protective casing. After the protective casing has been installed, the remaining concrete should be poured into the pad form.
18. Finish the concrete pad so it slopes away from the wellhead in all directions with a minimum thickness of 6 inches. If weather warrants, cover the concrete until cured. Lock the well cover.
 19. If the well design specifies traffic barriers, dig holes and install four steel protective posts (4 inches diameter, 6 feet length, 1/4 inch thickness and concrete filled ASTM A120) in concrete (separate from the concrete pad). Posts and concrete must extend to a depth of 2 feet.

After Installation:

20. Record appropriate construction/completion information in the field logbook and/or on appropriate field log forms.
21. Return to the well site after concrete has cured for at least 24 hours and remove the form. Drill two weep holes on opposite sides of the protective casing, just above the concrete pad.
22. Rivet the well identification plate on the protective casing.
23. Brush paint bumper guard posts with high-visibility yellow epoxy paint (American Association of State Highway and Transportation Officials [AASHTO] M220).

5.4.3 Deep Well Installation Contingency

The "deep" wells being installed during the RFI are generally always paired with a shallow well. The screened interval of the shallow wells is intended to bracket the water table which is approximately five feet below ground surface (bgs) at NAVBASE. The deep wells are installed on top of the Ashley Formation (formerly known as the Cooper Marl) which serves as the lowermost boundary of the surficial aquifer. Generally the top of the Ashley Formation is found between 35 to 60 feet bgs.

In some instances the Ashley Formation has been encountered at depths less than 30 feet bgs surface. If a "deep" were to be installed under these conditions with a 10 foot screened interval it would likely result in the collection of data with limited added value beyond the data obtained from the paired shallow well. To accommodate such situations the following logic will be adhered to by field personnel when making judgement decisions regarding the installation of deep wells.

If, during the drilling of the deep well ...

1. the Ashley Formation is encountered at a depth of ≤ 30 feet bgs and the proposed deep well is paired with a shallow well, the borehole will be abandoned as specified in Section 4.6 and the deep well will not be installed. If sample analysis from the paired shallow well indicate the potential DNAPLs are present, the need for a deeper well will be reevaluated.
2. the Ashley Formation is encountered at depths between 30 and 35 feet bgs the deep well will be installed using a five foot screen.
3. the Ashley Formation is encountered at depths > 35 feet bgs the well will be installed with a 10 foot section of screen in accordance with either Section 5.4.2 or 5.4.4 (whichever is appropriate).

5.4.4 Monitoring Well Installation (Confined Aquifers)

Before Installation:

1. Make sure area is clear of all underground and overhead utilities, and clear vegetation and debris from monitoring well site.
2. Place plastic sheeting on ground near the area to hold decontaminated equipment.

During Surface Casing Installation:

Drill the Hole

3. Using hydraulic rotary or auger techniques, advance an oversized borehole through unconsolidated surface deposits to a depth of 2 to 3 feet into the top of the confining bed. The auger I.D. should be 4 inches larger than the casing's diameter.
4. Condition the borehole by circulating drilling fluid (mud, water, or air) or by rotating augers without drilling until the hole is cleaned of cuttings. While conditioning the borehole, prepare necessary length(s) of surface casing.

Prepare and Set the Surface Casing

(Follow these procedures for each separate aquifer to be cased off.)

5. Pressure grout the bentonite slurry to fill the portion of the borehole in the confining bed.
6. Insert the surface casing into the borehole and push firmly **at least 5 feet** into the confining bed.
7. Mix cement/bentonite grout in accordance with Section E.3.5 of the ESDSOPQAM.
8. Begin pumping grout slowly to ensure even placement without bridging.
9. Allow grout to cure for at least 24 hours before proceeding.

Drilling and Installation of Monitoring Well

10. After the grout has cured, continue drilling with a smaller diameter bit, auger string, **or rotasonic casing**. The borehole must be 4 inches larger than the well casing diameter. Advance borehole to the desired depth. Drill the hole a few feet deeper than necessary to allow for cavings during casing placement. If more than one hydraulic unit will be encountered during drilling, the well must be cased in separate stages to prevent cross-contamination.
11. Condition the borehole by circulating drilling fluid (mud, water, or air) until the hole is cleaned of cuttings. Pull the drill string out of the borehole when no additional cuttings

reach the surface. Check depth of the hole with a weighted decontaminated surveyor's tape.

Prepare and Set the Casing String

12. Prepare the casing string in manageable sections while conditioning the borehole. Decontaminate the casing and screen in accordance with Section 15, but *do not* wash PVC materials with hot water or rinse with solvents. Tighten casing joints.
13. Insert first segment of the casing string and lower to a convenient height for adding the second casing segment.
14. Chock the casing, add the second segment, then release the chock and lower the casing. Repeat this process until the full casing string is hanging in the well.
15. Allow the casing string to hang in the well. Never allow casing strings with Schedule 40 PVC to sit on the bottom because the weight of the casing may significantly reduce the slot size and may cause the screen to collapse.

Install Filter Pack

16. Prepare the dry sand or sand slurry, then proceed from the next step listed below.
17. Tremie the filter material through the augers. Slowly withdraw the augers so the filter pack is placed evenly around the screen without bridging. Six inches or more of filter pack material should be spotted at the bottom of the hole, under the screen. The filter pack will extend to approximately two feet above the top of the screen for any monitoring well installed at NAVBASE, unless a specific variance is requested by NAVBASE and is approved by the USEPA and SCDHEC. The filter pack will not span the confining layer under any circumstances.

Install Bentonite Seal

18. Tremie the bentonite slurry onto the top of the filter pack. Bentonite pellets will be used where the seal is installed below the water table. The bentonite seal must extend 2 feet

into the confining layer, if possible. Slowly withdraw the augers as bentonite is added to ensure even placement around the casing without bridging.

19. If the bentonite seal is installed above the water table, hydrate the bentonite according to the manufacturer's specifications or eight hours, (not necessary if pure bentonite grout is used) whichever is greater.

Grout the Annular Space

20. Mix a high solids bentonite and water to make a pumpable slurry.
21. Pour the grout into the annulus. Slowly withdraw the augers as the annulus fills to ensure even placement. Grout the well to within 2 to 4 feet of the surface.
22. After installing grout, dismantle and decontaminate equipment. Allow adequate cure time (~24 hours) before proceeding with well development.

Construct Wellhead Pad

23. Mix and pour concrete for the wellhead pad. Concrete must extend to the top of the grout. Each well will be surrounded by a 3 feet x 3 feet x 6 inches elevated, outwardly sloping concrete pad. The pad will extend 6 inches below the ground surface. It may be convenient to first fill the annulus to the bottom of the pad form and then set the locking well cover or locking protective casing. After the protective casing has been installed, the remaining concrete should be poured into the pad form.
24. Lock the well cover.
25. Four steel protective posts (4 inches diameter, 6 feet length, 1/4 inch thickness and concrete filled ASTM A120) will be installed surrounding the well. Posts and concrete must extend to a 2-foot depth.

After Installation:

26. Record the appropriate construction/completion information in the field logbook and/or on the appropriate field logbook forms.

27. Return to the well site after the concrete has cured for at least 24 hours and remove the form. Drill two weep holes on opposite sides of the protective casing and just above the concrete pad.
28. Rivet the well identification tag to the protective casing.
29. Paint bumper guard posts with high-visibility yellow epoxy paint (AASHTO M220).

5.5 Rotasonic Drilling Method

Rotasonic drilling has recently emerged as a technology capable of solving the problems encountered when drilling in saturated unconsolidated sediments. Boreholes drilled to depths greater than 20 feet BGS may be installed using the rotasonic technique.

Rotasonic drilling combines rotational and high frequency vibrational forces to advance the drill bit and drill pipe in the borehole. The primary design difference between rotasonic drilling and other types of rotary systems is the incorporation of an oscillator, located in the drill head, that produces vibrational energy. The vibrational frequency generated by the oscillator can be adjusted for different drilling conditions. Rapid drilling rates result from matching the vibrational frequency of the drill pipe with the resonant frequency of each 10-foot core barrel or drill pipe section. The resulting high amplitude waves within the core barrel or drill pipe are transmitted to the drill bit. This vibrational energy, combined with the rotational energy, allows effective operation in both unconsolidated and consolidated material. Rotasonic drilling can be conducted at rates greatly exceeding those of other rotary techniques.

Basic equipment associated with a rotasonic drill rig includes the vibratory/oscillatory top-mounted drill head, mast, elevated drill platform, motor, hydraulic pump and lines, drill center, drill pipe, and core barrels. A support truck for holding drill pipe, core barrels, and other drilling materials is spotted at the rear of the drilling platform. Use of a second vehicle to hold drill pipe allows off-location decontamination of these materials without moving the drill rig itself. The drill rig also has the capability to carry 1000 gallons of potable drilling water.

The rotasonic drill rig can be operated by one driller and a driller's helper. The drill head is lowered down the mast to a working height above the drill platform and is mechanically rotated from a vertical to a horizontal orientation. Hydraulic mechanical vises rapidly connect drill pipe or core barrel sections to the drill head. The drill head is then raised and rotated to a vertical orientation prior to drilling. Incorporation of the rotating drill head, automated vises, and the elevated drill platform results in a safe, clean, efficient drilling process.

The borehole is drilled by advancing two lines of drill pipe. A studded drill bit is attached to the base of the core barrel, which has a 4-inch inner diameter (ID) and a 4.5-inch outer diameter (OD). The core barrel, which is 10 feet in length, is connected to the 4.5-inch drill pipe and is advanced to the desired depth by using high frequency vibration and rotation, forcing an undisturbed, continuous core into the core barrel. When the core barrel reaches the desired depth, a larger outer drill pipe with a 5.875-inch OD is advanced along the outside of the core barrel, to the same depth. The larger drill pipe is left in place to hold open the borehole while the inner drill pipe, core barrel, and sample are retrieved. This assembly is removed from the borehole and rotated to a 45 degree orientation relative to the drill mast. The core sample is extruded sonically into a plastic sleeve, which is placed on a core table for headspace analysis, lithologic description, and possibly retained for chemical analysis. The outer portions of the sample core will be shaved away to ensure that soil that was in contact with the plastic sleeve is not collected for analysis. Equipment rinse blanks must be taken of a small percentage of the plastic sleeves that the samples are extruded into. Refer to Section 13 of this volume for frequency of equipment rinse blanks.

The core barrel is removed, replaced with a decontaminated barrel and returned to the borehole. The process is then repeated, with the core barrel always driven ahead of the outer drill pipe to ensure representative sampling. Successive 4-inch diameter cores are laid end-to-end for lithologic description and sampling. In this manner, a complete lithologic core from ground surface to the desired depth can readily be obtained. This drilling method also offers the

advantages of faster drilling rates, reduced amounts of IDW, and reduced labor costs. Specific drilling and sampling procedures are outlined below.

Before Rotasonic Sampling:

1. Don personal protective clothing and equipment as required by the site-specific HASP.
2. Stake the location(s) to be sampled. Make sure area is clear of all underground and overhead utilities using Public Works Department utility maps. Clear vegetation and debris from monitoring well site.
3. Place plastic sheeting on ground near the area to hold decontaminated equipment. The drilling area will then be positively cleared using electromagnetic techniques. In highly developed areas a 5-foot pilot hole will be advanced manually prior to drilling.
4. Clear vegetation and debris from the ground surface.
5. Prepare the site by placing plastic sheeting over the sampling location and the sampling table.
6. Set up the decontaminated drill rig at the sampling location. Decon will be performed in accordance with Section 15 of the CSAP.
7. Set up a drilling fluid containment system over the borehole location. A water-tight seal between the ground surface and the bottom of the containment tank will be created using a pure bentonite powder.

During Rotasonic Sampling:

8. Advance the inner drill pipe and core barrel to the desired interval. Disconnect the drill head from the inner drill pipe and rotate the drill head to a horizontal orientation. Attach a length of outer drill pipe casing to the drill head and raise the drill head while rotating the drill head back to the vertical orientation.
9. Advance the outer drill pipe casing to the same depth as the inner drill pipe and core barrel.
10. Retrieve the inner drill pipe, core barrel, and sample.

11. Remove the sample core from the inner barrel. The sample is removed from the core barrel sonically and placed directly into a sample sleeve. Lithology can be determined through the plastic sleeve.
12. Collect analytical sample from sample core. Only the interval to be sampled needs to be exposed during this step to minimize personnel exposure.
13. Change out the lead inner core barrel with a decontaminated barrel. Advance the core barrel 10 feet past the outer drill pipe. Disconnect the drill head and rotate the head to a horizontal orientation. Connect another section of outer drill pipe casing. Rotate the drill head back to a vertical orientation and make-up the outer drill pipe casing joint.
14. Disconnect the drill head from the outer drill pipe casing and raise the drill head 1-2 inches for venting.
15. Pump potable water through the drill head to fill the annulus between the inner and outer drill pipe for lubrication. When water shows at the vent space, re-connect the drill head to the outer drill pipe casing and advance the outer drill pipe casing to the elevation of the lead core barrel.
16. Repeat steps 10-15 until the desired depth is reached.

After Rotasonic Sampling:

17. Pump any drilling fluid which has accumulated in the containment system into a clearly marked drum for disposal.
18. Backfill the borehole with neat cement grout, or install a permanent monitoring well according to the methods discussed in Section 5.4. The only exception to monitoring well installation with rotasonic is there is no need for a tremie pipe for wells greater than 20 feet in depth. The monitoring well is completed within the annulus of the outer drill pipe casing. As the outer drill pipe casing is pulled back, the sand pack is sonically vibrated into place against a smooth borehole wall eliminating the threat of bridging. The same holds true for emplacement of the bentonite seal.
19. Remove the drill rig to the heavy-equipment decontamination area.

20. Place used plastic sheeting and other disposable sampling equipment in a clearly marked drum for disposal.
21. Record all relevant information in the field logbook before leaving the site.

5.6 Developing Monitoring Wells

A monitoring well is developed after the bentonite grout in its annular space has cured at least 24 hours. Development restores the normal hydrologic conditions of the geologic formation near the borehole. Monitoring wells can be developed using various techniques such as bailing, surging and bailing, or surging and pumping. Wells with low aquifer recovery will be developed by bailing, or a combination of surging and bailing. Wells with high aquifer recovery will be developed by a combination of surging and pumping. *Before development* and *after development* procedures apply to surging, bailing, and pumping. All monitoring wells must be developed until temperature, specific conductivity and turbidity measurements stabilize and the well produces clear, sediment-free water. A log of these measurements must be maintained during development and submitted with the "as-built" well construction details.

Before Development:

1. Don personal protective clothing and equipment as required in the site-specific CHASP.
2. Cover the surface around the well with clean plastic sheeting to contain any spilled development water.
3. Open the well cover and check the wellhead's condition.
4. Measure the depth to static water level with an electronic water-level indicator.
5. Prepare the necessary equipment for well development in accordance with Appendix E, Section E.8 of the ESDSOPQAM.

During Development:

Wells may be developed by bailing, surging and bailing, or surging and pumping. These techniques are discussed separately but may be used either separately or in combination.

Various pumps that may be used during well development include:

- Brainard Kilman hand pump
- Centrifugal pump
- Peristaltic pump
- Bladder pump
- Grundfos pump

Surging:

1. Attach rope or PVC rod to a surge block.
2. Lower the surge block into the monitoring well with rope or rods.
3. Raise and lower the surge block so groundwater will be surged in and out of the monitoring well screen.
4. Continue for approximately 10 to 15 minutes.
5. Remove the surge block from the well for decontamination.

Bailing:

1. Assemble and lower the decontaminated bailer into the monitoring well and begin bailing.
2. The monitoring well shall be developed until the water column is as free of visible turbidity as possible given the subsurface conditions (between 10 and 30 nephelometric turbidity units [NTU]), and until the pH, temperature, and specific conductivity have stabilized to satisfy the following criteria.

Temperature:	within $\pm 1.0^{\circ}\text{C}$
pH:	within ± 0.5 standard unit
Conductivity:	within ± 10 percent from the duplicate
Turbidity:	relatively stable

Pumping:

1. Prepare the decontaminated pump and tubing, and lower them into the well.
2. Begin pumping the well.
3. If the productivity of the monitoring well is low, it will be alternately pumped then left idle to recover. The onsite geologist will determine when development is complete based on normal development criteria.
4. The monitoring well shall be developed until the water column is as free of visible turbidity as possible given the subsurface conditions (between 10 and 30 NTU), and until the pH, temperature, and specific conductivity have stabilized to satisfy the following criteria.

Temperature:	within $\pm 1.0^{\circ}\text{C}$
pH:	within ± 0.5 standard unit
Conductivity:	within ± 10 percent from the duplicate
Turbidity:	relatively stable

After Development:

1. Groundwater withdrawn from the monitoring wells during development will be placed in 55-gallon drums for disposal by the Navy in accordance with Section 16 of this CSAP.
2. Remove development equipment from the monitoring well and decontaminate (if required) in accordance with Section 15 of this CSAP.
3. Lock the well cover before leaving the site.
4. Record all pertinent information in the field logbook.

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6.0 GROUNDWATER SAMPLING

Groundwater samples will be collected in accordance with Section 4.9 of the ESDSOPQAM, included in Volume V of the RFI Work plan, with the following additions and/or modifications. All purging and sampling of monitoring wells will be conducted by using either a peristaltic, bladder, or Grundfos-type (helical rotor submersible) pump with Teflon™ vacuum container, depending on the depth of the well. All pump tubing will be constructed of a Tygon™- or Teflon™-lined material. If a pump is ineffective or impractical for successful purging and/or sampling, a Teflon™ bailer with a stainless-steel leader will be used. Collecting groundwater level data during sampling is addressed in Section 10.6.

6.1 Groundwater Screening Techniques

6.1.1 Hydropunch

The Hydropunch is a stainless-steel and Teflon™ sampling tool capable of collecting groundwater samples without installing a monitoring well. Because the device is pushed or driven into position, it is most suitable for used in unconsolidated clay, silt, sand, and fine gravel. Only a small amount of water (approximately 40 ml) may be collected with this device at a time, therefore, Hydropunch is best used as a VOA screening tool. Installation and sample collection procedures are provided below.

1. Don protective clothing and equipment as the site-specific CHASP specifies.
2. Prepare the site by covering the surface with plastic sheeting and arranging the required equipment for convenient use.
3. Connect the decontaminated Hydropunch to a small-diameter drive pipe.
4. Drive the closed sampler with a 140-pound hammer or hydraulically push the sampler to the desired sampling depth, which is at least 5 feet below the static water level. Less than 5 feet of penetration will result in slow fill times, inadequate sample volume, or improper check valve function.

5. Open the Hydropunch by pulling up the drive pipe approximately 1.5 feet. Groundwater will then flow freely into the sampler under the aquifer's hydrostatic pressure.
6. When the sample chamber is full, retrieve the Hydropunch. As the tool is retracted, check valves close, trapping the groundwater in the sample chamber.
7. At the surface, transfer the groundwater from the Hydropunch to the appropriate sample container.
8. Place any IDW generated into designated drums for disposal by the Navy in accordance with Section 16 of this CSAP.

6.1.2 Temporary Monitoring Wells

Temporary monitoring wells are useful when a full suite of analyses is required. Except for the lack of grout, temporary monitoring wells are installed following procedures for permanent monitoring wells. Temporary monitoring wells also are developed, purged, and sampled using the same criteria as for permanent monitoring wells. Procedures for temporary monitoring well installation and development are provided in Sections 5.4 and 5.5 of this CSAP. Monitoring well purging and sampling are detailed in Sections 6.2 and 6.3.

6.1.3 Groundwater Sampling Screening Using DPT

To obtain a groundwater sample, the probing rod is driven into the subsurface to the desired depth, then retracted to expose the sampling area. If the water bearing zone does not produce a sample in a timely manner, a temporary monitoring well will be installed in accordance with Section 6.1.2 of this CSAP. This will allow the DPT equipment to proceed to the next sampling location, while continuing to draw the groundwater sample. Once the required volume is recovered, the riser pipe will be removed accordingly. This screening method may be used where DQO Level II criteria is permitted.

A general procedure outlining the DPT method is provided below, however, these procedures may vary between DPT equipment manufacturers. The initial setup of equipment for

groundwater sampling is the same as for soil sampling. Refer to Steps 1 through 6 in Section 4.3.3 of this CSAP for the procedures to setup the DPT equipment.

7. Drive the probing rod using static force or hydraulically powered percussion hammers to the desired sampling depth. It is to be noted that this depth must be a minimum of 3 to 5 feet below the static water level.

For retractable assemblies with expendable drive points -

- When the desired sampling depth is reached, the sampler is pulled up, which disengages the drive point and creates an open borehole from which to sample.
8. Allow groundwater to fill the void area under the aquifer's hydrostatic pressure.
 9. Perform groundwater sampling in accordance with Steps 4 through 15 outlined in Section 6.3 of this CSAP.
 10. Remove probing rod from borehole.
 11. Upon completion of the sample recovery, perform Steps 11 through 14 outlined in Section 4.3.3 of this CSAP.

6.2 Purging Static Water

Field personnel will purge monitoring wells before collecting samples to remove stagnant water from the casing and surrounding borehole space.

General Purging Procedures

- Purge monitoring wells with a decontaminated pump.
- Monitoring wells will be purged of between three and five well casing volumes. In addition turbidity should be 10 NTU or less. Indicator parameters temperature, turbidity, specific conductivity, and pH will be measured in a sample of groundwater prior to purging and following removal of each well casing volume. If these parameters have

stabilized after removal of three well casing volumes, then the well will be sampled. If these parameters have not stabilized after removal of three well casing volumes, purging will continue until a maximum of five well casing volumes have been removed from the well. If the indicator parameters have still not stabilized after removal of five well casing volumes, then sampling will proceed. Contain purge water in a dedicated drum.

- Continue purging until three readings of specific conductance, temperature, and pH stabilize within 10 percent of previous reading.
- Begin sampling when purging is complete. Monitor groundwater turbidity. If high turbidity remains after purging three well volumes, the monitoring well may need to be redeveloped (see Section 5.5).
- Record well purging data in the field logbook and/or on the Groundwater Sampling Form provided in Figure 6-1.
- When purging is complete, allow monitoring wells to recharge before beginning sampling. Wells evacuated while purging will be sampled when sufficient volume has reentered the well. For this project, low recharge monitoring wells are defined as those with recharge rates not allowing sample collection within 12 hours of initial purging. These wells will be documented as *dry*. Specific procedures for monitoring well purging are provided below.

Before Purging:

1. Don personal protective clothing and equipment as the site-specific CHASP specifies.
2. Cover the surface around the well with clean plastic sheeting to contain water spilled during purging or sampling.
3. Check condition of the wellhead, protective casing, and lock.
4. Open the well cover and monitor the breathing zone using a PID and FID to measure ionizable organic vapors. If vapors are detected, an interface probe will be used to determine the thickness of free product if present. If product is present, a one-way check ball valve will be used to sample the layer.

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5. Measure static water level to the nearest 0.01 foot using an electronic water-level indicator. Record the measurement in the field logbook or on the groundwater sampling field form (Figure 6-1).
6. Calculate static volume using the following formula, taken from Section 4.9.7.2 of the ESDSOPQAM.

During Purging:

7. Prepare the decontaminated pump, and lower into the casing.
8. Begin purging the well; purge at least three volumes of water (water column).
9. Withdraw groundwater until temperature, pH, and conductivity have stabilized. A monitoring well is stabilized when three readings each of temperature, pH, and specific conductivity are within ± 10 percent of the previous reading.
10. Purge upgradient and background wells before downgradient wells to reduce the cross-contamination risk.
11. While purging the well, conduct free chlorine and sulfide spot checks on the purge water.

Free Chlorine Spot Check:

- Place drop of purge water on the potassium iodide (KI) test paper.
- If paper turns blue, free chlorine is present. Cyanide samples will require preservation as described in Section 11.2 of this CSAP.

Sulfide Spot Check:

- Place drop of purge water on the lead acetate test paper.
- If paper turns bluish-black, sulfide is present. Cyanide samples will require preservation as described in Section 11.2 of this CSAP.

Static Volume Formula:

$$V = 0.041 d^2h$$

Where:

- V = volume of water in gallons
- d = diameter of well in inches
- h = depth of water in feet (total well depth - static water level)

The static volume may also be calculated using the following formula:

$$V = hr^2(0.163)$$

Where:

- V = volume of water in gallons
- h = depth of water in feet (total well depth - static water level)
- r = radius of well in inches

After Purging:

12. Record data in the field logbook and/or on the Groundwater Sampling Form (Figure 6-1).
13. If well is purged dry, allow it to recharge before sampling. However, every effort should be made to avoid purging the monitoring well dry.
14. Document the wells as *dry* if it does not recharge within 12 hours of initial purging.
15. All IDW produced while purging will be drummed for disposal by the Navy in accordance with Section 16 of this CSAP.

6.3 Groundwater Sampling

Groundwater samples will be collected in accordance with the procedures in Section 4.9 of the ESDSOPQAM manual with modifications outlined below. Monitoring wells will be sampled with either a decontaminated pump or Teflon™ bailer. The type of pump used during sampling of monitoring wells must be a peristaltic pump, or another similar type of pump which will not chemically or physically alter groundwater samples.

- Newly installed wells will be allowed to recover for a period of two weeks before sampling.

- Peristaltic pumps will be used instead of bailers for purging and sampling when turbidity is greater than 10 NTU.
- Collect samples using a decontaminated pump with a Teflon™ vacuum container so that groundwater does not touch the pump. If a pump is ineffective or incapable of successfully sampling the monitoring well, a Teflon™ bailer may be used. When collecting VOA samples using a peristaltic pump, fill the tubing with sample then disconnect the tubing and cap. Withdraw the tubing from the well and uncap the tubing allowing the water to flow into the sample vial.
- Measure temperature, pH, and specific conductance for each sample collected and record in the field logbook or on the groundwater sampling form (Figure 6-1).
- Chemically preserve samples as specified in Section 11. After chemical preservation and labeling, chill the samples to 4°C.
- Record weather at the time of sample collection in the field logbook. Refer to specific procedures for groundwater sample collection provided below.

Before Groundwater Sampling:

1. Don protective clothing and equipment as site-specific CHASP specifies.
2. Prepare the site by covering the surface around the wellhead with plastic sheeting and arrange the required equipment for convenient use. If onsite decontamination is required, arrange the necessary supplies nearby in a separate location away from the wellhead.
3. Purge the well according to the procedures in Section 6.2 of this plan. If bailing, allow the water level to recover enough to completely submerge the bailer without touching the well bottom.
4. If bailing, securely attach the bailer to decontaminated Teflon™-coated stainless-steel leader. Then, securely attach the leader to the line. The end of the line also should be secured so the bailer is not lost down the well.
5. Arrange the sample containers in the order of sample collection. Groundwater samples will be collected in the following order (presented by Fred Sloan: volatile organic

analysis, dissolved gases and total organic carbon, semi-volatile organic analysis, metals and cyanide, major water quality cations and anions, and radionuclides.

During Groundwater Sampling:

6. Slowly lower the pump hose or bailer into the water to prevent aeration, particularly when VOA and SVOA samples are being collected.
7. Start pump or retrieve full bailer to the surface. If bailing, do not allow the line to touch the ground.
8. Unless the same pump or bailer is used for both purging and sampling, allow initial water from pump to discharge into drum or, if using a bailer, use the first bailer of water to rinse out the bailer; discard the water.
9. If using a bailer, repeat Steps 7 and 8.
10. When collecting VOA samples from pump discharge, decrease flow rate. If using bailer, either fill the VOA vials from the top of the bailer or attach VOA bottle filler to the bailer's base. For VOA samples, the sample bottles should be tilted when filling to prevent aeration. Check the filled vial for bubbles, making sure it has zero headspace.
11. Perform sample filtration with a 0.45-micron filter as soon as possible after sample retrieval, if required for the cyanide samples based on the sulfide spot check. Samples collected for total metals analysis will not be filtered.
12. If using a bailer and, after collecting VOA and SVOA samples, the remaining water is insufficient to completely fill another container, discard it. Lower the bailer again to collect more water for additional sample volume.
13. Fill the remaining sample containers to capacity. Add preservative (if needed), cap, seal, and properly label all containers. Place the filled containers in the cooler(s) immediately and preserve to 4°C.
14. If the free chlorine or sulfide spot checks are positive, preserve the cyanide samples in accordance with Section 11.2 of this CSAP.

After Groundwater Sampling:

15. Record sample identifications, types and amounts collected, as well as the time and date of collection in the field logbook and/or on the groundwater sampling form. Prepare chain-of-custody and analytical request documents as required in Section 11.6 of this plan.
16. Decontaminate sampling equipment if it is not dedicated to the monitoring well.
17. Clean up the area and place disposable materials (plastic sheeting, gloves, rope) in the designated drum for disposal by the Navy in accordance with Section 16 of this CSAP.
18. Close and lock the well cover.

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7.0 SEDIMENT/SURFACE WATER SAMPLING PROCEDURES

7.1 Designating Sediment/Surface Water Sample Collection Locations

Sediment and surface water sample collection locations will be designated to comply with the sample identification system presented in Section 11.4 of this CSAP to facilitate sample data management. Sediment and surface water collection locations will be designated according to SWMU (first three digits), media to be sampled (one matrix digit), and the unique well number (four digits). For example, if a sediment sample were collected from sampling location 16 at SWMU 21, the collection location identifier would be "021M0016." Another example: If both a sediment and a surface water sample were collected at location 12, SWMU 2, the locations would be identified by "002M0012" and "002W0012," respectively. Proper attention must be given to ensure unique numbers are assigned to all sampling locations.

7.2 Sediment Sampling

Procedures for sediment sampling will adhere to the guidance presented in Section 4.8 of the ESDSOPQAM (included in Volume V of the RFI Work Plan), which lists several acceptable sampling techniques (dredging, scooping, coring) for collecting sediment samples from surface water bodies and dry land areas, depending upon sampling objectives. Sediment samples generally will be collected to a maximum depth of 6 inches. Several general precautions must be followed to provide a representative sediment sample and to minimize disturbance regardless of sampling technique.

General Sediment Sampling Precautions:

- Avoid sediment plumes and density currents.
- If sediment and surface water samples are to be collected at the same location, collect the surface water first.
- Sediment sampling locations may be reached by wading or by boat, depending upon water depth and the substrate's nature. If wading to the sample location, approach from downstream to minimize disturbance.

Specific procedures for sediment sampling by dredging, coring, and scooping are discussed below. Any variations from the procedures will be discussed in the site-specific SAP.

7.2.1 Dredge Samples

A Ponar grab sampler will be used to collect underwater dredge samples. The Ponar sampler is a steel, clam-shell type scoop activated by a cantilevered system. Procedures for operating the Ponar grab sampler are provided below.

Before Dredge Sampling:

1. Don personal protective clothing and equipment as the site-specific CHASP specifies.
2. Lock open the jaws of the decontaminated sampler.

During Dredge Sampling:

3. Lower the sampler into the sediment.
4. Release tension on the rope and close sampler jaws.
5. Retrieve the sampler and open the jaws to collect the sediment sample.
6. To collect the VOA sample, either push a stainless-steel sleeve into the dredge sampler and cap, or release the sediment sample into a stainless-steel bowl and immediately collect the VOA samples. Fill the sample containers to capacity to achieve zero headspace.
7. Repeat the sample collection process (Steps 3 to 5) until enough volume has been collected to make the necessary composite samples. Homogenize the material in the stainless-steel bowl in accordance with ESDSOPQAM procedures and place in appropriate sample containers, using stainless-steel implements.
8. Describe lithology of sample collected and sample collection depth in the field logbook.

After Dredge Sampling:

9. Upon completion of sampling, decontaminate all equipment in accordance with Section 15 of this CSAP.

7.2.2 Core Samples

Coring is a useful sampling technique because it preserves any sequential layering of the sample and provides a historical profile. In addition, coring minimizes sediment disturbance caused by shock waves and, if used in conjunction with insertable sleeves, it minimizes the cross-contamination risk. Core samples will be collected in areas where samples must be collected at depths greater than 6 inches.

Coring Equipment: A Wildco-type or modified stainless-steel split-barrel push tube sampler with a 2-inch-diameter, 2-foot-long sample barrel will be used. These devices will be used with or without insertable 12-inch or 6-inch Teflon™ or stainless-steel sleeves. If sleeves are used to collect analytical samples, a second core will be collected at the location *without* sleeves for lithology description. Extension rods will be used offshore to collect samples in water deeper than wading depth. Procedures for collecting samples with the coring devices follow.

Before Core Sampling:

1. Locate the sample collection location on the site map and reference it appropriately in the field logbook.
2. Don personal protective clothing and equipment as the site-specific CHASP requires.
3. Place a decontaminated stainless-steel sampling sleeve inside the decontaminated sampler.

During Core Sampling:

Note: Except for VOA samples, all samples collected in sleeves will be composited and homogenized before laboratory analysis.

4. Drive the full length of sampler into the substrate.
5. Carefully remove the sampler from the substrate.

Samples collected with stainless-steel sleeves:

6. Remove sleeves from the sampler, minimizing disturbance.
7. Immediately install Teflon™ septa over the liner ends and seal with PVC caps.
8. These cores will be submitted to the laboratory for analysis in accordance with the site-specific SAP.

Samples collected without stainless-steel sleeves:

9. Extract sediment from the sampler and immediately fill the VOA container. Be sure the sample container has zero headspace.
10. Remove the remaining sample volume and place in a stainless-steel bowl. Homogenize the sample in accordance with ESDSOPQAM procedures with a stainless-steel spoon or spatula.
11. Fill the remaining sample containers.
12. Label the samples and preserve to 4°C. Mark top of the sample on outside of the liner.
13. Repeat above sampling procedures for a second 24-inch core *without* the sleeves. This core will be examined, but not disturbed, in the field by a geologist, who will describe sample lithology using the USCS.

Special Precautions for Deep Underwater Core Sampling:

A boat will be required for sampling sediment in water deeper than wading depth. Extension rods for sampler and/or diver assistance may be required in deep water. Although sampling procedures will be the same as the procedures listed above, special precautions must be taken:

- Cap top of the sampler while it is in the substrate to prevent suction during extraction from extruding the sample through bottom of the sampler.

- When the sampler is free from the substrate, cap bottom end before removing from the water.
- In deeper water, have a diver cap the sampler and assist in sampling.

After Core Sampling:

14. Decontaminate sampling equipment in accordance with Section 15 of this CSAP.
15. Record all pertinent information in the field logbook before leaving the site.
16. Place contaminated disposable materials in a designated drum for disposal by the Navy.

7.2.3 Scoop Samples

Samples from sediment buildup in constructed drains, gutters, or other impervious surfaces will be acquired with a stainless-steel spoon and bowl. Procedures for scooping are provided below.

Before Scoop Sampling:

1. Locate the sample collection location on the site map and reference it appropriately in the field logbook.
2. Don personal protective clothing and equipment as the site-specific CHASP requires.
3. Place clean plastic sheeting on the surface near the sample collection location to hold decontaminated sample collection equipment.

During Scoop Sampling:

4. Scrape the sediment surface with a decontaminated stainless-steel spoon or spatula to reach a previously unexposed surface.
5. Scoop the sediment with a decontaminated stainless steel-spoon or spatula.
6. For Grab or VOA samples:
 - For VOA samples completely fill the sample containers directly from the sampling device, avoiding twigs, large rocks, and grass. For remaining analytes, thoroughly homogenize the sample prior to containerization.

- Be sure to have zero headspace in the VOA sample container.

For Composite samples:

- Empty contents of the sampling device into a decontaminated stainless-steel or Teflon™-lined bowl. Collect enough sample to fill all the containers.
- Homogenize sample in accordance with ESDSOPQAM procedures.
- Place mixture into the appropriate containers.

For Toxicity samples:

- Empty contents of the sampling device into appropriate sample container.
- Collect sufficient sample to fill all the containers.

7. Secure container with Teflon™-lined cap.
8. Label each sample container with appropriate information.

After Scoop Sampling:

9. Place the samples in a cooler and preserve to 4°C.
10. Record pertinent information in the field logbook.
11. Place contaminated disposable materials in the designated drum for disposal by the Navy in accordance with Section 16 of this CSAP.
12. Decontaminate sample equipment in accordance with Section 15 of this CSAP.

7.3 Surface Water Sampling

Surface water will be sampled in accordance with Section 4.8 of the ESDSOPQAM, included in Volume V of the RFI Work Plan. The samples will be collected either by placing the sample bottle in the surface water body or by using a Kemmerer sampling device. After selecting sample locations, the number of samples to be collected will depend on the following criteria:

- Water depth
- Estuarine or fresh water
- Tidal influence
- Salinity profile
- Type of water body (lake, stream, impoundment, or wetland)

Where the water depth is greater than 3 feet, surface water quality parameter measurements (e.g., dissolved oxygen, temperature, pH, conductivity, salinity, and depth) will be collected at the following depths: 1 foot below the water surface, mid-depth, and 1 foot above the bottom.

General Surface Water Sampling Concerns:

- Collect samples from areas of least to greatest contamination and from upstream to downstream.
- Approach surface water sample locations from downstream to minimize sediment disturbance.
- In tidal areas, sample collection should be made at slack tide, preferably low slack.
- Collect samples so as to minimize agitation of underlying sediments.
- If surface water samples and sediment samples are to be collected at the same location, collect the surface water sample first.
- Determine the number of sample collection depth at the sample location.
 - If water is less than 1 foot deep, collect one sample at the surface.
 - If water is more than 1 foot and less than 10 feet deep, the sample shall be collected at mid-depth unless the salinity profile indicates the presence of a halocline (salinity stratification). If a halocline is present, a surface water sample shall be collected from each stratum.
 - If water is more than 10 feet deep, collect samples at 1 foot depth, mid-depth, and 1 foot above the bottom.

Surface water sample collection procedures for both submerged bottle and Kemmerer devices are discussed below.

7.3.1 Submerging Laboratory Bottle

Submerging the laboratory bottle is feasible only for surface water sample locations accessible by wading. If samples are to be collected from more than one depth, or if the sample location is not accessible by wading, another method should be used.

Before Sampling with Laboratory Bottle:

1. Locate the sample collection location on a site map and describe it in the field logbook.
2. Don personal protective clothing and equipment as the site-specific CHASP requires.

During Sampling with Laboratory Bottle:

3. Point open end of vials upstream. Slowly submerge unpreserved VOA vials and fill. Do not disturb bottom sediments. If the sample is to be collected at depth, uncap the bottle at the required sampling depth. Recap containers before returning bottle to the surface.
4. Cap the VOA vial underwater. Be sure to have zero headspace before sealing it.
5. If VOA vials are pre-preserved, collect surface water samples with a decontaminated glass or stainless-steel device and carefully decant into VOA vials.
6. Slowly submerge other unpreserved bottles into the surface water and fill. If the sample is to be collected at depth, uncap containers at the required depth and allow to fill. Recap the containers before returning sample to the surface.
7. Chemically preserve the samples as needed and seal with Teflon™-lined caps.
8. Collect additional surface water in the sample collection device for field measurement of pH, temperature, and conductivity. If the sample interval is at depth, probes will be used to measure these parameters. Other parameters may be added as the site-specific SAP requires.

After Sampling with Laboratory Bottle:

9. Place bottles in cooler and preserve to 4°C.
10. Note pertinent sampling information, including the tidal phase, in the field logbook.
11. Decontaminate all sampling equipment in accordance with Section 15 of this CSAP.

7.3.2 Kemmerer Sampler

Use a Kemmerer or similar sampling device when samples are needed at discrete intervals in a vertical water column. A Kemmerer is a cylinder with Teflon™ stoppers on the ends. The Teflon™ stoppers are open while the device is being lowered in a vertical position so water can pass freely through the cylinder. When the Kemmerer has reached the designated sampling interval, a weight (messenger) is dropped down the rope to close the device. Specific procedures for surface water sampling with a Kemmerer sampler are provided below.

Before Kemmerer Sampling:

1. Locate the sample collection location on a site map and describe in the field logbook.
2. Don personal protective clothing and equipment as the site-specific CHASP requires.
3. Determine the number of sample collection depths at the sample location.

During Kemmerer Sampling:

4. Lower the decontaminated Kemmerer device to the designated depth.
5. Drop a messenger down the rope to close the cylinder.
6. Raise the Kemmerer device.
7. Immediately fill VOA vials. Make sure there is zero headspace, chemically preserve the sample if needed, and secure with a Teflon™-lined cap.
8. Fill remaining bottles. Continue to collect sample volume from each designated depth until all bottles are filled.
9. Measure field parameters of pH, temperature and conductivity, and record in the field logbook at each sample depth.
10. Repeat procedure for each designated sample interval.

After Kemmerer Sampling:

11. Place bottles in cooler and preserve to 4°C.
12. Note sampling information in the field logbook.
13. Decontaminate all sampling equipment in accordance with Section 15 of this CSAP.

8.0 AIR SAMPLING

8.1 Soil-Gas Survey

A standard soil-gas survey is an effective screening tool for VOA contamination and is useful for establishing soil and groundwater sampling points. This survey will require establishing a grid system across the site to be surveyed, using procedures outlined below, then collecting samples at each of the established grid points.

Establishing the Grid System:

1. A South Carolina-registered surveyor or E/A&H personnel will define the two baselines (x and y axes) and record the baselines and other key elements of the grid on report maps.
2. The baselines will be flagged at regular intervals, according to the site-specific SAP.
3. The internal grid points will then be established using a Brunton compass and measuring tape.

General Soil-Gas Sampling Procedures

1. Collect measurements at each established grid point and record the values in the field logbook. If necessary, further investigate areas of elevated soil-gas readings by redefining the survey grid to a smaller interval.
2. Collect additional soil-gas readings at the redefined grid nodes. If the elevated readings need further definition, decrease the survey to smaller intervals as needed.
3. Note the sampling points on a site map.
4. Install the soil-gas probes using either a manual disposable drive-point method or a hydraulically powered, van-mounted probe.
5. Field control samples will be collected by drawing pre-purified nitrogen or filtered ambient air through the sampling apparatus and probe. Field control samples will be collected before each day's sampling activities, after every 20th sample, and after each day's sampling activities.

6. Between each sampling location, decontaminate the soil-gas probe. *Do not* use solvents. *Do not* re-use Teflon™ tubing.
7. Place any IDW into 55-gallon drums for disposal by the Navy.

Sample Collection with a Perforated Drive-Point

1. Assemble the soil-gas sampling point of stainless-steel pipe to a disposable sampling point.
2. Decontaminate the stainless-steel drive point assembly before use and advance it to slightly above the water table.
3. Use Teflon™ tubing to connect the soil-gas sampling point to the sample collection device; attach a vacuum pump with additional Teflon™ tubing.
4. Purge at least two sample volumes before collecting samples.
5. Collect sample in a pre-evacuated glass vial at two atmospheres of pressure.
6. Detach the self-sealing vial and analyze the sample with a portable gas chromatograph (GC).
7. Remove the sampling point.

Sample Collection with a Van-Mounted Probe

1. Advance the stainless-steel pipe, outfitted with a disposable stainless-steel tip on the lead drive point, into the ground with the percussion hammer.
2. After the pipe has been advanced to the desired depth, disengage the drive point and withdraw the drive pipe 8 to 10 inches to create a void in which soil gases can collect.
3. Insert the Teflon™ sample tubing into the drive pipe and connect the tubing to a sample collection device. Use additional Teflon™ tubing to attach to a vacuum pump.
4. Purge at least two volumes from the sampling apparatus before collecting samples.
5. Collect the sample in a pre-evacuated glass vial.
6. Detach the self-sealing vial and analyze the sample with a portable GC.
7. When sample collection is complete, remove the stainless-steel sampling tube.

8. Decontaminate all sampling equipment before use and between each sample collection point. *Do not* use solvents. *Do not* reuse Teflon™ tubing.
9. Place the IDW in 55-gallon drums for disposal by the Navy.

Soil Vapor Sample Screening Using DPT

DPT equipment is capable of performing soil vapor surveys to identify the approximate extent of fuels, solvents, and other VOCs by measuring their concentration in the unsaturated zone. DPT equipment can be used to obtain soil vapor samples at practically any desirable depth and location. This screening method may be used for sampling where DQO Level II criteria is permitted.

A general procedure outlining the DPT method is provided below, however, these procedures may vary between DPT equipment manufacturers. The initial setup of equipment for soil vapor sampling is the same as for soil sampling. Refer to Steps 1 through 6 in Section 4.3.3 of this CSAP for the procedures to setup the DPT equipment.

7. Drive the probing rod using static force or hydraulically powered percussion hammers to the desired sampling depth.
8. After the pipe has been advanced to the desired depth, disengage the drive point and withdrawing the drive pipe the required distance needed to create a void in which soil gases can collect.
9. If probing rod is not equipped with sample tubing, insert the sample tubing into the drive pipe and connect the tubing to a sample collection device.
10. Connect tubing to vacuum pump.
11. Purge at least two volumes from the sampling apparatus before collecting samples.
12. Collect and remove the sample per manufacturers requirements.
13. Analyze the sample with a portable G.C.
14. Remove probing rod from the borehole.

15. Upon completion of the sample recovery, perform Steps 11 through 14 outlined in Section 4.3.3 of this CSAP.

8.2 Passive Soil Gas

Passive soil-gas is a useful technique for collecting and detecting trace quantities of VOA and SVOA from the subsurface at the earth's surface. VOA and SVOA are adsorbed onto the passive soil-gas sampler over a few hours to a few weeks. Because of the increase in the sampling period, the detection limits for many compounds and the temporal variations in the analyses are lower than standard soil-gas techniques. The sampler consists of two or three collectors, each a ferromagnetic wire coated with an activated charcoal adsorbent in a screw-top glass culture tube. Collectors will be checked for cleanliness using mass spectrometry before release to the field.

Before Sampling

1. Don personal protective clothing and equipment as the site-specific CHASP requires.
2. Stake the location(s) to be sampled.
3. Decontaminate installation equipment in accordance with Section 15 of this CSAP.

Installing the Sampler

Installation methods will vary depending on surface conditions. If the surface is grassy or otherwise loosely consolidated, a coring shovel will be used. If the surface is concrete, asphalt or otherwise consolidated, an electric rotary hammer will be used. Both techniques are detailed below.

Loosely Consolidated Surface Conditions

1. Using a coring shovel, core a 14-inch-deep by 2-inch-diameter hole in the surface soil.
2. Place the soil-gas sampler open end down at the bottom of the hole.
3. Backfill the hole with an aluminum foil plug and the original excavated soil.

4. Mark the sample location with ribbon flagging and a number pin flag.
5. Detail all pertinent information in the field logbook before leaving the sampling location.

Consolidated Surface Conditions

1. Using an electric rotary hammer, drill an 18-inch by 1.5-inch-diameter hole (e.g., the drill bit dimensions) through the surface.
2. Attach a cleaned galvanized steel wire to the sampler and lower to the bottom of the hole.
3. Plug the hole with aluminum foil to approximately 2 inches below grade.
4. Cap each hole to land surface with hydraulic cement to protect the sampler from the surface environment.
5. Mark the sample location with ribbon flagging and a number pin flag.
6. Detail all pertinent information in the field logbook before leaving the sampling location.

Duration of Sampler Exposure

The length of time the samplers are exposed to soil gas will be determined by using time-calibration samplers. These samplers measure loading rates of volatile and semivolatile organic compounds emanating from the soil gas. Two sets of three to five time-calibration samplers will be installed in the AOC to represent the range of soil-gas response. These locations will be selected based on known site conditions including groundwater gradient and potential source areas. Generally, the first set of time-calibration samplers are retrieved after approximately one week. The second set of time-calibration samplers will be retrieved after approximately two weeks. At the first indication of significant ion count intensities and significant total ion count values, all of the samplers will be retrieved. If the second set of time-calibration samplers show no significant ion count intensities, the samplers are allowed to equilibrate for up to 30 days.

Retrieving the Sampler

Retrieving the sampler will depend on the surface conditions. Both techniques for retrieval are detailed below.

Loosely Consolidated Surface

1. Expose the backfilled sampler with a trowel.
2. Using a pair of tongs, lift the sampler to the surface.
3. Seal, clean, and label the sampler.
4. Backfill the hole with the original material and clean fill, as required.

Consolidated Surface

1. Remove the hydraulic cement pad and expose the sampler using a hammer and chisel.
2. Using the steel wire, lift the sampler to the surface.
3. Seal, clean, and label the sampler.
4. Backfill the hole with the original material and clean fill, as required.
5. Patch the surface with cement or asphalt.

Quality Assurance/Quality Control

Each sampler contains two or three collector wires that should have adsorbed identical compounds. The first and second wires are analyzed by thermal desorption/mass spectrometry (TD/MS). If the two analyses are similar, no further analysis is necessary for the sampler. If data vary, the second wire will be analyzed by thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS).

Approximately 10 percent of the samplers will contain a third wire to be used for quality control. The wire is used to test the mass spectrometer's operating conditions before survey analysis. In addition, the third wire may be used to test the sensitivity of the analyses or to compare the reproducibility of detected VOA.

Two samplers will be included to act as travel blanks used to check for contamination introduced during shipment.

8.3 Ambient and Indoor Air

Both ambient and indoor air quality samples for VOA analysis will be collected into evacuated stainless-steel Summa™ canisters as described in Section 4.13.2 of the ESDSOPQAM and the *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*. The canister may be used to collect grab samples or integrated composite samples over a prescribed time. The following procedures should be followed when collecting air samples.

1. Don personal protective clothing and equipment as the site-specific CHASP requires.
2. Select the sampling.
3. Before collecting the sample, attach a sample label to the canister detailing the location, time of collection, interval, and the signature of the person collecting the sample. Labels will be prepared in accordance with Section 11.4 of this CSAP.
4. For grab samples:
 - Fit the canister inlet valve with a clean stainless-steel particulate filter.
 - At the sample collection location, open the main valve and allow the canister to fill.
 - After approximately one minute or until there is no audible sound of rushing gas, close and cap the main valve of the canister.

For composite samples:

- Attach a vacuum flow regulator to the canister to control the sampling period. Adjust the flow rate so the ending pressure of the canister is approximately 0.9 atmospheres (atm). Record the initial flow rate and vacuum.
- Allow the canister to fill for the designated interval then close and cap the container.

5. Complete the chain-of-custody form (see Figure 11-3) and package canister for shipment to the selected laboratory according to the guidelines in Section 11.3 of this CSAP.

Sampling for particulate matter in air will be conducted using a PM_{10} sampler, in accordance to the procedures contained in 40 CFR, Part 50, Appendix J - *Reference Method for the Determination of Particulate Matter as PM_{10} in the Atmosphere*. Appendix E of this document includes 40 CFR, Part 50, Appendix J, and the instruction and operations manual for the High Volume PM_{10} Sampler.

9.0 MISCELLANEOUS SAMPLING TECHNIQUES

9.1 Wipe Sampling

Wipe sampling may be necessary to evaluate whether miscellaneous non-absorbent surfaces of walls, floors, equipment, etc., are contaminated. Ideally, the surface should be horizontal and facing upward since surfaces in this position generally are most susceptible to spills and settling dust, but this is not always the case.

All wipes in the jar will be used in accordance with Section 4.12.6 of the ESDSOPQAM, included in Volume V of the RFI Work Plan. Samples will be collected by swabbing or wiping the material or surface with pre-prepared gauze pads that are saturated with either methylene chloride, certified pesticide-grade hexane, or deionized water, depending on the parameters to be analyzed. The wipes will be supplied by the analytical laboratory in an 8-ounce precleaned glass jar. The wipes are to be removed from the sample jar using tweezers or gloves. The entire area to be sampled is wiped with firm strokes using only one side of the wipe. The wipe is then returned to the sample jar from which it was taken. Care should be taken to tightly reseal the jar to prevent evaporation of the solvent. The sample jar will be labeled in accordance with the procedures outlined in Section 11.4 of this CSAP.

A new pair of disposable gloves shall be worn to collect each individual wipe sample. The area sampled in square centimeters shall be noted on the chain-of-custody form (see Figure 11-3) and in the field logbook. The optimal area is 100 square centimeters. In order to ensure a consistent sampling area, a 100 square centimeter template will be used. However, due to the nature of the matrices to be sampled, the optimal area may not be available. In instances where a 100-square-centimeter sample area is not available, the actual sampled area will be measured and noted on the chain-of-custody form, sampling log, and the field logbook.

9.2 Waste Sampling

The waste sampling program's basic objective is to produce a set of samples representing the waste media under investigation and suitable for subsequent analysis. This section describes the methods and materials that will be used for sampling waste generated at Navy installations. Under many circumstances, the sampling and testing performed for the investigation will be sufficient to classify the waste and no additional sampling will be necessary. When additional sampling is required to characterize the waste, it is important that quality control (QC) sampling is performed to assess the sampling program's accuracy and precision. QC sampling methods should be the same as those stated in the approved work plan.

Sampling accuracy usually is achieved by using a random sampling technique. Sampling precision is achieved by collecting the appropriate number of samples and by maximizing their physical size.

A simple random sampling strategy will be employed for most solid waste cases where additional samples are required to characterize the waste. The rationale for using this type of sampling method is that typically little or no information is known about the distribution of the chemical contaminants within the waste. For most solid waste, distinct strata within the containers are not identified and variations in composition or stratification may have occurred at unknown and random depths.

Simple random sampling is a type of probability sampling that relies on mathematical and statistical theories. In simple random sampling, all locations or portions of the waste have an equal chance of being sampled. For simple random sampling, the appropriate number of samples to be collected is estimated by finding the regulatory threshold (RT) for the contaminants of concern (COC) and by estimating the sample mean (\bar{x}) and variance (s^2).

Simple random sampling may be used for liquid waste that is thought to be homogeneous. Stratified random sampling may be used for liquid waste sampling where the COC are thought to stratify due to their density relative to the other liquids. Stratified random sampling is different from simple random sampling in that x is calculated for each stratum in the population and then integrated into the overall estimates of those statistics. Systematic random sampling also may be used for instances where there are recognized trends or cycles associated with the contaminants in the waste. Cases where systematic random sampling may be used include drums with floating or sinking products.

It also is likely that if the waste is to be disposed of to a treatment, storage, or disposal facility (TSDF), its operators will want to perform their own waste characterization. Therefore, it is important to contact the potential TSDF before sampling and analyzing the waste to avoid duplicating efforts and costs. The potential TSDF for the waste should be contacted following environmental sampling. Their requirements regarding acceptable laboratory analyses change as do the wastes they are accepting and the rates they charge. Transportation requirements and costs should be determined before shipping.

The sampling method chosen for each of the waste media will, in part, be dependent on the potential contaminants of concern as shown by site history or analytical results of the field sampling program. The generation of additional decontamination fluids through waste sampling should be minimized and should be a factor considered in the final choice of sampling technique. Care should be exercised to avoid the use of sampling devices plated with chrome or other materials that might contaminate the sample.

The sampling methods for containerized media are divided into three sections that address (1) soil and sludges, (2) containerized liquids, and (3) containerized personal protective equipment (PPE). If required, wipe sampling will be used to analyze the surface of drums, disposable equipment, and PPE.

9.2.1 Soil and Sludge Sampling

Available options for sampling devices suitable for soil and sludge (or sediment) sampling include scoops, thin-walled tube samplers, hand augers, core samplers, and sampling triers. Using a scoop and a sampling trier 100 centimeters (cm) long is the recommended method for sampling containerized soil and sludge. However, site-specific conditions may necessitate a variety of sampling options, and therefore all of these sampling methods will be discussed. The presence of rocks, debris, or other sampling-specific considerations may complicate sampling and preclude using or require modification some of these sampling devices.

When sampling a previously sealed vessel, the presence of a bottom sludge should be checked. This is easily accomplished by measuring the depth to apparent bottom and then comparing it to the known interior depth. Methods for sampling a bottom sludge are described in the following sections. Sludges that develop in 55-gallon drums also can be collected by employing glass tubes used for the liquid portion of the sample.

9.2.2 Thin-Walled Tube Sampler

The thin-walled tube sampler is, as its name implies, a metal tube generally 2.5 to 7.5 cm in diameter and 30 to 60 cm long. The tube is forced into the soil or sludge and then extracted. Friction will usually hold the sample material in the tube during extraction. Interchangeable cutting tips facilitate penetration with reduced sample disturbance. Thin-walled tube samplers are available in various types and construction materials and are suitable for moist, dry, sandy, or heavy-duty applications.

Soil or sludge also can be sampled with a hand corer. This device is essentially the same type of thin-walled tube sampler described above. It is modified by adding a handle to facilitate driving the corer and a check valve on top to prevent washout during retrieval through an overlying water layer. Hand-auguring devices can be used in conjunction with a thin-walled tube sampler. In this manner, a thin-walled tube sampler can be used to sample both from the

surface or to the bottom of a 55-gallon drum. However, the presence of rocks or the collapse of the auger hole generally prohibits sampling at depth.

9.2.3 Aqueous Liquid Sampling

Beakers, glass tubes, bailers, and extended bottle samplers and composite liquid waste samplers (COLIWASA) are devices that may be used to sample containerized liquid media. Site-specific conditions may necessitate a variety of sampling options, and therefore all of these methods will be discussed below. Samples from drums also can be readily collected by merely submerging a sample bottle.

Beakers

Using a sampling device such as a beaker, either disposable or constructed of glass, Teflon™, or stainless steel, is the recommended method for sampling containerized liquids. The device typically has a capacity of at least 500 ml to provide an adequate sample volume for analysis and to minimize the number of times the liquid will be disturbed, thus reducing agitation of any sediment layer. Large sample volumes that are required for some analyses will require submerging the beaker several times to obtain the appropriate volume. A stainless-steel beaker with pour spout and handle works well. It is easily cleaned and considerably less expensive than Teflon™.

Glass Tubes and Bailers

Liquid samples from open containers, such as 55-gallon drums, may be collected. Bailers also may also be used to collect liquid samples from containers such as drums or tanks. The major disadvantages to using bailers are splash hazards, the need for decontamination of reusable bailers, and the generation of waste when using disposable bailers.

Composite Liquid Waste Samplers

The COLIWASA is designed to permit representative sampling of the complete water column from drums or other containerized liquid media. This type of sampler is used when contaminants of different densities, such as oil and water, are potentially present in the containerized liquid. A typical COLIWASA consists of a 152-cm long by 4-cm ID section of tubing with a neoprene stopper at one end. The stopper is attached to a rod running the length of the tube and terminating with a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sample by raising and lowering the neoprene stopper.

10.0 ANCILLARY DATA COLLECTION

10.1 Hydrolab Datasonde

The Hydrolab Datasonde 3 (DS3) Multiparameter Water Quality Dataloggers may be deployed to measure in-situ water quality and tidal phases in nearby or onsite water bodies. The multi-mode device will measure temperature, pH, dissolved oxygen, conductivity, salinity, depth, and oxidation/reduction potential (redox). Refer to Appendix B for Hydrolab operating procedures and to the zone-specific SAPs for deployment locations.

10.2 Current Meter

A current meter may be deployed with the Hydrolab Datasonde surveyor to aid in physically characterizing the surface water body. The Niskin Winged Current Meter will be deployed with the DS3 approximately 2 feet above the bottom during one of the wettest and one of the driest months of the year (based on historical climatological data). The meter measures current by measuring the angle of tilt of its own housing when suspended from a suitable mooring. The current meter will be operated, calibrated, and maintained according to the manufacturer's specifications. The operating manual for the Niskin Winged Current Meter is included as Appendix C. Alkaline batteries will be used instead of the lithium battery listed in the operating manual.

10.3 Rain Gauge

Rain gauges may be installed near selected sites of interest to document rainfall influence on water level. Rain gauges will be installed according to the manufacturer's specifications. Rain gauges will be read after every rain event or daily, whichever time period is less. A log of these measurements will be maintained.

10.4 Water Level Indicator

The static water level in monitoring wells and the depth of water at each surface water sampling location shall be measured before sample collection. For monitoring wells, an electronic water level indicator will be used. The decontaminated probe will be inserted down the well. A tone

will indicate the probe's contact with water. Pinpoint the water level by slowly raising and lowering the probe until the tone is heard consistently below, and not above, a specific point. Water level will be recorded to the nearest 0.01 foot on the Measurement of Groundwater Level Form provided in Figure 10-1 or in the field logbook.

10.5 Secchi Disk

Before collecting surface water samples, measure water clarity at each surface water sampling location. A secchi disk attached to the end of a graduated rope will be lowered into the water. The first depth at which the disk is no longer visible from the surface (or when it touches the bottom) will be recorded in the appropriate field logbook.

10.6 Hydrogeologic Assessment

The objective of the hydrogeologic assessment is to better understand the hydrogeology underlying the site(s). The hydrogeologic assessment will include an elevation survey of newly installed monitoring wells; water level measurements in all onsite monitoring wells and/or adjacent surface water bodies; and, as appropriate, multi-well pumping tests and slug tests on newly installed or existing monitoring wells.

All newly installed and existing monitoring wells will be surveyed during the cadastral or geodetic survey. Each well will be referenced to a common datum for elevation in accordance with NAD 1983 standards. In addition, staff gauges will be placed in the surrounding surface water bodies and surveyed relative to the same benchmark.

Static water levels will at a minimum be measured in all monitoring wells located on NAVBASE during quarterly groundwater sampling events. Water levels will be collected at both high and low tides and used to determine groundwater elevations for determining groundwater flow direction and calculating of the hydraulic gradient. Groundwater data will be input into a Geographic Information Systems (GIS) data management program to facilitate evaluating

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groundwater flow on both a zone- and base-wide scale. As appropriate, and especially for low-yield wells, slug tests will be conducted. Falling-head and/or rising-head slug tests may be conducted using electronic data loggers according to procedures provided below.

10.6.1 Slug Testing

Slug testing rapidly and easily estimates aquifer conductivity and transmissivity, and is superior to pump testing in most remedial investigations because it produces little or no contaminated water requiring containment and disposal.

General Procedures for Performing a Slug Test

1. Insert a decontaminated pressure transducer, calibrated to an electronic data logger, to an appropriate depth in the well to be tested.
2. Add or remove a known volume to (or from) the well or piezometer to create a rapid rise (or fall) in water level. In most cases, a stainless-steel or Teflon™ cylinder of known volume will be used.
3. Measure the rate of water-level recovery using the pressure transducer and data logger.
4. Graph data, in depth-time pairs, and determine hydraulic conductivity and aquifer transmissivity. A commercially available aquifer analysis will be used. Specific analytical techniques and assumptions made by the hydrogeologist will be provided in the zone-specific SAP and/or the report.

Procedures for Falling-Head Slug Test

Before Slug Testing:

1. Put on personal protective clothing, as specified in the zone-specific CHASP.
2. Place plastic sheeting around the wellhead. Arrange needed equipment and decontaminated materials on the sheet.
3. Open the locking and vented caps and inspect the wellhead. Note in particular the surveyed reference mark's conditions, if any.

4. Measure and record the static water level and the depth to bottom of the well. Record these data in the appropriate logbook.

During Slug Testing:

5. Check calibration of the pressure transducer at two different depths in the well. Check depths should be widely separated. Leave the transducer at the lower check point.
6. Rapidly insert slug (stainless-steel or Teflon™ cylinder) into the water.
7. Using the data recorder, record fall in water level vs. time.
8. Continue recording depth-time data until the well has recovered to nearly static water level. When using data recorders, check and record the reading every few minutes to ensure data are being properly recorded.

After Slug Testing:

9. Record the time of test completion in the logbook. If a data recorder with random access memory (RAM) or erasable programmable read only memory (EPROM) was used, record the file name used.
10. Decontaminate all equipment according to the guidelines in Section 15 of this CSAP. Clean up the site, and close and lock the well before leaving. Place contaminated plastic sheeting and disposable protective clothing in the designated drum for future disposal by the Navy in accordance with Section 16 of this CSAP.

NOTE: Both rising- and falling-head slug tests may be carried out in the same operation by first measuring the rate of water-level fall immediately after slug insertion, then measuring the rate of water-level rise after slug withdrawal. Be sure the well has recovered to static water level before conducting the rising-head slug test.

Procedures for Rising-Head Slug Test

If the monitoring well screen brackets the water table, the rising-head slug test generally will be more representative than the falling-head.

Before Slug Testing:

1. Lower a decontaminated slug (stainless-steel cylinder) of known volume into the well until it is fully submerged. Allow the well to re-equilibrate to static water level.
2. Turn on the data recorder, if used, or verify the static water level has been re-established with a water-level meter.

During Slug Testing:

3. Withdraw slug quickly, avoiding surging.
4. Using a data logger, record the rise in water level vs time.
5. Continue recording depth-time data until the well has recovered to nearly static water level. When using data recorders, check and record readings every few minutes to ensure data are being properly recorded.
6. Record time of test completion in the field logbook. If a data recorder with RAM or EPROM memory was used, record the file name used.

After Slug Testing:

7. Decontaminate all equipment. Clean up the site, and close and lock the well before leaving. Place any contaminated plastic sheeting and disposable protective clothing in a designated drum for disposal by the Navy in accordance with Section 16 of this CSAP.

Restrictions/Limitations

In wells where the static water level and those induced during testing are above the top of the screened or open hole interval, both rising-head and falling-head tests should be conducted to check results.

Quality Control Requirements for Slug Tests

- A pressure transducer and data logger, or strip chart recorder, must be used to perform these tests.
- Slug tests shall be performed after groundwater sampling to minimize contamination.
- All equipment must be decontaminated before each test.

10.6.2 Pumping Tests

Multi-Well Pumping Tests

In general, the investigation will contain slug test results and interpretations, which will be sufficient for site characterization. If evaluation shows groundwater remediation is required and the aquifer test data are insufficient for remedial design, then the data will be used to design a high-volume test for remedial design purposes. Multi-well pumping tests will be conducted by withdrawing groundwater at a constant, known rate from a designated production well. If the well can sustain enough discharge to adequately stress the aquifer, then aquifer tests will be performed in the unconfined surficial zone for a minimum of 72 hours (48 hours of discharge, 24 hours of recharge). A flow meter will determine if the pumping rate remains constant. During multi-well tests, water levels will be measured simultaneously in designated adjacent monitoring wells. In general, the tests will be based upon zone-specific objectives (e.g., steady state conditions or boundary conditions). Water-level recovery in production and monitoring wells will be monitored after the pump is turned off until the water recovers to its original level (less residual drawdown). Drawdown and recovery data from each pumping test will be plotted to produce time vs. drawdown graphs, which will be used to calculate hydraulic conductivity and transmissivity, and to determine the hydraulic connection between zones. Specific analytical

techniques and assumptions used by the hydrogeologist will be provided in the zone-specific SAP, the report, and/or appropriate deliverable documents.

10.6.3 Tidal Influence Study

At selected locations, the influence of tides on static groundwater levels will be evaluated. Monitoring wells oriented both perpendicular and parallel at various distances to the shoreline will be selected for study.

1. Lower a decontaminated pressure transducer or Well Sentinel into the well until it is fully submerged. Allow the well to re-equilibrate to static water level.
2. Turn on the data recorder, if used. The data recorder or Well Sentinel will record the rise and fall in water level vs. time at selected time intervals for the designated study period. The time intervals and the sampling period will be designated in the zone-specific SAP.
3. Record test completion time in the field logbook. If a data recorder with RAM or EPROM memory was used, record the file name. If a Well Sentinel was used, download the data into a computer.
4. Decontaminate all equipment. Clean up the site, and close and lock the well before leaving. Place any contaminated plastic sheeting and disposable protective clothing in a designated drum for disposal by the Navy accordance with Section 16 of this CSAP.

10.7 Radioactivity Screening - Gamma Sources

Charleston Naval Shipyard (CNS) will perform detailed radiological surveys at all locations within the shipyard having any potential for radioactivity and document radioactivity levels which are consistent with naturally occurring background. Additionally, the Navy will be performing detailed radiological surveys at certain sites on NAVBASE. This information may be independently verified by the USEPA and SCDHEC. If practical, sampling should not proceed at any sampling point within the shipyard, or at NAVBASE sites mentioned above until

applicable Navy radiological verification surveys have been completed at that sampling point. These surveys will be described in separate workplans and reports. This procedure provides guidance for gamma screening at locations where samples will be collected for determining RCRA remediation actions required. Where it is necessary to proceed with RCRA sampling in advance of planned surveys, in locations specifically designated as having some potential for radioactivity not yet surveyed by the Navy, gamma screening will be conducted in accordance with this section. Upon completion of the detailed surveys, gamma screening will only be required prior to taking samples from any areas specifically designated as having a potential for radioactivity. The purpose of the screening is to identify any sample location where the radioactivity level exceeds 50 microroentgens per hour ($\mu\text{R/hr}$) and warrants taking precautions during sample collection and analyses. The action level of 50 $\mu\text{R/hr}$ corresponds to those permissible for the general public by the applicable Code of Federal Regulations, i.e. Title 10 or 40, or State regulations.

Equipment Required

- Ludlum Model 3 survey meter
- Ludlum Model 44-5 gamma scintillation probe; 1-inch X 1 inch sodium iodide (NaI); and
- Cesium-137 check source

Radiation Screening Setup:

Check the equipment for proper condition and response to the Cesium-137 check source in accordance with the manufacturer's technical manual and operating instructions. The checks shall be at least daily prior to use and while in use in accordance with the manufacturer's technical manual and operating instructions.

Screening:

Prior to initiation of field activities, obtain concurrence from the shipyard and NAVFAC BRAC Environmental Coordinators (BEC) representatives on the specific locations for which to be

gamma surveys are proposed to be taken. Prior to taking samples perform a gamma radiation reading at the ground surface at each designated sampling point. All uR/hr readings shall be documented and independently verified in writing as accurately recorded for each location. If the gamma radiation level at any location is greater than 50 uR/hr in the area do not proceed with taking the sample. In this case, notify the task order manager immediately for further direction. The task order manager will promptly notify both the CNS and NAVFAC BEC representatives, to identify the causes of the deviation from expected background and whether further action is necessary (e.g. radiological precautions necessary for sample collection or analyses). For sites specifically designated as having a potential for radioactivity below surface (e.g. any landfill area), as core samples are taken, gamma survey all portions of the samples in accordance with this section taking standard precautions to avoid direct personnel contact with the samples. If the gamma radiation level on any core sample is greater than 50 uR/hr, discontinue sampling operations. Handle the sample and exposed sampling equipment surfaces as potentially radioactive pending further evaluation. Notify the task order manager immediately for further direction. The task order manager will promptly notify the CNS and NAVFAC BEC representative for further direction as discussed above.

11.0 MANAGING SAMPLES

Samples will be managed in accordance with Section 4.2 of the ESDSOPQAM, included in Volume V of the RFI Work Plan.

11.1 Sample Containers, Preservatives, Holding Times

Appendix D provides information on sample container type and size, preservation requirements, and holding times. The appropriate number of pre-cleaned sample containers, preservatives, and trip blank samples will be obtained from a NEESA-approved laboratory. Stainless-steel sampling liners, which may be used to collect soil samples, will be obtained from the manufacturer and decontaminated in the field before use. Heterotrophic plate count sampling will be conducted with sterile containers and scoops provided by the laboratory.

11.2 Sample Preservation

Samples will be chemically preserved in accordance with the guidelines presented in Section 4.2.7 of the ESDSOPQAM. All samples requiring chemical preservation will be prepreserved either before sample collection or immediately after collection in the field.

In accordance with the ESDSOPQAM the following samples will not be preserved:

- Samples collected within a hazardous waste site thought to be highly contaminated with toxic materials, as well as samples collected from source areas (i.e., barrels, drums, closed containers, or spillage).
- Samples with extremely high or low pH.
- Samples that may generate dangerous gases if preserved.

These procedures will be followed when preserving samples:

1. Ensure that the samples are not over-preserved because courier services may consider them dangerous goods requiring shipment in accordance with International Air Transport

- Association (IATA) Dangerous Goods Regulations. As a general rule, four drops of acid will preserve a 40-ml VOA sample and 40 drops of acid will preserve a 1-liter bottle.
2. When testing sample pH, pour a small aliquot of the sample over a piece of pH paper. Place the pH paper into the separate container to determine the pH.
 3. If the free chlorine test is positive (i.e., blue color change on the KI paper), preserve the cyanide sample using the following procedures:
 - Add a few crystals of ascorbic acid to the sample. Mix thoroughly.
 - Retest for free chlorine. If the test is positive, continue adding ascorbic acid until the result is negative.
 - When it is negative, add a few crystals of additional ascorbic acid crystals.
 - Add sodium hydroxide (NaOH) to the cyanide sample until the pH is > 12 .
 - Properly document the sample preservation on the sample label and the chain-of-custody form.
 4. If the sulfide test is positive (i.e., bluish-black color change on the lead acetate paper), preserve the cyanide sample following the procedures listed below:
 - Add a small amount of lead carbonate to the sample. Mix thoroughly.
 - Continue the procedure until a precipitate is formed.
 - Filter the sample using a 0.45-micron filter.
 - Add NaOH to the filtered sample until the pH is > 12 .
 - Properly document the sample preservation on the sample label and the chain-of-custody form.

11.3 Packaging Samples for Shipment

All samples will be packed for shipment according to Appendix, C Section C.3 of the ESDSOPQAM to avoid breakage and prevent cross-contamination.

Sample Packaging Procedures

1. Select a cooler in good condition. Seal the drain plug on the inside and outside of the cooler with tape to prevent leakage.
2. Line the cooler with a large plastic bag.

While Packaging Samples

1. Place one sample container in one sealable plastic bag. VOA vials may be bagged together.
2. To prevent breakage, either:
 - Wrap samples in bubble-wrap packing material. Seal bubble wrap around the containers with tape. Bubble wrap is not required for plastic containers, but take care when packing the coolers so containers do not directly touch each other;
 - OR
 - Place 2 to 4 inches of inert packing material (i.e., vermiculite or cellulose insulation) on bottom of the cooler. Place the bagged containers inside the cooler so the bottles do not touch. Completely fill any remaining space with inert packing material.
3. Include a temperature blank or temperature strip in each sample cooler.
4. Fasten the top of the large plastic bag with tape.
5. Place double-bagged ice inside cooler to preserve the samples to 4°C.
6. Place a chain-of-custody record describing the contents of each cooler in a sealable plastic bag and place it inside each cooler.
7. Seal the cooler with tape and custody seals so it cannot be opened without breaking the seal.

Labeling the Package

1. Clearly print "This End Up" or "This Side Up" on top of the cooler, and place upward pointing arrows on sides of the cooler.
2. Mark cooler with the addresses of both shipper and receiver.
3. If more than one cooler is to be shipped, mark with the sequential cooler number and the total number of coolers (e.g., 1 of 3, 2 of 3, and 3 of 3).

11.4 Sample Labeling

Section 3 of the ESDSOPQAM provides general instructions on labeling samples. Labels will be affixed to each sample container. A sample label is provided in Figure 11-1. Labels will include site, sample identification, collection time and date, method of preservation, sampler identification, and the analyses to be conducted.

**Figure 11-1
Sample Label**

<i>A Joint Venture for Professional Services</i> EnSafe/Allen & Hoshall (901) 383-9115	
Site:	Naval Base Charleston
Sample Number:	
Preservative:	4°C
Analysis:	
Date:	
Time:	
Sampler:	

Sample Number: Assign the sample identification number according to the following format and guidelines:

Format: X X X X / 1 2 3 4 5 6 7 8 9 0

X X X X / — This is a prefix that correlates all samples within a specific project. The prefix is not part of the actual sample identification. All samples collected as part of the NAVBASE investigation will use the prefix "NBC/".

Field Samples:

1 2 3 — The first three digits are for the site where the sample was collected: sites, SWMUs, plumes, buildings, background, etc.

4 — This digit will represent the matrix of the sample. In order to keep the data consistent and facilitate data management, the following master list of abbreviations for common matrices will be used when applicable:

- S — soil (surface, borings, and trenches)
- C — soil duplicate sample
- M — sediment (settled, fluid-borne solid)
- N — sediment duplicate
- G — groundwater
- H — groundwater duplicate sample
- W — surface water
- R — surface water duplicate sample
- U — sludge
- Y — sludge duplicate
- A — air
- Z — liquid waste
- V — solid waste

5 6 7 8 — These four digits designate the sampling location: boring or well number, sampling station, trench number, existing well identification, etc.

9 0 — The final two digits represent the sample-specific identification: depth to the nearest foot, depth interval, serial number for water samples, etc.

QC samples:

1 2 3 — The first three digits are for the site where the sample was collected, as above.

- 4 — This digit will represent the type of QC sample. Again, in order to keep the data consistent and facilitate data management, the master list of abbreviations for commonly collected QC samples below will be used when applicable:
- K — MS sample
 - X — MSD sample
 - T — trip blank
 - E — equipment rinsate blank
 - D — deionized water system blank
 - P — potable water blank
 - F — field blank
 - L — filter blank
 - B — USEPA blind spike sample
 - 2 — cement blank
 - 3 — drilling mud
 - 4 — grout blank
 - 5 — bentonite blank
 - 6 — sand blank
- 5 6 7 8 — These four digits correlate the QC sample with the field samples associated with it. A simple way to accomplish this is to use the sampling location, for example the boring or well number, of a sample collected on the same day as the QC sample. This also will aid in keeping the QC samples blind to the laboratory.
- 9 0 — The final two digits are the serial number for the QC samples. For example, the first rinsate blank collected at a particular site will have the serial number "01," the second rinsate will be "02," etc.

Sample Numbering Guidelines:

- This sample-numbering system uses 10 digits for each sample number. All 10 digits must be used. A master list of sample matrix and QC sample abbreviations is supplied above. Any abbreviations may be used for job site and sample locations, but they must fit into the sample number format. All spaces in the sample number format must be filled and no extra characters included. If all of the spaces are not necessary for a sample identification, zeroes will be used as space-fillers.

- Even though the format for sample numbers is standardized, the system still requires planning on the part of the project or site manager to ensure that every sample has a *unique* number. For example, if multiple sampling events will take place at the same site, this information should be incorporated into the site or sample location abbreviations for samples collected there.
- Define site and sampling location abbreviations as much as possible before starting the sampling event. When necessary, consult the well inventory and sample logbook before assigning new sample numbers. This will reduce the possibility of duplicating abbreviations as sample numbers.
- Samples to be used for MS/MSD analyses will be collected in triplicate to ensure that the analytical laboratory receives sufficient volume for the analyses. The extra sample aliquots will have -MS and -MSD added to the end of the sample number.
- The letters I and O and the numbers 1 and 0 are not used as the matrix/QC digit because they are easily confused on chains-of-custody and sample labels.
- The master abbreviation lists cover only routinely collected QC samples. Some sites may necessitate collecting uncommon sample matrices (i.e., animal or plant tissue samples, wipe sampling, building materials, etc.). These situations will require using a customized matrix and QC sample abbreviation list. When custom codes are necessary, all matrix codes will be defined and documented in the sample logbook and associated field logbook. These custom codes will be carefully selected to avoid confusion with existing sample numbers.
- If multiple soil samples from a trench are to be collected at the same depth, note each sampling location in the field logbook and incorporate both the trench number and sampling location into the sample identification as digits 5678.
- If a project requires collecting samples for total and dissolved constituent analyses, set up site or sample location identifiers indicating which samples are filtered and which are not.

Completing the Sample Label and Correcting Errors:

All information except date, time, and sample collector's signature will be preprinted on the labels. The remaining information will be recorded clearly on the label in non-erasable, waterproof black ink. Errors will be corrected on the sample label by marking through with a single line, initialing the error, and then recording the correct information.

11.5 Sample Custody

Sample custody or possession will be traceable from the time the sample is collected to its delivery at the analytical laboratory. Refer to Section 3.3 of the ESDSOPQAM for general instructions on maintaining chain-of-custody. Exceptions are outlined below.

Maintaining Field Custody

1. After collecting samples, label and seal the sample jar with a custody seal (see Figure 11-2).
2. Affix the seal so samples cannot be opened without breaking.
3. The sampler must sign and date the seal.

Chain-of-Custody Record

The chain-of-custody form will be used to record custody of the samples. An example of the chain-of-custody form is provided in Figure 11-3. Record the necessary information on the chain-of-custody clearly in non-erasable, waterproof, black ink. Use zeros and sevens with slashes through them to avoid confusion with O's and I's. Correct errors on the chain-of-custody by marking through with a single line. Initial the error and then record the correct information. The following information will be recorded in the appropriate spaces on the form.

Information about EnSafe/Allen & Hoshall:

- Client name (E/A&H) and address of E/A&H.
- Project Name/Number (Naval Base Charleston / Control Task Order [CTO] Number).



NAVY CLEAN
ENSAFE/ALLEN & HOSHALL

ENSAFE/ALLEN & HOSHALL
5720 SUMMER TREES DR. SUITE 8
MEMPHIS, TENNESSEE 38134
(901) 383-9115
OFFICIAL SAMPLE SEAL

SAMPLE #	DATE:
SIGNATURE:	
PRINT NAME & TITLE:	



FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 11-2
CUSTODY SEAL

DWG DATE: 08/08/94 | DWG NAME: 029SECSL

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- Project Manager's Name.
- Signature of Sampler(s).

Information about the Sample:

- Field sample identification (as described in previous section).
- Date and time of collection (24-hour clock).
- Type of sample.
- Type and size of sample containers.
- Preservation temperature and chemical.
- Number of sample containers per sample.
- Type of laboratory analysis required.
- Comments such as "strong odor" etc. go in the remarks section.
- Samples to be used for MS/MSD will be indicated in the "Remarks" section.

Information about Transfer, Shipment and Disposal:

- When sample custody is transferred, document it in the appropriate section of the form.
- The person relinquishing custody must print his or her name, company name, reason for the transfer, date, time, and signature on the form.
- The method of shipment and the air-bill number of the shipment will be noted on the chain-of-custody form.
- During shipment, the chain-of-custody form must be sealed in a plastic bag and secured inside the shipping cooler.
- Note any special instructions (e.g., priority turnaround) or comments in the appropriate section of the chain-of-custody and discuss them with the laboratory before collection and shipment.
- Note sample disposal or storage instructions after completing laboratory analysis.

11.6 Chain-of-Custody Transfer

Refer to Section 3.3.5 of the ESDSOPQAM for general instructions on transferring custody and shipping of samples. Specifics are listed below.

Transferring Custody

1. Record the air-bill number in the appropriate section on the chain-of-custody record and in the field notebook. Seal the chain-of-custody form in a plastic bag and place it inside the shipping cooler before closing.
2. Secure shipping coolers with tape and place a custody seal on each side of the cooler's exterior to prevent opening without breaking the seal.
3. Ship samples overnight to the selected analytical laboratory.
4. When relinquishing custody to a shipper, advise the laboratory of any time constraints on analysis. Notify the laboratory as early in the week as possible regarding samples intended for Saturday delivery.

Laboratory Sample Receipt Procedures

1. A sample custodian accepts custody of the shipped samples from the carrier and enters data about the package into a receipt log, including the status of the coolers' custody seals.
2. The laboratory sample custodian opens the shipping coolers, checks the contents, logs in the samples, and verifies that the information on the chain-of-custody agrees with samples received.
3. The custodian records information such as shipment, pickup, and courier on the "Remarks" section of the chain-of-custody record. The custodian also documents temperature of the cooler by checking the temperature blank or strip, as well as the general condition of sample containers.
4. The analyst verifies sample preservation before extraction, digestion, or analysis and records pH.

5. If samples are improperly preserved, the Laboratory Quality Assurance Coordinator (LQAC) documents this fact, along with the sample identification and other pertinent information, and notifies the task order manager and site manager. All other QA/QC discrepancies are handled similarly and must be documented as an out-of-control event with the corrective action taken.

12.0 ANALYSIS

12.1 Field Parameters

The QA/QC objectives for parameters to be measured in the field are presented in Table 12-1. Precision and accuracy targets for pH, temperature, and conductivity measurements are those specified by the USEPA ESDSOPQAM. QA/QC targets for other measurements are based on the manufacturer's specifications pertaining to precision and accuracy of the instrument.

Table 12-1 Field Measurements				
Field Measurements	Matrix	Precision	Accuracy	Completeness
pH	Water	± 0.5 Std. Units.	± 0.2 Std. Units	90%
Temperature	Water	± 1.0° C	± 0.2° C	90%
Specific Conductivity	Water	± 10%	± 1% of full scale	90%
Salinity	Water	± 2.0 ppt	± 1.0 ppt	90%
PID/FID	Air	± 10 ppm	± 2 ppm	90%
Static Water Level	Water	± 0.01 ft.	± 0.05 ft.	90%
Redox	Water	**	± 20 mV	90%
Dissolved Oxygen	Water	**	± 2 mg/l	90%
Turbidity	Water	0.01 NTU	0.1 NTU	90%
Wellhead Points	Spatial	± 5%	± 0.1 ft.	90%
	Vertical	± 0.05 feet	± 0.01 ft.	90%

Field Measurement References:

- **pH, Temperature, and Specific Conductivity:** Methods for Chemical Analysis of Water and Wastes, USEPA-600/4/79-020, Revised March 1983.
- **Salinity:** Manufacturer's SOP for salinity measurement.
- **PID/FID:** Manufacturer's SOP for operation of Photovac MicroTIP, Foxboro OVA, and HNu.
- **Water Level, Redox, Dissolved Oxygen:** Manufacturer's SOP for the Hydrolab Datasonde.
 ** SOP's precision values of these parameters = one month's stability of accuracy.
- **Wellhead Points:** Standard Land Surveying Methods in accordance with National Geodetic Survey.
- **Turbidity:** Manufacturer's SOP for turbidity meter.

Calibrating and Standardizing Equipment

Field measurement instruments will be calibrated at least twice daily (before use and at the end of the day) according to the manufacturer's specifications. Instruments also may be calibrated during the day if field personnel consider it necessary. Tracing each standard to National Institute of Standards and Technology (NIST) will be based upon the forms and product-specific information provided by the standard manufacturer/supplier. Instrument calibration will be recorded in the field logbook or calibration forms, and calibration procedures and calculations will be recorded on the calibration log forms in Figures 12-1 to 12-3.

Calibrating and Standardizing Temperature Probes

1. Initially, calibrate all thermometers against a NIST-certified thermometer or one traced to National Bureau of Standards (NBS) certification. Glass mercury-filled thermometers will not be used.
2. Test temperature probes for calibration quarterly by checking the unit against a NIST-certified thermometer. If values do not fall within specified ranges listed in Table 12-1, the probe will not be used and will be returned to the manufacturer for service.

Calibrating and Standardizing pH Meters

1. Check the pH meter before use for any mechanical or electrical failures, weak batteries, and cracked or fouled electrodes.
2. Standardize the pH meter before use each day in the field using a 2-point calibration. The meter slope will be checked initially using pH 4, 7, or 10 buffer solutions, depending on the expected pH value of the samples to be analyzed. A meter slope outside the range of 85 to 115 percent indicates meter or probe failure. The calibration check process will be repeated between sampling locations using one of two initial buffer solutions. Record the calibration in the field logbook, and all calibration procedures and calculations on the calibration log in Figure 12-1.

Figure 12-1
Calibration Log — pH Meter
Naval Base Charleston — Charleston, South Carolina

pH Meter:

Model: _____ Date/Time: _____

Serial Number: _____ Checked by: _____

Instrument Checklist:

	YES	NO
Is the instrument clean and in good condition?	_____	_____
Is the battery charge acceptable?	_____	_____
Is the liquid crystal display (LCD) functioning properly?	_____	_____
Is the probe filled with proper solution?	_____	_____
Are there any visible cracks or problems with the probe?	_____	_____

Two- or Three-point Calibration

	Reading	Lot #	Expiration Date
Buffer 4.0:	_____	_____	_____
Buffer 7.0:	_____	_____	_____
Buffer 10.0:	_____	_____	_____
Initial Slope:	_____		

Remarks:

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Figure 12-2
Calibration Log — Conductivity Meter
Naval Base Charleston — Charleston, South Carolina

Conductivity Meter

Model: _____ Date/Time: _____

Serial Number: _____ Checked by: _____

Instrument Checklist:

	YES	NO
Is the instrument clean and in good condition?	_____	_____
Is the battery charge acceptable?	_____	_____
Is the liquid crystal display (LCD) functioning properly?	_____	_____
Is the conductivity cell clean?	_____	_____
Are there any visible cracks or problems with the probe?	_____	_____

Conductivity Calibration Standards:

Source: _____ Date of Receipt: _____ Lot #/Expiration: _____

Two-point Calibration

100 μ mhos/cm Solution: _____ NIST Lot # _____

1000 μ mhos/cm Solution: _____

Temperature: _____ Instrument internal calibration: _____

Remarks:

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Figure 12-3
Calibration Log — PID/FID/OVA Meter
Naval Base Charleston — Charleston, South Carolina

PID/FID/OVA Meter:

Model: _____ Date/Time: _____

Serial Number: _____ Checked by: _____

Instrument Checklist:

	YES	NO
Is the instrument clean and in good condition?	_____	_____
Is the battery charge acceptable?	_____	_____
Is the readout display functioning properly?	_____	_____
Are there any visible cracks or problems with the meter?	_____	_____
Does ultraviolet lamp window or dust filter need cleaning?	_____	_____

PID/FID/OVA Calibration Standards:

Span Gas Type/Source: _____

Date of Receipt: _____

Lot #/Expiration: _____

Remarks:

This left blank intentionally.

Calibrating and Standardizing Specific Conductivity

1. Refer to the designated cell constant of the conductivity cell in the manufacturer's instruction book. Determine the actual cell constant each day before use.
2. Use a conductivity calibration solution to check the cell constant. If the values obtained during the check are within specification, any measured deviation will be used to extrapolate a more accurate sample reading as outlined in the manufacturer's instructions. If the check values are out of specification, the cell will be returned to the manufacturer for repair.
3. Check each conductivity meter before use to ensure the probe is intact, the batteries are sufficiently charged, and the cell is clean. Calibration procedures entail checking the conductivity cell with one potassium chloride standard in the expected range of the sample(s) to be collected.
4. If the conductivity meter does not automatically compensate for temperature, manually recalibrate it to account for temperature.
5. Record the calibration in the field logbook, and all calibration procedures and calculations on the calibration log in Figure 12-2.

Calibrating and Standardizing Photo/Flame Ionization Detectors and Organic Vapor Analyzers (OVA)

1. Calibrate the PID/FID/OVA quarterly using the kit provided by the manufacturer. Alternatively, rented instruments will be returned to the manufacturer/rental company for quarterly calibration.
2. Calibrate each PID/FID/OVA both before use and at the end of the day with the calibration span gas specified by the manufacturer.
3. Record background readings at the site.
4. Clean the instrument's exterior quarterly by wiping with a damp cloth, using a mild detergent when necessary.
5. Correct all field readings for ambient background readings by subtracting the measured background reading from the field reading. *Under no circumstances will the meter be zeroed based on ambient conditions in the AOC.*

6. Recharge the instrument's battery when the low-battery indicator appears. The instrument should be allowed to fully discharge before fully recharging. This will maximize its operating time.
7. Record the calibration in the field logbook, and all calibration procedures and calculations on the calibration log in Figure 12-3.

Quality Assurance Targets for Precision and Accuracy in the Field

Precision and accuracy targets for pH, temperature, and specific conductivity measurements are specified in Section 6 of the ESDSOPQAM and are provided in Table 12-1. Quality Assurance (QA) targets for other measurements are based on manufacturer's information pertaining to the precision and accuracy of the associated instruments.

12.2 Laboratory Analysis

Parameters and Analytical Methods to be Used:

Parameters and analytical methods are presented in Appendix D. Samples will be analyzed in accordance with the applicable methods as outlined in *Test Methods for Evaluation of Solid Waste (Physical/Chemical Methods)*, SW-846, Third Edition, September 1986. For DPT sample analyses, USEPA methods and/or laboratory SOP for screening methods will be followed to meet DQO level II criteria. The screening parameters for DPT analyses will be volatile organic compounds, polynuclear aromatic hydrocarbons, polychlorinated biphenyls, metals, and cyanide. Additional analytical methods for potentially analyzed parameters not included in the SW-846 analyses are listed below.

Additional Methods for Laboratory Analysis:

- *Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater*, 40 Code of Federal Regulations (CFR) Appendix A to Part 136, July 1987.
- *Methods for Chemical Analysis of Water and Wastes*, USEPA-600/4-79-020, Revised March 1983. The analytical laboratory will calibrate instruments according to protocols of the specified method to be performed and with the laboratory calibration procedures outlined in ESDLOPQCM, included in Volume V of the RFI Work Plan.

QA Targets for Laboratory Precision and Accuracy

Project QA objectives for analytical parameters for soil and groundwater are stipulated in the respective analytical methods and as determined by the analytical laboratory's historical data quality evaluation for these methods. The NEESA laboratory approval process ensures laboratory method QA/QC standards are appropriate to meet goals for intended data uses. General QA goals for these methods are presented in Tables 12-2 and 12-3.

The contract laboratories' QAPs are included in Volume V of the RFI Work Plan for EPA approval. If the services of additional laboratories are needed for this investigation, advance notice will be given and the laboratories' QAPs will be made available for USEPA and NEESA review and approval.

Table 12-2 Metals Analyses Data QA Objectives Matrix Spikes/Duplicate Analyses		
Compound (Metal)	Precision* (RPD)	Accuracy (% Spike Recovery)
Aluminum	± 20	80-120
Antimony	± 20	80-120
Arsenic	± 20	80-120
Barium	± 20	80-120
Beryllium	± 20	80-120
Cadmium	± 20	80-120
Calcium	± 20	80-120
Chromium	± 20	80-120
Cobalt	± 20	80-120
Copper	± 20	80-120
Iron	± 20	80-120
Lead	± 20	80-120
Magnesium	± 20	80-120
Manganese	± 20	80-120

Compound (Metal)	Precision* (RPD)	Accuracy (% Spike Recovery)
Mercury	= 20	80-120
Nickel	= 20	80-120
Potassium	= 20	80-120
Selenium	= 20	80-120
Silver	= 20	80-120
Sodium	± 20	80-120
Thallium	± 20	80-120
Tin	± 20	80-120
Vanadium	± 20	80-120
Zinc	± 20	80-120
Cyanide	± 20	80-120

Notes:

RPD - Relative Percent Difference

* — precision limits apply when metal is present at ≥ 10 times the instrument detection limit (IDL)

Fraction	Compound	Soil Precision (RPD)	Soil Accuracy (% Recovery)	Water Precision (RPD)	Water Accuracy (% Recovery)
VOA (8240)	Matrix Spikes				
	1,1-Dichloroethene	22	59-172	14	61-145
	Trichloroethane	24	62-137	14	71-120
	Chlorobenzene	21	60-133	13	75-130
	Toluene	21	59-139	13	76-125
	Benzene	21	66-142	11	76-127
VOA (8240)	Surrogate Spikes				
	Toluene-d ₈	—	84-138	—	88-110
	4-Bromofluorobenzene	—	59-113	—	86-115
	1,2-Dichloroethane-d ₂	—	70-121	—	76-114

Table 12-3 Organic Analyses Data QA Objectives Matrix Spikes/Matrix Spike Duplicates/Surrogate Spikes					
Fraction	Compound	Soil Precision (RPD)	Soil Accuracy (% Recovery)	Water Precision (RPD)	Water Accuracy (% Recovery)
SVOA (8270)	Matrix Spikes				
	1,2,4-Trichlorobenzene	23	38-107	28	39-98
	Acenaphthene	19	31-137	31	46-118
	2,4-Dinitrotoluene	47	28-89	38	24-96
	Pyrene	36	35-142	31	26-127
	N-Nitroso-Di-n-Propylamine	38	41-126	38	41-116
	1,4-Dichlorobenzene	27	28-104	28	36-97
	Pentachlorophenol	47	17-109	50	9-103
	Phenol	35	26-90	42	12-110
	2-Chlorophenol	50	25-102	40	27-123
	4-Chloro-3-Methylphenol	33	26-103	42	23-97
4-Nitrophenol	50	11-114	50	10-80	
SVOA (8270)	Surrogate Spikes				
	Nitrobenzene-d ₄	—	23-120	—	35-114
	2-Fluorobiphenyl	—	30-115	—	43-116
	p-Terphenyl-d ₄	—	18-137	—	33-141
	Phenol-d ₄	—	24-113	—	10-110
	2-Fluorophenol	—	25-121	—	21-110
	2,4,6-Tribromophenol	—	19-122	—	10-123
Pesticides (8080)	Matrix Spikes				
	Lindane (gamma-BHC)	50	46-127	15	56-123
	Heptachlor	31	35-130	20	40-131
	Aldrin	43	34-132	22	40-120
	Dieldrin	38	31-134	18	52-126
	Endrin	45	42-139	21	56-121
	4,4'-DDT	50	23-134	27	38-127
Pesticides (8080)	Surrogate Spikes				
	Decachlorobiphenyl	—	60-150*	—	60-150*
	2,4,5,6-Tetrachloro-m-xylene	—	60-150*	—	60-150*

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Table 12-3 Organic Analyses Data QA Objectives Matrix Spikes/Matrix Spike Duplicates/Surrogate Spikes					
Fraction	Compound	Soil Precision (RPD)	Soil Accuracy (% Recovery)	Water Precision (RPD)	Water Accuracy (% Recovery)
Herbicides (8150)	Matrix Spikes				
	2,4-D	40	40-150	30	40-130
	Silvex	40	40-150	30	40-130
Herbicides (8150)	Surrogate Spikes				
	Dicamba	—	50-140	—	50-130

Notes:

- VOA = Volatile Organic Analyses
- SVOA = Semivolatile Organic Analyses
- * = Advisory Limits
- = Not Applicable

13.0 QUALITY ASSURANCE PLAN

13.1 Introduction

This section presents policies, project organization, objectives, and functional activities, along with QA/QC measures intended to achieve the quality assurance goals of the facility investigation to be performed at NAVBASE.

This document is intended to fulfill requirements for ensuring all work will be conducted in accordance with QA/QC protocols and field procedural protocols for environmental monitoring and measurement data as established in the following documents.

Applicable Guidance Documents:

- U.S. Environmental Protection Agency. (February 1991). *Standard Operating Procedures and Quality Assurance Manual*. Athens, Georgia.
- U.S. Environmental Protection Agency. (September 1990). *Laboratory Operations and Quality Control Manual*. Athens, Georgia.
- Naval Energy and Environmental Support Activity. (June 1988) (NEESA 20.2-047B). *Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program*. Port Heuneme, California.
- Naval Energy and Environmental Support Activity. (February 1985). (NEESA 20.2-031A) *Groundwater Monitoring Guide*. Port Heuneme, California.
- Southern Division Naval Facilities Engineering Command, Revision 4. (March 1989). *SOUTHNAVFACENGCOCM Guidelines for Groundwater Monitoring Well Installation*.
- USEPA. (1986). Office of Solid Waste and Emergency Response (OSWER), *Test Methods for Evaluating Waste — Physical and Chemical Methods*, EPA SW-846. 3rd Edition.
- USEPA. (1986). *RCRA Groundwater Monitoring Technical Enforcement Guidance Document (OSWER-9950.1)*. Washington, D.C.

- South Carolina Department of Health and Environmental Control. (1985). *South Carolina Well Standards and Regulations*, (R.61-71). Columbia, South Carolina.

Where specific NEESA guidelines do not exist, applicable USEPA and/or SCDHEC guidelines and methods will be applied. The ESDSOPQAM and ESDLOPQCM will take precedence over NEESA guidance where there is a conflict. These regulations are referenced in specific sections of this document where applicable.

Before field investigations begin, a site meeting will be conducted for the Task Order Manager, all field personnel, a representative of the site management, and any subcontractors who will be working onsite to familiarize all parties with the site, discuss the logistics with management, and discuss health and safety procedures. The Southern Division Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) Engineer in Charge (EIC) and representatives from the SCDHEC and USEPA Region IV will be invited. The investigation will begin upon authorization from the EIC.

13.2 QA/QC Objectives

In general, quality assurance objectives as part of the Navy technical services contract assess and document the precision, accuracy, representativeness, completeness, and comparability of all sampling and analyses performed. Quality criteria are outlined here to assure data obtained during projects is suitable for its intended use, and to meet goals established by NEESA and in the USEPA document, *DQO for Remedial Response Activities Development Process* (March 1987), OSWER Directive 9355.0-7B. NEESA DQO Level B protocol (USEPA Level II) will be used for the physical surveys and screening level analyses of samples collected using DPT. At a minimum, soil, surface water, sediment, groundwater, and contaminant quantification investigations will be conducted at NEESA DQO Level C protocol (USEPA Level III). A percentage (to be negotiated with the regulatory agencies involved) of the soil, surface water, sediment, and groundwater samples collected will be submitted in duplicate to the laboratory for analysis with NEESA Level D protocols (USEPA

Level IV) for confirmation purposes. The following discussion presents the project specific level of effort for quality assurance and data quality criteria. Quality control sample collection will follow the frequency presented in Table 13-1.

Table 13-1 Quality Control Sample Collection Frequencies	
Duplicates:	One per 20 water, soil, and soil-gas samples collected
Field Blank:	One per sampling event (week) per source. (Potable Water and Reagent Grade Water—ASTM Type III)
Trip Blank:	One per sample shipping cooler containing VOA samples
Rinsate Blank:	One per week per media; one per 20 soil-gas samples collected
MS/MSD:	One per 20 water and soil samples collected; MS/MSD are to be the same sample used for duplicate analysis
Equipment/Material Blanks:	One sample each of filter pack sand, drilling mud, grout, bentonite pellets, or powder used in well construction per material source/site
Temperature Blank:	One per sample shipping cooler
Preservative Blank:	One at beginning and one at end of all major field investigations (20 samples or more. One at end of small studies.

Notes:

Trip blanks are for volatile organic analysis only.
Preservative blanks are for metals and general inorganics.

13.2.1 Precision

Precision is a measure of the reproducibility of measurements and methods, and is defined for qualitative data as a group of values' variability compared with its average value. To assess the precision of the measurement systems used in this project, duplicates will be obtained and analyzed with the samples collected. Precision, to be used as a criterion for data classification, is calculated as a relative percent difference in analytical outcome between a given sample and corresponding duplicate.

The type of duplicates used will depend on the part of the measurement system to be evaluated

for precision. Field-duplicated samples analyzed by the same laboratory will yield information about sampling method precision and matrix homogeneity. Laboratory-duplicated samples give an indication of sample preparation and analytical method precision.

A field duplicate is a sample collected in the field from the exact location as another sample and sent to the laboratory for analysis with the original sample. A laboratory duplicate is prepared in the laboratory and consists of a split from a sample sent there from the field.

13.2.2 Accuracy

The accuracy of an entire measurement system, which is an indication of any bias, is difficult to measure in environmental measurement systems. Sources of error are the sampling process, field and laboratory contamination, preservation, handling, sample matrix, and analysis. The accuracy of a method is an estimate of the difference between the true value and the determined mean value. In the field, methods used for detecting false positive results include the preparation of trip blanks, field blanks, and equipment rinse blanks. In the laboratory, MS/MSD samples and surrogate spike solutions are used to detect positive and negative bias.

Per NEESA definitions, a field blank consists of sample containers filled in the field with water from each source used for decontamination. Field blanks are prepared, preserved, and stored in the same manner as the samples. The field blank is analyzed along with the field samples for the constituents of interest to check for contamination imparted to the samples by the water source. Samples of the ASTM Type III water and tap water will be collected weekly. Field blanks may also be collected to determine if any contaminants present in the area, such as dust or VOAs from a source other than that being sampled, may impact sample integrity.

Trip blanks will be used to measure volatile constituents. A trip blank consists of a VOA sample vial that is filled with organic-free water in the laboratory and travels unopened with the sample bottles to the field. Trip blanks will be stored unopened with the sample bottles in a

contaminant-free area. The trip blank is then shipped back to the laboratory with volatile samples collected in the field. It is opened in the laboratory and analyzed along with the field samples for the volatile constituents of interest. Trip blanks will be submitted to the laboratory with samples for volatile analysis at a frequency of one per shipping container containing VOA samples. If trip blanks are received from the laboratory containing air bubbles (pinhead size or larger), the trip blanks will be discarded and the laboratory contacted.

An equipment rinsate blank is made by taking ASTM Type III water and placing it in contact with the field sampling apparatus (e.g., bailer, pump, stainless-steel split-barrel sampler, Xi-Tech™ sampling sleeve) after decontaminating equipment. The water will be collected in the same type of containers as the other samples, preserved in the same manner, and analyzed for the same parameters of interest. One equipment rinsate blank will be collected each week per sampling media. If sampling occurs in the same sample media using different equipment in the same week (e.g., if soil samples are collected with Xi-Tech™ sampler, split-barrel sampler, and hand auger) a separate rinsate blank will be collected for each piece of sampling apparatus.

MS/MSD samples prepared by the laboratory are useful in assessing the accuracy of the analytical methods, and can detect matrix effects where other sample components interfere with analyzing the chemical(s) of interest. The method of measuring analytical accuracy is percent recovery.

Analytical MS and MSD samples will be performed by the laboratory, typically at a frequency of one MS/MSD pair per 20 samples per matrix. Control limits for laboratory matrix spike recovery are published by USEPA or determined by historical laboratory results. Surrogate spikes, typically prepared from deuterated isomers of selected target compounds and added to each sample, provide an added measure of method accuracy in organic analyses. General precision and accuracy goals for laboratory analytical procedures (NEESA DQO Level C/USEPA DQO Level III) are as previously provided in Tables 12-2 and 12-3. To provide the

additional volume needed by the lab for MS and MSD analysis, double the volume for the first sample of each 20 soil, water, and sediment samples.

An equipment/materials blank shall be collected from the materials and liquids to be used in monitoring well construction at each investigation site. These blanks will be analyzed at DQO Level IV.

13.2.3 Representativeness

The goal of this investigation is to delineate the extent of any soil and groundwater contamination and to determine the most appropriate remedial option. Soil and groundwater samples will be properly collected and monitoring well parameters will be measured in accordance with NEESA and USEPA protocols to ensure samples collected during the investigation are representative of the AOC.

13.2.4 Completeness

Completeness goals for this project are set at 90 percent for laboratory analyses. Data completeness is the percentage of total valid tests conducted and the percentage of the total valid tests required in the scope of work.

Completeness goals of field measurements reflect the ability to re-sample immediately, before declaring well stability, and obtaining samples for laboratory analysis. The completeness goals consider unavoidable non-attainment of QA goals during the course of an investigation. Efforts will be made, however, to maintain soil and groundwater data completeness levels above 90 percent for field measurements, if possible.

13.2.5 Comparability

Comparability is assured by using established methods of field sampling by experienced field personnel and laboratory analyses as specified by the ESDSOPQAM and NEESA regulations.

13.3 Organization and Responsibilities

Overall responsibility for projects conducted in accordance with NEESA regulations will be vested in NEESA (or its approved representatives). Therefore, project coordination responsibilities lie with the SOUTHNAVFACENGCOM EIC. The components of the project chain-of-command will be performed as established in NEESA 20.2-047B. Project oversight will be organized along the following lines of authority.

Naval Energy and Environmental Support Activity: NEESA is responsible for ensuring the quality of laboratory analyses performed during the various phases of the Comprehensive Long-Term Environmental Action Navy (CLEAN) is acceptable. NEESA is also responsible for managing the NEESA contract representative (NCR).

Engineer in Charge: The EIC at the engineering field division provides the site information and history, provides logistical assistance, specifies the sites requiring investigation, and reviews results and recommendations.

The EIC is responsible for coordinating procurement, finance, and reports; for ensuring all documents are reviewed by the NCR; for communicating comments from the NCR and other technical review to the subcontractors; and for ensuring the subcontractors address all the comments submitted and take appropriate corrective actions.

NEESA Contract Representative: The NCR is responsible for ensuring each project has appropriate overall QA. The NCR reviews laboratory QA plans and work plans, submits performance sample data, provides field and laboratory audits, and reviews data from the site. The questions from subcontractors and the EIC regarding specific field and laboratory QC practices are directed to the NCR, who also evaluates referee samples.

State or Local Oversight: This CSAP will be submitted to the SCDHEC and the USEPA Region IV for review and approval. Field activities and meetings will be coordinated with these agencies as required.

Investigation Performance: The following individuals or firms will be responsible for the implementing of all work activities.

Engineering Contractor: E/A&H will serve as the engineering contractor for this project. As the engineering contractor, E/A&H is responsible for designing and implementing the Remedial Investigation/Feasibility Study (RI/FS) and preliminary site characterization activities.

Analytical Laboratory: The laboratory to be used will be NEESA-approved. SW-846 analytical methods using USEPA Level III protocols and USEPA Level IV protocol will be used by the selected laboratory. For DPT screening data, the laboratory must meet USEPA DQO Level II criteria. The laboratory must adhere to the laboratory requirements in NEESA 20.2-047B and follow the quality assurance/quality control guidance found in the ESDLOPQCM. Where discrepancies between the NEESA and USEPA QA guidelines occur, the USEPA document will take precedence. The laboratory must prepare and submit a laboratory QA plan, analyze and submit the results of proficiency testing, submit to an onsite inspection, and correct any deficiencies cited during the inspection by the NCR.

The laboratory is required to identify a Laboratory QA Coordinator (LQAC) responsible for overall quality assurance. The LQAC must not be responsible for schedule, costs, or personnel other than QA assistants. It is preferred the LQAC report to the laboratory director. The LQAC must have the authority to stop work on projects if QC problems arise affecting the quality of the data produced.

In addition to conforming to all NEESA regulations, all work shall be performed in a manner consistent with the regulations listed below.

Applicable Regulations:

- The National Oil and Hazardous Substances Contingency Plan (NCP), Title 40 CFR, Part 300, as amended.
- Other appropriate federal, state, and local guidelines, rules, regulations, and criteria.

14.0 DATA MANAGEMENT PLAN

This section describes the methods to be used throughout the investigation to document field work and manage collected data.

14.1 Field Documentation

The field project manager will be thoroughly familiar with appropriate documentation procedures. He or she will perform or directly oversee completion of the documents accompanying this investigation. Documentation tasks will be performed on a sample-by-sample or item-by-item basis throughout the day. Sample container labels and chain-of-custody forms will be prepared as completely as possible in advance.

General Field Documentation Procedures

- Complete all documentation in waterproof black ink.
- Mark through corrections with a single line, then date and initial the correction.
- Do not destroy or discard serialized documents, even if they are illegible or inaccurate.
- Maintain voided entries within project files.

Field documentation consists of a master site logbook, one or more site-specific field logbooks, field forms, photographs, sample labels, and chain-of-custody records. This allows detailed data to be recorded in various field logbooks and/or forms and cross-referenced in the site logbook.

Logbooks: Master site and field logbooks provide a daily handwritten record of all field activities at an investigation site. All logbooks must be permanently bound and have a hard cover. Field logbooks must be waterproof. The master site logbook is a master record of all site activities, and entries are usually made at the end of each work day. Field logbooks are detailed daily records kept in real time. A field logbook will be assigned to each site at NAVBASE. Additionally, a sample logbook will be prepared detailing the samples collected each day, but in less detail than the chain-of-custody.

Master Site Logbooks: The master site logbook chronicles all field investigation activities, but without the same level of detail as the field logbook. It delineates conditions and activities occurring on a given day and references the appropriate field logbooks and forms for specific information.

The field project manager completes the master site logbook and signs and dates the end of each page. Pages should not be removed and all partially used pages should be lined through to prevent data entry at a later date. The front of the master site logbook should include the project name and number, name of subcontractor, service client, contract number, and dates of use.

Master Site Logbook Contents:

- List of all field logbooks and brief outline of their required contents.
- Daily temperature, weather conditions, and names and titles of personnel present.
- Levels of personnel protection, and changes if required.
- Name, title, organization, and purpose of any site visitors.
- Brief outline of site activities and references to the appropriate logbook.
- Specific comments on any problems encountered, their resolution, and any impact on the field investigation.
- Any changes and supporting rationale for the change.
- Brief record of all telephone calls and how they affected the investigation.
- Instrument calibration, specifically name(s) of personnel who performed daily calibration.

Field Logbooks: All information required on the cover of the site logbook also must be provided on the cover of each field logbook. In addition, it must list the specific area to which it is assigned. Entries in the field logbook must be made using a 24-hour clock and signed by the responsible person at the bottom of each page. Unused pages or portions of pages not used must be lined out to prevent later entry of additional information. Copies of field logbooks will be made regularly to act as a backup.

Field Logbook Contents:

- Date and time task started and ended; weather conditions, and the names, titles, and organizations of personnel performing the tasks.
- Description of level of PPE and any changes.
- Description of site activities in specific detail or forms used.
- Description of field tests performed and test results.
- Detailed description of samples collected, and any quality control samples collected.
- List of the time, equipment type, and procedures followed for decontamination.
- Record of instrument calibration and any failures with a brief description of repairs and/or replacements.

Sample Logbook: A sample logbook will compile a record of samples collected and shipped (including QA/QC samples), analyses requested, the airbill number of the shipment, and any pertinent information concerning sample status.

Field Data Record Forms: Forms to be used during this investigation include subsurface boring logs, monitoring well construction diagrams, monitoring well development forms, sample records, and additional data as appropriate. Do not leave blank spaces on completed forms. If information on a form does not apply, mark the space "N/A." Complete all forms in the field as the task is performed. Copy forms regularly for backup. Field forms to be used during this investigation are discussed below.

Sample Labels: Attach completed sample labels to each sample container immediately after sample collection. Refer to Section 11.4 of this plan for labeling instructions. Sample label information (at least sample identification number and time of collection) will be recorded in the field logbook as a cross-reference at the time of collection.

Chain-of-Custody Records: The chain-of-custody record will summarize the contents of the shipment, dates, times, sample numbers, number and volume of sample containers; its purpose is to document the transfer of sample custody. See Section 11.6 of this CSAP for chain-of-custody transfer instructions.

Subsurface Boring Logs: Soil boring logs will be maintained by a qualified E/A&H geologist. Lithology will be described from split-barrel samples and auger cuttings using the USCS. Subsurface boring logs will be completed as the boring is advanced. Items to be recorded include materials encountered, depth to water, obvious contamination, and any other necessary information.

Monitoring Well Construction Diagrams: A monitoring well construction diagram will summarize the monitoring well construction. Data to be completed includes location, date drilled, drilling method, well depth, screen location, and general construction data. A general log will also be recorded in the field logbook as a cross-reference. Monitoring well schematics are found in Section 5 of this CSAP.

Photographs: Photographs will be taken of all pertinent field activities as directed by the Field Project Manager. The information listed below will be recorded in the field logbook:

- Date, time, location, and name of photographer.
- Description of photograph and orientation.
- Number of photographs on film roll.

After the film is developed, this information will be written to the back of each photograph.

14.2 Data Deliverables

For Level III and Level IV data, hard copy data shall be consistent with the USEPA DQO III and IV requirements, as applicable. For Level II data, copies of sample results, laboratory

blank results, and surrogate results will be considered hard copy deliverables. USEPA DQO Level IV data shall be submitted in a Contract Laboratory Program (CLP)-like deliverable package. Information and format of the CLP data packages may be obtained from the following documents:

- *USEPA Contract Laboratory Program Statement of Work for Organics Analysis (Document #OLM01.8)*
- *USEPA Contract Laboratory Program Statement of Work for Inorganics Analysis (Document #ILM02.1).*

Disk Deliverables

Each sample delivery group submitted to E/A&H must be accompanied with a diskette containing the following analytical data.

For CLP and non-CLP methods: The analytical data should be submitted on a high-density 5.25-inch or 3.5-inch diskette with the hard copy of the file.

For CLP methods: The USEPA Format A or Agency Standard format is required. This format applies to both organic and inorganic analyses. The format should be modified for handling the 10-digit E/A&H sample identification, plus any lab extensions (i.e., MS, MSD, etc.), OR an identification conversion table must be supplied identifying E/A&H sample identification with converted identification numbers. This file should be provided in ASCII format.

For non-CLP methods: An ASCII fixed-length field format is required; however, other formats may be acceptable, which will be determined on a case-by-case basis.

Each data record should contain the data for one analytical compound and one sample identification, and the following fields:

ASCII FIXED-LENGTH FORMAT

Field	Example	Columns
Case #	26345	1 - 5
Sample Delivery Group (SDG)	CT515	6 - 10
E/A&H Sample Identification	123X7890IM	11 - 20
Lab Extension (MS, MSD, DL, ..)	MSD	21 - 24
Lab Code — 6 digits, representing laboratory	ANALAB	25 - 30
Laboratory Name	ANALYTICAL LABS	31 - 60
Laboratory's Internal Sample Identification #	238396	61 - 72
Matrix (Soil / Water)	Water	73 - 77
Sample Date	04/01/94	78 - 85
Date Sample Was Received by Lab	04/02/94	86 - 93
Date Sample Was Extracted / Prepared	04/04/94	94 - 101
Date Sample Was Analyzed	04/09/94	102 - 109
Chemical Abstracts Services (CAS) #	79016	110 - 119
Compound / Analyte Name	Trichloroethene	120 - 159
Result / Detection Limit	10.0754	160 - 173
Units	UG/KG	174 - 178
Qualifier	U	179 - 186
Method	8240	187 - 196

14.3 Analytical Data Validation

The laboratory's data review will be consistent with the level of effort specified in NEESA 20.2-047B and specific to the laboratory QC level applied. All analytical data will be validated independently of the laboratories analytical data review. Analytical data will be validated by applying the procedures in *National Functional Guidelines for Organic Data Review*, June 1991, and *National Functional Guidelines for Inorganic Data Review*, July 1988, as applicable. Where these guidelines do not apply, data will be validated by applying USEPA precision and accuracy statements for the analytical methods employed. Independent data validation will be conducted on 10 percent of the samples by an independent subcontractor.

14.4 Other Related Data

Other related data will include illustrations, graphs, meeting summaries, audit reports, and laboratory results. This information will be compiled and reviewed for report presentation.

Meeting Summaries, Telephone Conversations, and Notes: These items will be recorded in the field logbooks along with the dates, time, and names of people involved. This information will be available for photocopying if requested. Meetings and conversations with a substantial impact on the project will be described in a memorandum to the project manager.

Illustrations, Computations, and Engineering Data: Original illustrations and graphics will be initialed and dated by the person originating the document. A second person will check for completeness and accuracy. All maps, calculations, and data will be reported or prepared to accepted standards and confidence levels.

Field Change Request Forms: Field change request forms (see Figure 14-1) will be submitted when any deviation from the work plan or SAP is required that will harm the quality of the data

generated, will significantly change the cost of the field effort, will be a major change in the scope of the field effort, or will significantly delay the schedule. Examples of this type of change follow:

- Significantly changing the number of wells,
- Significantly changing the number of sampling points,
- Changing decontamination procedures,
- Changing drilling method or well construction design, and
- Changing sampling methodology.

Information should include the nature of the change, reason for it, and date it will be implemented. These forms will be submitted to the EIC representing the Navy.

14.5 Reports

Progress Reports: Monthly progress reports prepared by the project manager will include the number of samples collected, sites investigated, monitoring wells installed, any deviations from approved field or laboratory procedures, and other appropriate information. These reports will be directed to the EIC.

Zone Reports: The zone RFI report will be written after sampling and validation of all laboratory analyses. The report will consolidate and summarize collected data and document the unit evaluation. An initial draft report will be submitted for comment by the Navy and the USEPA. Where appropriate, comments will be incorporated into the final document.

Final Report: The final RFI report will be written after all the zone reports have been submitted to USEPA for review and comment. The final report will be a comprehensive document that addresses NAVBASE as a whole. The report will consolidate and summarize the results and conclusions presented in each the zone reports.

FIGURE 14-1 FIELD CHANGE REQUEST FORM



NAVY CLEAN
ENSAFE/ALLEN & HOSHALL
(901) 383-9115

FIELD CHANGE REQUEST

E/A&H PROJECT NO. _____ FIELD CHANGE NO. _____

TO _____ LOCATION _____ DATE _____

DESCRIPTION:

REASON FOR CHANGE:

RECOMMENDED DISPOSITION:

FIELD MANAGER(SIGNATURE) _____ DATE _____

DISPOSITION:

SITE MANAGER _____ DATE _____

DISTRIBUTION: E/A&H PROJECT MANAGER _____ OTHERS AS REQUIRED _____
QUALITY ASSURANCE MANAGER _____
NAVY EIC _____
FIELD MANAGER _____

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Interim reports or technical memorandums will be completed as necessary to describe significant divergence of site conditions from those anticipated, secure concurrence on the need for emergency or interim corrective measures, or to gain regulatory input on unanticipated issues.

Tables, Graphs, and Illustrations: Data obtained from sampling and analysis procedures will be summarized and presented in tables. These tables will be supported by raw laboratory reports submitted to the EIC under separate cover. Several formats will be used to present sampling results graphically. Isoconcentration maps will be developed for soil and groundwater parameters, if possible. In addition, maps showing sample locations and results also will be completed. Groundwater surface contours, along with flow direction and gradient also will be displayed on the site base maps. Cross-sectional plots may be used if they would enhance understanding of the site. Forms completed during the investigation will be included in appendices of the report.

Accumulated data and analytical results will be interpreted as a project team effort. The expertise of each project team member will be used to develop proper conclusions and recommendations. The final decision about interpretation of data for the report will lie with the Task Order Manager, the Project Technical Director, and the South Carolina-registered Professional Geologist.

15.0 DECONTAMINATION

Decontamination procedures will be performed in accordance with Appendix B, Section B-8 of the ESDSOPQAM manual (included in volume V of the RFI Work Plan) for sampling equipment and in accordance with Appendix E, Section E-9 of the ESDSOPQAM manual for drilling equipment, with the following exceptions. The detergent for use on this project will be Liquinox™ because it contains powerful chelating agents to bind and remove trace metals from sampling equipment. When available, hot water will be used for field decontamination. A stainless-steel bowl, sink, or bucket will be used to contain the clean water wash solution. PVC well construction materials will not be solvent-rinsed or washed with hot water. Field reagent grade water will meet the specifications of ASTM Type III water (D 1193-77 re-approved 1983, federal test method 7916), providing deionized, filtered, and organic-free water for field use. The steam cleaner and/or high-pressure hot water washer will be capable of generating adequate pressure and producing hot water and/or steam. All wastes generated during decontamination will be containerized in designated drums for disposal by the Navy in accordance with Section 16 of this CSAP.

15.1 Decontamination Area Setup

Decontamination generally will occur at a designated area downgradient and downwind of the clean equipment storage area. The decontamination area is a concrete pad designed to promote surface runoff into a catch basin. Liquids contained within the catch basin will be pumped regularly into designated drums. All equipment will be cleaned on saw horses or auger racks above the concrete surface. If field cleaning is necessary, place plastic sheeting on the ground designated as the decontamination area to contain any spills.

15.2 Cross-Contamination Prevention

Follow procedures below to reduce cross-contamination risk during decontamination.

1. Don a new pair of disposable outer gloves before handling sampling equipment.

2. Use only Teflon™, glass, or stainless-steel spray bottles/pressurized containers to apply decontamination rinsates. Keep each solution in a separate container.
3. Transport all necessary decontaminated field equipment to each designated location to minimize the need for field cleaning.

15.3 Non-sampling Equipment

Non-sampling equipment includes drill rigs and backhoes. Any paint or coatings (e.g., rust) potentially touching a sample will be removed from the equipment by sandblasting before it is brought to the site.

1. Decontaminate with high-pressure steam.
2. Scrub with a laboratory-grade detergent and clean water wash solution.
3. Rinse with clean water as necessary.

15.4 Sampling Equipment

Sampling equipment includes any downhole equipment (e.g., augers, drill pipe, split-barrel samplers, Teflon™-coated stainless-steel leaders, stainless-steel liners, bailers, etc.) and any sampling utensils (e.g., stainless-steel spoons, stainless-steel spatulas, stainless-steel bowls, pumps, etc.) not dedicated to the sample location. Hollow downhole equipment or equipment with holes potentially transmitting water or drilling fluids will be cleaned on the inside and outside.

1. Don protective gloves before decontaminating the equipment.
2. Wash and scrub with a laboratory-grade detergent and clean water wash solution or decontaminate with high-pressure steam.
3. Rinse with clean water.
4. Rinse with organic free water.
5. Rinse twice with pesticide-grade isopropyl alcohol.
6. Rinse with ASTM Type III water.

7. Air dry. If weather prohibits air drying, repeat the isopropyl alcohol rinse and final ASTM Type III water rinse twice.
8. Wrap in aluminum foil or plastic sheeting for storage if the sampling equipment is to be stored or transported.
9. Augers and drill rods will be covered in clean plastic after decontamination.

Pump Decontamination

Pump decontamination differs from decontaminating most sampling equipment. The pump exterior and interior both require decontamination. The procedures for decontaminating the interior and exterior of the pump are outlined below:

1. Don protective gloves before decontaminating the equipment.
2. Immerse pump head in a detergent solution with the effluent hose prepared to discharge into a liquid IDW drum. A stainless-steel bucket or closed 4-inch pipe can be used to contain the pump head and pump solutions. All pump effluent will be containerized IDW.
3. Using a brush, scrub the exterior of the pump and hose with the detergent solution. Rinse the exterior of the hose with a clean water rinse solution followed by an ASTM Type III water rinse. Recoil the hose onto the spool.
4. Pump organic free water through the hose to purge the clean water rinse solution. Purge additional organic free water through the hose with the pump in reverse.
5. Rinse the outside of the pump housing and hose with deionized water.
6. Wrap the pump in plastic sheeting for transport to the field or for storage to prevent cross-contamination.

15.5 Personal Decontamination

Personal decontamination procedures are outlined in the comprehensive CHASP.

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16.0 INVESTIGATION-DERIVED WASTE

16.1 Introduction

The following discussion outlines the manner in which IDW will be managed to comply with all applicable requirements. IDW generated during the RFI will likely include soil produced while installing hand-auger borings, soil borings and monitoring wells; groundwater derived from completing and purging the monitoring wells; disposable PPE and sampling utensils; and decontamination fluids from cleaning of PPE, sampling equipment, and drilling equipment. As the IDW generator, the Navy will be responsible for the ultimate treatment, storage, or disposal of all IDW. E/A&H will provide technical assistance to the Navy while managing all IDW.

Federal environmental laws and regulations that determine disposition of IDW at this site include RCRA (Land Disposal Restrictions [LDR]) and Corrective Action Program, the Toxic Substances Control Act (TSCA), and the Clean Water Act (CWA). State and local environmental laws and regulations also apply. The state regulations have a great impact on how IDW is managed, since South Carolina has promulgated more stringent requirements than the federal requirements for many programs, including the solid and hazardous waste program.

16.1.1 Resource Conservation and Recovery Act

RCRA was passed by Congress in 1976 to meet three goals: (1) to protect human health and the environment, (2) to reduce waste and conserve energy and natural resources, and (3) to reduce or eliminate the generation of hazardous waste as expeditiously as possible. The Hazardous and Solid Waste Amendments (HSWA) of 1984 significantly expanded RCRA by adding new corrective action requirements, LDR, and Minimum Technical Requirements (MTR).

RCRA is the most important federal statute for managing IDW, because it specifically regulates disposal of solid waste and all aspects of transportation, treatment, storage, and disposal of hazardous wastes. RCRA has 10 subtitles addressing specific waste management activities. Two

of these subtitles and their implementing regulations are specifically applicable for IDW handling: Subtitle C (Hazardous Waste Management) and Subtitle D (Solid Waste Management). The regulations are codified in 40 CFR Parts 260 through 272.

RCRA was developed first and foremost as a prevention-oriented program, with its primary objective to prevent new releases resulting in contaminated sites. Following this objective, a stringent set of standards were developed to ensure human health and the environment were protected from such ongoing waste management. The Subtitle C regulations are specified as uniform, national standards that must be complied with at all RCRA-regulated facilities. These standards generally are considered very stringent because they must ensure an adequate level of protection nationally. The standards must prevent or minimize environmental releases over a wide range of hazardous waste types, environmental conditions, operational contingencies, and other factors. The HSWA amendments strengthened the RCRA prevention program by adding the LDR and MTR, which have become central features of the RCRA prevention program. These features added incentives to generators to minimize the amounts of waste being created by providing technology-based standards for treating hazardous waste, in the case of LDR, and designing land-based disposal units, in the case of MTRs.

Under RCRA Subtitle C, wastes are defined as hazardous based on their source or method of generation ("listed" wastes) or their chemical constituents or characteristics ("characteristic" wastes). The hazardous waste identification rules are codified in 40 CFR Part 261. For example, 1,1,1-trichloroethane is a listed waste when it is a spent solvent. Based on the "contained-in interpretation," soil, groundwater, and other investigation wastes containing this listed waste also would be considered hazardous (USEPA 1986). Characteristic hazardous wastes include those with one or more characteristics of ignitability, corrosivity, reactivity, and toxicity. Determining whether a waste is hazardous may be based on knowledge of the IDW and associated suspected or known contamination, rather than by direct testing (USEPA 1991). The IDW generator may choose to characterize the waste as hazardous or non-hazardous based

on corporate knowledge of the history of the site and environmental data for the surrounding area, provided that knowledge or data are specific enough to enable waste characterization, without actually collecting a sample of the waste and testing it for hazardous waste parameters.

Land Disposal Restrictions: With respect to IDW management, the LDR program is one of the most significant provisions of RCRA. The LDR program, defined in RCRA Section 3004 and codified in 40 CFR Part 268, establishes technology-based standards that must be met before placing hazardous waste into land disposal units, which include landfills, surface impoundments, waste piles, and other land-based units. Hazardous waste generators must notify the receiving hazardous waste facilities that a waste is restricted from land disposal. Certification is required for all restricted wastes meeting LDR treatment standards when the waste is land-disposed.

For the purpose of managing IDW, land disposal occurs when any of the following activities take place:

- Wastes from different SWMUs or AOCs are consolidated and disposed of in one AOC.
- Wastes are moved outside of a SWMU/AOC for storage or treatment and are returned to the same or a different SWMU/AOC.
- Wastes are excavated from a SWMU/AOC, removed to a separate unit such as a tank, surface impoundment, or incinerator that is within the SWMU/AOC, and then are redeposited into the SWMU/AOC (USEPA 1991).

Waste that does not contain hazardous constituents as listed in 40 CFR Part 261 Appendix VIII or Part 264, Appendix IX and is not mixed with other contaminated IDW does not trigger LDR and may be replaced at the site from which it originated, provided the surface conditions permit (i.e., unimproved surfaces).

LDR limits the constituent concentrations of wastes that may be disposed in land units (such as landfills and surface impoundments). An important consideration in evaluating the applicability

of LDR is whether land disposal of hazardous IDW will occur as a result of the proposed storage or disposal method. Based on the delineation of a SWMU/AOC, LDR do not apply when uncontained hazardous IDW (soil or sediment) is handled as follows:

- Capped in place
- Treated in-situ
- Processed within the SWMU/AOC to improve structural stability
- Left in place, moved, or stored within a single SWMU/AOC unit

LDR prohibits storing **acutely toxic** hazardous waste beyond specified time limits, unless the purpose of storage is to accumulate sufficient quantities of waste to promote proper disposal, treatment, or recovery.

Corrective Action Program: In addition to the prevention-oriented provisions of RCRA, the HSWA corrective action program created a very different mandate for the RCRA program: cleaning up releases from SWMU at more than 4,000 RCRA TSDFs. While implementing these requirements and through its experience with the Superfund program, USEPA found that Subtitle C requirements, when applied to remediation wastes, could act as a disincentive to more protective remedies. These requirements also provided very limited flexibility in choosing the most practical remedy at a specific site. In response to this disincentive, USEPA developed two new types of waste management units, the Corrective Action Management Unit (CAMU) and the Temporary Unit (TU), as a mechanism for providing more regulatory flexibility at remediation sites while maintaining a standard of environmental protection.

CAMUs are land-based units that can be used to manage wastes during a site remediation. CAMUs provide two primary advantages:

- Placing remediation wastes into or within a CAMU does not constitute land disposal of hazardous wastes, so LDR standards are not triggered.

- Consolidating or placing remediation wastes into or within a CAMU does not constitute creating a unit subject to MTR.

TUs are for short-term operation of tanks and container storage units used for treating or storing remediation wastes. These units may only be used for remediation wastes, and they must be located at the facility where the remediation is occurring. TUs do not include incinerators, non-tank thermal treatment devices, or units regulated under 40 CFR Part 264 Subpart X (miscellaneous units). The corrective action regulations for temporary units provide that an alternative design, operating, or closure standard may be applied rather than the standards that normally apply to permitted facilities. Wastes can be stored in a TU for up to one year, with extensions available case-by-case.

16.1.2 Toxic Substances Control Act

Congress passed the TSCA in 1976 to establish requirements and authorities for identifying and controlling toxic chemical hazards to human health and the environment. While the majority of regulations promulgated under TSCA address chemical manufacturing, the law also covers the management and disposal of wastes containing PCBs in 40 CFR Part 761 and asbestos in 40 CFR Part 763. These regulations potentially affect IDW management in at least two ways:

- Non-hazardous IDW under RCRA that contains PCBs at concentrations greater than specified limits must be managed at facilities permitted under TSCA. Incineration is the most common option for wastes containing 50 parts per million (ppm) PCBs or greater.
- Non-hazardous IDW with PCB concentrations less than 50 ppm are generally not regulated under TSCA, although some states regulate these wastes as hazardous.

At this site, waste that contains any concentration of PCBs or asbestos will be regulated and disposed of as special waste.

16.1.3 Clean Water Act

The CWA, developed in 1977, provides site-specific pollutant discharge limitations and performance standards for specific industries to protect surface water quality. During an investigation, the most likely situation where the CWA will be applied involves the indirect discharge of IDW water to a publicly owned treatment works (POTW) or a wastewater treatment plant for treatment. A less likely situation may involve direct discharge, either onsite or offsite, to surface water. The CWA also regulates criteria for selecting POTW and sets ambient water quality criteria (AWQC) to protect human health and aquatic life. Regulations under the CWA are codified in 40 CFR Parts 121 through 136.

16.2 Generation of IDW

Activities that may generate IDW during operations at IRP sites include site investigations, removal actions, and underground storage tank (UST) investigations. IDW may include drilling muds, soil cuttings, purged groundwater, decontamination fluids, disposable equipment (DE), and PPE.

16.3 Sources of IDW

Field activities performed during investigations that may generate IDW typically include some or all of the following:

ACTIVITY	WASTE
• Monitoring well installation	• Soil cuttings, decontamination fluids, drilling mud, PPE, DE
• Monitoring well development	• Development water, silt, decontamination fluid, PPE, DE
• Groundwater sampling	• Purge water, decontamination fluid, PPE, DE
• Soil boring	• Soil cuttings, drilling mud, decontamination fluid, PPE, DE

- | | |
|-----------------------------|---|
| • Soil excavation/trenching | • Soil cuttings, decontamination fluid, PPE, DE |
| • Soil sampling | • Soil cuttings, decontamination fluid, PPE, DE |
| • Sediment sampling | • Sediment, decontamination fluid, PPE, DE |
| • Surface water sampling | • Decontamination fluid, PPE, DE |
| • Aquifer testing | • Development water, decontamination fluid, PPE, DE |
| • Radiation monitoring | • PPE, DE |

The wastes described above will be sampled and analyzed for disposal and storage. Section 16.5 describes how this determination will be made and how IDW will be characterized. Once the IDW is characterized, a determination may be made as to the waste's proper management. In addition to the waste types listed above, general refuse may be generated during field activities, including packaging materials, broken or cut-off well screening and casings. This refuse will be managed as non-hazardous material and disposed of accordingly unless evidence exists that would indicate the possibility of contamination, in which case it will be managed as IDW.

16.4 IDW Volume Estimates

Various field activities conducted during the course of investigation activities may create IDW. Estimated typical volumes of IDW generated from field activities are shown below:

- **Screening:** Screening studies typically include soil-gas, soil-probe, geophysical surveys, and water-level measurements. These activities may generate several 55-gallon drums of decontamination fluid, PPE, DE, and groundwater during the course of the initial studies.

- **Drilling:** Drilling of an 8-inch-outside-diameter (OD) soil boring will generate a minimum of 0.35 cubic feet (ft³), or 2.6 gallons of soil cuttings per linear foot of borehole. A 25-foot soil boring therefore would generate approximately 9.0 ft³, or 65 gallons, of soil cuttings (approximately 1.25 55-gallon drums). Table 16-1 shows the relationship between the diameter of the borehole and the potential volume of soil cuttings generated. Larger-diameter soil borings will generate proportionately larger quantities of soil. Additional soil quantities should be expected due to soil expansion following removal from the borehole (known as the "fluff" factor) and slough created during drilling, especially if poorly consolidated materials are encountered. It is estimated that the fluff factor increases soil-cutting volumes 30 percent. Soil cuttings generated during drilling will typically be placed into 55-gallon containers.

- **Well Development or Purging and Groundwater Sampling:** The volume of groundwater generated through monitoring well development and groundwater sampling depends on a number of variables, including the turbidity of the groundwater, well diameter, length of screened interval, diameter of the saturated filter pack, and porosity of the material used as filter packing.

Complete well development requires removing at least three times the amount of water used during drilling and constructing the well, plus three times the volume of the standing groundwater in the well. Table 16-2 shows the estimated water volumes for various well screen diameters and borehole radius, and assumes a 30 percent porosity within the filter pack.

Table 16-1				
Volume of Soil Cuttings Generated for Typical Diameter Boreholes				
Hole Diameter (inches)	Undisturbed Volume of Soils per Lineal Foot of Hole		Volume of Loose Soil per Lineal Foot of Hole	
	Gallons	Cu. Ft.	Gallons	Cu. Ft.
6.0	1.5	0.20	2.0	0.26
8.0	2.6	0.35	3.4	0.46
10.0	4.0	0.54	5.2	0.70
12.0	5.8	0.78	7.5	1.01

Notes:

Miscellaneous Data:

1 Cu. Ft. = 7.5 gallons (approximately)

1 Gallon = 0.134 Cu. Ft. (approximately)

Table 16-2	
Volume of Water Generated for a Typical Well Casing and Borehole Combination	
Well Casing/Boring Diameter (inches)	Volume of Water Generated per Lineal Foot of Hole (gallons)
2/8	0.9
4/10	1.2
4/12	2.2

For example, a 4-inch well with a 10-inch borehole would contain approximately 1.2 gallons of fluid per foot of saturated zone. If no additional construction water was used and only three volumes of water were pumped to develop 15 feet of saturated material, the well would produce approximately 54 gallons of fluid.

For hollow-stem drilling, additional water typically is used for flowing sand conditions and when soil conditions bind the augers. For normal well construction, minimal

additional water would be used. Additional water would be generated during later purging and sampling and would be specific to the conditions for the well.

The water generated during these activities will typically be placed in 55-gallon containers or in portable storage tanks.

- **Aquifer testing:** Aquifer tests that may be conducted at the NAVBASE may generate large quantities of groundwater, depending on the hydraulic properties of individual screened formations. A well installed in a formation with high transmissivity will sustain a higher pumping rate and generate greater quantities of water. A typical test may run for 24 to 48 hours and generate up to several gallons per minute (gpm). With large volumes such as these, it will be necessary to use 20,000-gallon portable tanks to store water generated from these tests. This water will typically undergo onsite pretreatment for disposal to a POTW. Slug tests typically will generate a small to moderate volume of decontamination fluid. In some instances, it may be possible to combine fluids from several different aquifer tests into one storage container.
- **Trenching and Subsurface Exploration:** For trenching or other large-volume excavations, it will be necessary to store the wastes in large covered roll-off bins or on an appropriate liner material and provide a cover. If possible, and when appropriate and approved by the regulatory agencies, the best option may be to return the materials to the excavation. Due to the large volumes of materials associated with this type of exploration, it is best to consider other suitable investigative techniques.
- **PPE, DE, and Decontamination Fluid:** The volume of IDW generated as PPE, DE, and decontamination fluids during each field activity depends on a number of site-specific factors and will therefore vary in quantity. Site-specific factors include the USEPA health and safety work level (Level D, Level C, or Level B), number and type of field

activities per site, and total number of sites being investigated. PPE waste volumes will typically account for one-half of a 55-gallon container per day for a crew of four. Decontamination fluid will vary from a few gallons per day for decontaminating monitoring instruments to several hundred gallons per day for large equipment such as drilling rigs.

16.5 IDW Characterization

The process of identifying and characterizing IDW will be started when planning field activities. Characterizing IDW is a multi-step process that involves determining the origin of the waste and then considering the chemical contaminants and their concentration in the waste. Typically, sampling data obtained from site characterization or investigation activities will provide an initial determination of whether a waste is hazardous or non-hazardous. IDW will be sampled and analyzed to provide additional information and to determine specific hazardous waste characteristics. Environmental samples relevant to IDW are soil samples (for soil cuttings and excavated soil) and groundwater samples (for purge water and development water).

The RCRA program recognizes two general classes of solid waste at the federal level: hazardous and non-hazardous. Hazardous wastes are defined by either being a listed waste, by origin, or by contaminant concentrations in the waste. A characteristic waste exhibits properties of ignitability, corrosivity, reactivity, or toxicity. A hazardous waste may be characterized as both a listed and a characteristic waste.

16.5.1 Listed Hazardous Waste

E/A&H project manager is responsible for identifying any potential listed hazardous wastes that may be present at the site to the NAVBASE Occupational Safety, Health and Environmental Office (Code 106). The project manager establishes the site's history and use, and determines whether activities there generate, or have generated, listed hazardous wastes. Examples of activities that may generate listed wastes include using solvents, rinsing and managing pesticide

containers, electroplating, dry cleaning, landfills, chemical disposal areas, surface impoundments and equipment storage areas. Every available source of site information, manifests, storage records, and vouchers will be researched to ascertain the source of these contaminants. The environmental analytical data should be reviewed to determine if the IDW contains any hazardous constituent found in the RCRA listed waste. USEPA's "contained-in" policy states that media such as soil and groundwater that contain a listed hazardous waste must be managed as a listed hazardous waste until they no longer contain that waste. No established policy exists on how to determine when the media no longer contain the listed hazardous waste. Usually this is determined on a case-by-case basis. Two aspects should be considered for managing IDW: whether the waste may also be hazardous for characteristics (as described in Section 16.5.2) and whether the cost of additional analytical work will offset the cost of managing the waste as a listed hazardous waste.

16.5.2 Characteristic Hazardous Waste

Characteristic hazardous wastes are based on general criteria. In order for a waste to be considered a characteristic hazardous waste, it must exhibit one or more of the following properties, as defined in 40 CFR Part 261.21 through Part 262.24:

- Ignitability
- Corrosivity
- Reactivity
- Toxicity
 - Heavy Metals
 - VOAs
 - SVOAs
 - Pesticides and herbicides

IDW does not usually exhibit the characteristics of ignitability, corrosivity, or reactivity due to the nature and matrix of the waste. Typically, IDW wastes consist of low concentrations of contaminants in soil and water. The quantities of these contaminants are typically not sufficient

to cause the soil or water to exhibit any of the characteristics of ignitability, corrosivity, or reactivity.

The characteristic for toxicity is based on the leaching characteristics of the waste. The TCLP simulates the effect of hazardous constituents leaching from a waste, and regulatory limits to protect human health and the environment are set by USEPA based on the TCLP test. Environmental data are reviewed to initially screen the IDW to help eliminate some or all of the toxicity characteristics. USEPA provides that if a total analysis demonstrates that individual constituents are not present in the waste, or that they are present but at such low concentrations that the appropriate regulatory levels could not possibly be exceeded, the TCLP need not be run (40 CFR Part 261 Appendix II).

16.5.3 Sampling and Analysis

IDW would be sampled and analyzed when corresponding environmental sample data are not available or when additional information is needed about the waste. All samples collected for waste analysis should be representative of the waste being sampled. Guidelines for collecting representative samples are contained in Chapter 9 of SW-846, *Test Methods for Evaluating Solid Waste* (USEPA 1986a).

16.5.4 Waste Profile

IDW is characterized through knowledge of the waste, review of environmental data that correlate to the waste, or sampling and analyzing the waste itself. This characterization leads to a waste profile summarizing all the information available on the IDW. The waste profile is required for shipping any IDW to offsite facilities. It will be completed by NAVBASE Occupational Safety, Health, and Environmental Office (Code 106) for all wastes generated in investigation activities as an accurate record of the waste identification, source, and characteristics. The waste profile is used to describe wastes that are generated consistently and that have similar or identical characteristics. The waste analysis and profile procedures will be

in accordance with NAVBASE Environmental Protection Manual, Volume II-10, Standard Operating Procedure No. 8, which is available for review in the Code 106 office.

16.5.5 Management of Disposable PPE and Equipment

Disposable PPE and DE will be managed according to the type of activity and level of contamination encountered with the equipment. Non-hazardous IDW will be appropriately labeled and placed in plastic bags to be transferred to an onsite industrial dumpster, whose contents are disposed of in a municipal landfill.

PPE and DE will be placed in 55-gallon drums, accurately labeled as discussed in Section 16.7 and stored at a container storage area. They will be stored until adequate characterization is complete for the site or containerized PPE and DE. The environmental sampling results from the sites where the IDW was generated will be reviewed upon receipt. PPE and DE contaminated with hazardous waste will be managed as hazardous waste, and will be characterized in a manner consistent with the media being sampled.

16.5.6 Management of Empty Drums

Empty drums may be generated in rare cases, such as when IDW is consolidated onsite to minimize the number of containers shipped to offsite waste management facilities. Empty drums also may be generated when IDW is removed from containers for treatment or disposal onsite. Federal regulations require that empty containers that held hazardous waste to be emptied to the maximum extent practical. In addition, if the container was used for an acutely hazardous waste, it must be decontaminated via triple wash and rinsing before any further use.

16.6 Storage

Specific storage requirements for IDW depend on a number of factors, including the location of the storage area, the length of storage, the type of storage unit, the type of waste, and the

regulatory status of the storage unit. Storing non-hazardous waste and designated waste in drums and portable tanks is not regulated by USEPA.

Storage of hazardous waste is regulated on the federal and state levels with three available options:

- Storage in a TU
- Storage for up to 90 days from the date of characterization
- Storage in a unit that meets permitted facility standards

These storage units may be located within the SWMU/AOC, within a designated CAMU, at a designated storage area on the installation, or at the permitted storage facility.

16.6.1 Storage in a TU

Storing waste in a TU provides the greatest flexibility for the design and operation of the storage unit. A temporary storage unit may be established for containers or tanks and may be located either within or outside an SWMU/AOC or CAMU. A major advantage of the TU is that IDW may be stored for up to one year, and waste may be removed from the TU and returned to the SWMU/AOC or CAMU for treatment or disposal without triggering LDRs or MTRs. TUs must be administratively created with regulatory agency input. Design of a TU must consider:

- Length of time the unit will be in operation
- Type of unit
- Volumes of wastes to be managed
- Physical and chemical characteristics of the wastes to be managed in the unit
- Potential for releases from the unit
- Hydrogeological and other relevant environmental conditions at the facility that may influence the migration of any potential releases
- Potential for exposure of humans and environmental receptors if releases were to occur from the unit

Specific design and operating requirements for accumulation storage areas and permitted storage units may be used as guidelines in developing temporary storage units. It is important for the Navy and E/A&H to determine whether the TU will reside within a SWMU/AOC or CAMU, and the specific SWMU/AOC or CAMU should be identified in site-specific plans for the TU.

16.6.2 Less-than-90-Day Storage Areas

Generators may accumulate hazardous waste in container storage areas or storage tanks for up to 90 days before shipment to an offsite TSDF. These storage areas and tanks are commonly called Less-than-90-day storage facilities. An area adjacent to Building 1278 has been designated as less-than-90-day storage for IDW.

Accumulation container storage areas must meet specific design and operational requirements outlined in 40 CFR §262.34(a) and R.61-79.262 Subpart C, which include the following:

- Containers must be in good condition and compatible with the waste placed inside them.
- Containers must be kept closed, except when waste is being added or removed, and they must be managed in a manner preventing rupture or leakage.
- Containers must be marked as hazardous waste and with the accumulation start date, composition and physical state of the waste, hazardous properties of the waste, and the name and address of the generator.
- The accumulation storage unit must be inspected and recorded at least weekly.
- Personnel handling the containers must receive initial and annual training related to operating and maintaining the accumulation storage unit. Code 106 personnel will provide IDW handling and have received HAZWOPER training for TSDF personnel as required by 29 CFR 1910.120.
- A contingency plan must be developed and emergency equipment provided for the accumulation storage unit. The contingency plan outlined in the Part B permit application for the NAVBASE satisfies this requirement.

- The accumulation storage unit must be closed to meet the RCRA closure performance standard. The less-than-90-day storage area at Building 1278 will be closed under the requirements of 40 CFR Part 264.111 and 264.114.

16.6.3 Permitted Container Storage Facility

The last storage option for IDW is to store it in a facility that meets all the design specifications and operating requirements applicable to permitted facilities. The requirements for permitted facilities were developed to allow longer storage of a variety of wastes generated at industrial facilities, and these requirements are the most stringent under RCRA. Buildings 246 and 1640 meet these requirements for storage of wastes listed in the Part B permit. The list however does not contain many of the P- and U-listed wastes found during preliminary investigations, which necessitates the less-than-90-day storage area at Building 1278. Storage at a less-than-90-day area does not require the permit to list the constituents being stored.

16.6.4 Inspections and Inventory Log

The storage areas (TU and 90-day accumulation) will be inspected at least weekly. A standard inspection form is kept by Code 106 for the Building 1278 storage area, showing the items to be inspected, discrepancies noted, and corrective actions taken. Container storage inspections cover the following areas:

- Condition of containers
- Adequacy and completeness of labels
- Evidence of leaks and spills
- Adequate aisle space
- Loading and unloading areas
- Emergency equipment

In addition to completing weekly inspections, an inventory of containers will be maintained by Code 106 that reflects the following information:

- Number of containers currently in storage
- Date each container was characterized
- Dates, manifest numbers, and destination facilities for IDW that is shipped to offsite management facilities
- Dates and disposition information for IDW that is disposed of onsite

16.6.5 Use of Portable Storage Tanks

Portable storage tanks often are used to accumulate and store liquid IDW, such as groundwater or storm water runoff. USEPA regulates these portable tanks as containers for storage onsite. Storage tanks should be labeled in the same manner as containers. However, if the portable tanks will be used to transport liquids to facilities outside the installation, U.S. Department of Transportation (DOT) regulations for container specifications and labeling must be complied with.

16.6.6 Repackaging and Overpacking Containers

Containers may require repackaging or overpacking if they become damaged or weathered and are no longer suitable for use. Repackaging involves transferring the waste from the damaged drum into a new container, whereas overpacking involves placing the damaged drum into a larger container. When repackaging or overpacking occurs, the new container must be labeled in an identical manner, and a note should be made in the field logbook or storage inventory log of the change in packaging or drum size.

16.7 Container Labeling

Waste labeling and record-keeping requirements include initial labeling of containers:

"ANALYTICAL RESULTS ARE PENDING ON THE CONTENTS IN THIS CONTAINER."

A completed label should include the following information: date contents were placed in container, sample identification number(s) (See Section 11), IDW type, source site number, and boring or monitoring well number. A sample drum label used for identifying containerized IDW pending characterization is shown in Figure 16-1.

All labeling information for each drum will be entered into the field logbook. After the drums' contents are characterized, as described in Section 16.5, the labels will be replaced to reflect the appropriate classification of wastes within the drums and the logbook will be updated.

Drums containing hazardous IDW will be labeled "HAZARDOUS WASTE — South Carolina Law Prohibits Improper Storage or Disposal. If found, contact nearest police or public safety authority or the S.C. Department of Health and Environmental Control" in accordance with 40 CFR Part 172 and the applicable South Carolina Public Service Commission regulations (Figure 16-2). Drums containing non-hazardous IDW will be labeled "NON HAZARDOUS WASTE" (Figure 16-3). Drum labels will be placed on the side of the drum, not on the lid, to reduce weathering and to prevent the possibility of interchanging labels if lids are reused.

Plastic bags containing PPE and DE will be identified with a drum label wrapped around a piece of wire to produce a tag that will close the bag. In addition to labels, drums will be painted with unique identifiers in case the labels are lost or removed. The identifier will include the site number and a unique identification number and will be entered into the field logbook or storage inventory log.

16.8 Treatment and/or Disposal of IDW

Once the waste characterization process has been completed for IDW, treatment and disposal options may be considered that provide for appropriate waste management. The options available at a particular installation depend on:

- Availability of onsite management facilities, such as wastewater treatment plants, bioremediation facilities, and other treatment technologies that may have been developed for other cleanup sites.
- Availability of municipal POTW with the capability to treat wastewaters generated at the installation.
- Site conditions and regulatory approval for disposal of non-hazardous soil back onto the site where generated. Soil that does not contain chemicals of potential concern (COPC as defined by the Baseline Risk Assessment) above background concentrations will be recommended to be placed back on the site where generated.
- Any soil or sediment that contains COPCs at concentrations that may pose a risk to human health and the environment but is not determined to be a hazardous waste will be handled as a hazardous material. Proper disposal will be coordinated with the Navy, USEPA, and SCDHEC.

The offsite waste management options addressed in this section include management of aqueous liquids at installation wastewater treatment plants, management of aqueous liquids at POTWs, and management of offsite facilities using the waste management subcontract.



NAVY CLEAN
ENSAFE/ALLEN & HOSHALL
(901) 383-9115

ANALYTICAL RESULTS ARE PENDING ON THE CONTENTS OF THIS CONTAINER

THE CONTENTS WERE GENERATED FROM AN ENVIRONMENTAL INVESTIGATION

THIS CONTAINER HAS: SOIL

GROUND WATER

THIS CONTAINER HAS:

THIS CONTAINER HAS:

SOURCE: SITE

MW/SB#

DEPTH

DATE: OPENED

SEALED

DRUM #

CONTACT

FOR FURTHER INFORMATION

THIS CONTAINER WILL BE APPROPRIATELY LABELED AND THE CONTENTS DISPOSED OF
ACCORDING TO FEDERAL AND LOCAL REQUIREMENTS WHEN THE LABORATORY RESULTS ARE KNOWN

HANDLE WITH CARE



FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 16-1
DRUM LABEL
DATA PENDING

DATE: 08/08/94

DWG NAME: 29DRML8L

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HAZARDOUS WASTE

FEDERAL LAW PROHIBITS IMPROPER DISPOSAL

IF FOUND, CONTACT THE NEAREST POLICE, OR
PUBLIC SAFETY AUTHORITY, OR THE
U.S. ENVIRONMENTAL PROTECTION AGENCY

PROPER D.O.T.
SHIPPING NAME _____ UN OR NA# _____

GENERATOR INFORMATION:

NAME _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____

EPA ID NO. _____ EPA WASTE NO. _____

ACCUMULATION START DATE _____ MANIFEST DOCUMENT NO. _____

HANDLE WITH CARE!
CONTAINS HAZARDOUS OR TOXIC WASTES

STYLE WM 6

Printed by LABELMASTER, Div. of AMERICAN LABELMARK CO. CHICAGO, IL 60646



FINAL CSAP
NAVAL BASE
CHARLESTON
CHARLESTON, S.C.

FIGURE 16-2
HAZARDOUS WASTE LABEL

DWG DATE: 08/08/94 DWG NAME: 029HWLBL

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NAVY CLEAN
ENSAFE/ALLEN & HOSHALL
(901) 383-9115

INVESTIGATIVE DERIVED WASTE

NON-HAZARDOUS

ACCUMULATION
START DATE _____

CONTENTS
(CIRCLE)

SOIL WATER PPE

HANDLE WITH CARE!!!



FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 16-3
DRUM LABEL

DATE: 08/08/94

DWG NAME: 029IDHW

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16.8.1 Disposal of Aqueous Liquids through POTW

NAVBASE currently is operating under a National Pollution Discharge Elimination System **pretreatment** permit issued by the North Charleston Sewer District. Discharging IDW to the POTW will be considered under certain circumstances. Pursuant to the conditions of the **pretreatment** permit issued to the facility from the **North Charleston Sewer District**, any discharge of aqueous IDW will not exceed concentrations specified for listed constituents. Discharge of aqueous IDW will not occur until the POTW (North Charleston Sewer District) has reviewed the analytical data of the drum contents **and pH is determined by a state certified laboratory**.

16.8.2 Disposal of IDW through Offsite TSD Facilities

Currently Code 106 manages IDW within the hazardous waste management program at NAVBASE. The disposal is accomplished by another command, Defense Reutilization and Marketing Office (DRMO), under contract with an offsite TSDF. The Navy EIC and E/A&H may chose to establish a subcontract or use existing waste disposal subcontracts with waste management firms to provide waste management services for IDW including pickup, transportation, treatment, storage, and disposal of waste.

IDW transportation is coordinated and scheduled by Code 106. Code 106 is responsible for ensuring the following documentation is generated as well as maintenance of records for time specified in state regulations:

- **Uniform Hazardous Waste Manifest.** This document is used for cradle-to-grave tracking of waste regulated as RCRA hazardous under the federal regulations, and waste regulated as non-RCRA hazardous under South Carolina regulations. It must be signed by the generator (specifically, the Navy installation point of contact) before the shipment leaves the installation. The first transporter also must sign the manifest before the

shipment leaves the installation, and the generator copy of the manifest is retained by the Navy installation point of contact.

- **Non-hazardous Waste Manifest.** This document is used to track all IDW shipments of non-hazardous waste, including waste that is shipped to Class II and Class III landfills in South Carolina. The non-hazardous waste manifest also may be used for non-hazardous waste shipped to facilities outside South Carolina. The non-hazardous waste manifest is signed by the generator and the first transporter before the shipment leaves the installation, and the generator retains a copy.
- **Land Disposal Restriction Notification.** This notification is required for all RCRA hazardous waste that is restricted from land disposal under 40 CFR Part 268 and for RCRA hazardous and non-RCRA hazardous waste that is restricted from land disposal under R.61-79.268. This notification is signed by the waste generator, and it tells the receiving facility what standards must be met for the waste before it can be placed in a hazardous waste landfill. A copy of the LDR notification is kept by the generator, and the original is attached to the manifest. A shipment of waste may have more than one LDR notification that contains standards for several different waste streams.
- **Land Disposal Restriction Certification.** An LDR certification is required when a restricted waste is shipped directly to a hazardous waste landfill without pretreatment because it already meets the applicable treatment standards. The generator must certify that all the applicable standards have been met, and waste analysis to support that must be attached to the certification. A copy of the LDR certification is kept by the generator, and the original is attached to the manifest.

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APPENDIX A

COMPREHENSIVE SAMPLING AND ANALYSIS PLAN REVIEW FORM

Orientation Meeting

Instructions for Use: Before performing any actions at Naval Base Charleston, E/A&H personnel will attend an orientation meeting at which the following requirements will be fully explained. Sign and date this form to indicate that you have reviewed these requirements.

General Requirements

- Charleston map showing locations of Naval Base Charleston and selected courier office
- Map of Naval Base Charleston showing locations of site and site office trailer
- Health & Safety Plan (See Health & Safety Officer)

Sampling Requirements

- Unified Soil Classification System (USCS)
- Stainless Steel Sleeves
- Sample Numbering System
- QA/QC Frequency
- QA/QC Definitions
- Sample Packaging

Documentation Requirements

- Field Forms
- Field Logbooks
- Photographs

Acceptance

I have reviewed and understand all of the requirements listed above for field activities at Naval Base Charleston.

Name

Date

APPENDIX B

OPERATING MANUAL FOR HYDROLAB DATASONDE 3 DATALOGGER

Hydrolab Operating Procedures

The Hydrolab Datasonde 3 (DS3) Multiparameter Water Quality Datalogger is an on-line transmitter of in-situ water quality measurements. The device measures temperature, pH, dissolved oxygen (DO), conductivity, salinity, depth, and Redox readings in lakes, streams, estuaries, or other large or small water bodies. The DS3 is designed for multi-mode operation. Data output can be continuously monitored, or the unit can operate remotely with data stored on board until downloading. Its digital output can be displayed, logged, and downloaded to a personal computer, or remotely transmitted through a modem or communications link. The device is built for operation in abusive field conditions.

DS3 Data Display Variables (Accuracy)

- Temperature in deg C/F ($\pm 0.15^{\circ}\text{C}$)
- pH in units (± 0.2 units)
- Redox in millivolts ($\pm 20\text{mV}$)
- Dissolved Oxygen (DO) in milligrams per liter (mg/l) or % Saturation DO ($\pm 0.2\text{mg/l}$)
- Conductivity in milliSiemens/cm, microSiemens/cm, K ohms/cm, or resistivity ($\pm 1\%$ of range)
- Salinity in ppt or total dissolved solids (TDS) ($\pm 0.2\text{ppt}$)
- Depth (feet or meters) in level or total level ($\pm 0.45\text{m}$)

The DS3's waterproof cylindrical core is constructed of durable plastic and contains a battery pack, a real-time clock, a solid-state memory package, and logging software. Attached to the lower end of the core is a multi-probe unit containing a temperature sensor, a specific conductance/salinity sensor, a pH glass electrode, a Redox sensor, a DO sensor, and a depth sensor. The lower end also contains the unit's sensor guard and ballast weight, or stirrer assembly. The upper end of the DS3 unit contains the an RS-232 data output port, and a stainless steel anchoring bail.

Standard Operating Mode

Once communication is established between the DS3 and computer, the following introductory heading will appear on-screen:

HYDROLAB Datasonde 3 VX.YZ
(C)opyright 1990 Hydrolab Corporation

Time	Temp	pH	SpCond	Salin	DO	DO	Redox	Depth	Batt
HHMMSS	deg C	units	ms/cm	ppt	%Sat	mg/l	mv	meters	volts

This header appears only if the header function of the Variables Menu is enabled. The header denotes the DS3's software version, its alpha-numeric name, measurement parameters currently enabled, and the current measurement variables selected for those parameters. If these features are changed after the program is entered, the new alpha-numeric name and parameters will be displayed when communication with the unit is re-initiated. Immediately following the appearance of the header, the DS3 will enter its Standard Operating Mode (SOM), whereby row after row of parameters will appear on screen. The third and fourth lines of the introductory header will be reprinted once every 24 lines so the columns can be identified once the initial header has scrolled off-screen.

The Basic Menu

The Basic Menu is accessed from the SOM by hitting the space bar. The following then appears on-screen:

HYDROLAB Datasonde 3 V X.YZ

- (P)arameters
- (C)alibrate
- (V)ariables
- (L)ogging
- (H)earer
- (M)easure
- (I)dentify
- or (Escape or Ctrl X to cancel)

Typing any of the letters in parentheses will allow access to the menu of interest. Each entry within a menu results in the program returning to the SOM. The menu selection must therefore be re-accessed via the Basic Menu after each entry is made.

- **Parameters**

Typing a "P" will access the Parameters Menu, providing the following display:

- (p)H
- Specific (C)onductivity/Resistivity
- (S)alinity/TDS
- (%)Sat
- D(O)
- (R)edox
- (D)epth/Level
- (B)attery
- (A)ll
- or (Escape or Ctrl X to cancel)

Selecting the letter in parentheses allows individual parameters to be enabled or disabled from this menu. Care should be taken when using this function, as certain parameters are depend upon others. For instance, disabling all forms of specific conductance will automatically disable DO, or enabling DO will automatically enable specific conductance. Time and Temperature cannot be disabled.

- **Variables**

Typing a "V" from the Basic Menu will access the Variable Menu, which allows default settings to be made for measurement variables. The Variable menu appears as follows:

- (T)emperature
- Specific (C)onductance/Resistivity
- (%) Sat
- D(O)
- (D)epth/Level
- (A)utolog
- SDI-12 Addr(e)ss
- SDI-12 De(l)ay
- (H)eadler
- (B)uzzer
- (S)tirrer
- E(x)pert
- Ba(u)d Rate
- or (Escape or Ctrl X to cancel)

Typing any letter in parentheses will allow selection of a particular feature from the Variable Menu.

Temperature

This feature allows the temperature variable to be manipulated. Either the Centigrade or Fahrenheit scales are selected for temperature measurement.

Specific Conductance/Resistivity

This feature allows either specific conductance or resistivity to be selected as a measurement value, and permits additional attributes to be adjusted. Succeeding choice of measurement value, the presentation of this value is selected in either milliSiemens/cm or microSiemens/cm. Following selection of presentation format, the type of cell block is selected (freshwater if specific conductances between 0-10 mS/cm are anticipated, seawater if specific conductances greater than 10 mS/cm are anticipated). The specific conductance measuring range is then chosen. The measuring range can be automatic, or readings can be made in the high, medium, or low range. The next item selected is for salinity to be measured, or TDS. The final item selected is for specific conductance/resistivity and salinity/TDS readings to be compensated or uncompensated for temperature.

% Sat

This feature allows a barometric pressure that is different from the calibration value to be entered, if necessary.

DO

This feature allows certain aspects of the DO measurements to be specified. Standard or Hydrolab LoFlow membranes are selected, as are whether readings are to be compensated for salinity, or uncompensated.

Depth/Level

This feature allows manipulation of the depth/level variable. Either meters or feet are chosen to express depth. Following selection of the variable, either "depth" or "level" is chosen, depending on how the DS3 is equipped. If the unit is equipped with a depth transducer (having a range of 0 to 100 meters), depth is chosen for this expression. If the unit has a level transducer (having a range of 0 to 10 meters), level is chosen for this expression. The transducer type is printed on the DS3's label.

Autolog

This feature allows access to Autolog. This function enables or disables the automatically started logging sequence, which provides a record of all parameters once each hour. An enabled autolog can provide backup data for situations where the starting time or date, stopping time or date, or interval time has been incorrectly specified. Also, if for some reason there is a reset of transmitter electronics (power fluctuations, etc.), Autolog is set by default to be enabled.

SDI-12 Address

This feature allows the unit to be personalized. The SDI-12 address that the user wishes to assign a particular DS3 is entered.

SDI-12 is an interface bus designed to allow connection of a wide variety of transducers without having to worry about incompatible sensor outputs. It sends information to a single data recorder (the SDI-12 Controller) with a single cable bus.

SDI-12 Delay

This feature allows incorporation of a measurement delay (normally 30 or 120 seconds).

Header

This feature allows the display of header information to be enabled or disabled. If enabled, header information is included in the data lines.

Buzzer

This feature allows the buzzer function to be enabled or disabled. If enabled, a buzzer sounds each time a reading is made.

Stirrer

This feature allows the stirrer function to be enabled or disabled. Once enabled, the DS3 automatically actuates the stirrer for each logging run.

Expert

This feature enables or disables the expert function, which abbreviates items appearing on the menu screen and data printout.

Baud Rate

This feature allows the unit to be set to a different baud rate before dumping a memory file. The DS3 starts up at 1200 baud. However, 1200 baud is not fast enough to keep up with a DS3 during recovery of logged data. The Baud Rate feature allows selection from five available baud rates (9600, 44800, 2400, 1200, or 300). The communications program for the computer will need to be set to the selected baud rate.

Report

This feature provides a report of all of the default settings currently selected from the Variable Menu.

- **Calibration**

Before deploying the DS3, the unit should be checked for calibration and operation. Calibration should also be checked periodically when the unit is deployed in the field for extended periods. The unit is calibrated by pouring a calibration standard into the calibration cup that comes with the apparatus. Alternately, the entire unit can be immersed in a bucket of calibration standard.

Typing a "C" from the Basic Menu will access the Calibrate Menu, which is displayed as follows:

- (p)H
- Specific (C)onductivity/Resistivity
- (S)alinity/TDS
- (%)Sat
- D(O)
- (R)edox
- (D)epth/Level
- (L)abel
- (T)ime
- (I)nterval
- (M)essage
- or (Escape or Ctrl X to cancel)

Typing any of the letters in parentheses will allow calibration of that particular function. Temperature is permanently set at the factory and cannot be field calibrated.

pH

pH calibration is initiated by using a pH 7 buffer solution to first adjust the pH system's zero. Subsequently, a slope buffer solution is used to adjust the pH system's slope. The unit will accept any pH value between 6.8 and 7.2 for the zero setting. Typing in the value of the buffer automatically calibrates the pH system to zero. To adjust pH slope, the calibration procedure is repeated with the slope buffer solution. The slope buffer value must be below 6.8 or higher than 7.2 for proper adjustment.

Specific Conductance/Resistivity

Specific conductance calibration is initiated by monitoring readings until they have stabilized for the standard solution, and then entering the value for the standard. If the default setting has been set to measure resistivity, the resistivity value for the standard is entered.

Salinity/TDS

Salinity calibration is initiated by accessing the salinity/TDS function. If the default setting is set for salinity, the value of the salinity calibration standard in parts per thousand at 25°C is entered. If TDS is the default selection, the TDS for the calibration standard is entered.

Dissolved Oxygen

DO calibration can be set for % saturation or for mg/l. Type "%" to calibrate for % saturation. Once into this function, enter the local barometric pressure (in millimeters of mercury). This adjusts calibration for both DO mg/l and DO % saturation (calibration should be 100.0 for the standard membrane, or 102.5 for the Hydrolab LoFlow membrane). Alternatively, type "O" to calibrate for DO mg/l. Enter the local barometric pressure as before, subsequently entering the DO concentration of the calibration standard as measured via Winkler titration or other instrumentation.

Redox

The Redox value of the calibration standard can be entered upon access to the Redox function.

Depth/Level

Depth calibration can be zeroed in air, at or near the surface of the water to be sampled, or at a known water depth. The depth is entered in either meters or feet, depending upon the default variable.

Additional Features of the Calibrate Menu

Entering the Label function allows the name of the transmitter to be changed (up to 12 characters). Accessing the Time function, allows the month/day/year/time to be entered. The military time format is used (HHMMSS). The Interval function allows the time to be set for the data printing interval. The Message Interval allows notes to be entered into the data record being created, if necessary, to help maintain clarity of the record.

- **Logging**

The Logging Menu allows the set up of a logging routine for automatic, unattended monitoring. The DS3 transmitter can log in two forms of memory, depending upon the configuration of the unit. Standard memory can log up to 32,000 readings (allowing all parameters to be logged twice an hour for approximately 60 days). Extended memory can log up to 70,000 readings.

If information is downloaded to a computer, the PC must be IBM compatible, possess a serial or COMM port, have DOS version 2.0 or higher installed, and be compatible with a DB25F to DB25M adapter cable. The PROCOMM Plus Software Terminal Emulator Program is required to properly interface the PC with the DS3. To communicate with a PC, make sure the baud rates for both DS3 and computer are compatible. The unit's default setting is 1200 baud, but can be changed through the Variable Menu. An interface cable, underwater cable, or calibration cable can be used to connect the DS3 to the computer. Since the DS3 needs to be powered during the logging sequence, sufficient battery power needs to be available. Once connected, if the DS3 and computer are properly interfaced, pressing the space bar accesses the SOM/Basic Menu.

Typing an "L" from the Basic Menu allows access to the Logging Menu, which is displayed as follows:

- (D)ump
- (E)rase
- (S)etup
- S(t)atus
- (R)evuew
- (A)nnotate
- St(o)re
- or (Escape or Ctrl X to cancel)

Typing any of the letters in parentheses will allow entry into that particular logging function.

Dump

This feature allows the user to erase files no longer needed. Logging runs can be set up, and data files can be reviewed. Data storage on the manual file can be initiated, or this file can be annotated. Data can be dumped as "printer ready" if it is to be used for disk archiving or for word processing. Data can also be dumped into a file that is pre-formatted for a spreadsheet.

The Dump function allows selection of different configurations of variables/calibrations:

- Variables/calibrations in effect when the logging run was setup can be used,
- If re-calibration took place at any time during a run, data can be adjusted to reflect the calibration changes as they took place,
- The variables/calibrations current at the time of data dump can be used.

This feature allows comparison of readings for an indication of calibration drift. If improper variables were set, (cell block type, DO membrane type, etc.), corrections can be made by re-dumping with those variables changed to a proper setting.

Selection of the Printer Ready function allows automatic statistical work to be done. Statistics are compiled for each parameter in the form of the number of readings taken, the number of readings taken that were out of the parameter's measurement range, minimum and maximum readings, maximum rate of change between measurements, and mean/standard deviation. Daily statistics, total statistics, both daily/total statistics, or no statistics can be chosen.

If any parameter values are accompanied by an asterisk (*), that value is based on a default calibration setting. This means that the DS3 has forgotten the calibration information provided for the sensor measuring that parameter, and has replaced it with a nominal calibration setting. The affected sensor needs re-calibration, and if the parameter affects other parameters, these will also appear with asterisks (i.e., specific conductance, which affects salinity, DO and depth readings).

Selection of the Spreadsheet Importable function pre-formats data for spreadsheet distribution, quoting all text. This download is accomplished via an X-modem transfer. The Spreadsheet Importable function does not compute any statistics, however.

Erase

The erase function allows a file to be erased to regain use of the memory space occupied by that file.

Setup

This function allows a logging run to be setup. Before starting the logging run, the status of all enabled/disabled parameters should be checked, as well as the status of the stirrer and buzzer. The stirrer and buzzer cannot be altered during a logging run, while calibration and variables can be changed during a run.

To set up a run, the menu calls for the name of the logging run to be entered. It then asks for entry of commencement date/time (in MMDDYY/HHMMSS), and stopping date/time (in MMDDYY/HHMMSS). The program then asks for the time between logging scans (in HHMMSS), and if a warmup is desired prior to commencement of the run. The warmup function allows the DS3 to warmup for 2 minutes prior to the logging run, recommended if a stirrer is used or if DO-pH-Redox sensors are not continuously polarized. Power consumption must be considered. This 2-minute warmup is not necessary if the DO-pH-Redox internal polarizing batteries are used. These batteries continuously power the pH and Redox amplifiers, and the DO sensor, doing away with their 2-minute warmup requirement. A possible shortened life span for the DO sensor must be considered. Even if no warmup is chosen, the DS3 automatically warms up for 30 seconds before beginning a logging scan.

Once a logging run has been set up, the DS3 is disconnected from the interface cables. The transmitter will activate automatically when the logging run starts. It will continue to activate until logging is scheduled to stop, the power supply is depleted, or the memory is full.

Status

This function displays a logging status report. The name and number of each logging run is listed (start/stop/interval). Remaining memory (number of scans/readings based on current parameters) is listed, and remaining battery time (% battery life) is estimated.

Review

This function allows stored data to be scanned without dumping the entire file. The scan can begin at the beginning of a file, the end of a file, or at a specific date and time.

Annotate

This function allows a 49-character annotation to be entered in a text format adjacent to a particular file. The note will then be downloaded along with the file.

Store

This function allows a manual entry of data for a particular situation. If during a survey, the readings for a particular station have stabilized, the data can be immediately stored as a manual file.

- **Header**

Typing an "H" from the Basic Menu allows access to the Header Menu. This causes the header to be printed, and is useful if the Header function has been disabled through the Variables Menu.

The header will appear as:

ABCDEF123456

Time	Temp	pH	SpCond	Salin	DO	DO	Redox	Depth	Batt
HHMMSS	deg C	units	ms/cm	ppt	%Sat	mg/l	mv	meters	volts

- **Measure**

Typing an "M" from the Basic Menu allows access to the Measure Menu. Actuating this feature will cause one line of data to be printed immediately. This is useful if the user wants to take occasional discretionary readings.

- **Identify**

Actuation of this feature from the Basic Menu causes the DS3 to print its software version and parameters which the unit will currently support. It will appear as:

Hydrolab DS3 VX.YZ TPCS%ORDB

Power Supply

The internal battery pack uses 10 "AA" batteries, which are contained in the upper part of the unit. The internal battery pack will support a unit for 20 days (stirrer used) or 30 days (no stirrer used). A submersible external battery pack also can be used, and will support the DS3 for up to 140 days, but cannot be used with a stirrer. Power can also be furnished by cable. The power source must remain connected to the transmitter during the logging function.

Unit Configuration

Configuration of a DS3 should be carefully considered. If the HydroLab LoFlow DO sensor is used, internal polarizing batteries are necessary. This is because the LoFlow DO sensor requires a 5-minute warmup period, and should therefore be continuously powered. If the standard membrane DO sensor is used, a stirrer is necessary unless a flow rate of 25 cm/sec is maintained past the sensor. The 2-minute warmup is sufficient for the standard DO membrane. If the LoFlow DO sensor is used, the weighted sensor guard is used over the multiprobe unit. The stirrer replaces the sensor guard when used, and also provides sensor protection and negative buoyancy.

Deployment

The DS3 is anchored by tying a rope or chain to the stainless-steel bail at the top of the unit. The device should be fixed either upright or level. The unit should be protected from floating debris, and should not be deployed in a location that makes it a navigation hazard. If marked with a buoy, it should not be made attractive to vandals. It is recommended that the multiprobe weighted sensor guard or stirrer be installed, as well as the DO sensor guard. The pH reference electrode should be uncapped. Be prepared to re-calibrate as necessary. The DO membrane may require changing after only a few days. If the unit is stationed in shallow water, there is a danger it could be hit by boats or outboard motor propellers.

DS3 Maintenance

Contaminated or worn out sensors will produce unreliable data. The maintenance manual provides instructions on replacing or servicing worn sensors. This requires careful disassembly of some of the sensors, and re-calibration. A maintenance schedule needs to account for periodic down time for each unit.

APPENDIX C
OPERATING MANUAL FOR THE NISKIN WINGED CURRENT METER



GENERAL OCEANICS

MODEL 6011 MKII
NISKIN WINGED CURRENT METER
OPERATING MANUAL
RAM MEMORY
MARCH 1991

Preliminary

YOUR CURRENT METER SHOULD BE RECEIVED WITH THE FOLLOWING ITEMS.
PLEASE CHECK WHEN UPACKING TO BE SURE THEY ARE INCLUDED.

1. 6011MK2 CURRENT METER
2. VISIBLE SENSORS, PRESSURE & CONDUCTIVITY
3. WIRE MOORING STANDOFF FRAME (W/ANODES) AND WIRE STOP
- * 4. RAM MEMORY CARTRIDGE
5. OPERATORS MANUAL

*RAM MEMORY CARTRIDGES AND RAM READER KITS ARE PRICED SEPARATELY
IF ANY OF THE ITEMS ARE MISSING, PLEASE CONTACT G.O. ASAP

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1 INTRODUCTION

The General Oceanics model 6011 MkII is a battery-powered RAM recording current meter. It measures current by measuring the angle of tilt of its own housing when suspended from a suitable mooring. Wings on the housing orient the meter with the current, the direction of which is then determined by a solid-state flux-gate compass. The absence of rotors and other delicate external sensors, together with its extremely low power consumption, make the meter ideal for long term deployments in the deep ocean, while its small size and ease of handling make it the choice for much inshore work.

The meter incorporates a real-time clock. This means that Universal Coordinated Time (GMT) is recorded with each data point on the RAM cartridge. Log keeping and data analysis are thereby simplified and there is less chance of ambiguity in interpreting the data record. The real-time clock is powered by its own battery, which is separate from the meter's main power battery, and which has a five-year lifetime.

The basic meter records temperature as well as the data for current speed and direction. Sensors to measure conductivity and pressure are also available as options.

In the "Vector-Averaging" mode, the internal microprocessor computes the average east and north components of current from a number of individual readings and records only those averages on the RAM cartridge, a data compression technique which increases the effective capacity of the cartridge by up to thirty-two times. The microprocessor also computes and records the standard deviation of the averages to provide information on the noise environment of the meter. Vector-averaging is the preferred mode of operation. It provides the maximum amount of data and requires the least amount of post-deployment data processing.

After the meter has been recovered the RAM cartridge must be processed. General Oceanics offers the service of reading RAM cartridges and supplying a complete range of data products. Alternatively, the user can acquire a model 6011RR RAM reader to interface with any one of a range of desk-top computers, which allows the user to process the data himself.

General Oceanics can supply auxiliary hardware to facilitate deployment of the model 6011 current meter in a wide range of situations. Deployment from a fixed structure such as an oil rig or harbor pier is the easiest to set up. For near-bottom measurements, a "gallows" frame is available which provides a fixed point mooring at a known height in the water. Most deployments use a wire mooring with either a surface or sub-surface float. For this application a "stand-off" is used, which can be clamped to the wire at any depth without cutting or damaging the wire in any way. The stand-off not only keeps the

meter clear of the wire, but also de-couples the meter from mooring motion. Both a standoff and a wire stop are supplied with the meter.

The design of the stand-off and the operating principle of the meter itself both help to simplify mooring design. Being able to clamp the stand-off at any point along the wire makes it easy to re-configure a mooring to meet changing operational requirements. Also, since the meter takes up an angle of tilt determined only by the current, the tilt of the mooring itself is a secondary consideration. This means that, particularly in high current regimes, buoyancy requirements and anchor weights can be greatly reduced.

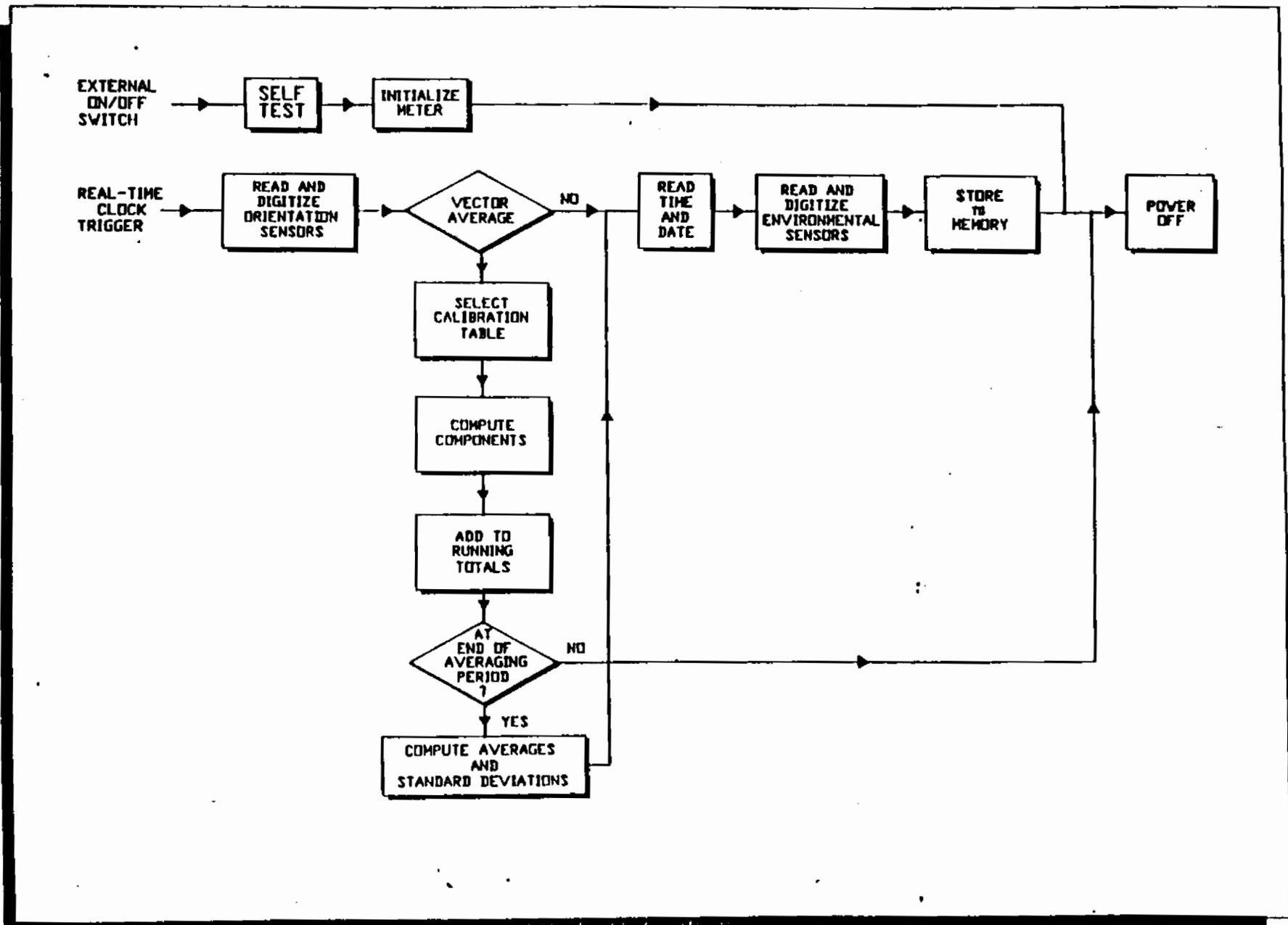
The meter is normally supplied with a standard fin which covers the speed range zero to 225 cm/sec. For greater resolution at low speeds or to extend the range to higher speeds, low-speed and high-speed fins are available.

2 PRINCIPLES OF OPERATION

2.1 Basis

The Model 6011 MK II current meter is a microprocessor controlled data logger which captures data from a number of sensors and then records them on a RAM cartridge. The overall operation of the meter is best explained by the simplified program flow chart shown in Fig. 1.

Fig. 1 Simplified Program Flow Chart

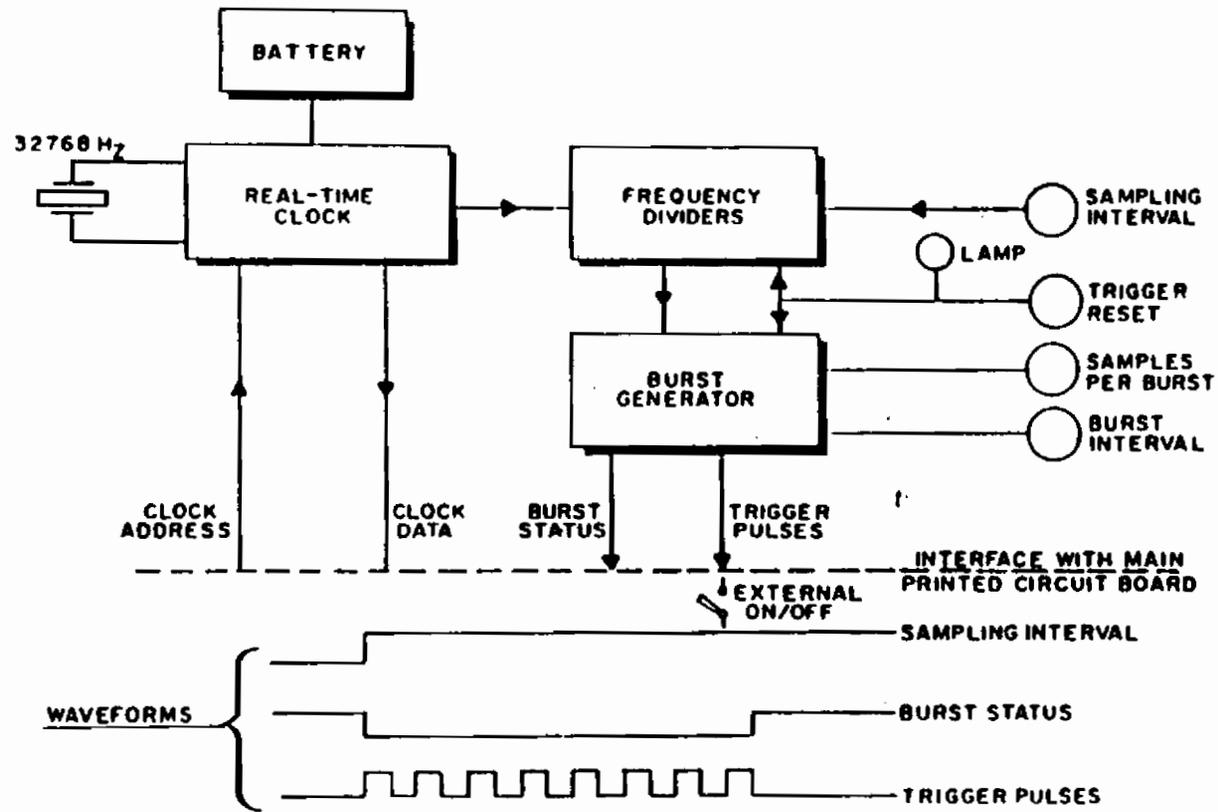


2.2 Vector Averaging

In the vector-averaging mode, the microprocessor proceeds to compute the north and east components of current immediately after it has read the orientation sensors. To compute the components it needs to know which of the three fins are fitted to the meter. This information is provided by the setting of the mode selector switch: positions 2, 3 and 4 for vector averaging with low, standard and high speed fins. The number of samples over which the average is taken is determined by the setting of the samples-per-burst switch on the real-time clock board. As shown in Fig. 2, a line called "burst status" remains low during the burst period. All the time the status line is low, each component is added to a running total. If it is high, signalling the end of the averaging period, the running total is divided by the number of samples to arrive at the average. Standard deviation is treated in a similar way. The meter then goes on to read the real-time clock and the outputs of the environmental sensors. Each reading is tagged with time and recorded to RAM. Finally the meter is powered down. This means that battery power to the sensors and any other high current components is switched off; only the essential time-keeping components and some of the data memory remain operating. Hence, current consumption between samples is reduced to a few microamps, allowing the meter to operate for up to one year on a single battery. One can see from the last part of the flow chart that time, date and the readings of the environmental sensors that are recorded correspond to the LAST of the samples used to form the vector averages of current, a point that may be significant in data interpretation.

Calibration tables for all three fins are stored in the meter so that if a fin is changed it is necessary to set the mode selector switch to the new position. The tables for meters fitted with pressure and conductivity sensors are slightly different from those without.

Fig. 2 Real-Time Clock.
Block Diagram



2.3 Self test

An external ON/OFF switch is mounted on the end cap of the meter's pressure housing. As the hardware block diagram in Fig. 2 indicates, when the switch is in the ON position trigger pulses from the real-time clock are allowed to reach the power control circuitry and the meter cycles through its measuring and recording functions as already described. In the OFF position the meter remains in the quiescent, low power, condition. Turning the switch from OFF to ON triggers a self-test and initialization sequence.

3 CONTROLS AND INDICATORS

3.1 User Operated Controls

The Model 6011 Mk II current meter has a number of user-operated controls which select the various operating modes and sampling intervals. Most of the controls are mounted on the main printed circuit boards (see Fig.3) and are accessible only when the meter is withdrawn from its pressure case. The one external switch is mounted on the end cap opposite to the swivel end. Conductivity and pressure sensors, when fitted, are mounted on the same end cap.

3.2 External ON/OFF Switch

This rotary action switch controls the flow of trigger pulses from the clock board to the main board. In the OFF position no pulses get through and the meter remains in its standby state drawing minimum battery current. In the ON position the meter is triggered into operation at the rate set by the sampling-interval and burst-sampling switches. If the meter is out of its pressure case, the successful progress of the routine can be followed by counting the eight flashes of the self-test lamp.

Normally, this switch will be turned ON or OFF once or twice as part of the check out procedure and then left OFF until just before deployment.

3.3 Sampling Interval

This switch sets the basic sampling interval of the meter in all its operating modes. Operated with the aid of a small screwdriver, this 10-position switch selects intervals from 7.5 seconds to 60 minutes. See SPECIFICATIONS for the full range of available intervals.

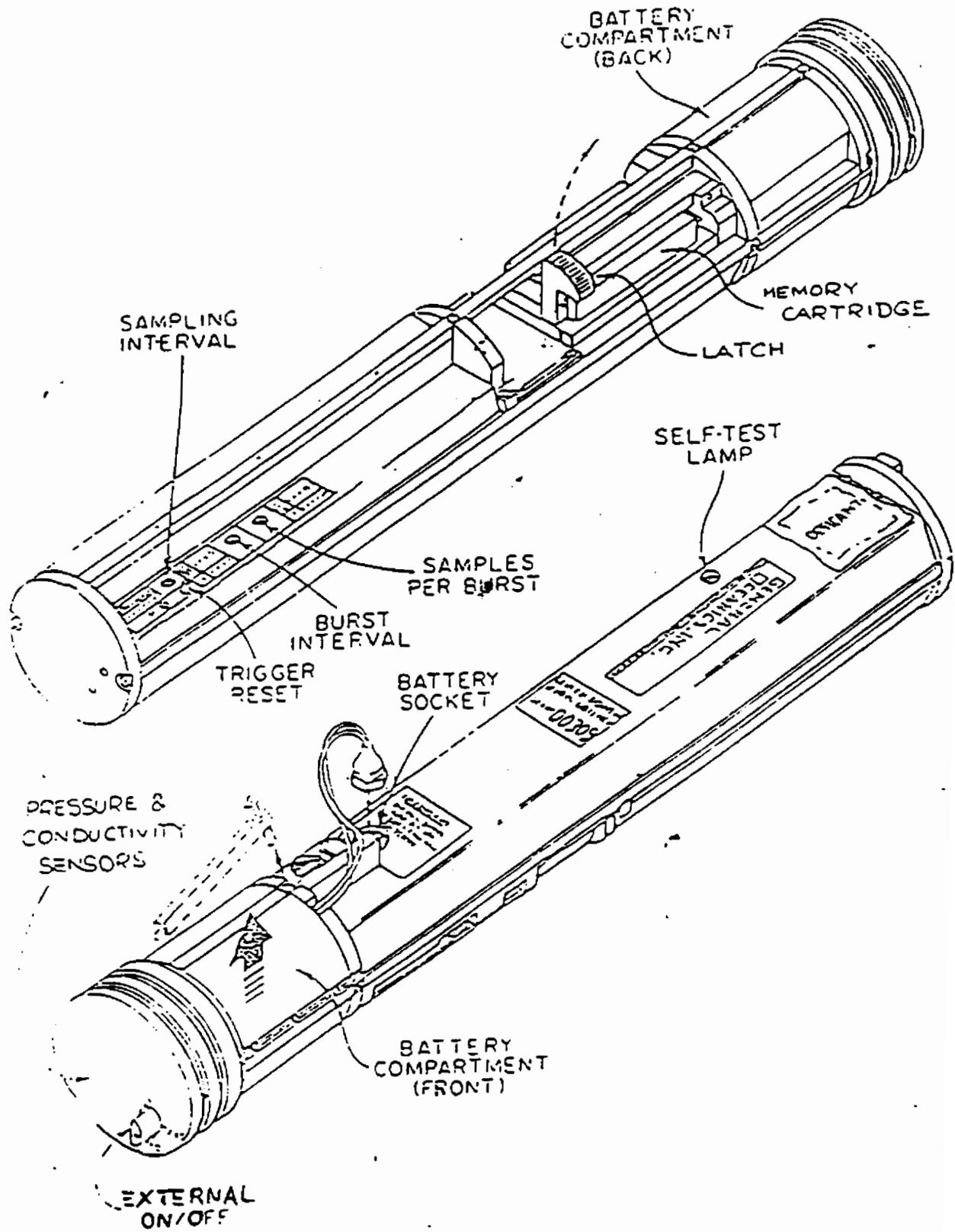


Fig.3 Layout of main features and controls

3.4 Burst Length

A 6-position switch selects the number of samples in a burst. The numbers available are one to 32 in 1:2 steps. This switch selects the number of samples over which the average is taken. In position six, for example, a burst of 32 samples will be averaged before being recorded as a single value. With the switch in position one, the burst length is a single sample.

3.5 Burst Interval

A 4-position switch determines the interval between the samples to be used in a vector average. Thus, if a burst of eight samples and an interval of four seconds are selected, the effective averaging period will be 32 seconds.

3.6 Trigger Reset

Pressing this button resets the counting circuitry so that trigger pulses can be made to occur at a known time in each hour. The general rule is that the first trigger pulse occurs at a time one half of the selected sampling interval after pressing the reset button. If a sampling interval of one minute has been selected, for example, then the first trigger will occur 30 seconds after pressing the trigger reset button, the next at one minute and thirty seconds, the next at two minutes and 30 seconds and so on. The general rule does not apply for the 30 and 60 minute sampling intervals. In both cases the first trigger occurs 22.5 minutes after reset; all the following ones are at the selected intervals.

The red indicator lamp next to the button provides a positive indication that reset has occurred.

The push-button has no effect on the setting of the real-time clock.

3.7 Mode Selector

This switch, mounted on the opposite side of the meter from the other four controls, determines the vector-averaging mode. Position 1 is for factory use. Positions 2, 3 and 4 select the vector averaging mode. Position 2 should be used if a low-speed fin is fitted to the meter, 3 for a standard fin and 4 for a high-speed fin. When computing the vector averages, the microprocessor examines the switch setting in order to select the correct fin calibration look-up table.

3.8 Self-Test Lamp

When the meter self-test is triggered by actuating the external ON/OFF switch, this lamp flashes at the rate of eight times in three seconds as the test proceeds.

4 RAM MEMORY OPERATION

4.1 Introduction

RAM Memory is a solid-state memory system which replaces the more traditional tape recorder and data cassette for long term storage of the data gathered by the current meter. It makes use of a removable data cartridge containing its own 10-year battery power source. The cartridge is smaller than a standard audio cassette, offers up to twice the data capacity, and can be quickly and conveniently changed in the field with no external equipment.

The design of the RAM Memory incorporates a number of features to ensure that recording will take place reliably during a deployment and that data cannot be accidentally erased after a recovery of the meter. For instance, a mechanical interlock prevents the user closing the pressure housing if the cartridge is incorrectly seated in its holder and a self test procedure warns if the cartridge's internal battery has run down. After recovery, a write-protect switch on the cartridge can be set, thus making it almost impossible to inadvertently erase the stored data.

A simple reader is available (601iRR) which plugs into an expansion slot of an I.B.M.* P.C. or PC/XT desktop computer. This, together with software which is supplied by General Oceanics, allows the user to read and process the data stored in the cartridge.

*Registered trademark of International Business Machines Corporation.

4.2 Cartridge Data Capacity

Cartridges are available in nominal capacities of 64, 128, 256 and 512 kilobytes. Each data record in the meter is stored as a 13-byte word. In addition, 13 bytes are used to store the instrument serial number together with some information used internally by the meter itself. Taking as an example a 128 kbyte cartridge, we can now calculate its capacity in terms of data records. The actual size of the cartridge is 131,072 bytes. This leaves 131,059 bytes for useful data, which is equivalent to

10,081 complete data records. The corresponding figures for the other sizes are 5,040, 20,163 and 40,328 data records. The largest capacity cartridge, therefore, allows recording once every ten minutes for almost a full year.

5 INSTRUMENT PREPARATION

5.1 Battery Capacity

First check that there is sufficient battery capacity remaining to run the instrument for the planned deployment period. The only way to be sure of this is by keeping an accurate record of battery use on the label provided on the side of the battery. If there is any doubt, use a new battery. (Refer to section 6.3.1 Battery Life.)

5.2 Battery Replacement

The actual removal and replacement of the battery is very straight forward. The grey plastic battery holder is held in place by a short retaining bar which is secured with a single captive screw. Battery connection is via the blue 5-pin connector at the end of the short pigtail. As the battery holder is being slid into position, take care to guide the pigtail into the slot provided.

5.3 Switch Settings

First select the mode, selector switch. If vector averaging then make sure the switch points to the correct fin. Then set the burst-interval and samples-per-burst switches for the desired averaging period. Thirdly, bearing in mind the constraints pointed out in paragraph 8., select the sampling interval to match the planned deployment period. Finally, press the trigger reset button to lock the triggering sequence in the right phase with the real-time clock.

Again, for many applications, averaging over 32 samples at 2-second intervals (Samples-per-Burst=32: Burst Interval=2sec.) provides good coverage. The sampling interval can be set anywhere between 2 minutes and 30 minutes, depending on the duration of the deployment.

When the instrument has been prepared as just described, activate the external ON/OFF switch to trigger the self test sequence (eight flashes of the self test lamp). Some practice may be needed in positioning the meter so that the self-test lamp can be observed while activating the external switch. If all is well at this stage the switch should be turned off and the meter sealed in its pressure housing.

5.4 Sealing Up

The important points at this stage are (1) place a desiccant bag in the pressure housing, and (2) make sure that the single O-ring seal, and its mating surface, are clean, lightly greased and undamaged. CHECK THAT THE SERIAL NUMBER OF THE HOUSING MATCHES THAT OF THE METER'S ELECTRONICS. Slide the meter carefully into the housing, checking that the battery pigtail is tucked out of the way. Turn the meter so that the alignment hole in the end cap matches the one in the housing. As the meter is driven home, the pin at the end of the meter should engage the locating hole in the far end cap. Secure the meter using the thick nylon monofilament locking cord. It should slide into the matching half-grooves in the end cap and the pressure housing until only the L-shaped termination is exposed. The short end of the L is then pressed into the aligned holes. This ensures that the meter's internal sensors are lined up with the center line of the fin.

5.5 Deployment

After the meter has been prepared as described in the foregoing paragraphs, all that remains is to TURN THE EXTERNAL SWITCH ON and attach the meter to the mooring.

5.6 Fin Change

If the meter is to be used in areas where very high or very low currents are expected, the standard fin can be replaced by one with the appropriate range (see SPECIFICATIONS for ranges available). The fin is secured by two cable ties which rest in grooves in the pressure housing (see section 12.3 for part numbers of replacement ties). The fin is aligned with the meter's direction sensors by the nylon bolt at the swivel end of the housing; the bolt is in turn secured by a locking screw in one of the lugs of the end cap. Note that although the fin can be changed, THE PRESSURE HOUSING AND ELECTRONICS PACKAGE MUST STAY TOGETHER AS A PAIR TO PRESERVE THE ACCURACY OF CALIBRATION.

6 DEPLOYMENT

6.1 Preparing for Deployment

In preparing a meter the user should, in general, follow the procedures detailed in Section 5 (INSTRUMENT PREPARATION) of the Operating Manual.

The mode selector switch (described in section 3.7) should be set to position 2, 3, or 4 depending on whether a low, standard or high speed fin is fitted to the meter.

Fig.1' shows the RAM Memory cartridge in place in the current meter. To plug in the cartridge simply lift the latch, turn the cartridge so the write-protect switch faces outwards, and insert it into the 30-pin socket. If the cartridge is not properly seated, the latch will not spring back to its fully closed position and it will be impossible to slide the meter into the pressure housing.

Finally, set the write-protect switch on the cartridge to OFF, plug in the battery, and turn on the external ON/OFF switch. The meter will then go through a self-test routine as indicated by the Self-Test lamp flashing eight times. If the lamp does not flash, check that the cartridge is properly plugged in with the write-protect switch off.

6.2 Unplugging the Cartridge

When the current meter is recovered at the end of a deployment it will be necessary to remove the cartridge from the meter in order to read it. The cartridge is so designed that is very difficult to lose or alter the stored data while unplugging it. However, to be absolutely sure, the following procedure should be followed:

- a) As the meter arrives on deck set the External ON/OFF switch to the OFF position and note the time.
- b) Rinse with fresh water and dry the meter as usual.
- c) Remove the meter from the pressure housing.
- d) Set the write-protect switch on the RAM cartridge to the ON position.
- e) Unplug the battery.
- f) Lift the latch (see Fig 1) and remove the cartridge from its socket.

All the time the cartridge is out of the meter the write-protect switch should be left in the ON position.

6.3 Other Notes

6.3.1 Battery Life

RAM Memory draws less power from the battery allowing more readings to be taken. For instance, when taking 32-sample averages, the battery has enough energy for 40,000 32-sample averages. So, the maximum deployment time is one year OR the time to record 40,000 32-sample averages OR 80,000 16-sample averages OR 160,000 8-sample averages, whichever is the shortest. Note that the 40,000 averages could be recorded in a single deployment using a 512 kbyte cartridge or in a series of deployments using a 128 kbyte cartridge several times.

6.3.2 Last Record Data Loss

The RAM Memory system can lose some data as a result of the averaging process itself. For example in the process of assembling a 32-reading average, the meter is switched off just before taking the 32nd reading 31 data points have been lost.

6.3.3 Monitor Connector

The monitor connector is disabled except for the manufacturer's use. To check out a meter, it is a simple matter to record a few minutes' worth of data and then read the cartridge.

6.3.4 Serial Number Record

The first two bytes in the RAM Memory cartridge are used to record the meter's full serial number.

6.3.5 Data Format

Data within the meter are handled as binary numbers, each having sufficient bits to match the required precision. As the data are prepared for recording the individual numbers are stacked end to end to form a string 104 bits long. During the recording process itself the string of bits is stored in the RAM Memory cartridge eight bits at a time as 13 bytes. The bits for each record are organized as follows in the order shown:

<u>Data</u>	<u>Number of Bits</u>
Month	4
Day	5
Hour	5
Minute	6
Pressure	12
Temperature	12
Conductivity	12
East current component	12
West current component	12
Standard deviation in east component	12
Standard deviation in west component	12
Total	<hr/> 104

The way in which each piece of data is encoded and the significance of each bit in the record are as follows:

<u>Number of bits</u>	<u>Vector Averaging</u>
1	1
7	Serial Number
4	Month
5	Day
5	Hour
6	Minute
12	Pressure
12	Temperature
12	Conductivity
12	East Component
12	North Component
12	E. Std. Deviation
12	N. Std. Deviation

112

7 BATTERY

7.1 Battery Safety

Lithium batteries store a large amount of energy in a small volume so they should always be handled with care. The following rules should be followed:

- DO NOT incinerate, short circuit, puncture, crush or disassemble the battery.
- DO NOT attempt to re-charge the battery.
- DO NOT store or use the battery at temperatures above 72 deg. C.

8 CAUTIONARY NOTES

8.1 Choice of Sampling Interval

When vector averaging, the sampling interval must be long enough to allow the meter to complete its cycle of operation. For example, if a burst length of 32 samples is selected together with a burst interval of two seconds the cycle takes almost 64 seconds to complete. In this case the sampling interval should be no less than two minutes

(since the next shortest interval, one minute, is insufficient to accommodate the complete cycle).

If too short an interval is inadvertently selected the meter automatically compensates, for many combinations of burst length and burst interval, by ignoring the intermediate trigger pulses. However, at best, this can only complicate later interpretation of the data record.

9 SPECIFICATIONS

Speed:

Sensor: Force-balance tilt sensor.
Range: 0 to 300 cm/sec. (with appropriate fin)
Accuracy: +/- 1 cm/sec.
Resolution: +/- 1 cm/sec.

Direction:

Sensor: Three-axis flux-gate compass
Accuracy: +/- 2 degrees.
Resolution: +/- 1 degree.

Temperature:

Sensor: Aged linear thermistor
(Yellow Springs Instrument Co. Type 44202).
Range: -5 to +45 degrees C.
Accuracy: +/- 0.25 Degree C.
Resolution: +/- 1/64 Degree C.
Thermal time constant: < 2 MINUTES

Conductivity:

Sensor: Inductive Toroid
Range: 0 to 75 mS/cm.
Accuracy: +/- 2.5 mS/cm.
Resolution: +/- 0.1 mS/cm.

Pressure:

Sensor: Strain gauge.
Range: 0 to 10,000 p.s.i.
Accuracy: +/- 0.5%
Resolution: +/- 0.1%

Internal clock:

Type: Quartz crystal.
Accuracy: +/- 0.1 second/day
Outputs: Trigger pulses. Date and time information.
Power: Lithium battery independent of meter's main battery. Battery life: 5 years.

Sampling interval:

Selected by 10-position switch.
Available intervals: 7.5, 15, 30, 60 seconds,
2, 5, 10, 20, 30, 60 minutes.

Burst sampling:

Samples per burst selected by 6-position switch;
2, 4, 8, 16, 32 samples per burst.
Burst interval selected by 4-position switch;
2, 4, 8, and 16 seconds.

Data capacity:

Cartridges are available in nominal capacities of 64, 128, 256 and 512 kilobytes. Each data record in the

meter is stored as a 13-byte word. In addition, 13 bytes are used to store the instrument serial number together with some information used internally by the meter itself. Taking as an example a 128 kbyte cartridge, we can now calculate its capacity in terms of data records. The actual size of the cartridge is 131,072 bytes. This leaves 131,059 bytes for useful data, which is equivalent to 10,081 complete data records. The corresponding figures for the other sizes 5,040, 20,163 and 40,328 data records. The largest capacity cartridge, therefore, allows recording once every ten minutes for almost a full year.

Data translation:

Using Model 6011RR reader with desk-top computer (e.g., I.B.M. *P. C. or compatible).

Battery:

Two D-size lithium cells with capacity of 14 amp-hours.
Output: 7.8 volts
Life: up to one year, depending on operating mode.

Pressure case dimensions:

Length: 54.9 cm. Diameter: 10.5 cm.

Weights:

In air: 9/0 Kg. In water: 4.5 Kg.

Pressure Seal:

Single O-ring.
Tool-free opening and closing using General Oceanics' standard plastic cord sealing system.

Exposed material:

Plastic and hard-coat anodized dichromate sealed aluminum.

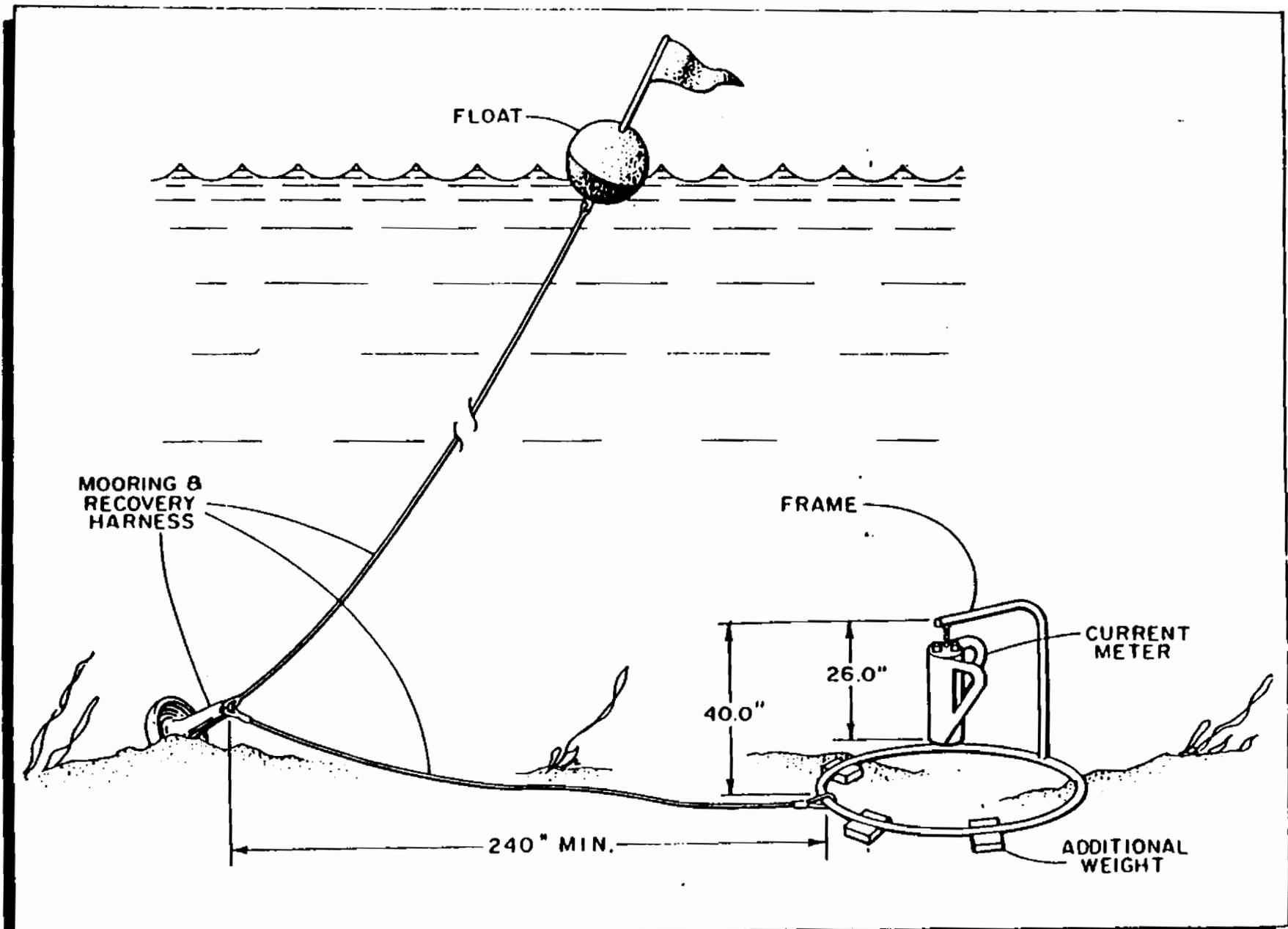
Wing characteristics:

Low speed: 0 to 70 cm/sec.
Standard: 0 to 225 cm/sec.
High speed: 0 to 300 cm/sec.

10 MOORING METHODS

Figs. 4 and 5 illustrate possible ways of deploying the Model 6011 MkII current meter. Its lightness and compactness considerably ease the expense and difficulty of designing moorings. In deep-sea moorings, especially, the savings are enhanced by the reduced requirements in flotation, anchor weight and cable size.

Fig. 4 Deployment for Near-Bottom Measurements



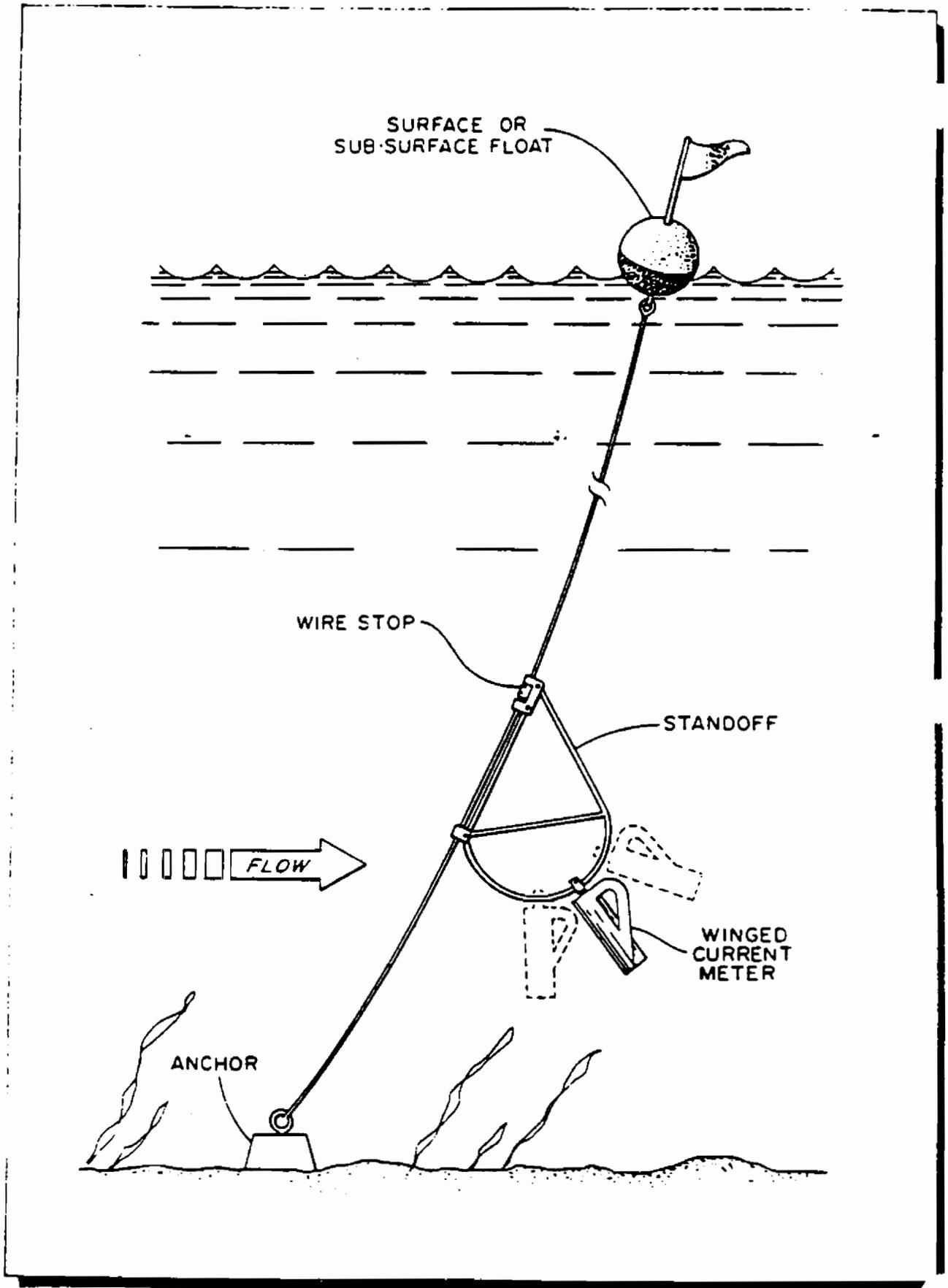


Fig.5 Typical Deep-Sea Deployment

11 CALIBRATION CURVES

On the following pages are six calibration curves showing tilt angle as a function of current speed for the low-speed, standard and high-speed fins. For each speed there are two curves. One is for meters that have no environmental sensors the other is for meters fitted with a conductivity sensor. The addition of a pressure sensor does not change either calibration curve. A temperature sensor is fitted to all model 6011 meters but since it is buried in the end cap, it too has no effect on the calibration curves.

Model 6011 Calibration Curve

Low Speed Fin; No Environmental Sensors

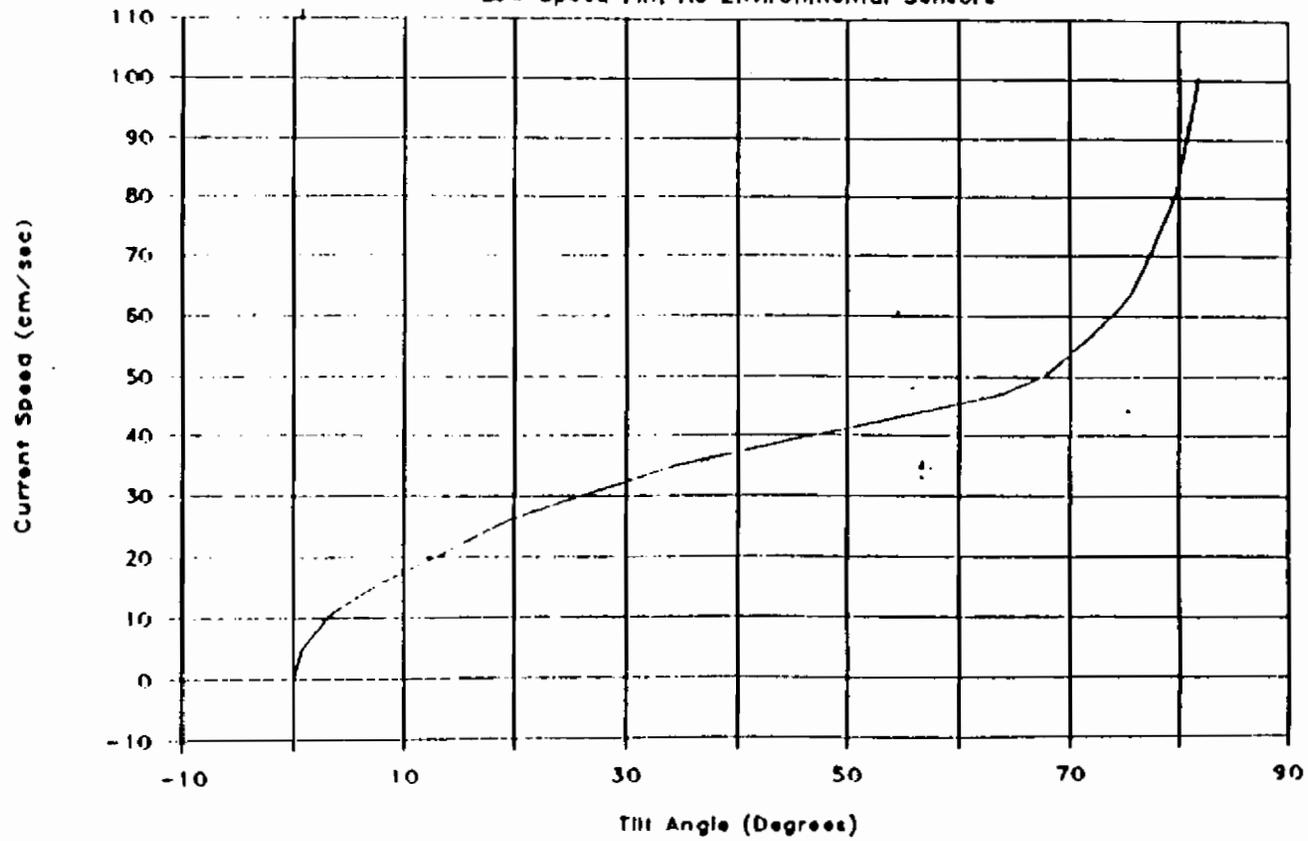


Fig. 6 Calibration Curve
Low-Speed Fin; No Environmental Sensors

Model 6011 Calibration Curve

Low Speed Fin with Conductivity

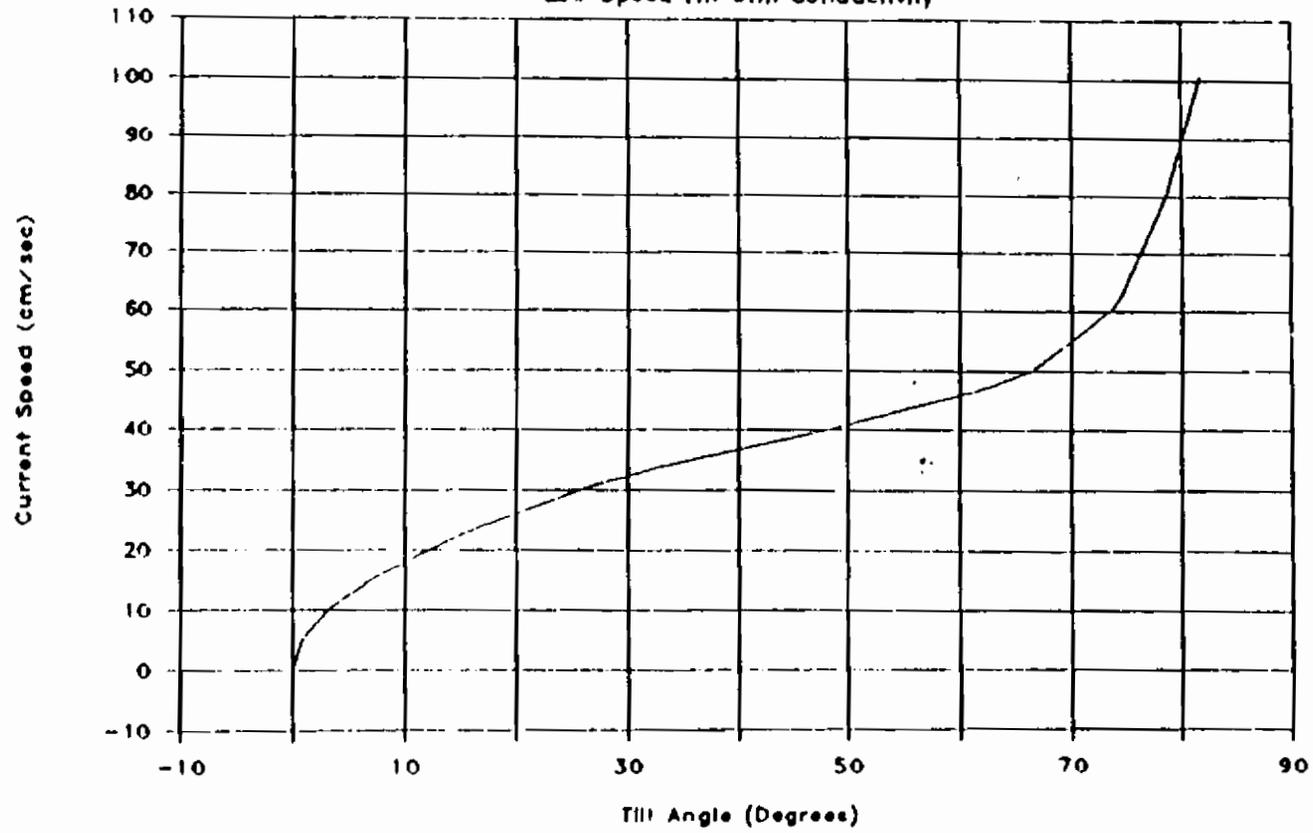


Fig. 7 Calibration Curve
Low-Speed Fin with Conductivity

Model 6011 Calibration Curve

Standard Fin; no Environmental Sensors

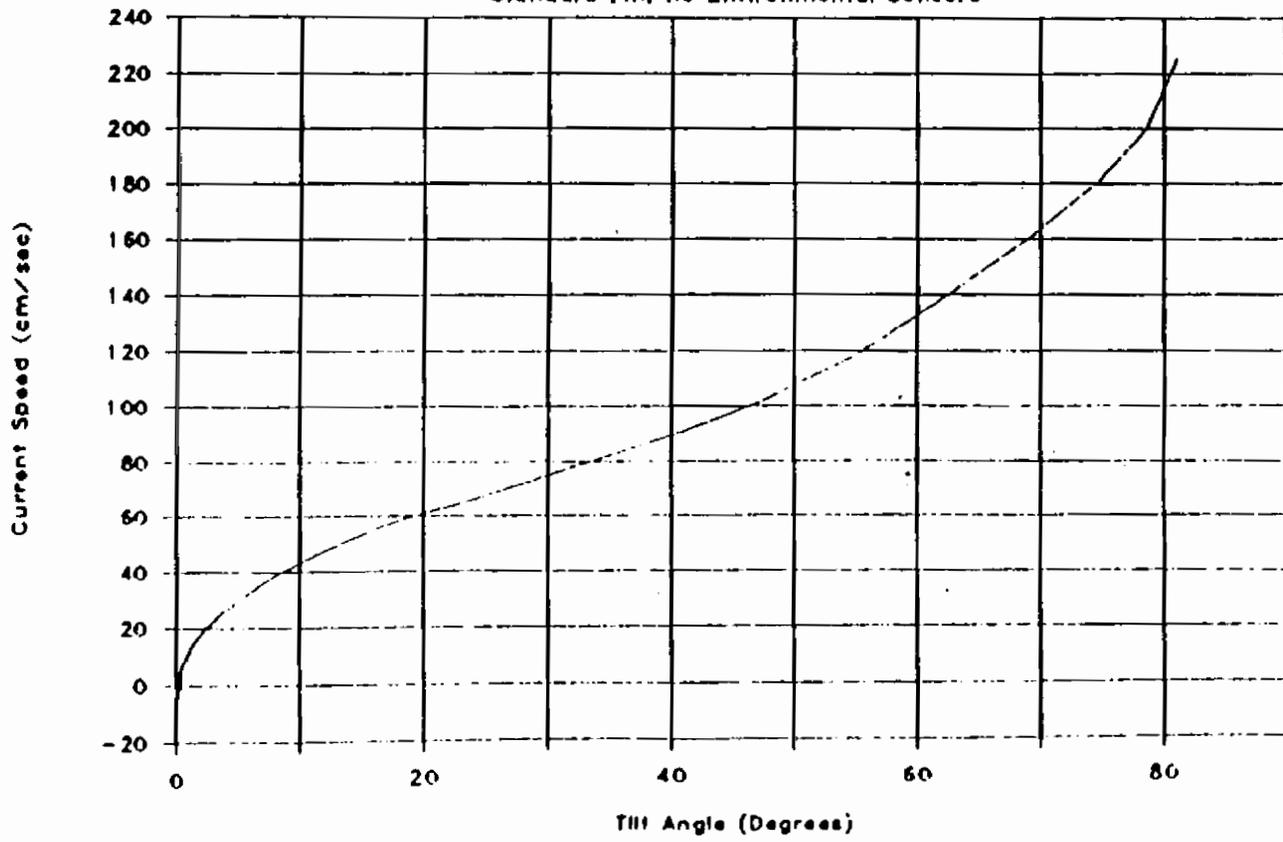


Fig. 8 Calibration Curve
Standard Fin; No Environmental Sensors

Model 6011 Calibration Curve

Standard Fin with Conductivity

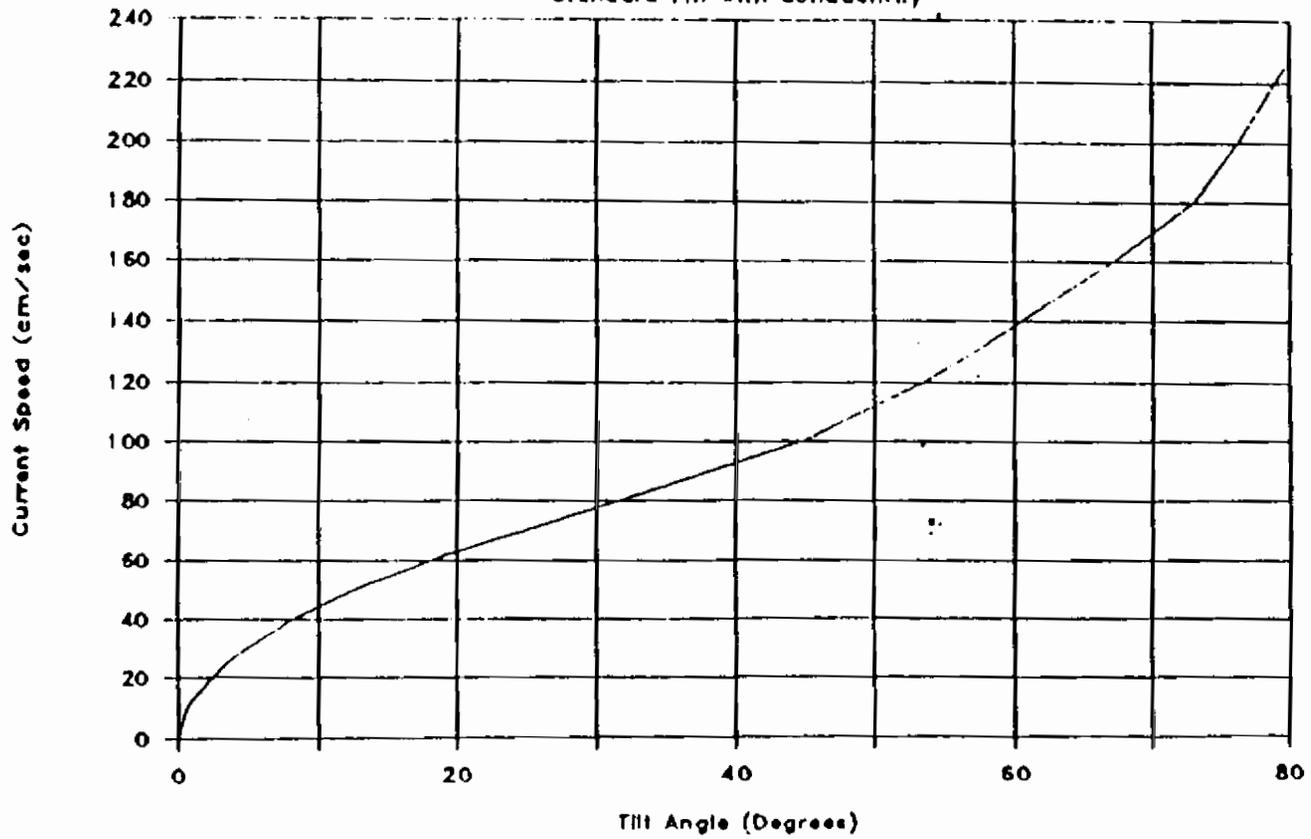


Fig. 9 Calibration Curve
Standard Fin with Conductivity

Fig. 10 Calibration Curve
High-Speed Fin: No Environmental Sensors

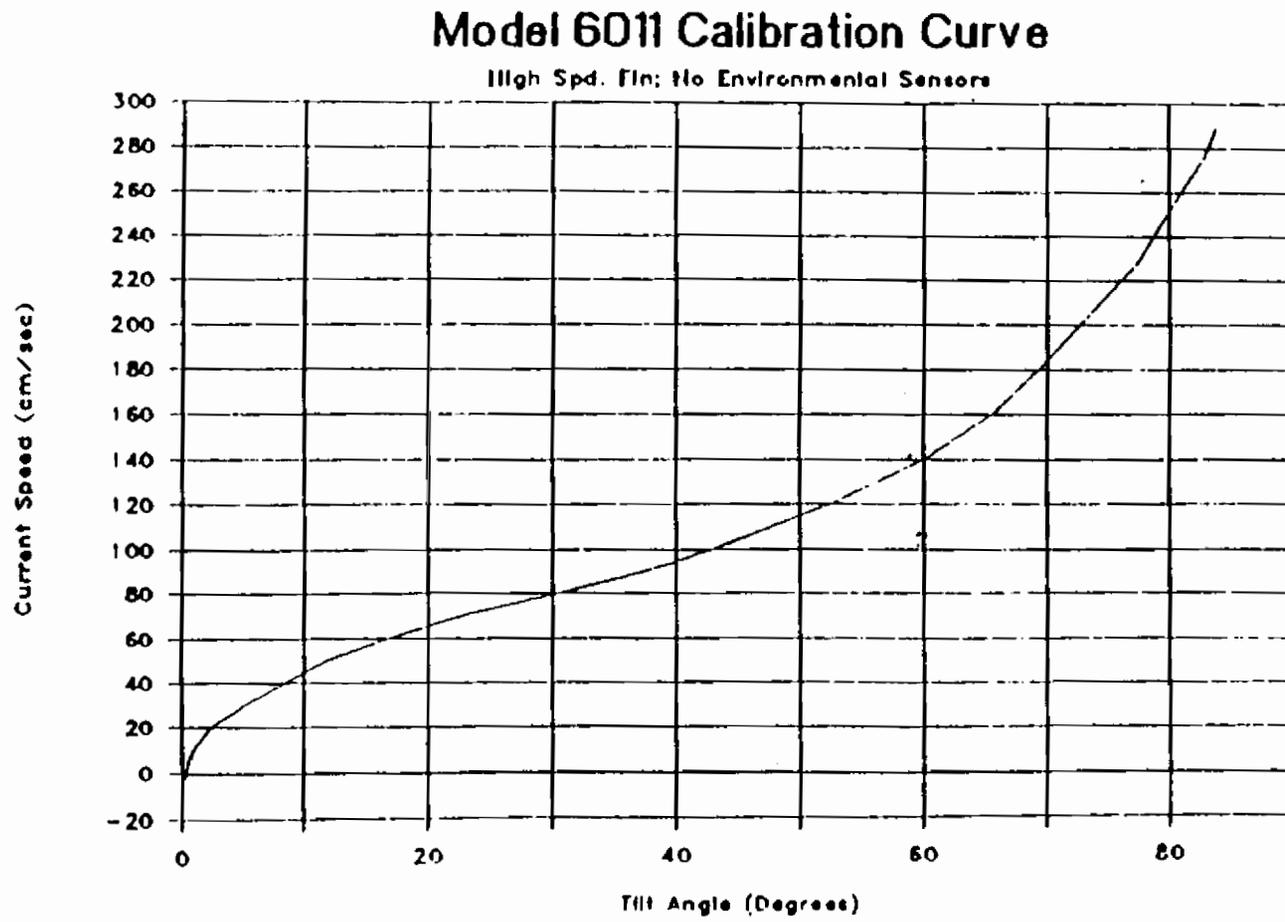
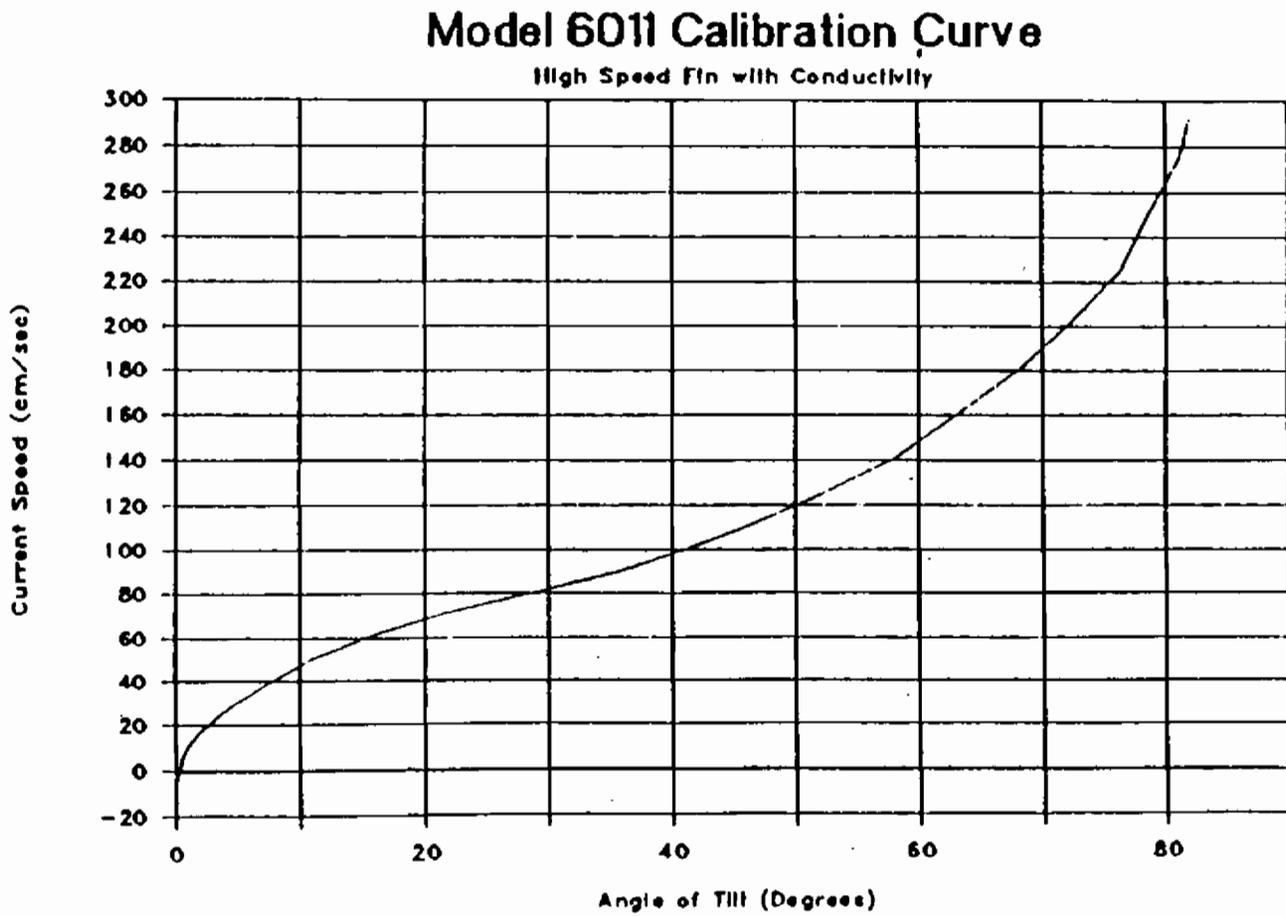


Fig. 11 Calibration Curve
High-Speed Fin with Conductivity



12 MAINTENANCE

12.1 Routine Care

Because of its simple design, the Model 6011 requires very little in the way of routine maintenance. The main battery should be replaced as recommended in section 6.3.1 of this manual. The batteries in the real-time clock have a life of five years. Changing these batteries entails removing the protective covers and re-setting the clock using special equipment available only at the factory. For this reason, it is recommended that meters be returned to General Oceanics, Inc. when the clock batteries become due for replacement.

Before each deployment, lightly grease the O-ring seals and check them for damage. If there is any doubt about their integrity, they should be replaced. After a deployment, remove any marine growth, exercising special care in the region of the conductivity and pressure sensors, and thoroughly rinse the meter in fresh water. Remove the main battery and store it separately if the meter is left unused for more than a few weeks.

12.2 Antifouling Treatment

To protect it against marine growth during extended deployments, the meter can be treated with anti-fouling paint. The following procedure uses material which are readily available at boat supply stores and which are compatible with the aluminum of the pressure case and the plastics of the fins. The layers of paint have a negligible effect on meter calibration.

Step 1: Clean housing thoroughly with hot, soapy water and rinse. Allow to dry and wipe thoroughly with acetone to degrease surface.

Step 2: Remove the ABS wing from the current meter pressure housing. Then apply two thin coats of Pettit Metal Primer to the pressure housing, allowing at least 2 hours drying time between coats.

Step 3: Apply two thin coats of Pettit Vinyl Red Undercoater. This forms the prime barrier to protect the aluminum. It is important that two thin coats, instead of one thick one, be used to ensure total coverage of the aluminum. Also apply two coats of undercoater to the ABS wing to ensure better adhesion of the antifouling coating. Remember to leave at least 2 hours between coats. If possible, apply the undercoater with a sprayer. For thinning and cleaning use Pettit # 140 Vinyl Thinner.

Step 4: Applying the antifoulant. Pettit Alumiguard is recommended because of its compatibility with aluminum. The current meter may be painted then shelved for up to 3 months without the treatment losing its effectiveness. Two or more

thin coats should be applied; if expected use is in a high growth area put on up to 5 thin coats. Recoat time is from 1 to 4 hours. Wait at least 16 hours after the last coat before immersion. Remember to coat the wing when using the antifoulant. Pettit # 140 Vinyl Thinner is used to thin the paint and for cleanup.

12.3 Spare Parts

The following are the General Oceanics reference numbers to the more frequently used spare parts.

Item	G.O. Reference #
----	-----
Standoff	6011SO
Wire Stop	6011WS
O-ring	81-0153
Desiccant bag	99-0611
Cable tie - fin	48-1225
High-speed wing	6011000004
Low-speed wing	6011000003
Standard wing	6011000002
Battery	6011BL



GENERAL
OCEANICS

MODEL 6011 RR

RAM READER

OPERATING MANUAL

JANUARY 1991

A COPY OF THIS MANUAL IS INCLUDED ON YOUR FLOPPY DISK



GENERAL OCEANICS

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1 INTRODUCTION

1.1 Function

The General Oceanics Model 6011RR RAM Reader is designed to read the data cartridges used on the 6000 series of oceanographic recording instruments. These data cartridges contain banks of CMOS memory chips together with a lithium battery which allows them to retain recorded data for over ten years. The Reader plugs into an IBM PC/XT, or compatible, desktop computer. Data are taken from the cartridge, displayed on the computer screen, and recorded on a disk file. The user can then access the file and carry out any further processing he wishes.

2 INSTALLATION

2.1 Component Parts

The Model 6000RR is shipped as a package of four items:

1. The RAM Reader main unit. This holds the socket into which is plugged the data cartridge.
2. An interface card which plugs into one of the expansion slots in the IBM PC/XT. (MetraByte Corp. Model PIO-12)
3. A ribbon cable with 37-pin connectors to connect items 1 and 2.
4. The floppy disk containing the operating and installation software.

2.2 Hardware Installation

2.2.1 Base Address Selection

The IBM PC/XT accesses the interface card by way of four consecutive address locations in the PC I/O address space. These addresses start at a base address which is selected by an 8-position DIP switch (see Fig.1). The base address can in theory be placed anywhere in the I/O address space, but base addresses below FF hex (255 decimal) should be avoided as this address range is used by the internal I/O of the computer. The 200-3FF hex (512-1023) address range provides extensive unused areas of I/O space, though you should check with page 2-23 of the "Technical Reference Manual" for possible conflicts with commonly installed peripherals.

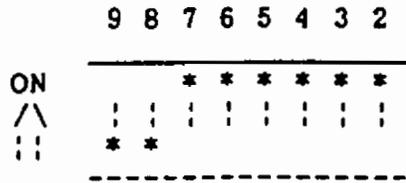


Fig.1 Base address switch setting for 300 hex (768 decimal)

TABLE I. Switch Position Address Equivalents.

Switch posn.	Address line	Decimal equivalent
9	A9	512
8	A8	256
7	A7	128
6	A6	64
5	A5	32
4	A4	16
3	A3	8
2	A2	4

Switches have decimal values as shown above, in the "off" position. In the "on" position the decimal value is zero.

Conflict with other peripherals that may be installed often manifests itself as erratic data displayed on the screen, in which case a different base address should be selected.

2.2.2 PIO Card Installation

Turn off the computer, disconnect the power cords, and move it so that you can work on it from the back. Open the computer and remove the screw holding the filler plate that is in line an empty expansion slot. Remove the filler plate and plug the interface card into the slot making sure it is seated firmly in the connector. Finally, secure the card bracket with the screw that was removed earlier, and return the computer to its case. You can now proceed to install the software.

2.2.3 System Assembly

Position the RAM Reader main unit alongside the computer for convenient access. Use the 37-way ribbon cable to connect it to the interface card in the computer.

2.3 Software Installation

2.3.1 Introduction

The diskette supplied with the RAM Reader contains a number of programs and files. MANUAL.DOC contains the text for this manual. The second is a program labelled SETUP; it allows the user to select which disk drive will be used to store the data that is read from the RAM cartridge. It also tells the actual reading programs the base address that has been selected on the interface card. The remaining files contain the programs which control the reader and format the data (e.g. RDCM will read the RAM cartridge from a MKII Current Meter). These programs are all very similar and differ only because different instruments in the 6000 series use slightly different data formats (see Section 3).

2.3.2 Running SETUP

First you should make a working copy of the software disk supplied, using the normal DOS commands. The original disk can then be stored as a back-up.

At this stage it is worth giving some thought to the general arrangement of your data handling system. The overall aim is to transfer data from the RAM cartridge to a disk file on either a floppy or hard disk. Once in a disk file the data can be accessed much more quickly and conveniently than by re-reading the cartridge. For a system with two floppy disks, it will normally be most convenient to run the program disk in drive A: and to store the transcribed data on a separate disk in drive B:. With a

hard disk system, running the program on the hard disk - drive C: - and storing data on a floppy disk in A: may be best.

Whatever arrangement you use, transfer all the files on the General Oceanics disk to the selected drive, either by inserting the floppy disk in the drive or by copying them to drive C:. Then make the selected drive the default drive (e.g. if C: then type 'C:' followed by RETURN). Then type 'SETUP' followed by RETURN. After a few seconds you will see the introductory banner followed by a prompt to select the data storage disk drive. Make your selection, following the guidelines in the opening remarks of this section.

The next prompt calls for the entry of the base address which you have already selected on the DIP switch on the interface card. Enter this address as a decimal number.

Once you have entered these two pieces of information they are stored in a file SETUP.DAT on the default drive. There is no need to run the SETUP program again unless you wish to change these initial conditions.

2.3.3 Reading Data

To read data, type the appropriate program name followed by RETURN. The program name can be found in Section 3, DATA FORMAT, under the name of the instrument on which the data were recorded. For example, if data were recorded on a Model 6011 MK II current meter, then the program to use is RDCM.

The program will start by displaying the following information:

- a. The serial number of the recording instrument.
- b. The number of samples stored in the cartridge.
- c. The disk drive being used for data storage.

The program will issue a warning if you attempt to read data without a cartridge plugged into the reader, or if the reading program does not match the recording instrument i.e. if you try to read Current meter data with the Inclinator program.

To proceed, follow the prompts as they appear on the screen. Reading will continue until all the samples have been read or until you reach the last address in the cartridge.

The default read operation will display the date/time group and the orientation sensor data on the screen along with the number of samples. Using the "h" key to halt the process other options become available.

They include:

- "s" - to start the read process at the beginning of the cartridge (re-starting will write over previously stored file!);
- "c" - to continue process at present position (always continues in default mode);
- "o" - to display the environmental sensors (instead of orientation data) continuing from present position;
- "b" - blanks the screen while processing (speeds up operation considerably);
- "e" - terminate processing at present position.

Since the generated file is an ASCII delimited file it can reach quite a size with respect to the number of bytes. If you have designated a floppy drive as the storage drive then the program will pause after each group of 5000 readings to allow you to change diskettes if necessary. Hard disks 'C' through 'F' will continue to write the data until the cartridge end is reached.

The following table will help to determine the correct floppy disk size and whether to replace it or to continue:

Cartridge Size	Readings Available	Size of file (bytes)	Disk size
64K	5,000	300,000	360K min.
128K	10,000	600,000	720K min.
256K	20,000	1,200,000	1.2Meg. min.
512K	40,000	2,400,000	10Meg. Hard drive

(The above examples are for a MKII Current Meter which averages about 60 bytes per reading).

2.3.4 Examining Data

The data file (e.g. CM2DAT.DAT) can be viewed using a number of different methods. DOS utilities MORE, TYPE, EDLIN and PRINT are bottom line methods of viewing, editing and printing the data. Any word processor capable of handling ASCII files can be used also. The file can also be imported into any number of spreadsheet and database environments available commercially.

Section 3 of this manual gives the data format and respective column designations for instruments in this series.

3 DATA FORMAT

3.1 Common Features

The format of the data displayed on the screen will vary from instrument to instrument. However, certain features remain common through out the range. Columns 1 through 4 are used to display the month, day, hour and minute recorded by the instrument's real-time clock. The last column is the sequential sample number. The columns in between display data as described in the sub-sections relating to each instrument.

Data are recorded on the disk file in essentially the same format as the display except that there are no spaces and no column headings. Data values are separated by commas and each line is terminated by a carriage return.

3.2 Model 6011U Inclinator

The program to read data from Model 6011U Inclinator is RDINC. For a Model 6011UP (an inclinometer fitted with a pressure sensor) use RDINCP.

The file used to store cartridge data is INCDAT.DAT.

Data are stored on disk as twelve columns. The first four and the twelfth are as described in Section 3.1. Column 5 is used to store pressure as a percentage of the sensor's full scale reading. Column 6 stores temperature in degrees Centigrade. Column 7 represents conductivity in units of milliseimans/meter.

Columns 8 and 9 are used to store tilt angle (relative to the vertical) and tilt direction (relative to magnetic north), both in degrees.

Alternatively, columns 8 and 9 can be used to store tilt information in Cartesian form as easterly and northerly components. These components are derived, in principle, as follows. First the tilt angle is converted to its trigonometric sine - a number in the range zero to 1. Then, this number is

multiplied by the sine of the direction angle to obtain the easterly component. Similarly, the northerly component is $\sin(\text{tilt})$ multiplied by $\cos(\text{direction})$. We end up, therefore, with numbers in the range -1 to +1. On this scale -1 in the column 9 would represent 90 degrees of tilt to the south. The Cartesian representation has an advantage, in some applications, of allowing tilt angles to be handled vectorially.

The tenth and eleventh columns are values of the standard deviations of the two tilt components.

If conductivity or pressure sensors are not fitted to the inclinometer, dummy data will be stored in the corresponding columns on the disk.

3.3 Model 6011 MkII Current Meter

The program to read data from the Model 6011 MkII Current Meter is RDCM.

The file used to store cartridge data is CM2DAT.DAT.

Data are displayed in 12 columns as follows:

Column	Data
1	Month
2	Day
3	Hour
4	Minute
5	Pressure (as % FSD of sensor)
6	Temperature (deg. C.)
7	Conductivity (mS/m)
8	East-West current (cm./sec.)
9	North-South current (cm./sec.)
10	E-W Std. Devn. (cm./sec.)
11	N-S Std. Devn. (cm./sec.)
12	Sample Number

3.4 Model 6070 Thermograph

The program to read data from the Model 6070 Thermograph is RDPTC.

The file used to store cartridge data is DATLOG.DAT

Data are displayed in 8 columns as follows:

Column	Data
1	Month
2	Day
3	Hour
4	Minute
5	Pressure
6	Temperature
7	Conductivity
8	Sample Number

3.5 Model 6051 Pressure Gauge

The program used to read cartridges from the Model 6051 Pressure Gauge is RDPG.

Data are stored in DATLOG.DAT.

APPENDIX D

**ANALYTICAL METHODS, SAMPLE CONTAINERS,
PRESERVATION, AND HOLDING TIMES**

Analytical Methods, Sample Containers, Preservation, and Holding Times					
Parameter	Analytical Method	Sample Matrix	Minimum Container Size / Material ^a	Sample Preservation ^b	Holding Times
Nitrate-N	USEPA 352.1	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C	2 days until analysis
		Soil	(1) 4-oz Glass Jar (1) 1-liter Glass Jar	Chill, 4° C	2 days until analysis
Total Kjeldahl Nitrogen	USEPA 351.4	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C, H ₂ SO ₄ pH < 2 (.25 ml)	28 days until analysis
		Soil	(1) 4-oz Glass Jar (1) 1-liter Glass Jar	Chill, 4° C	28 days until analysis
Total Petroleum Hydrocarbons (TPH)	USEPA 418.1	Water	(1) 1-liter Amber Glass Teflon-lined septum	Chill, 4° C H ₂ SO ₄	28 days until analysis
		Soil	(1) 4-oz Glass Jar (1) 1-liter Glass Jar	Chill, 4° C	28 days until analysis
Total Petroleum Hydrocarbons (TPH)—Low to Medium Boiling Point Fuels (gasoline)	USEPA 5030A	Water	(1) 1-liter Amber Glass Teflon-lined Septum	Chill 4° C ^d HCl to pH2	14 days
		Soil	(1) 4-oz Glass Jar (1) 1-liter Glass Jar	Chill to 4° C	14 days
Total Petroleum Hydrocarbons (TPH)—High Boiling Point Fuels (Diesel, kerosene)	USEPA 3510 USEPA 8100	Water	(1) 1-liter Amber Glass with Teflon-lined septum	Chill 4° C	14 days until extraction; 40 days after extraction
		Soil	(1) 4-oz Glass Jar (1) 1-liter Glass Jar	Chill 4° C	Extract within 14 days Analyze within 40 days
Total Phosphorus	USEPA 365.3	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum	H ₂ SO ₄ pH < 2	Analyze within 28 Days
		Soil	(1) 4-oz Glass Jar (1) 1-liter Glass Jar	Chill, 4° C	Analyze within 28 Days

Final Comprehensive Sampling and Analysis Plan
 Naval Base Charleston
 Revision No: 02
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Analytical Methods, Sample Containers, Preservation, and Holding Times					
Parameter	Analytical Method	Sample Matrix	Minimum Container Size / Material ^a	Sample Preservation ^b	Holding Times
Total Organic Carbon (TOC)	USEPA 415.1, 415.2	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C, H ₂ SO ₄ pH < 2 (.25 ml)	28 days until analysis
		Soil	(1) 4-oz Glass Jar (1) 1-liter Glass Jar	Chill 4° C	28 days until analysis
Heterotrophic Plate Count	SM 9215B	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum (sterilized)	Chill, 4° C	Not to exceed 24 hours
		Soil	(1) 4-oz Glass Jar (1) 1-liter Glass Jar (sterilized)	Chill, 4° C	14 days
Metals by Inductively Coupled Argon Plasma (ICAP) Spectroscopy	USEPA 6010A	Water	(2) 500-ml HDPE jar	Chill, 4° C, HNO ₃ pH < 2	6 months
		Soil	(1) 4-oz HDPE jar	Chill, 4° C	6 months
Metals by Graphite Furnace Atomic Absorption (GFAA)	USEPA 7000 Series	Water	(2) 500-ml HDPE jar	Chill, 4° C, HNO ₃ pH < 2	6 months
		Soil	(1) 4-oz HDPE jar	Chill, 4° C	6 months
Mercury by Cold Vapor Atomic Absorption (CVAA)	USEPA 7470A	Water	(2) 500-ml HDPE jars	Chill, 4° C, HNO ₃ pH < 2	28 days
	USEPA 7471A	Soil	(1) 4-oz HDPE jar	Chill, 4° C	28 days
Cyanide	USEPA 9010A	Water	(1) 500-ml HDPE jar	Chill, 4° C, NaOH pH > 12 ^c	14 days
		Soil	(1) 4-oz HDPE jar	Chill, 4° C	14 days

Analytical Methods, Sample Containers, Preservation, and Holding Times					
Parameter	Analytical Method	Sample Matrix	Minimum Container Size / Material ^a	Sample Preservation ^b	Holding Times
Volatile Organic Compounds (VOC)	USEPA 8260	Water	(3) 40-ml vials with Teflon-lined septa	Chill, 4° C, HCl pH < 2, store in dark ^c	14 days
		Soil	(1) 4-oz Glass Jar with Teflon-lined septa	Chill, 4° C, store in dark	14 days
Semivolatile Organic Compounds (SVOC) (Base-Neutral/Acid Extractables)	USEPA 8270B	Water	(2) 1-liter Amber Glass Jars with Teflon-lined septa	Chill, 4° C ^d	Extract within 7 days, analyze within 40 days
		Soil	(1) 4-oz Glass Jar with Teflon-lined septa	Chill, 4° C	Extract within 14 days, analyze within 40 days
Chlorinated Pesticides/PCBs	USEPA 8080A	Water	(2) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C ^d	Extract within 7 days, analyze within 40 days
		Soil	(1) 8-oz Glass Jar with Teflon-lined septum	Chill, 4° C, store in dark	Extract within 14 days, analyze within 40 days
Chlorinated Herbicides	USEPA 8150B	Water	(2) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C ^d	Extract within 7 days, analyze within 40 days
		Soil	(1) 8-oz Glass Jar with Teflon-lined septum	Chill, 4° C	Extract within 14 days, analyze within 40 days
Organophosphorous Pesticides	USEPA 8140	Water	(2) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C ^e	Extract within 7 days, analyze within 40 days
		Soil	(1) 8-oz Glass Jar with Teflon-lined septum	Chill, 4° C	Extract within 14 days, analyze within 40 days
Dioxins	USEPA 8290	Water	(2) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C	Extract within 30 days, analyze within 45 days of collection
		Soil	(1) 8-oz Glass Jar with Teflon-lined septum	Chill, 4° C	Extract within 30 days, analyze within 45 days of collection

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Analytical Methods, Sample Containers, Preservation, and Holding Times						
Parameter	Analytical Method	Sample Matrix	Minimum Container Size / Material ^a	Sample Preservation ^b	Holding Times	
Hexavalent Chromium	USEPA 3060A USEPA 218.4	Water	(1) 1-liter Plastic	Chill 4° C	24 hours	
		Soil	(1) 4-oz Glass Jar (1) 1-liter Glass Jar	Chill 4° C	None specified	
Volatile Organic Compounds in Ambient Air	T014	Air	Summa canisters	None	None	
Cation Exchange Capacity (CEC)	USEPA 9081	Soil	Shelby Tube	None	None	
Percent Moisture	ASTM D-2216-80	Soil	Shelby Tube	None	None	
Bulk Density	ASTM D-4253	Soil	Shelby Tube	None	None	
Porosity	ASTM D-4645	Soil	Shelby Tube	None	None	
Grain Size	ASTM D-422	Soil	Shelby Tube or Stainless Steel Sampling Sleeve	None	None	
Specific Gravity	ASTM D-845	Soil	Shelby Tube	None	None	
Permeability	ASTM D-5084	Soil	Shelby Tube	None	None	
Toxicity Characteristic Leaching Procedure (TCLP)	SW-846 1311	Soil	(1) 1-liter Glass Jar	Chill, 4° C	Volatiles ^c	28 days
					Semi-Volatiles ^c	61 days
					Mercury ^c	56 days
					Metals, except mercury ^c	360 days

Analytical Methods, Sample Containers, Preservation, and Holding Times						
Parameter	Analytical Method	Sample Matrix	Minimum Container Size / Material ^a	Sample Preservation ^b	Holding Times	
Synthetic Precipitation Leaching Procedure (SPLP)	SW-846 1312	Soil	(1) 1-liter Glass Jar	Chill, 4° C	Volatiles ^f	28 days
					Semi-Volatiles ^f	61 days
					Mercury ^f	56 days
					Metals, except mercury ^f	360 days
Hardness	USEPA 130.1	Water	(1) 500-ml Plastic Jar	Chill, 4° C, HNO ₃ pH < 2 (.25 ml)	28 days after sampling	
Total Suspended Solids (TSS), non-filterable	USEPA 160.2	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum ^c	Chill, 4° C	7 days until analysis	
Alkalinity	USEPA 310.1	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum ^c	Chill, 4° C	14 days until analysis	
Total Dissolved Solids (TDS)	USEPA 160.1	Water	(1) 1-liter Amber Glass with Teflon-lined septum	Chill 4° C	7 days until analysis	
Chlorides	USEPA 325.1	Water	(1) 1-liter Amber Glass with Teflon-lined septum	Chill 4° C	28 days until analysis	
Sulfates	USEPA 375.4	Water	(1) 1-liter Amber Glass with Teflon-lined septum	Chill 4° C	28 days until analysis	
Carbonate/Bicarbonate	APHA 2320B	Water	(1) 1-liter Amber Glass with Teflon-lined septum	Chill 4° C	14 days until analysis	
Nitrate + Nitrite	USEPA 353.2	Water	(1) 1-liter Amber Glass with Teflon-lined septum	Chill 4° C H ₂ SO ₄ to pH < 2	28 days until analysis	
Phosphate	USEPA 365.1	Water	(1) 1-liter Amber Glass with Teflon-lined septum	Chill 4° C H ₂ SO ₄ to pH < 2	28 days until analysis	

Analytical Methods, Sample Containers, Preservation, and Holding Times					
Parameter	Analytical Method	Sample Matrix	Minimum Container Size / Material ^a	Sample Preservation ^b	Holding Times
Sulfite	USEPA 377.1	Water	(1) 1-liter Amber Glass with Teflon-lined septum	Chill 4° C	24 hrs until analysis
Sulfides	USEPA 376.1	Water	(1) 1-liter Amber Glass with Teflon-lined septum	Chill 4° C Add zinc acetate and NaOH pH>9	7 days until analysis
Biological Oxygen Demand (BOD)	USEPA 405.1	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C	Start analysis within 48 hours
Chemical Oxygen Demand (COD)	USEPA 410.1	Water	(1) 500-ml Plastic Jar	Chill, 4° C, H ₂ SO ₄ pH < 2 (.25 ml)	28 days until analysis

Notes:

- a Soil samples collected with split-barrel samplers shall be submitted to the laboratory in stainless steel sampling sleeves.
- b Any preserving agents used must be ACS Certified Reagent Grade.
- c Total suspended solids, sulfate, orthophosphate, and alkalinity will be collected in same sample container.
- d Add 3ml of 10 percent sodium thiosulfate per gallon in the presence of free or combined chlorine.
- e Use ascorbic acid if residual chlorine is present.
- f

Sample Maximum Holding Times (days) for TCLP and SPLP				
	From: Field Collection To: 1312 Extraction	From: 1312 Extraction To: Preparative Extraction	From: Preparative Extraction To: Determinative Analysis	Total Elapsed Time
Volatiles	14	NA	14	28
Semi-volatiles	14	7	40	61
Mercury	28	NA	28	56
Metals, except mercury	180	NA	180	360
NA = Not Applicable				

APPENDIX E

40 CFR 50, Appendix J

Instruction and Operation Manual - High Volume PM₁₀ Sampler

SOUTH CAROLINA AMBIENT AIR QUALITY STANDARDS

(South Carolina Department of Health and Environmental Control; Regulation 61-62.5 — Air Pollution Control Standards; Amended effective May 22, 1982; February 25, 1983; April 22, 1983; June 24, 1983; May 24, 1985; February 28, 1986; November 27, 1987; February 26, 1988; April 22, 1988; January 19, 1989; February 24, 1989; March 24, 1989; May 25, 1990; August 24, 1990; Corrected February 22, 1991; Amended effective May 24, 1991; June 26, 1992)

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- Standard No. 1 — Emissions from Fuel Burning Operations
- Standard No. 2 — Ambient Air Quality Standards
- Standard No. 3 — Waste Combustion and Reduction
- Standard No. 3.1 — Medical Waste Incineration
- Standard No. 4 — Emissions from Process Industries
- Standard No. 5 — Volatile Organic Compounds
- Standard No. 5.1 — Lowest Achievable Emission Rate ("LAER") Applicable to Volatile Organic Compounds
- Standard No. 6 — Alternative Emission Limitation Options
- Standard No. 7 — Prevention of Significant Deterioration
- Standard No. 8 — Toxic Air Pollutants

REGULATION NO. 62.5 AIR POLLUTION CONTROL STANDARDS

STANDARD NO. 1 EMISSIONS FROM FUEL BURNING OPERATIONS

SECTION I — VISIBLE EMISSIONS

A. Existing Sources

No one shall discharge to the ambient air from any existing source constructed prior to February 11, 1971, smoke which exceeds an opacity of forty (40) percent. For a total of six (6) minutes in one hour or twenty-four (24) minutes in a twenty-four

(24) hour period, forty (40) percent opacity may be exceeded for soot blowing, but shall in no case exceed an opacity of sixty (60) percent.

B. New Sources

No one shall discharge to the ambient air from any source constructed on or after February 11, 1971, smoke which exceeds an opacity of twenty (20) percent. For a total of six (6) minutes in one hour or twenty-four (24) minutes in a twenty-four (24) hour period, twenty (20) percent opacity may be exceeded for soot blowing, but shall in no case exceed an opacity of sixty (60) percent.

C. Special Provisions

The opacity standards set forth above do not apply during startup or shutdown. Owners and operators shall, to the extent practicable, maintain and operate any source including associated air pollution control equipment in a manner consistent with good air pollution control practices for minimizing emissions. In addition, the owner or operator shall maintain a log of the time, magnitude, duration and any other pertinent information to determine periods of startup and shutdown and make available to the Department upon request.

D. Test Method

The method which is approved by the Department for determining compliance with opacity limitations under this Section is EPA Reference Method 9 (40 CFR 60, Appendix A, as revised July 1, 1986).

Alternate methods may be utilized only if approved in advance by the Department and by the Environmental Protection Agency.

SECTION II — PARTICULATE MATTER EMISSIONS

A. Allowable Discharge

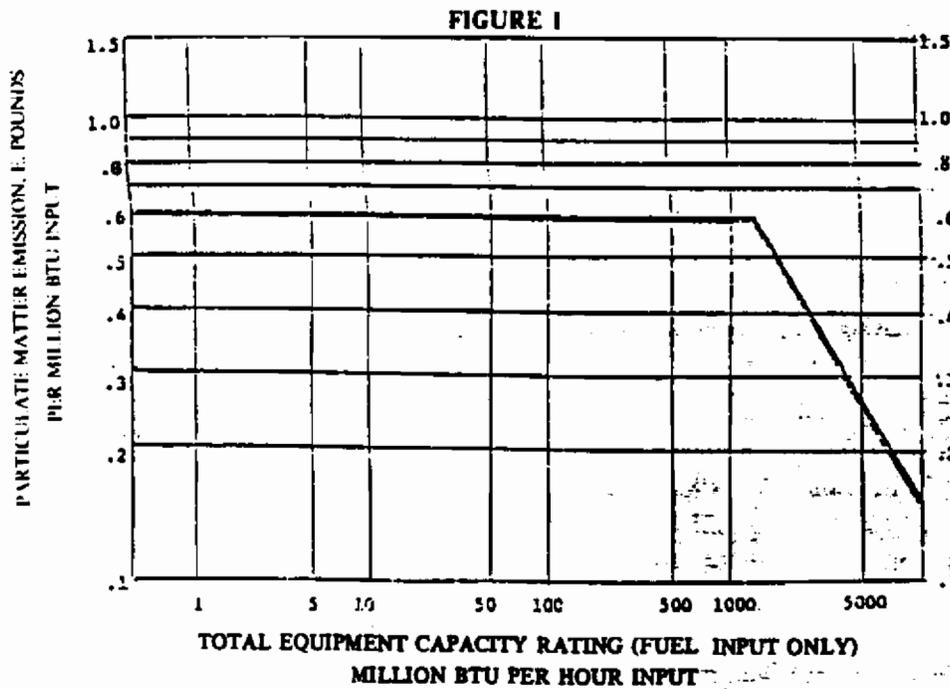
The allowable discharge of particulate matter resulting from fuel burning operations shall be limited to the values obtained by use of Figure 1 and/or Part B. (For the purpose of determining heat input, total equipment capacity refers to total equipment capacity discharging through each stack. If a boiler has more than one (1) stack the total rated capacity will be the boiler rated capacity discharging to these stacks). Interpolation of Figure 1 for fuel burning operations of 1300 million BTU per hour heat input and larger shall be accomplished by use of the equation:

$$E = 57.84 P^{-0.637}$$

where E = the allowable emission rate in pounds per million BTU heat input, and P = million BTU heat input per hour

B. Special Provisions

All fuel burning operations of 10 million BTU per hour heat input and smaller constructed prior to February 11, 1971, shall be allowed 0.8 pounds per million BTU input.



SECTION III — SULFUR DIOXIDE EMISSIONS

A. General

The maximum allowable discharge of sulfur dioxide (SO₂) from fuel burning operations shall be in accordance with a system of priorities as specified hereinafter in paragraph B. The classifications shall be delineated on a county basis. The maximum allowable discharge for the various classes is specified in paragraph C of this Section.

B. Classifications

1. The class into which a given county falls has been determined by mathematical atmospheric diffusion models and other methods which evaluate those factors which necessitate limits on sulfur dioxide emissions. These factors included but were not limited to: (1) total sulfur dioxide emissions; (2) spatial distribution of sulfur dioxide sources; (3) effects of single, large sources; (4) existing, measured air quality; (5) topographical features of the county; (6) contributions to background levels due to sources outside the county being considered; (7) population density.

2. The assigned classifications will be reviewed periodically at intervals not to exceed three years, and changes will be made as required. When a county is assigned to a more restrictive class, individual compliance schedules will be established in such a way that reasonable time will be allowed for the sources to make necessary changes in equipment and/or fuel contracts.

3. The following classifications are assigned:

- Class I — Charleston County
- Class II — Aiken County — Anderson County
- Class III — All others

C. Allowable Discharges

Sulfur dioxide emissions from fuel burning sources located in various counties will not exceed the following limits:

Rated Source Size	Maximum Allowable Emissions (lb SO ₂ /million BTU Input)
1. Counties in Class I	
Up to and including 10 million BTU/hr	3.5
Greater than 10 million BTU/hr	2.3
2. Counties in Class II	
Rated Source Size	Maximum Allowable Emissions (lb SO ₂ /million BTU Input)
Up to 1000 million BTU/hr	3.5
1000 million BTU/hr and larger	2.3
3. Counties in Class III	
Rated Source Size	Maximum Allowable Emissions (lb SO ₂ /million BTU Input)
All	3.5

D. Special Provisions

If it can be demonstrated to the satisfaction of the Board that ambient air standards will not be contravened by a source, alone or in combination with other sources, a greater allowance for sulfur dioxide discharges may be made on a case by case basis.

SECTION IV — OPACITY MONITORING REQUIREMENTS

A. Applicable Sources

- 1. Fossil Fuel Fired Boilers. The owner

or operator of any fossil fuel-fired steam generator of more than 250 million BTU per hour heat input capacity shall install, calibrate, operate, and maintain no later than June 14, 1978, continuous monitoring system(s) for the measurement of opacity which meets the performance specifications of Paragraph D of this Section except where:

- a. Gaseous fuel is the only fuel burned;
- b. Oil or a mixture of gas and oil are the only fuels burned and the steam generator is able to comply with the provisions of Sections I and II of this Standard without utilization of particulate matter collection equipment, and where the steam generator has never been found, through any administrative or judicial proceedings, to be in violation of Section 4 of this Standard.

c. The steam generator operates with an annual average capacity factor of 30 percent or less, as reported to the Federal Power Commission for calendar year 1974 or otherwise adequately demonstrated to the Department; and has not subsequently increased this factor to more than 30 percent.

2. Woodwaste Boilers. The owner or operator of any woodwaste boiler, not equipped with a wet scrubber, will be required to install, calibrate, operate and maintain continuous monitoring system(s) approved by this Department for the measurement of opacity, if it meets one or more of the following criteria:

- a. Any woodwaste boiler of at least 100 × 10⁶ BTU/hr. rated heat input.
- b. Any woodwaste boiler, regardless of size, that has been operating in non-com-

pliance with any applicable state air pollution control regulations and standards.

If a boiler is fired on more than one fuel, the total capacity will determine the applicability of above requirements.

B. Continuous Opacity Monitor Reporting Requirements

1. The owner or operator of any fossil fuel fired steam generator subject to the provisions of Paragraph A of this Section shall submit a written Continuous Opacity Monitor report to the Department quarterly or more often if requested. All quarterly reports must be postmarked by the 30th day following the end of each calendar quarter.

The report shall include the following minimum information:

a. All integrated six minute opacity measurements for periods during which the applicable provisions of Section I have been exceeded, together with their nature and cause.

b. For periods of monitoring system malfunction:

(i) The date and time identifying each period during which the monitoring system was inoperative, except for zero and span checks.

(ii) The nature of monitoring system repairs or adjustments.

(iii) Proof of opacity monitoring system performance may be required by the Department whenever repairs or adjustments have been made.

c. boiler system repairs or adjustments made to correct violations of the provisions of Section I.

If no reportable incidents occur during a quarter, a report is also required indicating as such.

2. Alternative data reporting procedures may be allowed if the owner or operator shows, to the satisfaction of the Department, that these procedures are at least as accurate as those described.

3. The owner or operator shall maintain a file of all information contained in the quarterly reports, calibration data for the opacity monitoring system(s), relevant records of adjustments and maintenance performed on such system(s), and all other data generated by the continuous opacity monitoring system(s), for a minimum of two years from the date of submission of such reports or collection of such data. The information contained on file must be made available for review by Department personnel upon request.

C. Exemption from Reporting Requirements

A temporary exemption from the opacity monitoring and reporting requirements of this Section may be granted during any

period of monitoring system(s) malfunction, provided the owner or operator shows, to the satisfaction of the Department, that the malfunction was unavoidable and is being repaired as expeditiously as possible.

D. Equipment Performance Specifications

The continuous opacity monitoring system(s) required by Paragraph A.1 of this Section (for fossil fuel fired steam generators) shall conform with the performance specifications set forth in 40 CFR, Part 60, Appendix B, Performance Specification 1 as revised July 1, 1986, which is incorporated by reference as a part of this Standard except that where the term "Administrator" is used the term "Department" shall be substituted. In addition, the opacity monitoring system(s) shall complete a minimum of one cycle of operation for each successive 10-second period; be installed such that representative measurements of opacity from the affected steam generator are obtained; and have an instrument span of approximately 80 percent opacity.

The owner or operator shall record the zero and span drift in accordance with the method prescribed by the manufacturer of such opacity monitoring system(s); subject the system(s) to the manufacturer's recommended zero and span check at least once daily unless the manufacturer has recommended adjustments at shorter intervals, in which case such recommendations shall be followed; adjust the zero and span whenever the 24-hour zero drift or 24-hour calibration drift limits of 40 CFR, Part 60, Appendix B, Performance Specification 1 as revised July 1, 1986 are exceeded; adjust the opacity monitoring system(s) purchased prior to September 11, 1974 whenever the 24-hour zero drift or 24-hour calibration drift exceeds 4 percent opacity for those generators constructed prior to February 11, 1971 and 2 percent opacity for those generators constructed after February 11, 1971.

The monitoring systems must be approved by this agency prior to installation.

E. Monitor Location

When the effluents from two or more affected steam generators of similar design and operating characteristics are combined before being released to the atmosphere, the opacity monitoring system(s) shall be installed on the combined effluent. When the affected steam generators are not of similar design and operating characteristics, or when the effluent from one affected steam generator is released to the atmosphere through more than one point, the owner or operator shall apply

for an alternate procedure to comply with the requirements of this Section.

F. Exemptions from Monitoring Requirements

Whenever the requirements for continuous opacity monitoring cannot be implemented by the owner or operator due to physical plant limitations, extreme economic burden, or infrequent steam generator operation of less than 30 days per year, or when the specified monitoring procedure would not provide accurate opacity determinations, alternate monitoring and reporting requirements may be approved on a case-by-case basis provided the owner or operator submits a written request to the Department which includes, but is not limited to:

1. The basis of reason(s) that alternate requirements are necessary;
2. A proposal of the alternate monitoring and reporting requirements; and
3. Any other information needed by the Department to make a determination that the alternate requirements are adequate to meet the intent of this Section.

SECTION V — EXEMPTIONS

The following sources shall be exempt from the provisions of this standard:

- A. Residences of four families or less.
- B. Ocean-going vessels actually engaged in the physical process of national or international trade or defense.

SECTION VI — PERIODIC TESTING

Scheduled periodic tests for particulate matter emissions will be required of the sources listed below every two years, or as required by permit conditions to demonstrate compliance with this Standard. Compliance with sulfur dioxide will be by source testing, continuous monitoring, or fuel analysis as required by the permit conditions.

- A. Oil-fired boilers greater than 250×10^6 BTU/hr. rated input.
- B. Coal-fired boilers greater than 50×10^6 BTU/hr. rated input.
- C. Woodwaste, or combination woodwaste boilers greater than 20×10^6 BTU/hr. rated input.

SECTION VII — SOURCE TEST REQUIREMENTS

A. The owner or operator required to comply with Section VI above shall conduct such tests as required by the Department in order to demonstrate compliance with this Standard. The test methods and procedures used shall be approved EPA test methods or such alternative methods as approved by the Department prior to testing.

Tests shall be conducted while the source is operating at the expected maxi-

imum production rate or other production rate or operating conditions which would result in the highest emissions. Any production rate less than rated capacity may result in production limitations on the permits.

All tests shall be made by, or under the direction of, a person qualified by training and/or experience in the field of air pollution testing.

B. Any source owner or operator proposing to conduct tests in accordance with paragraph A. above shall notify the Department in the manner set forth below of the intent to test, not less than two weeks before the proposed initiation of the tests so the Department may observe the test if it desires to do so.

Notification shall include the following minimum information:

1. the purpose of the proposed test.
2. a description of the source to be tested.
3. a description of the test procedures, equipment, and sampling sites.

4. a timetable, setting forth the dates on which the testing will be started and concluded.

C. The final test reports must be submitted no later than 30 days after completion of on-site testing, containing as a minimum, the following supporting information:

1. process weight rates (lb/hr).
2. process design and load rates at which the test was conducted.
3. procedure used for determining process weight rates.
4. calculations used to determine process weight rates.
5. signature of responsible company official.

D. The owner or operator proposing a source test under the provisions of this section shall be responsible for providing:

1. sampling ports, pipes, lines, or appurtenances for the collection of samples and data required by the test procedure.
2. safe access to the sample and data collection locations.

3. light, electricity, and other utilities required for sample and data collection.

E. Any proposed deviations from the procedures and requirements stated above must be thoroughly explained and must be approved by this Department prior to testing. Failure to observe any of these procedures or requirements may be grounds for not accepting the tests.

STANDARD NO. 2 AMBIENT AIR QUALITY STANDARDS

The following table constitutes the ambient air quality standards for the State of South Carolina. The analytical methods to be used will be those applicable Federal Reference Methods published in 40 CFR 50, Appendices A-H as revised July 1, 1986. In the case of fluorides either the double paper-tape sampler methods (ASTM D-3266-79) or the sodium bicarbonate-coated glass tube and particulate filter method (ASTM D-3268-78) may be used.

<u>POLLUTANT</u>	<u>MEASURING INTERVAL</u>	<u>MICROGRAMS PER CUBIC METER UNLESS NOTED OTHERWISE (1)(2)</u>
Sulfur Dioxide	3 hour	1300(4)
	24 hours	365(4)
	annual	80
Total Suspended Particulates	Annual Geometric Mean	75
PM ₁₀	24 hours	150(3)
	annual	50(3)
Carbon Monoxide	1 hour	40 mg per cubic meter
	8 hour	10 mg per cubic meter
Ozone	1 hour	0.12 ppm (3)
	12 hr. avg.	3.7
	24 hr. avg.	2.9
	1 wk. avg.	1.6
Gaseous Fluorides (as HF)	1 mo. avg.	0.8
	annual	100
Nitrogen Dioxide	annual	100
Lead	Calendar Quarterly Mean	1.5

(1) Arithmetic Average except in case of total suspended particulate matter

(2) At 25° C and 760 mm Hg.

(3) Attainment determinations will be made based on the criteria contained in Appendices H and K, 40 CFR 50, July 1, 1987.

(4) Not to be exceeded more than once a year.

each year, the number of days with maximum hourly concentrations above 0.12 ppm is determined and this number is averaged with the results of previous years. As long as this average remains "less than or equal to 1," the area is in compliance.

3. Estimating the Number of Exceedances for a Year

In general, a valid daily maximum hourly average value may not be available for each day of the year, and it will be necessary to account for these missing values when estimating the number of exceedances for a particular calendar year. The purpose of these computations is to determine if the expected number of exceedances per year is less than or equal to 1. Thus, if a site has two or more observed exceedances each year, the standard is not met and it is not necessary to use the procedures of this section to account for incomplete sampling.

The term "missing value" is used here in the general sense to describe all days that do not have an associated ozone measurement. In some cases, a measurement might actually have been missed but in other cases no measurement may have been scheduled for that day. A daily maximum ozone value is defined to be the highest hourly ozone value recorded for the day. This daily maximum value is considered to be valid if 75 percent of the hours from 9:01 a.m. to 9:00 p.m. (LST) were measured or if the highest hour is greater than the level of the standard.

In some areas, the seasonal pattern of ozone is so pronounced that entire months need not be sampled because it is extremely unlikely that the standard would be exceeded. Any such waiver of the ozone monitoring requirement would be handled under provisions of 40 CFR Part 58. Some allowance should also be made for days for which valid daily maximum hourly values were not obtained but which would quite likely have been below the standard. Such an allowance introduces a complication in that it becomes necessary to define under what conditions a missing value may be assumed to have been less than the level of the standard. The following criterion may be used for ozone:

A missing daily maximum ozone value may be assumed to be less than the level of the standard if the valid daily maxima on both the preceding day and the follow-

ing day do not exceed 75 percent of the level of the standard.

Let z denote the number of missing daily maximum values that may be assumed to be less than the standard. Then the following formula shall be used to estimate the expected number of exceedances for the year:

$$e = v + [(v/n)8(N-n-z)] \quad (1)$$

(*Indicates multiplication.)

where:

e =the estimated number of exceedances for the year,

N =the number of required monitoring days in the year,

n =the number of valid daily maxima,

v =the number of daily values above the level of the standard, and

z =the number of days assumed to be less than the standard level.

This estimated number of exceedances shall be rounded to one decimal place (fractional parts equal to 0.05 round up).

It should be noted that N will be the total number of days in the year unless the appropriate Regional Administrator has granted a waiver under the provisions of 40 CFR Part 58.

The above equation may be interpreted intuitively in the following manner. The estimated number of exceedances is equal to the observed number of exceedances (v) plus an increment that accounts for incomplete sampling. There were $(N-n)$ missing values for the year but a certain number of these, namely z , were assumed to be less than the standard. Therefore, $(N-n-z)$ missing values are considered to include possible exceedances. The fraction of measured values that are above the level of the standard is v/n . It is assumed that this same fraction applies to the $(N-n-z)$ missing values and that $(v/n)*(N-n-z)$ of these values would also have exceeded the level of the standard.

[Appendix H added at 44 FR 8220, Feb. 8, 1979]

APPENDIX I—[Reserved]

APPENDIX J TO PART 50—REFERENCE METHOD FOR THE DETERMINATION OF PARTICULATE MATTER AS PM₁₀ IN THE ATMOSPHERE

1.0 Applicability.

1.1 This method provides for the measurement of the mass concentration of

particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM₁₀) in ambient air over a 24-hour period for purposes of determining attainment and maintenance of the primary and secondary national ambient air quality standards for particulate matter specified in §50.6 of this chapter. The measurement process is nondestructive, and the PM₁₀ sample can be subjected to subsequent physical or chemical analyses. Quality assurance procedures and guidance are provided in part 58, appendices A and B, of this chapter and in References 1 and 2.

2.0 Principle.

2.1 An air sampler draws ambient air at a constant flow rate into a specially shaped inlet where the suspended particulate matter is inertially separated into one or more size fractions within the PM₁₀ size range. Each size fraction in the PM₁₀ size range is then collected on a separate filter over the specified sampling period. The particle size discrimination characteristics (sampling effectiveness and 50 percent cutpoint) of the sampler inlet are prescribed as performance specifications in part 53 of this chapter.

2.2 Each filter is weighed (after moisture equilibration) before and after use to determine the net weight (mass) gain due to collected PM₁₀. The total volume of air sampled, corrected to EPA reference conditions (25°C, 101.3 kPa), is determined from the measured flow rate and the sampling time. The mass concentration of PM₁₀ in the ambient air is computed as the total mass of collected particles in the PM₁₀ size range divided by the volume of air sampled, and is expressed in micrograms per standard cubic meter ($\mu\text{g}/\text{std m}^3$). For PM₁₀ samples collected at temperatures and pressures significantly different from EPA reference conditions, these corrected concentrations sometimes differ substantially from actual concentrations (in micrograms per actual cubic meter), particularly at high elevations. Although not required, the actual PM₁₀ concentration can be calculated from the corrected concentration, using the average ambient temperature and barometric pressure during the sampling period.

2.3 A method based on this principle will be considered a reference method only if (a) the associated sampler meets the requirements specified in this appendix and the requirements in part 53 of this

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chapter, and (b) the method has been designated as a reference method in accordance with part 53 of this chapter.

3.0 Range.

3.1 The lower limit of the mass concentration range is determined by the repeatability of filter tare weights, assuming the nominal air sample volume for the sampler. For samplers having an automatic filter-changing mechanism, there may be no upper limit. For samplers that do not have an automatic filter-changing mechanism, the upper limit is determined by the filter mass loading beyond which the sampler no longer maintains the operating flow rate within specified limits due to increased pressure drop across the loaded filter. This upper limit cannot be specified precisely because it is a complex function of the ambient particle size distribution and type, humidity, filter type, and perhaps other factors. Nevertheless, all samplers should be capable of measuring 24-hour PM_{10} mass concentrations of at least $300 \mu\text{g}/\text{std m}^3$ while maintaining the operating flow rate within the specified limits.

4.0 Precision.

4.1 The precision of PM_{10} samplers must be $5 \mu\text{g}/\text{m}^3$ for PM_{10} concentrations below $80 \mu\text{g}/\text{m}^3$ and 7 percent for PM_{10} concentrations above $80 \mu\text{g}/\text{m}^3$, as required by Part 53 of this chapter, which prescribes a test procedure that determines the variation in the PM_{10} concentration measurements of identical samplers under typical sampling conditions. Continual assessment of precision via collocated samplers is required by Part 58 of this chapter for PM_{10} samplers used in certain monitoring networks.

5.0 Accuracy.

5.1 Because the size of the particles making up ambient particulate matter varies over a wide range and the concentration of particles varies with particle size, it is difficult to define the absolute accuracy of PM_{10} samplers. Part 53 of this chapter provides a specification for the sampling effectiveness of PM_{10} samplers. This specification requires that the expected mass concentration calculated for a candidate PM_{10} sampler, when sampling a specified particle size distribution, be within ± 10 percent of that calculated for an ideal sampler whose sampling effectiveness is explicitly specified. Also, the particle size for 50 percent sampling effectiveness is required to be 10 ± 0.5 mi-

crometers. Other specifications related to accuracy apply to flow measurement and calibration, filter media, analytical (weighing) procedures, and artifact. The flow rate accuracy of PM_{10} samplers used in certain monitoring networks is required by Part 58 of this chapter to be assessed periodically via flow rate audits.

6.0 Potential Sources of Error.

6.1 *Volatile Particles.* Volatile particles collected on filters are often lost during shipment and/or storage of the filters prior to the post-sampling weighing³. Although shipment or storage of loaded filters is sometimes unavoidable, filters should be reweighed as soon as practical to minimize these losses.

6.2 *Artifacts.* Positive errors in PM_{10} concentration measurements may result from retention of gaseous species on filters^{4, 5}. Such errors include the retention of sulfur dioxide and nitric acid. Retention of sulfur dioxide on filters, followed by oxidation to sulfate, is referred to as artifact sulfate formation, a phenomenon which increases with increasing filter alkalinity⁶. Little or no artifact sulfate formation should occur using filters that meet the alkalinity specification in section 7.2.4. Artifact nitrate formation, resulting primarily from retention of nitric acid, occurs to varying degrees on many filter types, including glass fiber, cellulose ester, and many quartz fiber filters^{5, 7, 8, 9, 10}. Loss of true atmospheric particulate nitrate during or following sampling may also occur due to dissociation or chemical reaction. This phenomenon has been observed on Teflon[®] filters⁸ and inferred for quartz fiber filters^{11, 12}. The magnitude of nitrate artifact errors in PM_{10} mass concentration measurements will vary with location and ambient temperature; however, for most sampling locations, these errors are expected to be small.

6.3 *Humidity.* The effects of ambient humidity on the sample are unavoidable. The filter equilibration procedure in section 9.0 is designed to minimize the effects of moisture on the filter medium.

6.4 *Filter Handling.* Careful handling of filters between presampling and post-sampling weighings is necessary to avoid errors due to damaged filters or loss of collected particles from the filters. Use of a filter cartridge or cassette may reduce the magnitude of these errors. Filters must also meet the integrity specification in section 7.2.3.

6.5 *Flow Rate Variation.* Variations in the sampler's operating flow rate may alter the particle size discrimination characteristics of the sampler inlet. The magnitude of this error will depend on the sensitivity of the inlet to variations in flow rate and on the particle distribution in the atmosphere during the sampling period. The use of a flow control device (section 7.1.3) is required to minimize this error.

6.6 *Air Volume Determination.* Errors in the air volume determination may result from errors in the flow rate and/or sampling time measurements. The flow control device serves to minimize errors in the flow rate determination, and an elapsed time meter (section 7.1.5) is required to minimize the error in the sampling time measurement.

7.0 Apparatus.

7.1 PM_{10} Sampler.

7.1.1 The sampler shall be designed to:

a. Draw the air sample into the sampler inlet and through the particle collection filter at a uniform face velocity.

b. Hold and seal the filter in a horizontal position so that sample air is drawn downward through the filter.

c. Allow the filter to be installed and removed conveniently.

d. Protect the filter and sampler from precipitation and prevent insects and other debris from being sampled.

e. Minimize air leaks that would cause error in the measurement of the air volume passing through the filter.

f. Discharge exhaust air at a sufficient distance from the sampler inlet to minimize the sampling of exhaust air.

g. Minimize the collection of dust from the supporting surface.

7.1.2 The sampler shall have a sample air inlet system that, when operated within a specified flow rate range, provides particle size discrimination characteristics meeting all of the applicable performance specifications prescribed in part 53 of this chapter. The sampler inlet shall show no significant wind direction dependence. The latter requirement can generally be satisfied by an inlet shape that is circularly symmetrical about a vertical axis.

7.1.3 The sampler shall have a flow control device capable of maintaining the sampler's operating flow rate within the flow rate limits specified for the sampler inlet over normal variations in line voltage and filter pressure drop.

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7.1.4 The sampler shall provide a means to measure the total flow rate during the sampling period. A continuous flow recorder is recommended but not required. The flow measurement device shall be accurate to ± 2 percent.

7.1.5 A timing/control device capable of starting and stopping the sampler shall be used to obtain a sample collection period of 24 ± 1 hr ($1,440 \pm 60$ min). An elapsed time meter, accurate to within ± 15 minutes, shall be used to measure sampling time. This meter is optional for samplers with continuous flow recorders if the sampling time measurement obtained by means of the recorder meets the ± 15 minute accuracy specification.

7.1.6 The sampler shall have an associated operation or instruction manual as required by part 53 of this chapter which includes detailed instructions on the calibration, operation, and maintenance of the sampler.

7.2 Filters.

7.2.1 *Filter Medium.* No commercially available filter medium is ideal in all respects for all samplers. The user's goals in sampling determine the relative importance of various filter characteristics (e.g., cost, ease of handling, physical and chemical characteristics, etc.) and, consequently, determine the choice among acceptable filters. Furthermore, certain types of filters may not be suitable for use with some samplers, particularly under heavy loading conditions (high mass concentrations), because of high or rapid increase in the filter flow resistance that would exceed the capability of the sampler's flow control device. However, samplers equipped with automatic filter-changing mechanisms may allow use of these types of filters. The specifications given below are minimum requirements to ensure acceptability of the filter medium for measurement of PM_{10} mass concentrations. Other filter evaluation criteria should be considered to meet individual sampling and analysis objectives.

7.2.2 *Collection Efficiency.* ± 99 percent, as measured by the DOP test (ASTM-2986) with $0.3 \mu m$ particles at the sampler's operating face velocity.

7.2.3 *Integrity.* $\pm 5 \mu g/m^3$ (assuming sampler's nominal 24-hour air sample volume). Integrity is measured as the PM_{10} concentration equivalent corresponding to the average difference between the initial and the final weights of a random sample

of test filters that are weighed and handled under actual or simulated sampling conditions, but have no air sample passed through them (i.e., filter blanks). As a minimum, the test procedure must include initial equilibration and weighing, installation on an inoperative sampler, removal from the sampler, and final equilibration and weighing.

7.2.4 *Alkalinity.* <25 microequivalents/gram of filter, as measured by the procedure given in Reference 13 following at least two months storage in a clean environment (free from contamination by acidic gases) at room temperature and humidity.

7.3 *Flow Rate Transfer Standard.* The flow rate transfer standard must be suitable for the sampler's operating flow rate and must be calibrated against a primary flow or volume standard that is traceable to the National Bureau of Standards (NBS). The flow rate transfer standard must be capable of measuring the sampler's operating flow rate with an accuracy of ± 2 percent.

7.4 Filter Conditioning Environment.

7.4.1 Temperature range: 15° to $30^\circ C$.

7.4.2 Temperature control: $\pm 3^\circ C$.

7.4.3 Humidity range: 20% to 45% RH.

7.4.4 Humidity control: $\pm 5\%$ RH.

7.5 *Analytical Balance.* The analytical balance must be suitable for weighing the type and size of filters required by the sampler. The range and sensitivity required will depend on the filter tare weights and mass loadings. Typically, an analytical balance with a sensitivity of 0.1 mg is required for high volume samplers (flow rates >0.5 m^3/min). Lower volume samplers (flow rates >0.5 m^3/min) will require a more sensitive balance.

8.0 Calibration.

8.1 General Requirements.

8.1.1 Calibration of the sampler's flow measurement device is required to establish traceability of subsequent flow measurements to a primary standard. A flow rate transfer standard calibrated against a primary flow or volume standard shall be used to calibrate or verify the accuracy of the sampler's flow measurement device.

8.1.2 Particle size discrimination by inertial separation requires that specific air velocities be maintained in the sampler's air inlet system. Therefore, the flow rate through the sampler's inlet must be maintained throughout the sampling period within the design flow rate range specified

by the manufacturer. Design flow rates are specified as actual volumetric flow rates, measured at existing conditions of temperature and pressure (Q_a). In contrast, mass concentrations of PM_{10} are computed using flow rates corrected to EPA reference conditions of temperature and pressure (Q_{std}).

8.2 Flow Rate Calibration Procedure.

8.2.1 PM_{10} samplers employ various types of flow control and flow measurement devices. The specific procedure used for flow rate calibration or verification will vary depending on the type of flow controller and flow indicator employed. Calibration in terms of actual volumetric flow rates (Q_a) is generally recommended, but other measures of flow rate (e.g., Q_{std}) may be used provided the requirements of section 8.1 are met. The general procedure given here is based on actual volumetric flow units (Q_a) and serves to illustrate the steps involved in the calibration of a PM_{10} sampler. Consult the sampler manufacturer's instruction manual and Reference 2 for specific guidance on calibration. Reference 14 provides additional information on the use of the commonly used measures of flow rate and their interrelationships.

8.2.2 Calibrate the flow rate transfer standard against a primary flow or volume standard traceable to NBS. Establish a calibration relationship (e.g., an equation or family of curves) such that traceability to the primary standard is accurate to within 2 percent over the expected range of ambient conditions (i.e., temperatures and pressures) under which the transfer standard will be used. Recalibrate the transfer standard periodically.

8.2.3 Following the sampler manufacturer's instruction manual, remove the sampler inlet and connect the flow rate transfer standard to the sampler such that the transfer standard accurately measures the sampler's flow rate. Make sure there are no leaks between the transfer standard and the sampler.

8.2.4 Choose a minimum of three flow rates (actual m^3/min), spaced over the acceptable flow rate range specified for the inlet (see 7.1.2) that can be obtained by suitable adjustment of the sampler flow rate. In accordance with the sampler manufacturer's instruction manual, obtain or verify the calibration relationship between the flow rate (actual m^3/min) as

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indicated by the transfer standard and the sampler's flow indicator response. Record the ambient temperature and barometric pressure. Temperature and pressure corrections to subsequent flow indicator readings may be required for certain types of flow measurement devices. When such corrections are necessary, correction on an individual or daily basis is preferable. However, seasonal average temperature and average barometric pressure for the sampling site may be incorporated into the sampler calibration to avoid daily corrections. Consult the sampler manufacturer's instruction manual and Reference 2 for additional guidance.

8.2.5 Following calibration, verify that the sampler is operating at its design flow rate (actual m³/min) with a clean filter in place.

8.2.6 Replace the sampler inlet.

9.0 Procedure.

9.1 The sampler shall be operated in accordance with the specific guidance provided in the sampler manufacturer's instruction manual and in Reference 2. The general procedure given here assumes that the sampler's flow rate calibration is based on flow rates at ambient conditions (Q_a) and serves to illustrate the steps involved in the operation of a PM₁₀ sampler.

9.2 Inspect each filter for pinholes, particles, and other imperfections. Establish a filter information record and assign an identification number to each filter.

9.3 Equilibrate each filter in the conditioning environment (see 7.4) for at least 24 hours.

9.4 Following equilibration, weigh each filter and record the presampling weight with the filter identification number.

9.5 Install a preweighed filter in the sampler following the instructions provided in the sampler manufacturer's instruction manual.

9.6 Turn on the sampler and allow it to establish run-temperature conditions. Record the flow indicator reading and, if needed, the ambient temperature and barometric pressure. Determine the sampler flow rate (actual m³/min) in accordance with the instructions provided in the sampler manufacturer's instruction manual. NOTE.—No onsite temperature or pressure measurements are necessary if the sampler's flow indicator does not require temperature or pressure corrections or if seasonal average temperature and aver-

age barometric pressure for the sampling site are incorporated into the sampler calibration (see step 8.2.4). If individual or daily temperature and pressure corrections are required, ambient temperature and barometric pressure can be obtained by on-site measurements or from a nearby weather station. Barometric pressure readings obtained from airports must be station pressure, not corrected to sea level, and may need to be corrected for differences in elevation between the sampling site and the airport.

9.7 If the flow rate is outside the acceptable range specified by the manufacturer, check for leaks, and if necessary, adjust the flow rate to the specified setpoint. Stop the sampler.

9.8 Set the timer to start and stop the sampler at appropriate times. Set the elapsed time meter to zero or record the initial meter reading.

9.9 Record the sample information (site location or identification number, sample date, filter identification number, and sampler model and serial number).

9.10 Sample for 24 ± 1 hours.

9.11 Determine and record the average flow rate (Q_a) in actual m³/min for the sampling period in accordance with the instructions provided in the sampler manufacturer's instruction manual. Record the elapsed time meter final reading and, if needed, the average ambient temperature and barometric pressure for the sampling period (see note following step 9.6).

9.12 Carefully remove the filter from the sampler, following the sampler manufacturer's instruction manual. Touch only the outer edges of the filter.

9.13 Place the filter in a protective holder or container (e.g., petri dish, glassine envelope, or manila folder).

9.14 Record any factors such as meteorological conditions, construction activity, fires or dust storms, etc., that might be pertinent to the measurement on the filter information record.

9.15 Transport the exposed sample filter to the filter conditioning environment as soon as possible for equilibration and subsequent weighing.

9.16 Equilibrate the exposed filter in the conditioning environment for at least 24 hours under the same temperature and humidity conditions used for presampling filter equilibration (see 9.3).

9.17 Immediately after equilibration, reweigh the filter and record the post-

sampling weight with the filter identification number.

10.0 Sampler Maintenance.

10.1 The PM₁₀ sampler shall be maintained in strict accordance with the maintenance procedures specified in the sampler manufacturer's instruction manual.

11.0 Calculations.

11.1 Calculate the average flow rate over the sampling period corrected to EPA reference conditions as Q_{std}. When the sampler's flow indicator is calibrated in actual volumetric units (Q_a), Q_{std} is calculated as:

$$Q_{std} = Q_a \times (P_{av}/T_{av})(T_{std}/P_{std})$$

where

Q_{std}=average flow rate at EPA reference conditions, std m³/min;

Q_a=average flow rate at ambient conditions, m³/min;

P_{av}=average barometric pressure during the sampling period or average barometric pressure for the sampling site, kPa (or mm Hg);

T_{av}=average ambient temperature during the sampling period or seasonal average ambient temperature for the sampling site, K;

T_{std}=standard temperature, defined as 298 K;

P_{std}=standard pressure, defined as 101.3 kPa (or 760 mm Hg).

11.2 Calculate the total volume of air sampled as:

$$V_{std} = \bar{Q}_{std} t$$

where

V_{std}=total air sampled in standard volume units, std m³;

t=sampling time, min.

11.3 Calculate the PM₁₀ concentration as:

$$PM_{10} = (W_f - W_i) \times 10^6 / V_{std}$$

where

PM₁₀=mass concentration of PM₁₀, μg/std m³;

W_f, W_i=final and initial weights of filter collecting PM₁₀ particles, g;

10⁶=conversion of g to μg.

NOTE: If more than one size fraction in the PM₁₀ size range is collected by the sampler, the sum of the net weight gain by each collection filter [Σ(W_f-W_i)] is used to calculate the PM₁₀ mass concentration.

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[Appendix J added at 52 FR 24663, July 1, 1987; amended at 52 FR 29467, Aug. 7, 1987]

APPENDIX K TO PART 50—INTERPRETATION OF THE NATIONAL AMBIENT AIR QUALITY STANDARDS FOR PARTICULATE MATTER

1.0 General.

This appendix explains the computations necessary for analyzing particulate matter data to determine attainment of the 24-hour and annual standards specified in 40 CFR 50.6. For the primary and secondary standards, particulate matter is measured in the ambient air as PM₁₀ (particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers) by a reference method based on Appendix J of this part and designated in accordance with part 53 of this chapter, or by an equivalent method designated in accordance with part 53 of this chapter. The required frequency of measurements is specified in part 58 of this chapter.

Several terms used throughout this appendix must be defined. A "daily value" for PM₁₀ refers to the 24-hour average concentration of PM₁₀ calculated or measured from midnight to midnight (local time). The term "exceedance" means a daily value that is above the level of the 24-hour standard after rounding to the nearest 10 µg/m³ (i.e., values ending in 5 or greater are to be rounded up). The term "average" refers to an arithmetic mean. All particulate matter standards are expressed in terms of expected annual values: expected number of exceedances per year for the 24-hour standards and expected annual arithmetic mean for the annual standards. The "expected annual value" is the number approached when the annual values from an increasing number of years are averaged, in the absence of long-term trends in emissions or meteorological conditions. The term "year" refers to a calendar year.

Although the discussion in this appendix focuses on monitored data, the same

principles apply to modeling data, subject to EPA modeling guidelines.

2.0 Attainment Determinations.

2.1 24-Hour Primary and Secondary Standards.

Under 40 CFR 50.6(a) the 24-hour primary and secondary standards are attained when the expected number of exceedances per year at each monitoring site is less than or equal to one. In the simplest case, the number of expected exceedances at a site is determined by recording the number of exceedances in each calendar year and then averaging them over the past 3 calendar years. Situations in which 3 years of data are not available and possible adjustments for unusual events or trends are discussed in Sections 2.3 and 2.4. Further, when data for a year are incomplete, it is necessary to compute an estimated number of exceedances for that year by adjusting the observed number of exceedances. This procedure, performed by calendar quarter, is described in Section 3. The expected number of exceedances is then estimated by averaging the individual annual estimates for the past 3 years.

The comparison with the allowable expected exceedance rate of one per year is made in terms of a number rounded to the nearest tenth (fractional values equal to or greater than 0.05 are to be rounded up; e.g., an exceedance rate of 1.05 would be rounded to 1.1, which is the lowest rate for nonattainment).

2.2 Annual Primary and Secondary Standards.

Under 40 CFR 50.6(b), the annual primary and secondary standards are attained when the expected annual arithmetic mean PM₁₀ concentration is less than or equal to the level of the standard. In the simplest case, the expected annual arithmetic mean is determined by averaging the annual arithmetic mean PM₁₀ concentrations for the past 3 calendar years. Because of the potential for incomplete data and the possible seasonality in PM₁₀ concentrations, the annual mean shall be calculated by averaging the four quarterly means of PM₁₀ concentrations within the calendar year. The formulas for calculating the annual arithmetic mean are given in Section 4. Situations in which 3 years of data are not available and possible adjustments for unusual events or trends are discussed in Sections 2.3 and 2.4. The expected annual arith-

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INSTRUCTION AND OPERATION MANUAL

HIGH VOLUME PM10 SAMPLER

GRASEBY ANDERSEN
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Revised
July, 1988

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ATTENTION!

1. To avoid an electrical shock, disconnect the 115 volt A.C. power prior to performing any maintenance activities on the HVPM10 sampler.
2. Proper alignment of the Model 1200 Inlet halves is required to maintain a proper seal. Check alignment pins and holes for proper seating before locking the inlet hook-catches.
3. Handling care and technique should be developed to ensure the quartz fiber filter media is not damaged prior to or after a sample run (this media is extremely brittle). A filter cartridge is mandatory with all ASI/GMW HVPM10 systems.
4. Because of the size of the PM10 fractionating inlet, it is required that the sampler be firmly anchored to the site platform or a pallet. Model 2021 (PN G2021) accessory support feet are recommended.
5. The Model 1200 collection shim must be checked routinely for overloading. Refer to Section 7.1 for procedures.
6. Adequate voltage is required for HVPM10 samplers equipped with mass flow controllers. A minimum line voltage of 90 VAC is necessary to ensure proper operation. Ground fault interrupters are recommended for all HVPM10 systems.

1.0

Introduction

On July 1, 1987, the U.S. Environmental Protection Agency (U.S. EPA) promulgated a new size-specific air quality standard (refer to Appendix A) for ambient particulate matter. This new primary standard applies only to particles with aerodynamic diameters smaller than, or equal to, 10 micrometers (PM10), and replaces the original rules for total suspended particulate matter (TSP). To measure concentrations of these particles, the EPA also promulgated a new federal reference method (FRM). This method is based on the fractionation of non-PM10 particles from their size distribution, followed by filtration and gravimetric analysis of PM10 mass on the filter substrate.

The new primary standard (adopted to protect human health) limits PM10 concentrations to 150 micrograms per standard cubic meter ($\mu\text{g}/\text{std. m}^3$) during a 24-hour period. It is believed that these smaller particles are able to reach the lower regions of the human respiratory tract, and thus be responsible for most of the adverse health effects associated with suspended particulate pollution. The secondary standard, used to assess the impact of pollution on public welfare, has also been established 150 $\mu\text{g}/\text{std. m}^3$.

Andersen Samplers, Inc (ASI) and General Metal Works (GMW) High Volume PM10 (HVPM10) systems meet all FRM performance specifications for the measurement of PM10 and hence, have been designated as an approved method for the determination of suspended PM10 particulate concentrations. Each ASI/GMW HVPM10 sampler bears an identification label with an inlet-specific FRM designation number. Table 1.1 presents a description of each inlet and its respective designation number.

Regardless of the model of ASI/GMW inlet employed, the reference method also requires that the measurement system be equipped with the following components:

- A. Anodized aluminum high volume shelter identified as G8500,
- B. PM10 fractionating inlet identified as either Model 1200, 321-B, or 321-C,
- C. Either an acrylonitrile-butadiene styrene-plastic filter holder, motor housing and 0.6 hp motor (Sierra-Andersen Product and available only upon request), or a stainless-steel filter holder and phenolic plastic motor housing with a 0.6 hp motor (GMW product),

Table 1.1 Description of ASI/GMW HVPM10 Sampler Inlets

REFERENCE METHOD DESIGNATION and MODEL NUMBER	INLET DESCRIPTION
RFPS-1287-063 SA/G 1200	<ol style="list-style-type: none"> 1. Single Acceleration Nozzle Stage 2. 9.7μm, 50% cut point 3. Greased Collection Shim 4. Inlet Body Hinged for Cleaning
RFPS-1287-064 SA/G 321-B	<ol style="list-style-type: none"> 1. Two Acceleration Nozzle Stages 2. 9.7μm, 50% Cut Point 3. Greased Collection Shim on first stage 4. Inlet lid Removable for Cleaning
RFPS-1287-065 SA/G 321-C	<ol style="list-style-type: none"> 1. Single Acceleration Nozzle Stage 2. 9.7μm, 50% Cut Point 3. Greased Collection Shim 4. Inlet lid Removable for Cleaning

Note: An inlet originally purchased as Model 321 (single stage inlet without greased shim) or Model 321-A (two stage inlet without greased shim) must be modified to meet reference method designation. Please contact the factory.

- D. Either an electronic mass flow or volumetric flow control system (Variacs and step-down transformers are not eligible flow control systems for PM10 sampling).
- E. Either a digital timer/programmer, seven-day mechanical timer, six-day timer/programmer, solid state timer/programmer, or elapsed time indicator.
- F. Either a continuous flow recorder or an alternate method for recording operation flow rate (e.g., pre-and post flow checks).

If an HVPM10 sampler is not equipped with a component from each of the above categories, data collected cannot be directly or ultimately reported to the U.S. EPA. If there are questions regarding the authenticity of the monitoring system, please contact the factory as soon as possible.

This document will address the recommended methods of operation for ASI/GMW HVPM10 monitoring systems. The procedures presented herein are within all quality assurance and operational specifications required by the FRM, compatible with procedures presented in the "Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Section 2.11" and are specific to ASI/GMW systems.

2.0 Principles of Operation

2.1 Method Summary

The FRM describes in detail the performance requirements for all PM₁₀ samplers. The instrument must meet the basic requirements simplified in Table 2.1. All ASI/GMW HVPM₁₀ monitoring systems satisfy these criteria. Only particles $\leq 10 \mu\text{m}$ are drawn through the inlet and a constant, controlled flow rate is maintained by either a mass flow (MFC) or volumetric flow controller (VFC). Particles are collected on a micro-quartz fiber filter that is equilibrated and weighed before (tare) and after (gross) sampling to determine the weight (net mass) gain of the sample. Sample duration is either controlled by a timer accurate to ± 15 minutes over a 24-hour sample period or measured by an elapsed time indicator.

To calculate the mass concentration of PM₁₀, the total volume of air sampled is determined from the measured actual flow rate and the sampling time. The concentration of PM₁₀ in the ambient air is then computed as the net mass collected divided by the volume of air sampled. Since the sampler is operated in terms of actual or seasonal average conditions (to meet the design specifications of the inlet), the operational flow rate (and thus, the sample volume) must be corrected to U.S. EPA reference conditions (298°K, 760 mmHg) for data reporting. Reported concentrations must be expressed as micrograms per standard cubic meter ($\mu\text{g}/\text{std. m}^3$).

As previously indicated, the Size-Selective Inlet (SSI) is the sampler component that characterizes the reference method designation number of an HVPM₁₀ sampler. Since several modifications have occurred, the following brief history of the evolution of the ASI/GMW SSI may be helpful.

The original SSI's were developed by Dr. A.R. McFarland under an U.S. EPA grant to meet a potential Inhalable Particulate standard. At that time, the U.S. EPA proposed to regulate only those particles with an aerodynamic diameter (a.d.) of $15 \mu\text{m}$. After research and field studies, the U.S. EPA reconsidered this particulate indicator and decided that an indicator based on the concentration of Thoracic Particulates (those particles that can be entrained in the respiratory system, $\leq 10 \mu\text{m}$ a.d.) provided a better indication of the potential health effects from particulate pollution.

Table 2.1 Federal Reference Method HVPM10 Performance Requirements

SPECIFICATION	PART NUMBERS
1. Draw a measured quantity of ambient air through a specially designed, particle size discriminating inlet	SA/G 1200 SA/G 321-B* SA/G 321-C* <i>(*no longer sold)</i>
2. Maintain a constant flow rate within the design specifications of the HVPM10 inlet	SA350 / G310 (mass flow rate) G360 (volumetric flow rate)
3. Collect the sample on approved filter media	GQMA (Micro-Fiber Quartz)
4. Have a timing control system within accuracy limits stipulated by the FRM.	G70, G70i, G76, G76i, G302, G801, G8000 G901, G901R, G901, G901R

Dr. McFarland modified the single stage, 15 μm (Model 320) SSI to obtain a 10 μm cut point under funding from ASI and this inlet was sold from March, 1982 until May, 1984 under a Model 321 designation. Although the Model 321 inlet met all of the prevailing performance specifications for PM10 inlets, Dr. McFarland developed an improved SSI, the two stage Model 321-A. During subsequent U.S. EPA field performance evaluations however, it was determined that a greased collection surface was required (within the SSI) to prevent a potential "carry-through" of large particles ($>20 \mu\text{m}$) at PM10 monitoring sites subject to high concentration of wind-blown dust.

Later TAMU data analysis determined that the of 10.2 μm inlet cut point (original design of Model 321 and 321-A inlets) could be modified to a cut point of 9.7 μm by using a smaller diameter acceleration nozzle. A 9.7 μm cut point meets not only all Federal Reference Method (FRM) inlet specifications (inlet cut point of $10 \mu\text{m} \pm 0.5 \mu\text{m}$) but also results in lower mass concentration measurements. Hence, the development of greased shim and nozzle insert retro-fit kits for both the 321 and 321-A inlets. ASI/GMW offer these modification kits free to all customers who purchased Models 321 and 321-A inlets, it is only necessary to contact the manufacturer. Retro-fit instructions are presented in Appendix E of this manual.

Once modified with a greased collection surface, the 321 and 321-A inlets are designated Reference Methods (RFPS-1287-065 and RFPS-1287-064, respectively) and are referred to as Model 321-C and 321-B, respectively. Note: Nozzle inserts for Model 321-A inlets are not required for FRM designation, they are however, recommended by the manufacturer.

Since the greased collection shim all ASI/GMW HVPM10 inlets needs to be routinely cleaned, Dr. McFarland later developed a hinged-body (Model 1200) SSI to facilitate these maintenance procedures.

This section will examine each portion of the monitoring system and provide a discussion on the principle of operation for each individual component. For simplicity and organizational purposes, it will be assumed that the Model 1200 inlet will be mounted on a high-volume sampler fitted with a volumetric flow controller, elapsed time indicator, and a continuous flow recorder. It will also be assumed that the 321-B inlet (note: These inlets are no longer being manufactured; however, due to the number of these inlets in operation, their operational principles are being included here.) has been mounted on a high volume sampler equipped with a mass flow controller, continuous flow recorder, and a 6-day on/off timer. These configurations are not required nor necessarily recommended. As indicated in

Table 2.1, if the monitoring system satisfies the requirements presented in 40 CFR 53, Appendix J, the individual components are interchangeable; any combination of inlets, flow controllers and timers is allowed.

2.2 Model 1200/VFC HVPM10 Sampler, RFPS-1287-063

Figure 2.1 presents a schematic indicating the basic elements of the Model 1200 VFC HVPM10 sampler. As ambient air is drawn into the inlet, it is evacuated from the buffer chamber through nine acceleration nozzles into the impaction chamber where particles larger than 10 μm are impacted onto a greased collection shim. The air containing the PM10 particle fraction is then channeled through an additional 16 vent tubes and filtered through a specially formulated micro-quartz fiber filter. The acceleration nozzles have critical diameters calculated and performance tested to provide the necessary velocity to effect correct particle size fractionation within the impaction chamber. Because air velocities are critical to maintain a PM10 cut point within the inlet, maintaining the correct design flow rate of 1.13 m^3/min ($\pm 10\%$) at actual conditions is important.

Sample flow rate is controlled and maintained by a volumetric flow controller (VFC). Simply stated, the VFC is a dimensional venturi device used to control gas flow. When applied to a high volume air sampler, this flow control principle incorporates a smooth-wall venturi that gradually opens to a recovery section. Vacuum is provided by a blower/motor downstream of the venturi.

Flow control is accomplished by occluding, and thus accelerating, the air flow through the venturi. At some point in the flow stream, the air velocity will equal the acoustic velocity, and critical flow will be achieved. As long as downstream changes are small, all conditions at the venturi (including the flow rate) are determined by upstream conditions. This condition is referred to as "choking" and is a distinctive characteristic of all VFC's. The ASI/GMW VFC utilizes this principle of choked flow to maintain a constant actual flow rate of 1.13 m^3/min over a sample period. Note: If data are to be reported to the U.S. EPA, the flow rate must be corrected to standard conditions before calculating the sample volume. These calculations are presented in Section 6.0 of this document.

Since critical flow through the venturi is not greatly affected by changes in filter loading, ambient temperature or station barometric pressure, a stable volumetric flow rate is maintained as long as sufficient power is provided to the unit. To determine the sampler's operational flow rate (as required by the FRM) a calibration must be conducted. Specific calibration procedures are presented in

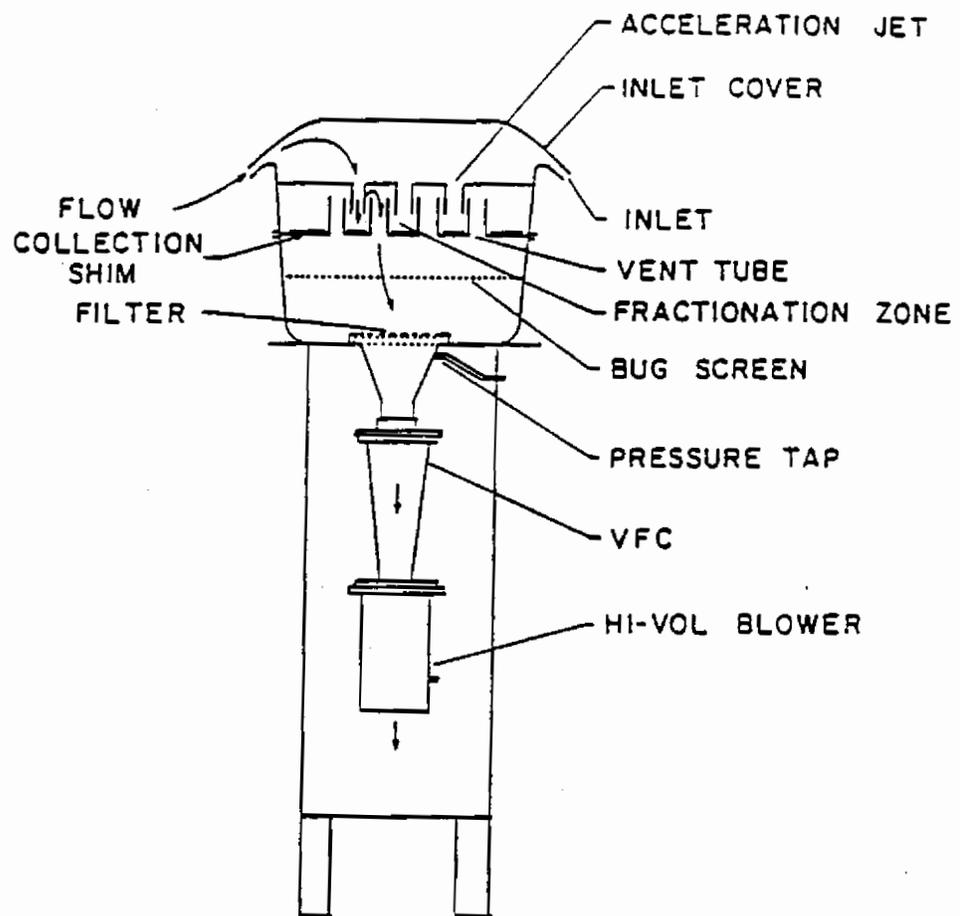


Figure 2.1 Schematic Diagram of Sierra - Andersen/GMW Model 1200 with VFC

Section 4.0. The sampler's indicated flow and the reading from an elapsed time meter, is then used to compute the sample volume. ASI/GMW have two models of elapsed time indicators: one that can be reset, the other provides a non-stop record of the samplers total operational time. The model selected is optional.

2.3 Model 321-B/MFC HVPM10 Sampler, RFPS-1287-064

It is assumed for simplicity that the Model 321-B inlet has been mated with a mass flow controller. However this is not necessary since, a 321-B inlet will perform as designed with a volumetric flow controller.

Figure 2.2 presents a schematic indicating the basic elements of the Model 321-B/MFC HVPM10 sampler. As ambient air is drawn into the inlet, it is evacuated from the buffer chamber where the particles larger than 10 μm are impacted onto a greased collection shim. The air is then accelerated through an additional 16 jets into a second impaction chamber. The acceleration nozzles have critical diameters calculated and performance tested to provide the necessary velocity to effect correct particle size fractionation within the impaction chamber. The air flow finally exits the inlet through nine vent tubes onto a micro-quartz fiber filter. Currently, the micro-quartz filter is the only commercially available filter media that satisfies the requirements stipulated in 40 CFR 53, Appendix J for PM10 monitoring. ASI/GMW are researching alternate media and will inform our customers if any become available.

Air is pulled through the filter into the intake of a motor and subsequently exits into the atmosphere. The actual mass flow rate of the sampled air is controlled with a reference/sensing flow probe mounted in the throat section of the filter holder. The electrical output of the flow probe and associated solid state circuitry is used as the control signal to adjust the motor speed. Thus, as ambient conditions or filter loadings change, the controller increases or decreases the electrical power to the motor in such a manner that the mass flow rate is maintained at a constant velocity. The desired sampler flow rate is adjusted by a potentiometer following the sampler's calibration.

The specific mass flow rate at which the sampler should be set will depend upon local conditions of temperature and barometric pressure. The Model 321-B SSI is designed to maintain a $10 \pm 0.5 \mu\text{m}$ cut point over a flow rate range of 1.02 to 1.24 m^3/min at actual conditions. It is imperative that the operator choose a set-point that will "center" the flow rate in respect to fluctuating run day temperature and barometric pressure conditions. To accomplish this, a seasonal average

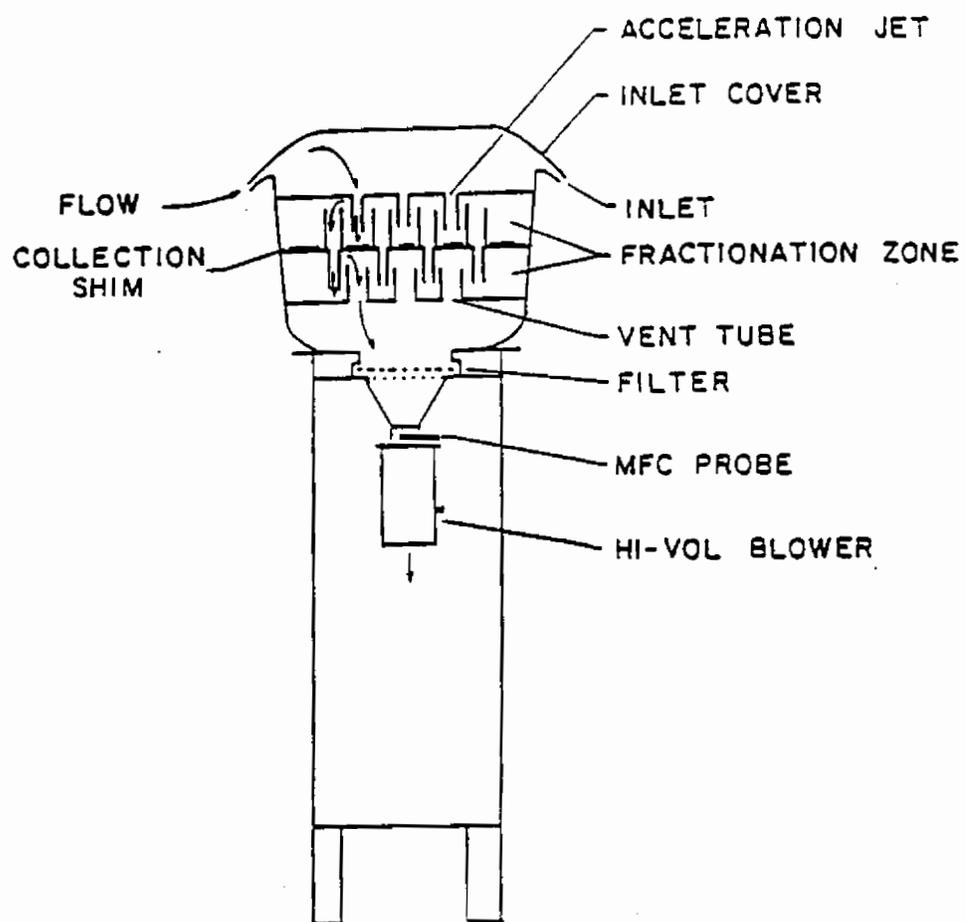


Figure 2.2 Schematic Diagram of Sierra - Andersen/GMW Model 321b HVPM10 with MFC

temperature and barometric pressure for each monitoring site should be determined. Using these values, an optimum seasonal average adjusted flow rate is calculated and a set-point determined. Calculations and set point adjustment procedures are presented in Section 4.4. A continuous recording of the sampler's flow rate is provided by a pressure transducer. This instrument is connected to the exhaust pressure port of the motor and monitors the difference in pressure between atmospheric and the motor plenum. The response of the flow recorder is calibrated and can be used to not only measure the sampler's flow rate, but also to monitor the line-voltage stability and flow controller performance. It is assumed that the Model 321-B/MFC sampler is also equipped with a mechanical 6-day timer. This timer is designed to operate with the HVPM10 sampler to comply with the sixth day format outlined in the Federal Register and is accurate to within ± 15 minutes over a 24-hr sample period. Once properly set, this timer will energize the sampler every sixth day, at midnight, and allows rotation of the sample period over an entire week.

2.4 Calibration Equipment

A conventional orifice device, identical to that used in the calibration of a total suspended particulate sampler, is used to calibrate the ASI/GMW HVPM10 sampler. Two orifice models are available: one equipped with a set of five resistance plates (PN G25), and the other with a valve allowing for variable resistance (PN G335). In either case, the orifice device must be calibrated against a standard of known accuracy every year and provided with a calibration relationship (orifice pressure drop vs. actual flow rate) by either the calibrating agency or the operator.

3.0 HVPM10 Sampler Assembly Instructions

The ASI/GMW HVPM10 sampler is delivered in two cartons: one contains the Size-Selective Inlet (SSI), the second contains the sampler shelter or base unit. This section presents assembly instructions for the Model 1200 inlet and a basic base unit.

Specific instructions for retro-fitting HVPM10 samplers (e.g., exchanging a Model 321-B inlet for a Model 1200 or installing a VFC in a sampler previously equipped with an MFC) are available from the manufacturer and are not presented here. Retro-fit instructions for modifying a Model 321-A inlet to a Model 321-B are presented in Appendix E.

3.1 Model 1200 Size-Selective Inlet (SSI) Assembly Instructions

The Model 1200 SSI is packaged basically complete; only minor assembly is necessary. When removing the SSI from the shipping carton, take care not to drop the dome-shaped hood. The SSI is packaged with two protective cushions: one rests between the hood and the inlet, the second above the acceleration nozzles. Remove both cushions and the four cardboard corner braces. Gently lift the SSI from the carton and place it on the floor or on a workbench. Save the shipping container and packing material for future use. Locate the hardware bag taped to the acceleration nozzle plate and assemble the SSI as follows:

1. Place the hood (dome side up) onto the SSI housing.
2. Align one hole (8 total) on the hood with one located on the inlet rain deflector ramp (PN SSI-106). The rain deflector ramp is the gently curved section of the acceleration plate adjacent to the nozzles.
3. Place an aluminum spacer (PN SSI-60) between the hood and the acceleration nozzle plate.
4. For each spacer, place a thumb screw and nylon washer in-line. Loosely fasten the spacer to the nozzle plate and hood. Repeat steps 1-3 for the remaining spacers. When all spacers are installed, finger tighten the thumbscrews to ensure a complete seal.

5. Release the 4 stainless steel inlet hook-catches and tilt back the top portion of the SSI. Latch the inlet support strut in its upper most position.
6. Release the collection shim from its 2 shim clips. Lift the shim carefully past the nozzles and out of the inlet.
7. Place the shim on a clean flat surface and spray with a thick coating of Dow Corning Silicone #316. Do not substitute any other grease or oil without contacting the manufacturer; particle bounce characteristics may be affected by changing the viscosity of the oil.
8. Handling only the edges, return the collection shim (oiled side up) to the sampler inlet and secure.
9. While holding the inlet support strut forward, close and secure the top portion of the sampler inlet. Note: It may be necessary to adjust the inlet hook-catches. To accomplish this, loosen the lock-nut on the hook-catch rod. To shorten the catch length, turn the rod clockwise; counter-clockwise to lengthen. After adjustments are complete, re-tighten the lock-nut.

3.2 HVPM10 Sampler Shelter Assembly Instructions- VFC SAMPLERS

The instructions presented in this section are specific to ASI/GMW HVPM10 sampling systems ordered with Volumetric Flow Controllers (VFC).

The HVPM10 sampler shelter is easiest removed from the shipping container by tipping the carton horizontally and then slowly removing the shelter. The two additional boxes included in the shelter shipping carton house the motor and VFC and the filter holder assembly. The procedure to assemble the shelter are as follows:

1. Remove the VFC, motor (Figure 3.1) and filter holder assembly from their respective boxes.
2. Remove the male adapter (PN G2002) by removing the four (4) 1/4 20 x 1" hex-head bolts. This will expose the motor.
3. If a neoprene gasket has not been glued on the bottom of the VFC, install one (1) of the VFC flange gaskets directly on top of the motor housing. Make sure that the gasket is present and undamaged before continuing.

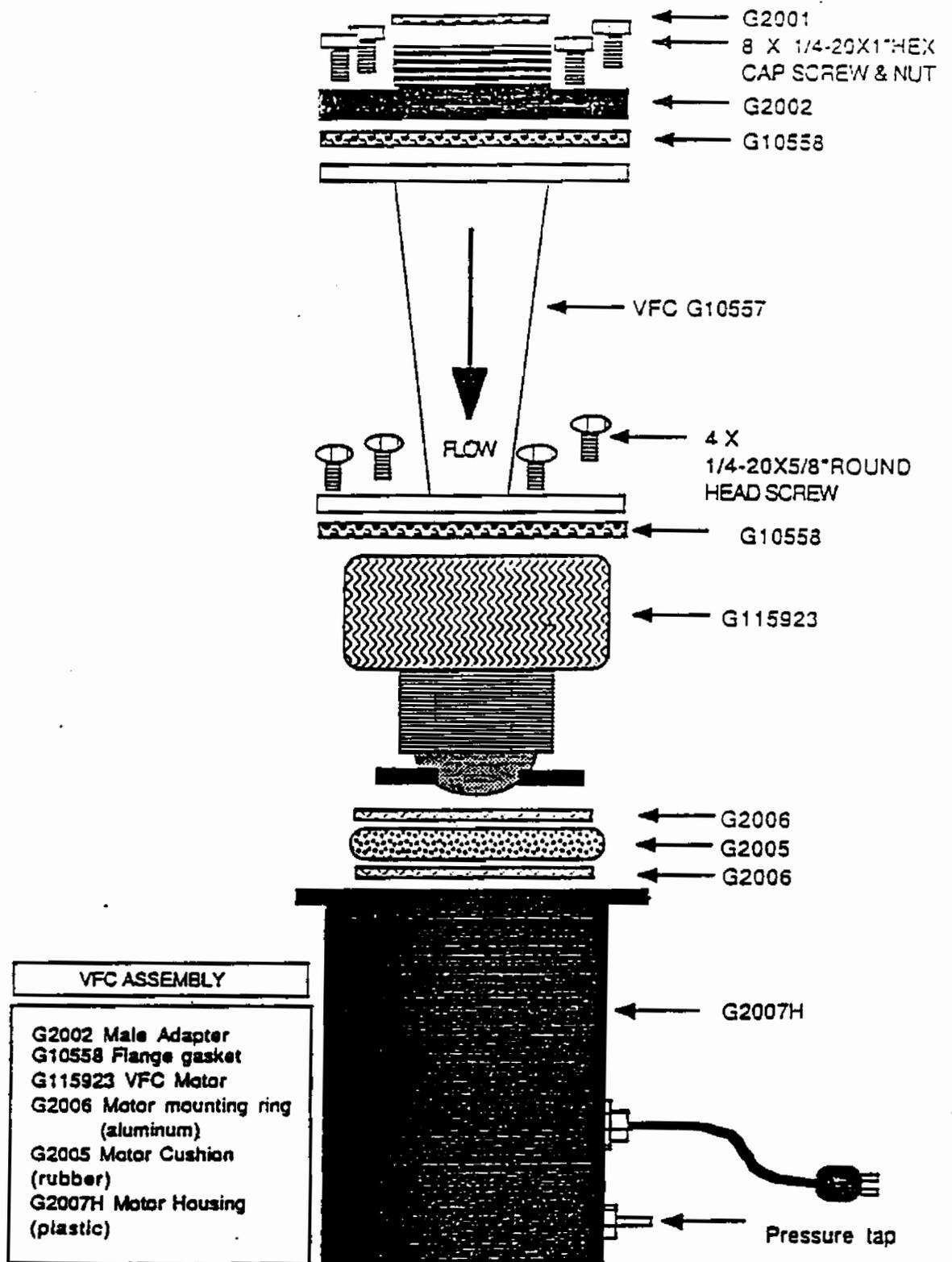


Figure 3.1 VFC Component Parts

4. Using the four (4) 1/4-20 x 5/8" hex-head screws, attach the VFC to the motor housing. Do not over-tighten as damage to the VFC flange gasket may result. Make sure that the arrow on the VFC is pointing down (toward the motor).
5. Place the second VFC flange gasket on the top of the VFC. Attach the male adapter to the VFC by installing and tightening the eight (8) 1/4 x 20 x1 hex-head bolts. Do not over-tighten.
6. Attach the assembled VFC system to the filter holder. Make sure that the motor plate gasket (PN G2001) is present before tightening.
7. Center the FH-sealing gasket (8 x 10 x 3/8") over the rectangular hole in the shelter pan. With the aid of another person, lift the entire filter holder/VFC assembly and gently drop it into the rectangular shelter pan hole. Make sure that FH-sealing gasket is centered evenly around the hole. Adjustment may be necessary after the assembly is placed inside.
8. Connect the tubing between the continuous recorder and the motor pressure tap. Connect the tubing between filter pressure tap and quick-connect fitting on shelter.

Note: If the sampler is being assembled at a central location (not where it will be operated), it is recommended to skip steps 9-12 until the sampler is deployed. It is much easier to transport the sampler without the inlet attached. Once deployed, the shelter must be firmly anchored before installing the inlet.

Extended support feet (PN G2021) are suggested.

9. With the aid of another person, carefully place the assembled SSI on the shelter.
10. Secure the inlet to the shelter body by installing the four (4) 10-24 x 1" machine screws in the sides of the shelter (refer to Figure 3.2) and through the shelter pan (PN G12006). Pre-punched holes are provided in each new shelter body.
11. Cut free the SSI shelter pan support strut (PN G120018). Unlatch the 6 draw catches that attach the base plate to the shelter pan section.
12. Attach the shelter pan support strut to the right side of the shelter pan. Make sure the large washer is placed on the outside of the shelter pan support strut. Carefully open the inlet.

MODEL 1200 SSI
MOUNTING HOLES
FOR 10-24x1"
MACHINE SCREWS
(4 PLACES)

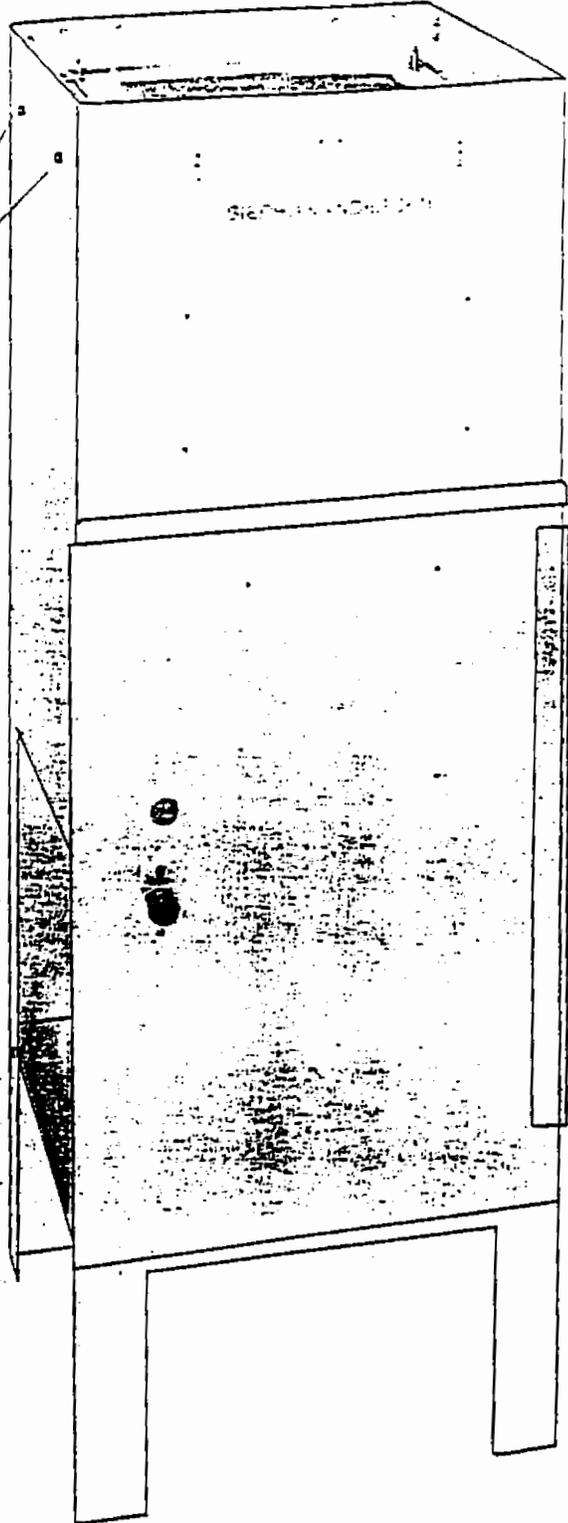


Figure 3.2 High Volume Shelter without TSP Gabled Roof
or HVPM10 Inlet

13. Place a loaded filter cartridge on the sampler and connect the male power cord to line voltage. Energize the sampler and ensure that the recorder indicates an upscale response. Contact the manufacturer immediately if failure is suspected.
14. Turn off the sampler. Following instructions in Appendix D for the specific timer model installed, connect the motor to the timer and program, if necessary. Close the shelter door.
15. While holding the shelter pan support strut toward you, close the inlet. Latch the 6 shelter draw-catches. If necessary, adjust the shelter pan draw-catches following the procedure presented in Step 9, Section 3.1.
16. Conduct a leak test and calibration as presented in Section 4.2.

4.0 Flow Calibration Procedures

As discussed in Section 2.1, it is assumed in this document that the Model 1200 inlet has been mated with a volumetric flow controller; and Model 321-B with a mass flow controller (MFC). As mentioned previously, this is not required or necessarily recommended, either inlet will perform as designed regardless of which flow controller is employed. The type of flow controller does however, dictate the calibration method. Operating personnel should refer to the section dealing with their specific type: Section 4.3 presents procedures for VFC samplers and, Section 4.4 for MFC samplers. These two sections are completely independent; it is possible to remove and bind (if necessary) only those pages that deal with the type of sampler operated in the monitoring network. It is recommended however, that this entire section be reviewed and the two methods evaluated. In-house equipment, procedural simplicity, and subsequent data applications may warrant a new or retro-fitted PM10 measurement system.

To ensure an accurate calibration, ASI/GMW recommend a leak test be conducted after assembling the HVPM10 sampler and routinely thereafter. The leak test must be conducted after motor maintenance to determine the integrity of the seals. Complete leak test procedures are presented in Section 4.2

4.1 Discussion of Flow Rate Designations

The particle size discrimination characteristics of the Models 1200 and 321-B inlets are dependent upon the air velocity through the acceleration jets. A change in the entrance velocity will result in a change in the nominal particle size collected. For this reason, it is imperative that the flow rate through the inlet be maintained at a constant actual flow rate of 1.13 actual m³/min (±10%).

Since this actual flow rate is so critical for particle fractionation, the operator must have an understanding of the flow rate designations used in PM10 monitoring. Confusion between various air monitoring units is the most frequent source of error in a particulate monitoring network. Table 4.1 presents a summary of PM10 flow rate designations; their primary use and conversion equations.

TABLE 4.1 COMMON FLOW RATE DESIGNATIONS USED IN PM10 MONITORING

Flow Rate Designation	Temp. Conditions	Temp. Designation	Barometric Pressure Conditions	Barometric Pressure Designation	Primary Use	Conversion Calculations
Qa	Current	Ta	Current	Pa	1. Inlet Design Flow 2. Calibration Flows 3. Audits and Flow Checks	$Q_{std} = Q_a(P_a/P_{std})(T_{std}/T_a)$
	24-hour average	Tav	24-hour average	Pav	1. Operational Flow Rates	$Q_{std} = Q_a(P_{av}/P_{std})(T_{std}/T_{av})$
Qstd	EPA reference	Tstd (298°K)	EPA reference	Pstd (760mmHg)	1. Data Reporting	$Q_a = Q_{std} (P_{std}/P_a)(T_a/T_{std})$
SQa* seasonally adjusted Qa flow rate	seasonal average	Ta	seasonal average	Pa	1. Operational Flow Rates	$Q_{std} = SQ_a(P_a/P_{std})(T_{std}/T_a)$

*This is not a flow rate! Flow rates can only be expressed in terms of mass units (standard flow) or volume units (actual flow). This designation simply refers to a seasonally adjusted Qa flow rate.

4.2 Pre-Calibration Leak Test

4.2.1 VFC HVPM10 Sampler. This test should be conducted after sampler assembly, after motor maintenance and at routine intervals throughout the year. The following procedures should be followed:

1. Set up the calibration system as illustrated in Figure 4.1. VFC HVPM10 samplers are calibrated without a filter or filter cartridge in line. The operating filter pressure drop is simulated with multi-hole load plates, or an adjustable Vari-flo® orifice. When installing the orifice face plate adapter to the filter support screen, tighten the face plate nuts on alternate corners first to prohibit leaks and to insure even tightening. The fittings should be hand tightened; too much compression can damage the sealing gasket. Make sure the orifice gasket is in place between the face plate adapter and orifice, tighten down the orifice to the face plate adapter making sure not to cross thread the lock-down ring.
2. Cover or tape over the inlet of the orifice unit with one or more strips of duct tape. Check that the manometer valves of both manometers are fully closed by removing the tubing to the orifice pressure tap and blowing into the tube. Valve are closed by turning the plastic elbows at the top of a monometer fully clockwise. If the valves are closed no movement of the fluid will take place. Replace the tube to the orifice pressure tap. Connect tubing to pressure tap on filter holder housing located 1.5 inches below screen on side of holder. This pressure tap is accessible through door of sampler. Close off this tube with a tubing clamp. This tube should be closed during operation and leak tests when a manometer is not connected to the tube. Production VFC units have a quick-connect valve located on the shelter which closes automatically when manometer is disconnected.
3. Connect the motor blower power cord to a stable voltage source which has a power switch (e.g. the sampler's on-off timer (if so equipped), or another source of line voltage, 60 hz /120 vac).
4. Turn on power to the sampler. Gently wiggle the orifice and listen for a whistling sound that would indicate a leak in the system. A leak-

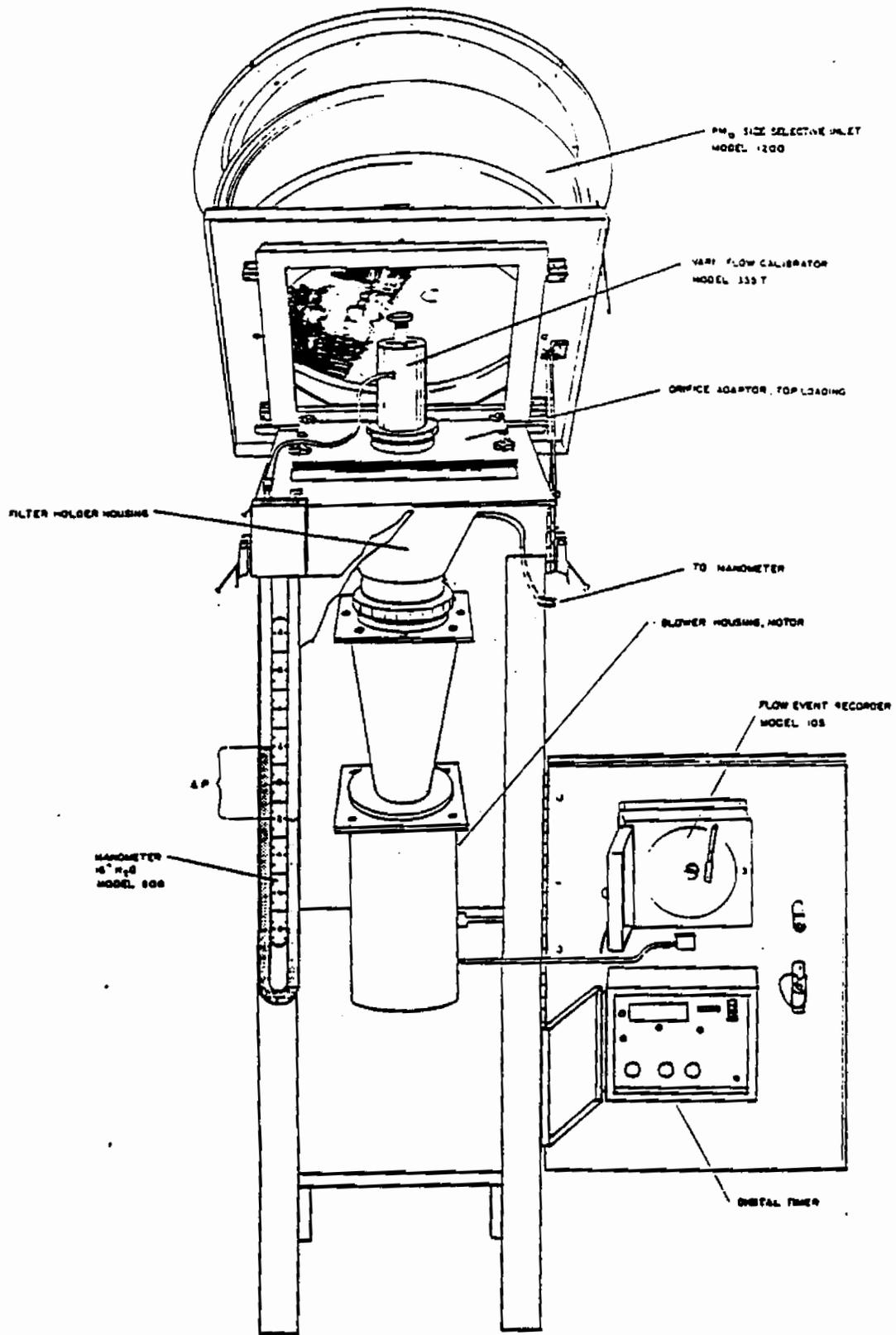


Figure 4.1 VFC Sampler Calibration Equipment

free system will also indicate no upscale response on the recorder. Leaks are usually caused by either a missing gasket at the junction of the orifice and face plate, cross threading the orifice to the face plate, or cross threading the VFC to the filter holder.

5. If the VFC HVPM10 is leak free, turn off the sampler and remove duct tape from the orifice.
6. Inspect the manometer connecting tubes for crimps or cracks. Open the valves on the manometers and gently blow through the tubing, watch for the free flow of the manometer fluid. Adjust the manometer sliding scale so that the zero line is at the bottom of the meniscii.
7. Proceed to one point flow verification of sampler, in Section 4.3.1.

4.2.2 MFC HVPM10 Sampler. This test should be conducted after sampler assembly, after motor maintenance and at routine intervals throughout the year. The following procedures should be followed:

1. Set up the calibration system as illustrated in Figure 4.2. MFC HVPM10 samplers are to be calibrated without a filter or filter cartridge in-line. When installing the orifice on the sampler filter support screen, tighten the face plate nuts on alternate corners to prohibit leaks and to ensure even tightening. The fittings should be hand tightened: too much compression can damage the sealing gasket. Make sure the the orifice gasket is in place and the orifice is not cross threaded on the face plate.
2. If possible, disconnect the motor from the flow controller and plug it directly into a stable voltage source (e.g. the sampler's on-off timer, if so equipped, or other source of line voltage).
3. Check that the continuous flow recorder is connected to the pressure tap on the lower side of the sampler motor housing and that there are no crimps or cracks along the tubing.
4. Install a clean recorder chart.
5. Cover or tape the inlet of the orifice calibration unit with one or more strips of duct tape. Check the manometer valves and verify that they are fully closed. Note: the valves are closed by turning the plastic elbows at the top of a manometer fully clockwise.

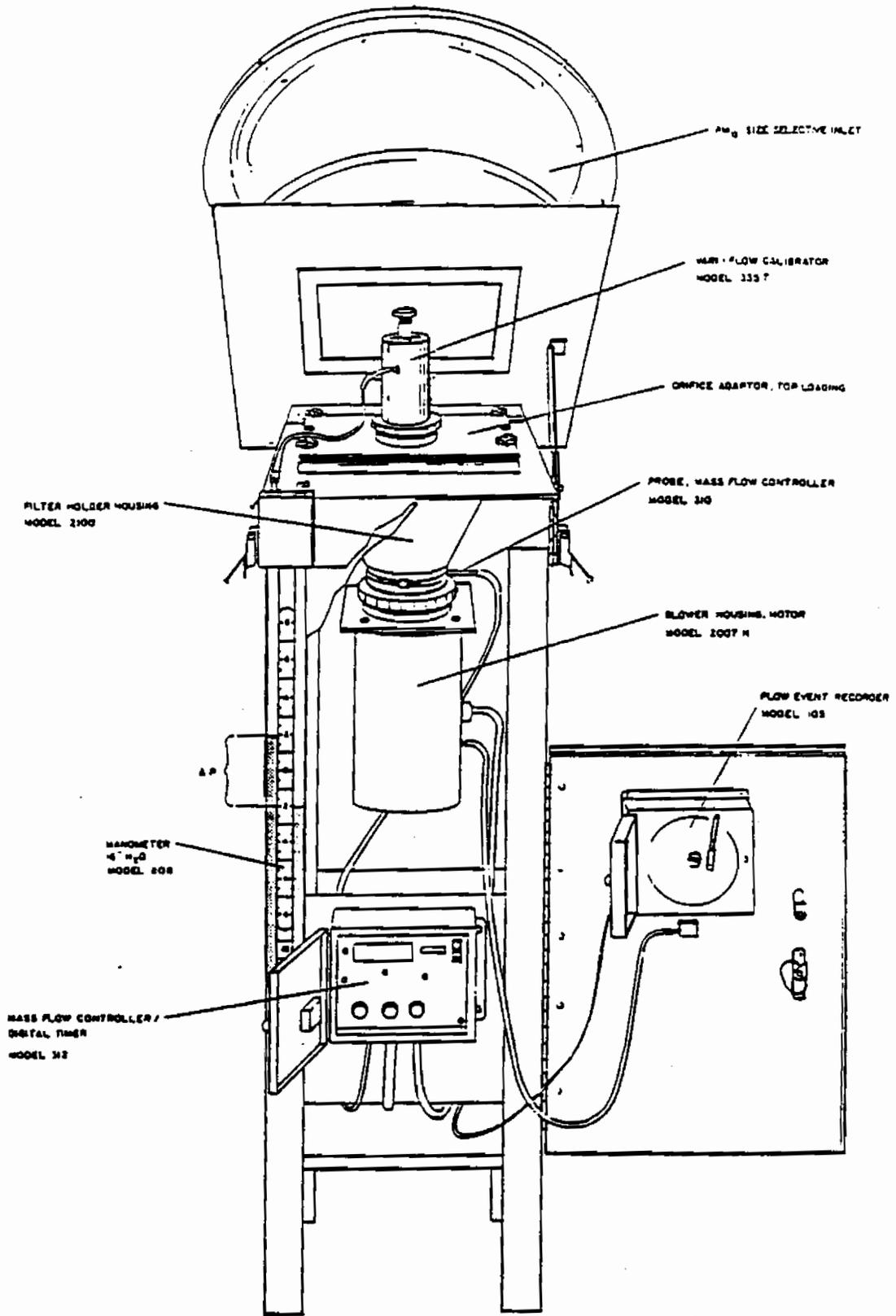


Figure 4.2 MFC Sampler Calibration Equipment

6. Energize the sampler. Gently wiggle the orifice and listen for a whistling sound that would indicate a leak in the system. A leak-free system will also indicate no upscale response on the recorder. Leaks are usually caused by either a missing gasket at the junction of the orifice and face plate, cross-threading the orifice on the face plate or cross threading the motor on the filter holder.
7. Turn off the sampler and remove the tape from the orifice.
8. Inspect the manometer for crimps or cracks in the connecting tubing. Open the valves and blow gently through the tubing, watch for the free flow of the fluid. Adjust the manometer sliding scale so that the zero line is at the bottom of the meniscii.
9. If the HVPM10 sampler is leak free, proceed to calibrate the sampler according to procedures presented in Section 4.4.

4.3 Basic Calibration Procedure for the VFC HVPM10 Sampler

The sampler calibration procedure in this section simply verifies the accuracy of the look-up chart and condition of the critical venturi used for flow control in VFC HVPM10 sampler. During operation of the sampler the flow controller will maintain an actual flow rate of 1.13 m³/min ($\pm 10\%$). This flow rate is a function of ambient conditions and the pressure differential across the filter. The approved filter media is a quartz fiber filter GQMA. Clean filter media will have a pressure drop ranging from 15 to 20 Inches-of-water. The VFC is designed so that proper operating flow rate is maintained over a broad range of temperature and pressure conditions.

Regardless of which type of orifice calibrator used, (multi-hole load plate unit or the Vari-flo®) the calibration procedure remains the same (Figure 4.3). The sampler inlet should be opened completely to prevent flow interference with the calibration transfer orifice. Flexible tubing is used to connect the orifice pressure tap with a water manometer. The pressure tap on the filter housing is connected to a separate water manometer. Pressure drops and indicated flow recorder readings are measured and the results checked against a calibration curve for the top loading orifice and the lookup table for the VFC. The flows determined from the orifice and lookup table should be within $\pm 3\%$. If this is not the case the VFC should be checked for internal obstructions and leakage in the system. Flow rate calculations should be repeated. If the difference in flow rates is not eliminated, contact the manufacturer.

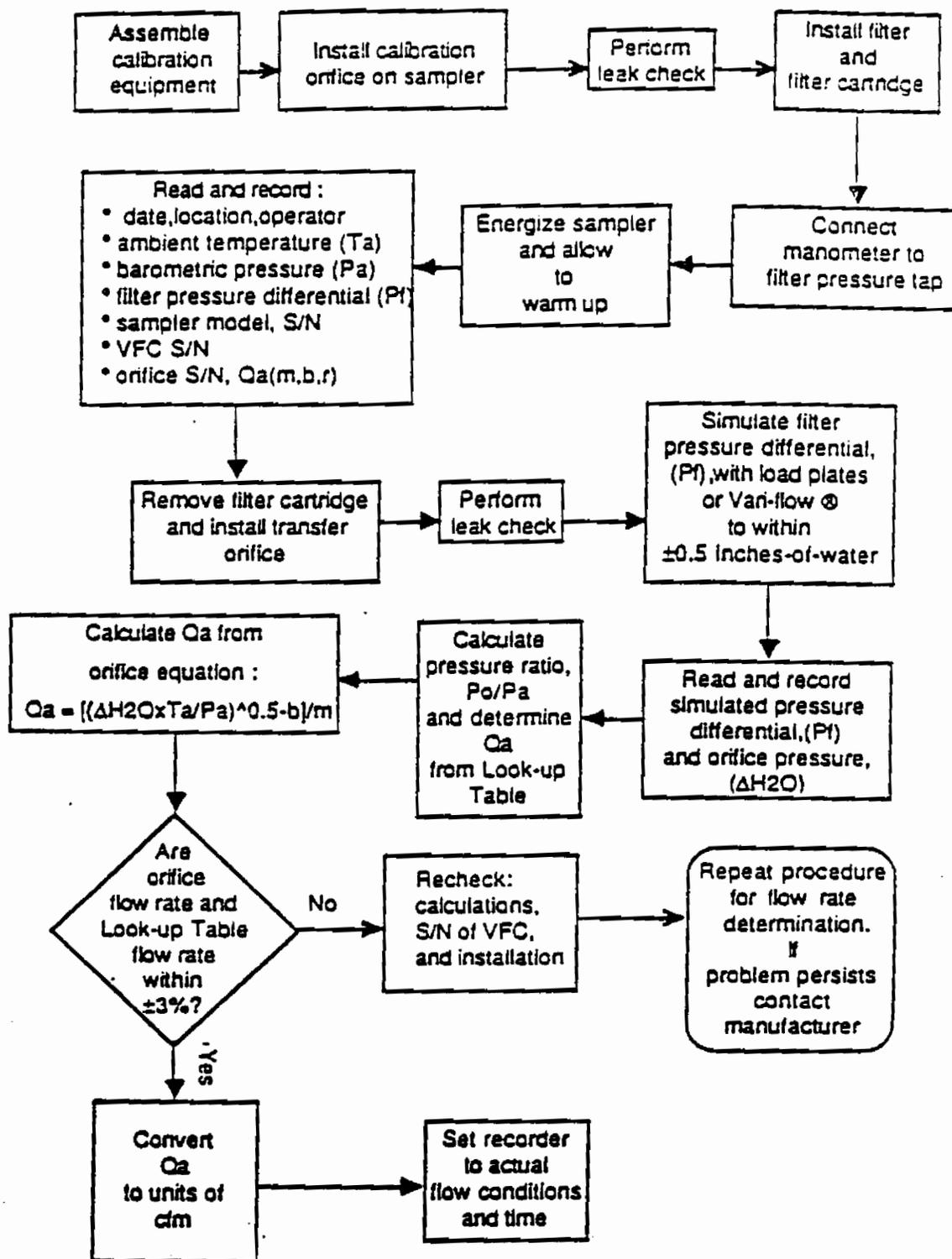


Figure 4.3 VFC Calibration Flow Chart

The U.S. EPA stipulates calibration frequencies for all samplers that are used to report data into the National data base. Please refer to "Quality Assurance Handbook of Air Pollution Systems, Volume II, Section 11.2" for basic requirements. ASI/GMW recommend calibration at least twice a year.

Since the orifice transfer standard can be calibrated in terms of actual or standard conditions, the operating personnel must determine which calibration curve has been generated and modify their calibration curves accordingly. The HVPM10 sampler must be calibrated in terms of actual conditions. Two types of orifice calibrators are available: one equipped with multi-hole load plates (PN G25) to simulate various pressure drops, and the other with an adjustable flow restrictor valve, or "Vari-flo®" orifice (PN G335).

4.3.1 VFC One Point Flow Verification. For optimum accuracy and performance, the following calibration procedures are recommended:

1. Assemble the calibration equipment.
 - ° Calibrated (traceable to NBS) orifice device (load plate or Vari-flo®)
 - ° Duct tape
 - ° Manometer with a range of 0 to 16 Inches-of-water and a minimum scale division of 0.1 inch.
 - ° Manometer with a range of 0 to 30 Inches-of-water and a minimum scale division of 0.1 inch.
 - ° Thermometer (with verified accuracy). All temperatures must be expressed in degrees Kelvin for the calculations in this section to be correct. ($^{\circ}\text{K} = ^{\circ}\text{C} + 273$).
 - ° Barometer (with verified accuracy). All pressures must be expressed in mmHg for the calculations in this section to be correct, ($\text{mmHg} = \text{Inches of Hg} \times 25.4$). Note: Barometric pressure readings can be obtained from nearby weather station; however, such readings must be "station pressure" which is uncorrected to sea level. Pressures may however, need to be corrected for changes in elevation between the weather station and the monitoring site if elevation difference is greater than 1000 ft.

- Spare recorder charts, miscellaneous hand tools, calibration data sheets, or sampler log book.
2. To verify the flow during normal operating conditions, the filter pressure differential must be matched using the Vari-flo[®] restrictor or appropriate load plate. The approved filter media is a quartz fiber filter, GQMA. The pressure differential across a clean quartz fiber filter varies from 15 to 20 Inches-of-water.
 3. Remove the orifice and orifice transfer plate from filter holder. Place a clean filter and a filter cartridge on the filter holder. Tighten the filter holder nuts on alternate corners to ensure even tightening. Hand tighten the nuts to prevent over-compression of the gasket.
 4. Connect tubing to the pressure tap on the filter screen holder. The tap is located 1.5 inches below the screen on the side of the holder. This pressure tap is accessible through the door of the sampler. Production VFC units have a quick-connect located on the shelter which closes automatically when manometer is disconnected. Connect tubing to one side of the manometer with 0-30 Inches-of-water range. The other side of the manometer is left open to the atmosphere.
 5. Turn on the sampler blower and allow it to warm up to a stable operating temperature. Five minutes is usually sufficient.
 6. Read and record the following parameters on a VFC HVPM10 Field Data sheet or in the log book of the sampler.
 - Ambient temperature, (Ta), °F or °C. Convert to °K
 - Ambient pressure, (Pa), mmHg
 - Sampler Model, S/N, and VFC S/N
 - Orifice S/N, and its Qa relationship (m,b,r)
 - Date, location and operator
 7. Read the pressure differential (Pf) across the filter and filter cartridge. Record this on the VFC Data Sheet or log book of the sampler. This is the operating pressure differential that will be matched by the using the restrictor of the Vari-flo[®] orifice or the load plate.
 8. Turn off sampler and remove filter cartridge and filter. Install the orifice and perform precalibration leak test (Section 4.2).

9. Turn on sampler and, if necessary, allow to warm up to operating temperature.
10. Simulate filter pressure differential (Pf) by adjusting knob on Vari-flo[®] orifice or by placing appropriate load plate between orifice and face plate adapter. The approximate pressure drops across multi-hole load plates at 1.13 m³/min (40 cfm) is given in Table 4.2
Choose a load plate which has a pressure drop approximately the same, but not greater than the filter pressure to be simulated but not greater than the filter pressure drop. Fine tune the load plate by placing duct tape over holes one at a time until the pressure differential is matched. the pressure drop match should be within one Inch-of-water. A leak test should be performed each time the orifice is removed.
11. Once the differential pressure has been matched, the sampler will be operating at approximately the same flow conditions as will take place during sampling. Record the orifice and filter pressure differentials (ΔH_2O) and (Pf), respectively.
12. For the VFC, calculate pressure ratios and find the flow rate on the look-up table. See Section 6.1 for sample calculations.

Table 4.2. Approximate Values of Pressure Drop across Orifice and Load Plates

<u>Load Plate Number of Holes</u>	<u>Pressure Differential, Inches-of-water</u>
22	7.3
18	9.1
13	13.7
10	20.6
7	35.2
orifice only	3.9

13. If the orifice calibrator has not been furnished with a calibration curve in terms of Q_a , use the calibration data provided with the orifice to generate a calibration relationship in the form of:

$$y = m(Q_a) + b$$

where: Q_a = orifice flow rate, actual m^3/min
 $y = \sqrt{(\Delta H_2O \times T_a / P_a)}$
 b = intercept of orifice calibration relationship
 m = slope of orifice calibration relationship

See Section 6.3 for sample calculations.

14. Calculate Q_a for the calibration point as :

$$Q_a = [\sqrt{(\Delta H_2O \times T_a / P_a)} - b] / m$$

where: ΔH_2O = orifice pressure drop, Inches-of-water
 T_a = ambient temperature, °K
 P_a = ambient pressure, mmHg
 b = intercept of orifice calibration relationship
 m = slope of orifice calibration relationship

15. If a discrepancy greater than 3% appears between the orifice calculated flow rate (Q_a) and the look-up table flow rate, recheck calculations and procedures. Make sure serial numbers of hardware and calibration curves match. Recheck for leaks in the system. Inspect the VFC for debris or corrosion in throat. If necessary clean with a bottle brush and soap and water. Inspect motor blower operation. Check to be sure there are no leaks in the manometers. To make this check, disconnect tubes from the sampler or orifice. Connect a second tube to the manometer that is used for the filter pressure drop. For each manometer blow air into one side of the manometer in order to get a differential reading of approximately 15 Inches-of-water. Next pinch the tubing on both sides of the manometer by doubling the tubing back onto itself and squeezing the

pinched location. This will prevent air from entering the manometer. Check the reading on the manometer. Wait approximately one minute and re-read the manometer. The reading should not have dropped by more than 0.3 inches. If it has, check the connections and tubes to determine the source of the problem. If problem cannot be resolved contact the manufacturer.

16. Continue to recorder calibration

4.3.2 One Point Calibration of Dixon Recorder. The Dixon flow event recorder simply verifies that the sampler operated without failure during the 24 hour sampling period and maintained normal operational flow rate. Large deviations from the mean flow rate on the recorder would indicate that there has been a power failure, or a motor blower, or power problem.

This calibration procedure is:

1. Install a new recorder chart (G106) into the Dixon event recorder which has been properly labeled on the back of the chart. Replace ink pen if needed.
2. Ensure that the continuous flow recorder is properly connected to the pressure tap on lower side of the sampler motor housing.
3. While sampler is running, determine the operating flow rate from the Look-up Table. Convert flow rate to actual cfm.
4. Adjust the reading on the Dixon recorder using the set screw. Gently tap the side of the recorder to make sure pen is not hung-up on the chart.
5. Lift the pen off the chart then rotate the chart by center slot using a coin or screw driver in the center slot until the time is properly indicated on recorder. Be sure the pen is back down on the chart surface.

4.4 Basic Calibration Procedure for the MFC HVPM10 Sampler

The sampler calibration procedure presented in this section relates known flow rates (as determined by a calibrated transfer standard orifice device) to the pressure differential across the orifice at the exit of the blower housing. This pressure differential is referred to as the plenum pressure, where the plenum is the region within the motor housing (downstream of the motor

unit) where the pressure level exceeds atmospheric pressure.

The calibration orifice used in this procedure may have been calibrated either in terms of "actual" or "standard" conditions. Operating personnel must determine which calibration curve has been supplied. The HVPM10 sampler must be calibrated in terms of actual conditions. Two types of orifice calibrators are available: one equipped with multi-hole load plates (PN G25) to simulate various pressure drops, and the other with an adjustable flow restrictor valve, or "Vari-flo®" orifice (PN 335).

Regardless of the type of orifice used, the calibration procedure remains the same (Figure 4.4). The calibrator is installed directly beneath the inlet of the HVPM10 sampler. Flexible tubing is used to connect the orifice pressure tap with a water manometer. Pressure drops and indicated flow recorder readings are recorded and checked against the calibration curve for the top loading orifice. The relationship between the flow rates determined by orifice and responses indicated by the sampler becomes the calibration equation. Note: When using the multi-hole load plates to calibrate the continuous flow recorders, use load plates in increasing resistance in order (e.g. 18-, 13-, 10-, and 7-, and 5-hole).

The U.S. EPA stipulates calibration frequencies for all samplers that are used to report data into the national data base. Please refer to "Quality Assurance Handbook of Air Pollution Systems, Volume II, Section 11.2", for basic requirements. ASI/GMW recommends calibration at least twice a year.

For optimum accuracy and performance, the following calibration procedures are recommended:

1. Assemble the calibration equipment.

- Calibrated (traceable to NBS) orifice device
- Manometer with a range of 0 to 16 inches-of-water and a minimum scale division of 0.1 inch.
- Thermometer (with verified accuracy). All temperatures must be expressed in Kelvin for the calculations in this section.
(°K = °C + 273).
- Barometer (with verified accuracy). All pressures must be expressed in mmHg for use in the calculations in this section, (mmHg = in.Hg x 25.4). Note: Barometric pressure readings can be obtained from nearby weather stations and must be "station

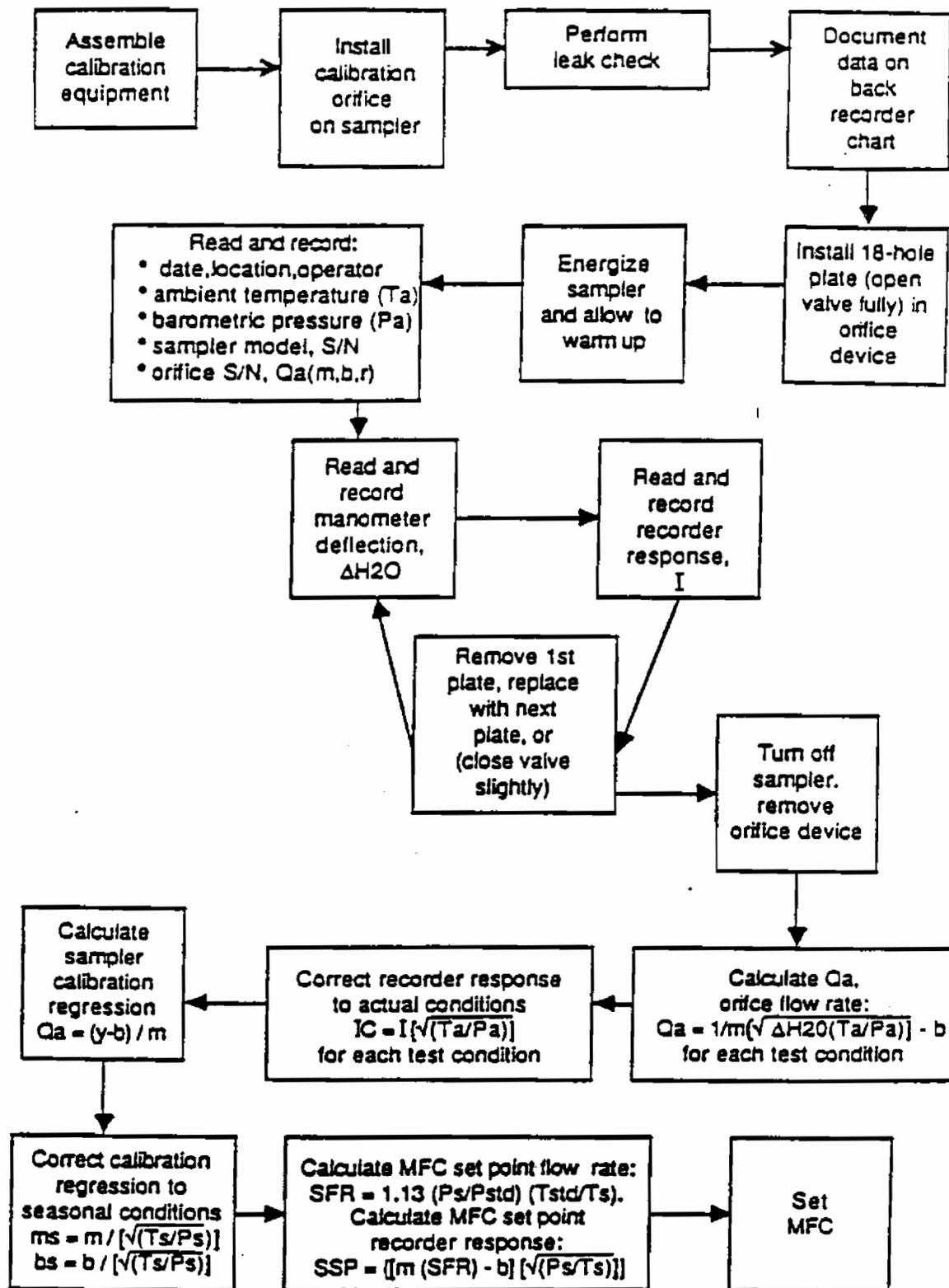


Figure 4.4 MFC Calibration Flow Chart

pressure" or uncorrected to sea level. Pressures may however, need to be corrected for changes in elevation between the weather station and monitoring site. If the difference in elevation is greater than 1000 ft.

- Spare recorder charts, miscellaneous hand tools, calibration data sheets; or sampler log book
2. Install the calibration system as pictured in Figure 4.2. Position the orifice faceplate on the sampler filter support screen and tighten the four corner nuts. Do not use a filter or filter cartridge during calibration. If a leak test is required, refer to Section 4.2.2
 3. Install the 18-hole plate in the orifice calibrator by loosening the orifice retaining ring (or open the Vari-flo[®] valve fully). Make sure there is a gasket on the bottom of the restriction plate and on the bottom of the orifice device.
 4. Check that the flow event recorder is properly connected to the pressure tap on the lower side of the sampler motor housing and that it is properly zeroed (pen rests on the inner most circle of the chart). Adjust the set-screw on the front of the recorder as necessary.
 5. Record the site location, sampler S/N, date, and the operator's initials on the back of a clean recorder chart. The same chart used for the leak test (if performed) can be employed in this step.
 6. Disconnect the mass flow controller. The motor is to be connected directly to a stable power source, 110 VAC/60Hz. Energize the sampler and allow it to warm up to operating temperature. A period of five minutes is usually sufficient.
 7. Read and record the following parameters on an MFC HVPM10 calibration data sheet (Table 4.3) or in the sampler log book.
 - Ambient temperature, (T_a), °K
 - Station barometric pressure (Pa), mmHg
 - Sampler S/N, model, and motor number
 - Orifice S/N and Q_a relationship
 - Date and Location
 8. Read and record the manometer deflection (in Inches-of-water) and its corresponding recorder response.

Table 4.3 MFC Calibration Data Sheet

**HVPM10 SAMPLER CALIBRATION DATA SHEET
MASS FLOW CONTROLLED UNIT**

Sampler Location: _____		Date: _____
Conditions:	Ta(K): _____	Pa(mmHo): _____
	Ts(K): _____	Ps(mmHg): _____
Sampler Model: _____	Sampler S/N: _____	Motor No.: _____
Orifice S/N: _____	Orifice Cal. Date: _____	Orifice Model: _____
Orifice Qa Cal. Relationship: $m =$ _____ $b =$ _____ $r =$ _____		

Calibration Conducted by: _____

Cal. Point	Plate No.	Total ΔH2O	Qa(orifice) flow rate m3/min	Sampler Response I	Corrected Response IC
1					
2					
3					
4					
5					

$Qa(\text{orifice}) = 1/m [\sqrt{\Delta H20(Ta/Pa)} - b]$

$IC = I \cdot (\sqrt{Ta/Pa})$

Sampler's Qa Calibration Relationship:

Qa(orifice), x-axis, IC, y-axis

$m =$ _____ $b =$ _____ $r =$ _____

Set Point Flow Rate: _____

$SFR = 1.13(Ps/Pa)(Ta/Ts)$

Sampler Seasonally Adjusted
Calibration Relationship

$ms =$ _____ $bs =$ _____

$ms = m / [\sqrt{(Ts/Ps)}]$

$bs = b / [\sqrt{(Ts/Ps)}]$

Sampler Set Point: _____

9. Read the samplers response I, from the chart of the event recorder, and enter on data sheet or log book.
10. Repeat Step 3,8 and 9 for each of the remaining resistance plates or Vari-flo® settings. When installing each plate, be sure the orifice plate is properly seated and that no cross threading has taken place.
11. Turn off the sampler and remove the calibration orifice and recorder chart.
12. If the orifice calibrator has not been furnished with a calibration curve in terms of Q_a , use the calibration data provided with the orifice to generate a calibration relationship in the form of:

$$y = m(Q_a) + b$$

where: Q_a = orifice flow rate, actual m^3/min
 $y = \sqrt{(\Delta H_{2O} \times T_a / P_a)}$
 b = intercept of orifice calibration relationship
 m = slope of orifice calibration relationship

See Section 6.3 for sample calculations.

13. Verify that the correct event recorder response, I has been inscribed on the calibration data sheet and that the orifice calibration curve is current and traceable to an acceptable primary standard.
14. Calculate Q_a for each calibration point as:

$$Q_a = [\sqrt{(\Delta H_{2O} \times T_a / P_a)} - b] / m$$

where: Q_a = Orifice flow rate, actual m^3/min
 ΔH_{2O} = pressure drop across the orifice, inches-of-water
 T_a = ambient temperature, °K
 P_a = station barometric pressure, mmHg
 b = intercept of the orifice calibration relationship
 m = slope of the orifice calibration relationship

15. Calculate and record the flow event recorder actual correction (IC) for each calibration point as:

$$IC = I [(T_a/P_a)^{1/2}]$$

where: IC = actual correction

I = recorder response, arbitrary units

16. On a sheet of graph paper, plot the sampler corrected recorder units, IC (y-axis) versus the corresponding calculated orifice flow rates Q_a (x-axis), to obtain a visual calibration curve and indication of the calibration linearity. A five-point calibration should yield a regression equation with a correlation coefficient of $r > 0.990$. Since the determination of a Q_a flow rate requires the addition of an ambient average temperature and pressure correction, it is not recommended to use a graphic plot of the calibration relationship for subsequent data reduction.

Each sampler therefore, must be provided with a mathematical expression that indicates the slope, intercept, and the linearity of the calibration relationship. Using a programmable calculator, determine the best-fit straight line by the method of least squares. The equation for this fit is:

$$IC = m(Q_a) + b$$

17. The slope, m , and intercept, b , are then calculated to determine the sampler's actual flow rate (Q_a) from :

$$Q_a = 1/m [I (T_a/P_a)^{1/2} - b]$$

18. To avoid making daily temperature and pressure corrections to determine the sampler's operational flow rate, adjust the sampler's slope and intercept to seasonal average conditions.

$$m_s = m / [\sqrt{(T_s/P_s)}]$$

$$b_s = b / [\sqrt{(T_s/P_s)}]$$

where: m_s = seasonally adjusted sampler calibration slope
 b_s = seasonally adjusted sampler calibration intercept
 T_s = seasonal average temperature, °K
 P_s = seasonal average station barometric pressure, mmHg

The sampler is now equipped with two calibration relationships: actual (Q_a) and seasonally adjusted actual (SQ_a). To calculate the sampler's instantaneous flow rate for flow checks or audits, use the formula presented in step 17.. For routine operation however, determine the flow rate as:

$$SQ_a = (I - b_s) / m_s$$

where: SQ_a = sampler's seasonally adjusted flow rate, m^3/min

19. Calculate and record on the calibration data sheet (or in the sampler log book) the set point flow rate (SFR).

$$SFR = 1.13 (P_s/P_a) (T_a/T_s)$$

where: SFR = sampler's seasonally adjusted set point flow rate, m^3/min .

20. Calculate and record the sampler's calibration data sheet the MFC set point (recorder response that corresponds to the SFR calculated in Step 19).

$$SSP = \{[m (SFR) - b] (P_a/T_a)^{1/2}\}$$

where: SSP = sampler's seasonally adjusted set point, recorder response

21. Re-connect the motor to the mass flow controller.
22. Install a clean filter (within a filter cartridge) in the sampler. Tighten the four wing-nuts to ensure an even seal, do not over-tighten or the gasket may warp.

22. Install a clean recorder chart in the flow recorder and verify that the recorder is zeroed (the pen rests on the innermost circle of the chart). Gently tap on side of sampler to seat ink pen. Rotate chart with coin or screw driver until chart indicates correct time.
24. Energize the sampler and allow it to warm up to operating temperature. Adjust the flow rate potentiometer (pot) on the mass flow controller until the recorder response indicates the sampler seasonally adjusted set point (SSP) as calculated in Step 20. Refer to Appendix B for the location of the flow rate pot for a particular model of flow controller.
25. Verify that the flow controller will maintain this flow rate for at least 10 minutes. Turn off the sampler. The sampler can now be prepared for the next sampler run day.

5.0

Field Operation

This section presents information pertaining to the routine, basic operation of an HVPM10 sampler. Also included are references to direct the operator to information on U.S. EPA site requirements, laboratory procedures, and routine quality control/quality assurance activities. Since our customers are not exclusively governmental agencies, specific U.S. EPA-sanctioned guidelines are not presented here.

5.1 Siting Requirements

Complete siting criteria (for samplers collecting data to be directly or ultimately reported to the U.S. EPA) can be found in 40 CFR 58. Minimum ASI/GMW requirements are presented below:

1. Sampler should be at least 20 meters (m) from trees, buildings or other large obstacles. A general placement rule is that the sampler should be located at least twice as far away from the obstacle as the height of the obstacle..
2. Sampler inlet should be 2 to 7 m above the ground
3. Sampler must have unrestricted air flow
4. Sampler inlet should be at least 2 m from any other high-volume sampler inlet. For collocated samplers, the inlets must be within 4 m of each other.
5. Do not place the sampler directly upon the ground or gravel roof top.
6. Do not place sampler near exhaust flues or vents.
7. If samples are to be chemically analyzed (e.g. mass spec., A.A., etc.) evaluate the site for potential contamination.

5.2 Sampler Installation Procedures

1. Carefully transport the assembled inlet and sampler shelter to the monitoring site. The sampler must be either bolted or anchored to the site platform. Extended support feet (PN G2021) are available from the manufacturer and can be easily installed on the sampler to provide extra stability.
2. Attach the sampler inlet according to Assembly Procedures presented in Section 3.1.

3. Check all the power cords and pressure recorder tubing for crimps, cracks, etc..
4. Plug the male power cord into a grounded line voltage outlet of compatible AC voltage. Be sure that the electrical connectors are not exposed to inclement weather.

An electrical surge suppressor and a ground fault interrupter (GFI) are recommended to protect the system from transient voltage spikes and for safety. For any sampler equipped with an MFC, an independent AC power circuit is suggested; alternating current voltage (VAC) at the sampler cannot be below 90 VAC for the 115 VAC system; or below 200 volts 220 VAC system. If it is necessary to run extension cords to provide power, a lower gauge (heavier conductor wire) is necessary.

5. Perform a flow rate calibration, as described in Section 4.

5.3 Sampling Operations

The HVPM10 sampler is a user-friendly instrument capable of providing accurate, reproducible data when calibrated, operated and maintained properly. If the calibration procedures presented in this manual are followed, the routine operation of the HVPM10 sampler can be highly simplified by:

1. Eliminating daily temperature and pressure readings,
2. Using identical calculations (for both MFC and VFC samplers) to determine the sampler's operational flow rate, and
3. Not requiring any extraneous equipment (i.e. manometer, orifice, etc) to determine the operational flow rate.

As with the calibration procedures presented in Section 4, all operational procedures are in accordance and agreement with U.S. EPA protocol and the FRM. If the operator has any questions regarding these procedures, please contact the factory.

With reference to Figure 5.1, the steps taken prior to sampling in the field are:

1. Collect the following monitoring equipment:
 - ° Filter Cartridge (PN G3000), *required on all ASI/GMW HVPM10 samplers*

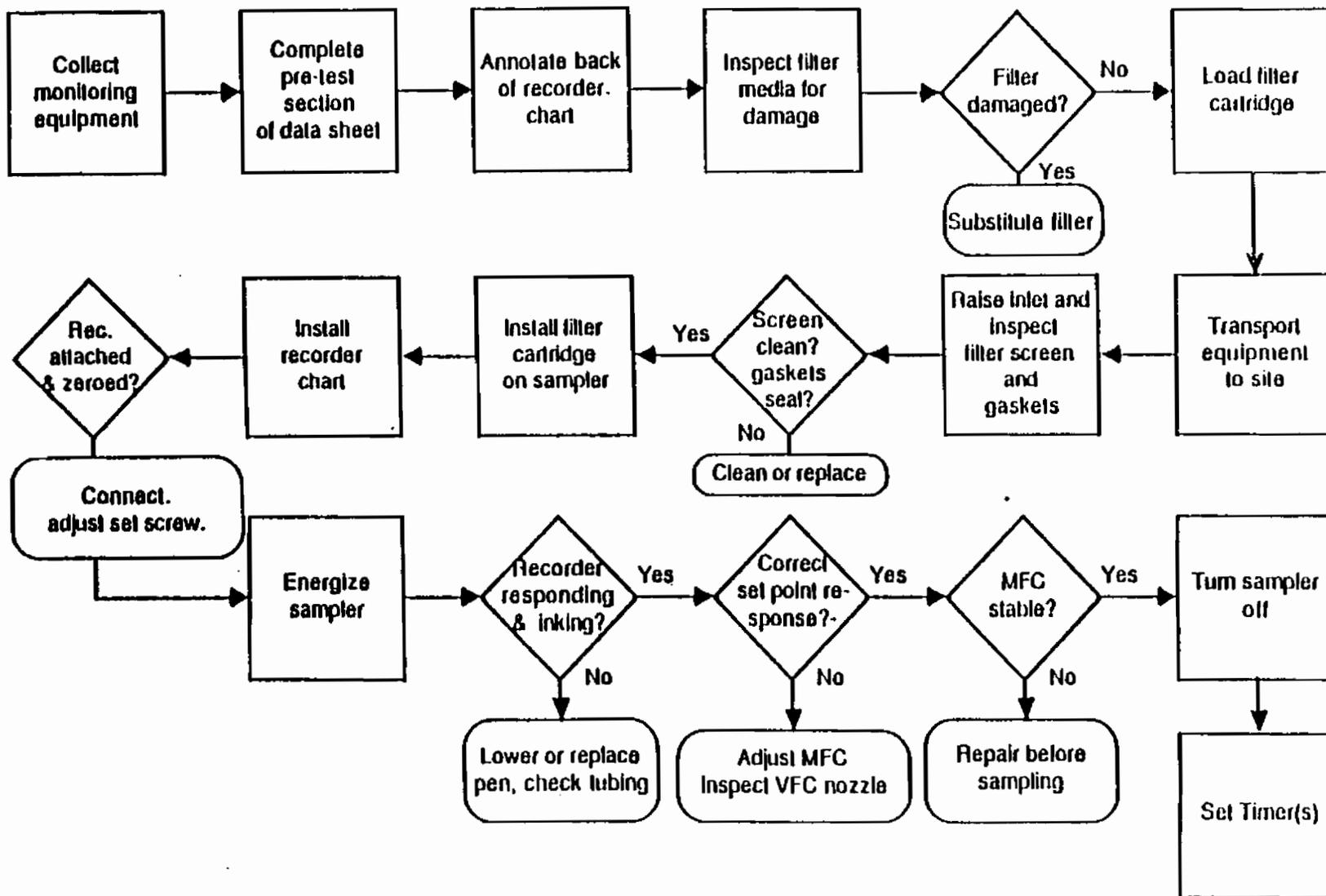


Figure 5.1 HVPM10 Pre-Sampling Flow Chart

- Quartz Fiber Filter (PN GQMA), *required for PM10 sampling*
 - Clean Recorder Chart
 - Sampler log book or field data sheet (Table 5.1 and 5.2 for VFC and MFC)
2. Fill out the top portion of the Field Data Sheet, Table 5.1 for VFC or Table 5.2 for MFC.
 3. On the back side of the flow event recorder chart, record the sampler S/N, sampler location and date of the sample period.
 4. Inspect the filter for any pinholes, tears, or irregularities. If found, reject and select another filter. Record the selected filter identification number (ID) on the back side of the recorder chart and on the Field Data Sheet.
 5. Load the filter cartridge with 1 quartz filter.
 - A. Loosen the four nuts that clamp the cartridge together and remove the upper portion of the filter cartridge .
 - B. Inspect the filter cartridge screen for deposits or foreign material. Clean if necessary. Ensure that the cartridge gasket is not damaged or compressed.
 - C. Center the filter on the cartridge support screen. Every filter has an "up" side on which the particulate matter should be deposited. For GQMA filters, this is the rough side. It is recommended that the purchaser request the analysis laboratory emboss the filter with a filter ID consistently on the bottom of the filter. This will allow access to the ID number when the sample is folded (post-sampling) and also provide the operator with a fool proof method for determining the "up" side.
 - D. Replace the top cover and tighten the nuts.
 - E. If the cartridge is equipped with a protective, snap-on screen, cover the cartridge.
 6. Transport the monitoring equipment to the sampler location.
 7. Raise the sampler inlet by releasing the six shelter pan draw-catches and gently tilting back the inlet until the shelter pan support strut is locked in the second position.
 8. Inspect the sampler's filter screen and remove any deposits or foreign matter.

Table 5.1 Example HVPM10 Field Data Sheet

VFC HVPM10 FIELD DATA SHEET

Site Location: _____	Sample Date: _____
Sampler S/N: _____	Sampler Model: _____
	Motor No. _____
	VFC No. _____
Filter ID Number: _____	Average operating pressure drop _____ "H2O
Seasonal operating conditions Ps, _____ mmHg	Ts, _____ °C
Seasonal operating pressure ratio Po/Ps _____	
$Po/Ps = (1 - Pf/Ps)$, note Pf and Ps are in mmHg	
Seasonal operating flow rate from lookup table @Ts and Po/Ps, SQa _____ m ³ /min	
Recorder pen setting, Actual flow conditions, Qa _____ cfm	

Filter Differential Start (Pf) _____ "H2O Filter Differential Stop (Pf) _____ "H2O
 Sample Start Time: _____ Sample Stop Time: _____
 Sampler Timer Start _____ Sampler Timer Stop _____

Average Recorder Response: _____
 Average Filter Differential (Pfa) _____ "H2O
 Pressure Ratio Po/Ps _____
 $Po/Ps = (1 - Pfa/Ps)$
 Look-up Flow SQa = _____ m³/min

Circle One:
 Qa between 1.02 and 1.24 m³/min? Yes No
 Sampler recalibrated? Yes No

Pressure Ratio Po/Pa _____
 $Po/Pa = (1 - Pfa/Pa)$
 Look-up Flow Qa = _____ m³/min
 Comments:

Qstd = _____ m³/min :
 $Qstd = SQa (Ps/Pstd) (Tstd/Ts)$
 Elapsed Time (min): (t) _____

Std. Vol. _____ m ³
Std. Vol. = Qstd (t)

Optional. Calculate periodically and when temperature and pressure conditions during sample period are unseasonal.

Operator: _____

Table 5.2 Example HVPM10 Field Data Sheet

MFC HVPM10 FIELD DATA SHEET

Site Location: _____ Sample Date: _____

Sampler S/N: _____ Sampler Model: _____ Motor No. _____

Filter ID Number: _____

Sampler's Qa calibration relationship: $m = \underline{\hspace{1cm}}$ $b = \underline{\hspace{1cm}}$ $r = \underline{\hspace{1cm}}$
 $Qa = 1/m (I \sqrt{(Ta/Pa)} - b)$

Sampler's seasonal adj. calibration relationship: $m = \underline{\hspace{1cm}}$ $b = \underline{\hspace{1cm}}$ $r = \underline{\hspace{1cm}}$
 $SQa = (I - bs)/ms$

Average Recorder Response: _____

Sample Start Time: _____

SQa = _____ m³/min

Sample Stop Time: _____

Qa = _____ m³/min *

Elapsed Time (min): _____

Optional. Calculate periodically and when temperature and pressure conditions during sample period are unseasonal.

Qstd = _____ m³/min :
Qstd = SQa (Ps/Pstd) (Tstd/Ts)

Circle One:

Qa between 1.02 and 1.24 m³/min? Yes No
Sampler recalibrated? Yes No

Std. Vol. _____ m ³
Std. Vol. = Qstd (t)

Comments: _____

Operator: _____

9. Inspect the filter holder-sealing gasket located beneath the filter screen for compression or damage. Replace, if necessary, before the next sample period.
10. Remove the filter cartridge top cover (if so equipped) and center the cartridge on the the sampler's filter screen. Tighten the four swing bolts. The wing nuts should be tightened at diagonally opposite corners simultaneously to assure even compression of the gasket.
11. Open the shelter door and the flow event recorder. Install the annotated recorder chart by raising the pen arm and placing the chart center hole over the recorder slotted drive. Lower the pen arm. If the sampler is controlled by a master On/Off timer, and data are to be reported to the U.S. EPA, set the chart at 12 midnight. The chart is advanced by rotating the slotted drive clockwise, until the desired sample start time is beneath the pointed indicator on the lower right side of the recorder.
12. Make sure that the flow recorder is connected to the motor housing pressure tap and and it is properly zeroed (the pen rests on the inner most circle of the chart). Adjust the zero by the rotating the small set screw located on the bottom right of the recorder.
13. Energize the sampler. Ensure that the recorder pen is inking and indicates that the sampler is operating at its correct set-point.
 - A. No adjustment can be made to the VFC sampler flow rate. If the recorder indicates that the sampler is not operating within 3 chart divisions of the correct set point, check the recorder connections. If problem persists, contact the manufacturer.
 - B. If the sampler is equipped with an MFC, allow the sampler to operate for 3-5 minutes. If necessary, adjust the potentiometer on the MFC (refer to Appendix B) until the correct set point is indicated. Note: If the MFC is operating correctly, there will be no "searching" of the motor.
14. Turn off the sampler and close the recorder and shelter doors. Lower the sampler inlet and attach the six shelter pan draw-catches.
15. Following procedures presented in Appendix D, set the master timer (if so equipped) to activate the sampler on the next scheduled run day. Reset the elapsed time indicator to 0000.

The post sampling steps are illustrated in Figure 5.2. As soon as possible after the run day, the operator must:

1. Return to the monitoring site. Release the six shelter pan draw-catches and raise the sampler inlet. Reversing the installation procedure (step 10), remove the filter cartridge. Replace the snap-on cover.
2. Open the shelter door. Open the recorder door and remove the recorder chart. Examine the chart. The trace should be stable without peaks or interruptions. Investigate any irregularities before continuing.
 - spikes and peaks indicate power fluctuations
 - blank spots indicate power failures or that the pen failures
 - slow downward trend indicates MFC or motor brush failure
 - wavering trace indicates MFC failure
3. Observe conditions around the monitoring site and record any unusual activities that might affect the sample.
4. Complete the Field Data Sheet.
5. Calculate the sampler's operational flow rate:

a) For the VFC:

Calculate average filter pressure differential P_{fa}

$$P_{fa} = (P_{fi} + P_{ff}) / 2$$

Calculate Pressure Ratio P_o/P_a

$$P_o/P_s = (1 - P_{fa}/P_s)$$

Look-up seasonally adjusted flow

$$SQ_a, \text{ at } T_s, P_o/P_s$$

where: P_{fi} = initial filter pressure differential
 P_{ff} = final filter pressure differential
 P_s = seasonal average barometric pressure
 T_s = seasonal average temperature

Note; If unseasonal weather conditions occur, perform calculations with ambient pressure and temperature.

b) For the MFC, use:

$$SQ_a = (I - bs) / ms$$

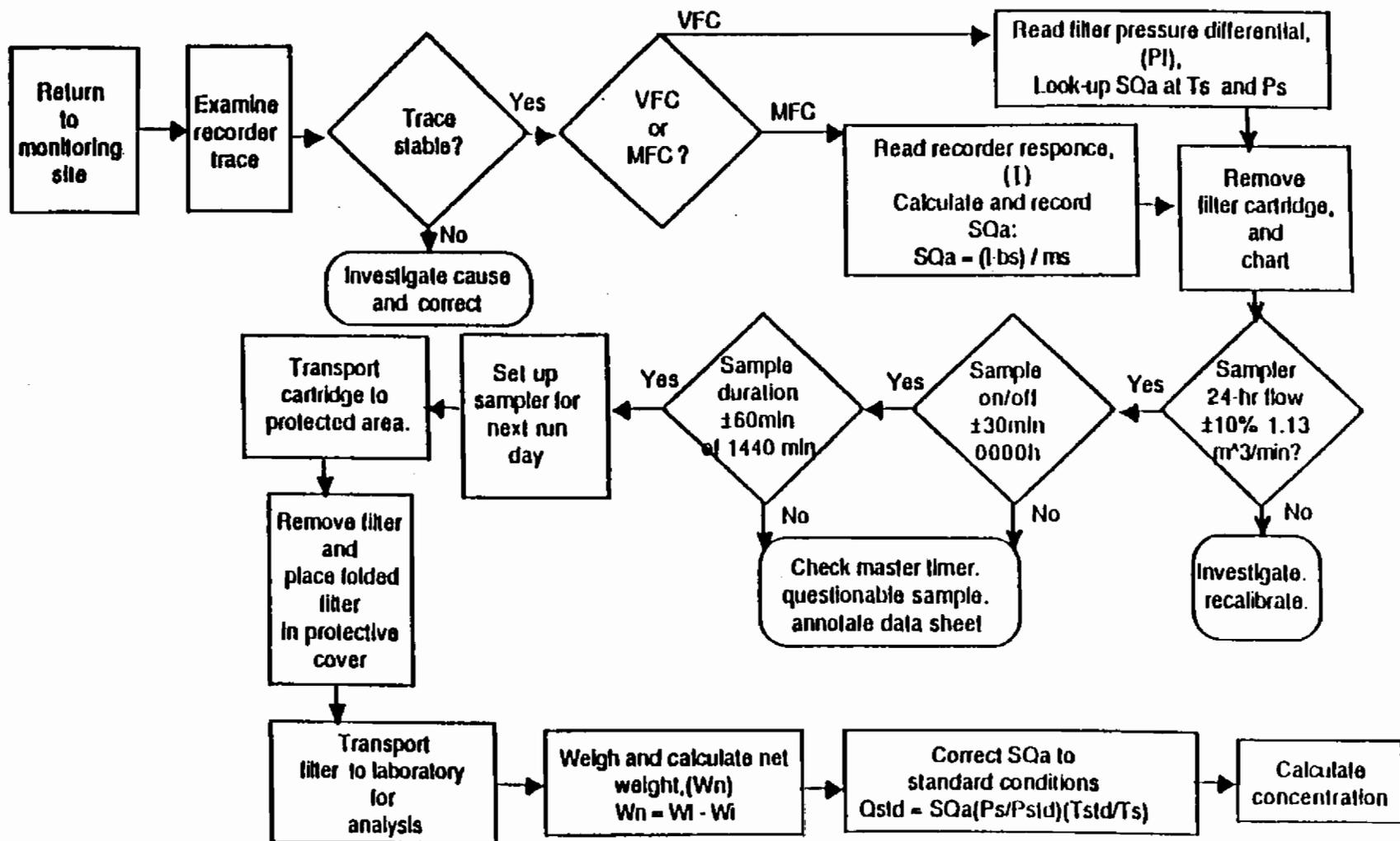


Figure 5.2 HVPM10 Post-Sampling Flow Chart

where: SQa = sampler's seasonally adjusted flow rate, m³/min
 I = continuous recorder response, arbitrary units
 bs = seasonally adjusted sampler calibration intercept
 ms = seasonally adjusted sampler calibration slope

6. Determine whether the operational flow rate is within design specification requirements of the HVPM10 sampler:

$$\% \text{ Difference} = [(SQa - 1.13) / 1.13] (100)$$

where: SQa = sampler's seasonally adjusted flow rate, m³/min
 1.13 = sampler's design flow rate, m³/min

Difference must be <10%. If exceeded, recalibrate the sampler before the next sample period.

7. Record the sample period's elapsed time. If reporting to the U.S. EPA, the sample duration must be 1440 min. ±60 min; and, the sampler must have turned on and off within 30 min. of midnight.
8. The sampler can now be prepared for the next sample period.
9. Transport the filter cartridge to a protected area.
10. Reversing the installation procedure, carefully remove the filter from the cartridge. Handle the filter only by the edges to avoid disturbing any of the deposit. Fold length-wise, aligning the deposit edges. Place the filter in a protective cover and transport it, the recorder chart and data sheet to the analysis laboratory.

5.4 Laboratory Procedures

Complete information regarding laboratory procedures and quality assurance functions can be found in the "Quality Assurance Handbook for Air Monitoring Systems, Volume II", Section 11.4.

The laboratory is responsible for providing tare (Wt) and gross (Wg) weights for each sample filter. The difference of these two weights, the net

mass (W_n), is then used to calculate the concentration of PM₁₀ collected on the filter. The calculations necessary to report data to the U.S. EPA are as follows:

1. Correct all operational flow rates to standard reference conditions

$$Q_{std} = SQ_a (P_s/T_s)(298/760)$$

where: Q_{std} = flow rate at reference conditions, std. m³/min
 SQ_a = flow rate adjusted to seasonal conditions
 P_s = seasonal average station barometric pressure, mmHg
 T_s = seasonal average temperature, °K
 298 = standard reference temperature, °K
 760 = standard reference barometric pressure, mmHg

2. Calculate the standard sample volume

$$V_{std} = Q_{std} (t)$$

where: V_{std} = standard volume, std. m³
 t = sample duration, minutes

3. Calculate the net weight of the sample filter

$$W_n = W_g - W_t$$

where: W_n = net weight of the sample filter, g
 W_g = gross weight of the sample filter, g
 W_t = tare weight of the sample filter, g

4. Calculate the PM₁₀ concentration of the sample filter

$$PM_{10} = (W_n)(10^6) / V_{std}$$

where: PM_{10} = PM₁₀ concentration, µg std. m³
 10⁶ = conversion for grams to micrograms

5.5 Quality Control/Quality Assurance Procedures

The U.S. EPA stipulates that routine quality control and periodic quality assurance procedures be conducted in each monitoring network. These activities are used to assess data quality, precision and accuracy. Complete U.S. EPA requirements and procedures can be found in the "Quality Assurance Handbook for Air Monitoring Systems, Volume II," Sections 11.3 and 11.7.

6.0 PM10 Monitoring Routine Calculations

When an HVPM10 sampler is being operated with the intention of submitting data either directly or ultimately to the U.S. EPA, it must be reported as the mass concentration of PM10 expressed in micrograms per standard cubic meter ($\mu\text{g}/\text{std.m}^3$). For particulate sampling, standard or reference conditions are 298K and 760 mm Hg. This section presents the calculations required to compute and report ambient PM10 concentrations as per the U.S. EPA's Quality Assurance Manual.

As discussed in the Introduction, an HVPM10 sampler must be equipped with either a volumetric flow or mass flow controller.

The U.S. EPA stipulates that routine quality control data validation checks be conducted on all data collected in a PM10 monitoring network. These activities are used to assess data quality and accuracy. Complete U.S. EPA requirements and procedures can be found in the "Quality Assurance Handbook for Air Monitoring Systems, Volume II", Section 11.5.

The U.S. EPA reference conditions of temperature and barometric pressure as reported in the Federal Register / Vol. 52, No. 126 / Wednesday, July 1, 1987 Appendix J are:

T_{std} = standard temperature, defined as 298 °K

P_{std} = standard barometric pressure, defined as 760 mm Hg

This standard reference condition, converted to some commonly used units is shown in Table 6.1

Table 6.1 Reference Conditions in Common Units

<u>Standard Temperature</u>	<u>Standard Pressure</u>
298 °K	760 mm Hg
25 °C	101.3 kPA
537 °R	29.92 in Hg
77 °F	

Note: Existing calibration orifices, prior to the release of this manual, were supplied with calibration curves for standard flow rates. The VFC and MFC HVPM10 sampler flow rate is calculated at actual conditions so that the proper operating flow rate may be determined.

6.1 VFC Look-up Table Use and Sample Calculations

6.1.1 Use of Look up Table for Determination of Flow

1. Determine and record the atmospheric properties:
 - ° ambient temperature (Ta), °F or °C
 - ° ambient barometric pressure (Pa), mm Hg or In Hg
2. Operate sampler and allow to warm up. Perform leak test as per instructions in Section 4.2.
3. Read the differential pressure across the filter (Pf), inches or mm of water. Reading is taken with a differential manometer with one side of the manometer connected to the pressure tap on the filter housing and the other side open to the atmosphere. Filter must be in place during this measurement or pressure drop is being simulated by load plates.
4. Convert filter pressure drop readings to units consistent with those of barometric pressure using the conversions given in Table 6.2.

Table 6.2 Pressure Conversion Factors

<u>To convert from:</u>	<u>To units of:</u>	<u>Divide by:</u>
In H ₂ O	In Hg	13.61
mm H ₂ O	mm Hg	13.61
mm H ₂ O	In H ₂ O	25.4
mm Hg	In Hg	25.4
mm	In	25.4

5. Calculate pressure ratio, P_o/P_a .

$$P_o/P_a = (1 - P_f/P_a)$$

Note: P_f and P_a must have consistent units.

6. Read flow rate from look-up table that is supplied with each VFC unit. Table 1 (provided with the unit), is set up with temperature in °F and the flow rate is read in units of actual cfm (acfm). In Table 2 (provided with unit), the temperature is in °C and the flow rate is read in m³/min (actual).
7. Determine flow rate in units of standard air, Q_{std}

$$Q_{std} = Q_a \left(\frac{P_a}{P_{std}} \right) \left(\frac{T_{std}}{T_a} \right)$$

In English units

$$Q_{std} = Q_a \left(\frac{P_a}{29.92 \text{ in Hg}} \right) \left(\frac{537^\circ\text{R}}{460 + T_a} \right)$$

where the units of P_a and T_a are:

$$[P_a] = \text{inches Hg}$$

$$[T_a] = ^\circ\text{F}$$

In Metric Units

$$Q_{std} = Q_a \left(\frac{P_a}{760 \text{ mm Hg}} \right) \left(\frac{298^\circ\text{K}}{273 + T_a} \right)$$

where the units of P_a and T_a are:

$$[P_a] = \text{mm Hg}$$

$$[T_a] = ^\circ\text{C}$$

6.1.2 VFC Example of Flow Rate Determination

1. Suppose the ambient conditions are:

Temperature: $T_a = 27.5\text{ }^\circ\text{C}$

Barometric Pressure: $P_a = 752\text{ mm Hg}$ (this must be station pressure which is not corrected to sea level pressure but is corrected for density changes in Hg due to temperature)

2. Assume system is allowed to warm up for stable operation.
3. Measure filter pressure differential, P_f . Assume that:

$$P_f = 16.85\text{ in H}_2\text{O}$$

4. Convert P_f to same units as barometric pressure.

$$P_f = (16.85\text{ in H}_2\text{O}) \left(\frac{1\text{ in Hg}}{13.61\text{ in H}_2\text{O}} \right) \times 25.4 \frac{\text{mm}}{\text{inch}} = 31.45\text{ mm Hg}$$

$$P_f = 31.45\text{ mm Hg}$$

5. Calculate Pressure Ratio.

$$P_o/P_a = (1 - P_f/P_a)$$

$$= (1 - 31.45 / 752)$$

$$P_o/P_a = 0.958$$

6. Determine actual Flow rate from Look up Table.

a) on Table 2 (provided with VFC unit), locate the temperature and pressure ratio entries nearest the conditions of:

$$T_a = 27.5\text{ }^\circ\text{C}$$

$$P_o/P_a = 0.958$$

Example: Look-up Table for Actual Flow Rate in Units of m³/min

Temperature °C					
P ₀ /Pa	26	28	30	32	34
0.950	1.121	1.124	1.126	1.129	1.131
0.952	1.125	1.127	1.130	1.133	1.135
0.954	1.128	1.131	1.134	1.136	1.139
0.956	1.132	1.135	1.138	1.140	1.143
0.958	1.135	1.138	1.141	1.144	1.147
0.960	1.139	1.142	1.145	1.148	1.150

b) by interpolation, the reading of the flow rate is:

$$Q_a = 1.137 \text{ m}^3/\text{min} \text{ (actual)}$$

7. Determine flow rate in terms of standard air.

$$Q_{std} = 1.137 \frac{\text{m}^3}{\text{min}} \left(\frac{752 \text{ mm Hg}}{760 \text{ mm Hg}} \right) \left(\frac{298^\circ\text{K}}{(273+27.5)^\circ\text{K}} \right)$$

$$Q_{std} = 1.116 \text{ m}^3/\text{min}$$

6.2 MFC Flow Determination and Sample Calculations

6.2.1 MFC Determination of Flow with Calibration Orifice

1. Determine and record the atmospheric properties:
 - ° ambient temperature (Ta), °C or °F
 - ° ambient barometric pressure (Pa), mm Hg or In Hg
2. Operate sampler and allow to warm up. Perform leak test as per instructions in Section 4.2.
3. Read the differential pressure drop across the orifice (ΔH_2O), Inches of water. Reading is taken with a differential manometer with one side of the manometer connected to the pressure tap on the calibration orifice and the other side open to the atmosphere. Do not use a filter or filter cartridge when calibrating the sampler.
4. Convert ambient temperature and barometric pressure to units consistent with those required for the orifice calibration curve, which are °K and mm Hg.

Temperature Conversion Formulas

$$^{\circ}K = 273 + ^{\circ}C$$

$$^{\circ}C = (^{\circ}F - 32) \times 5/9$$

Table 6.3 Pressure Conversion Factors

<u>To convert from:</u>	<u>To units of:</u>	<u>Divide by:</u>
In H ₂ O	In Hg	13.61
mm H ₂ O	mm Hg	13.61
mm H ₂ O	In H ₂ O	25.4
mm Hg	In Hg	25.4
mm	In	25.4

5. Read and record the orifice calibrator's calibration relationship constants, m and b. The calibration relationship is in the form of:

$$Q_a = (y - b) / m$$

where: Q_a = Orifice flow rate, actual m^3/min
 $y = \sqrt{(\Delta H_2O \times T_a / P_a)}$
 b = intercept of the orifice calibration relationship
 m = slope of the orifice calibration relationship
 ΔH_2O = orifice differential pressure, Inches-of-water
 T_a = ambient temperature in $^{\circ}K$
 P_a = station barometric pressure in mm Hg

6. Calculate Q_a for the calibration point as:

$$Q_a = [\sqrt{(\Delta H_2O \times T_a / P_a)} - b] / m$$

7. Determine flow rate in units of standard air, Q_{std}

$$Q_{std} = Q_a \left(\frac{P_a}{P_{std}} \right) \left(\frac{T_{std}}{T_a} \right)$$

In English units

$$Q_{std} = Q_a \left(\frac{P_a}{29.92 \text{ in Hg}} \right) \left(\frac{537^{\circ}R}{460 + T_a} \right)$$

where the units of P_a and T_a are:

$[P_a]$ = inches Hg

$[T_a]$ = $^{\circ}F$

In Metric Units

$$Q_{std} = Q_a \left(\frac{P_a}{760 \text{ mm Hg}} \right) \left(\frac{298^\circ\text{K}}{273 + T_a} \right)$$

where the units of P_a and T_a are:

$$[P_a] = \text{mm Hg}$$

$$[T_a] = ^\circ\text{C}$$

6.2.2 Example of Flow Rate Determination

1. Suppose the ambient conditions are:

Temperature: $T_a = 27.5^\circ\text{C}$

Barometric Pressure: $P_a = 752 \text{ mm Hg}$ (this pressure must be station pressure which is not corrected to sea level pressure but is corrected for density changes in Hg due to temperature)

2. Assume system is allowed to warm up for stable operation.
3. Measure orifice pressure differential, ΔH_2O . Assume that:

$$\Delta H_2O = 3.1 \text{ in H}_2\text{O}$$

4. Convert ambient temperature and barometric pressure to units $^\circ\text{K}$ and mm Hg.

Temperature: $T_a = 273 + 27.5^\circ\text{C}$

$$T_a = 300^\circ\text{K}$$

Pressure: $P_a = 752 \text{ mm Hg}$ (no change)

5. Assume the calibration relationship constants are:

$b = -0.01851$, intercept of orifice calibration relationship

$m = 0.96162$, slope of orifice calibration relationship

6. Calculate calibration point as:

$$Q_a = [\sqrt{(\Delta H_2O \times T_a / Pa)} - b] / m, m^3/min$$

$$Q_a = \left(\sqrt{\frac{(3.1 \text{ in H}_2\text{O}) \times (300.5 \text{ }^\circ\text{K})}{(752 \text{ mm Hg})}} + 0.01851 \right) / 0.976162$$

$$Q_a = 1.159 \text{ m}^3/\text{min}$$

7. Determine flow rate in terms of standard air.

$$Q_{std} = 1.159 \frac{\text{m}^3}{\text{min}} \left(\frac{752 \text{ mm Hg}}{760 \text{ mm Hg}} \right) \left(\frac{298^\circ\text{K}}{(273+27.5)^\circ\text{K}} \right)$$

$$Q_{std} = 1.137 \text{ m}^3/\text{min}$$

6.3 Orifice Calibration Relationship and Sample Calculations

6.3.1 Procedure for Determining Calibration Relationship

1. Obtain the following information from the orifice calibration sheet supplied with the unit and enter in the sampler log book or Table 6.1:

- ° Orifice calibration S/N
- ° Roots meter S/N
- ° Date of calibration
- ° Date in Service
- ° Ambient temperature during calibration (T_a)°K

Table 6.1 Orifice Calibration Relationship Worksheet

Cal. Point	Plate No. VDC	Volume Initial	Volume Final	ΔVolume	ΔTime (minutes)	ΔHg (mm)	ΔH2O (Inches)

DATA TABULATION

Orifice S/N _____
 Rootsmeter S/N _____
 Date of Calibration _____
 Date in Service _____
 Ta (°K) _____
 Pa (mmHg) _____
 Calibration performed by: _____

Va (m ³)	x-axis Qa (m ³ /min)	y-axis √[ΔH20 x Ta/Pa]

CALCULATIONS AND CONVERSIONS

$V_a = \Delta \text{Volume} \left(\frac{P_a - \Delta Hg}{P_a} \right)$
mm = inches x 25.4
ft³ = m³ x 35.31

$Q_a = V_a / \Delta \text{Time}$ Linear Regression: Qa, x-axis; $\sqrt{[\Delta H20(Ta/Pa)]}$, y-axis

m = _____
 b = _____
 r = _____

- ° Station barometric pressure during calibration (P_a) mmHg
- ° Operator

2. Record the orifice differential pressure (ΔH_2O) and corresponding pressure differential at inlet of roots meter (ΔHg), run time (t), and volume passed through system for each test condition (ΔV).
3. Calculate the actual flow rate for each test condition

$$Q_a = \left(\frac{P_a - \Delta Hg}{P_a} \right) \times \Delta V / t$$

Note: P_a and ΔHg must be in consistent units.

4. The orifice calibration relationship is in the form

$$Q_a = (y - b)/m$$

where: Q_a = orifice flow rate, actual m^3/min

$$y = \sqrt{(\Delta H_2O \times T_a / P_a)}$$

b = intercept of orifice calibration relationship

m = slope of orifice calibration relationship

Calculate y for each test condition.

$$y = \sqrt{(\Delta H_2O \times T_a / P_a)}$$

5. Using a programmable calculator, determine the best-fit straight line by method of least squares. The equation to be fit is:

$$y = m(Q_a) + b$$

Enter the data pairs of Q_a and y for each test condition into the calculator. perform the linear regression on the data set and record the intercept (b), slope (m), and the correlation coefficient (r) of the curve fit.

6. the correlation coefficient (r) must be ≥ 0.99 in order for the calibration to be valid. If $r < 0.99$, recheck calculations. If necessary, repeat calibration procedure.
7. To determine the actual flow rate in m^3/min from the orifice calibration relation, use:

$$Q_a = [\sqrt{(\Delta H_2O \times T_a / P_a)} - b] / m$$

6.3.2 Example for Determination of Calibration Relationship

1. Assume the following data are applicable to an orifice which is to be calibrated:

Orifice S/N F-139
 Roots S/N 7064132
 Date of calibration 5-9-1988
 Date in service 6-1-1988
 $T_a = 300.65 \text{ } ^\circ\text{K}$
 $P_a = 752.6 \text{ mm Hg}$

Test Condition	Volume Through		Roots	Orifice
	Roots meter (ΔV), m^3	Time (t), min	Pressure Differential (ΔHg), mm Hg	Pressure Differential (ΔH_2O), Inches-of -water
1	2.562	1	104.1	11.73
2	2.025	1	78.7	7.98
3	1.774	1	63.5	6.34
4	1.512	1	53.3	4.69
5	1.249	1	43.2	3.29

2. For test condition 1:

where: $\Delta Hg = 104.1 \text{ mm Hg}$

$\Delta V = 2.562 \text{ m}^3$

$(t) = 1 \text{ min}$

$P_a = 752.6 \text{ mm Hg}$

$$Q_a = \left(\frac{P_a - \Delta Hg}{P_a} \right) \times \Delta V / t$$

$$Q_a = \left(\frac{(752.6 \text{ mm Hg} - 104.1 \text{ mm Hg})}{(752.6 \text{ mm Hg})} \right) \times \left(\frac{2.563 \text{ m}^3}{1 \text{ min}} \right)$$

$$Q_a = 2.208 \text{ m}^3/\text{min}$$

3. Calculate y for test condition 1:

where: $\Delta H_2O = 11.73 \text{ Inches-of-water}$

$T_a = 300.65 \text{ }^\circ\text{K}$

$P_a = 752.6 \text{ mm Hg}$

$$y = \sqrt{(\Delta H_2O \times T_a / P_a)}$$

$$y = \sqrt{\frac{(11.73 \text{ Inches-of-water} \times 300.65 \text{ }^\circ\text{K})}{(752.6 \text{ mm Hg})}}$$

$$y = 2.165 \left(\frac{\text{Inches-of-water} \times \text{ }^\circ\text{K}}{\text{mm Hg}} \right)^{1/2}$$

4. For all the test conditions there results:

$Q_a, \text{m}^3/\text{min}$ (Qa-value)	$\sqrt{\Delta H_{2O} \times T_a/P_a}$ (y-value)
2.208	2.165
1.813	1.785
1.624	1.591
1.405	1.369
1.177	1.146

Performing a linear regression of this data provides the slope, intercept and correlation coefficient for the orifice; namely, $m = 0.991556$, $b = -0.02014$, and $r = 0.9999$

5. The correlation coefficient meets the criteria of: $r > 0.99$.

7.0 Maintenance

A regular maintenance schedule will allow a monitoring network to operate for longer periods of time without system failure. Our customers may find that adjustments in routine maintenance frequencies are necessary due to the operational demands on their sampler(s). ASI/GMW recommend however, that these cleaning and maintenance activities intervals be observed until a stable operating history of the sampler has been established. Table 7.1 presents a summary of recommended maintenance procedures and frequencies.

This section presents maintenance procedures specific to a Model 1200 SSI, the sampler shelter and both VFC and MFC motors (Models GBM2000V and GBM2000H, respectively). For information concerning the Model 321-B inlets, please refer to Appendix E.

7.1 Model 1200 Size-Selective Inlet (SSI)

The SSI hood should be inspected every sampling period for dents or irregularities in the inlet gap. Contact the manufacturer if dents exceeding 1/2" are noted.

In general, ASI/GMW recommends a thorough cleaning of the SSI after 15 days of sampling; which, on a 6 day schedule would correspond to 3 calendar months. If the TSP can be estimated from historical data to the site, it is recommended that the schedule shown in Table 7.1 be used.

Table 7.1 Inlet Cleaning and Maintenance Schedule

AVERAGE ESTIMATED TSP AT SITE STD. $\mu\text{g}/\text{m}^3$	MAINTENANCE FREQUENCY	
	NUMBER OF SAMPLING DAYS	INTERVAL, ASSUMING 6-DAY SAMPLING SCHEDULE
40	30	6 months
75	15	3 months
150	10	2 months
200	5	1 months

Procedures for cleaning and maintaining the Model 1200 inlet (Figure 7.1) are as follows:

1. Inspect the four inlet hook-catches for proper tension. The sealing gasket should be slightly compressed when the inlet is closed. Adjust as necessary by first loosening the lock-nut on the hook-catch rod. To shorten the catch length, turn the rod clockwise; counter-clockwise to loosen. After adjustments are complete, re-tighten the lock-nut.
2. Remove the hood (reverse assembly procedure presented in Section 3.1) and clean the nine acceleration nozzles with a small bottle brush. Wipe all internal surfaces with a damp cloth or Kimwipe. Replace the hood.
3. Release the four inlet hook-catches located on the sides of the SSI. Open the inlet fully; the support strut should lock on the second slot and support the inlet. The sixteen vent tubes and the collection shim (Figure 7.2) will be visible. Inspect the collection shim pattern. A normal greased shim pattern is indicated by a circular pattern of particle collection directly beneath the acceleration nozzles. An overloaded shim can be identified by bars or stripes of deposit between the vent tube holes.
4. Remove the collection shim (PN G120027) by rotating the shim clips 90°.
5. Carefully lift the shim (handling by the edges only) over the vent tubes. Use a putty knife to first remove bulk of deposited material. Wipe with a clean cloth or Kimwipe to remove oil and place on a workbench. (Acetone can be applied to completely clean the shim.)
6. Inspect all gaskets for wear and compression. Replace as necessary.
 - a. Carefully remove the gasket by scraping with a small, dull knife and wiping with acetone. The RTU adhesive must be thoroughly removed to ensure a complete seal for the new gasket.
 - b. Evenly spread silicone adhesive to the surface of the gasket and gently press on the inlet edge.
 - c. Wait at least 24-hours before resuming sampling to allow the adhesive to "cure." As with all chemicals, caution must be exercised if any organic analysis will

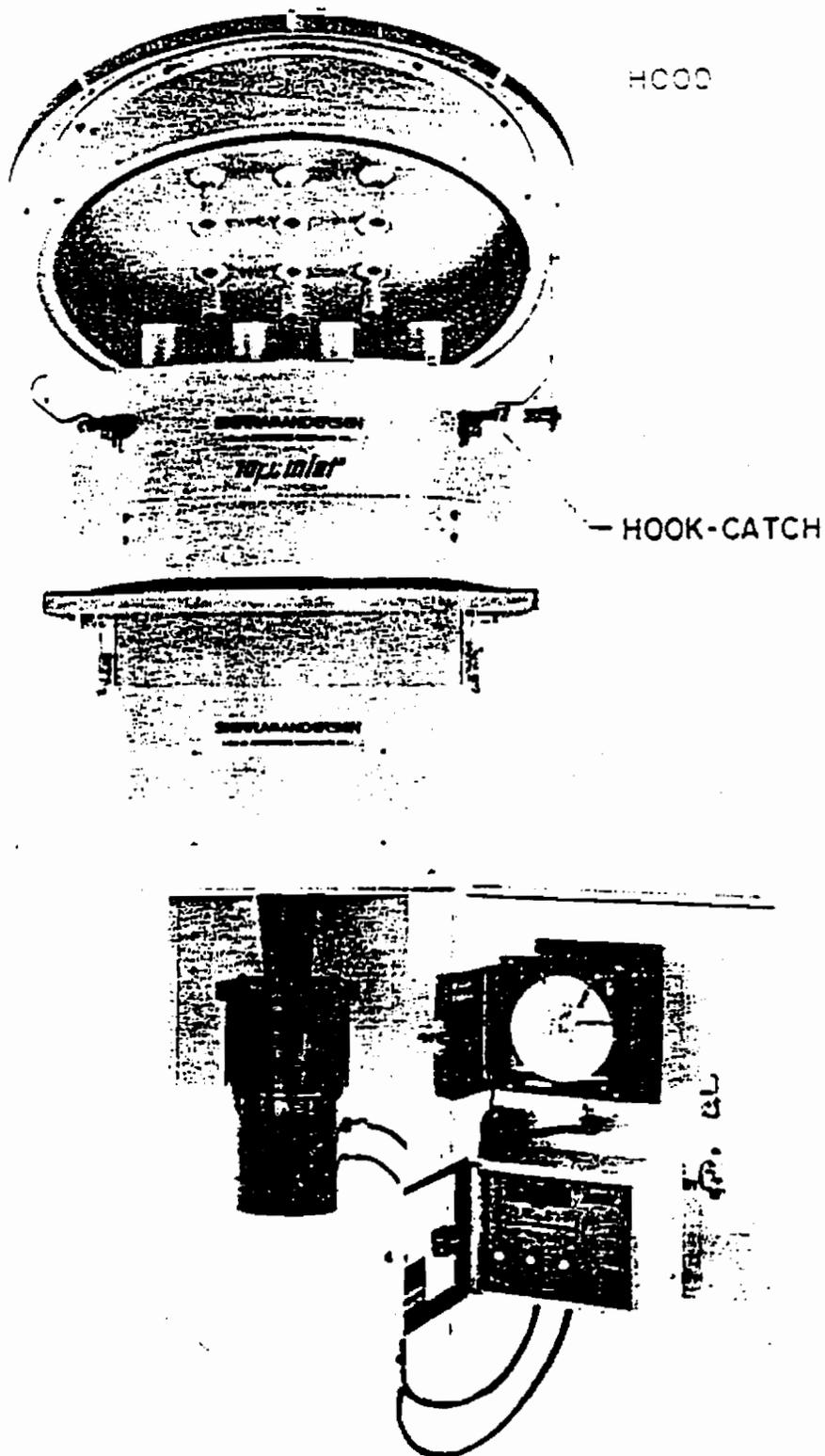


Figure 7.1 Sierra - Andersen/GMW Model 1200 HVPM10 Inlet

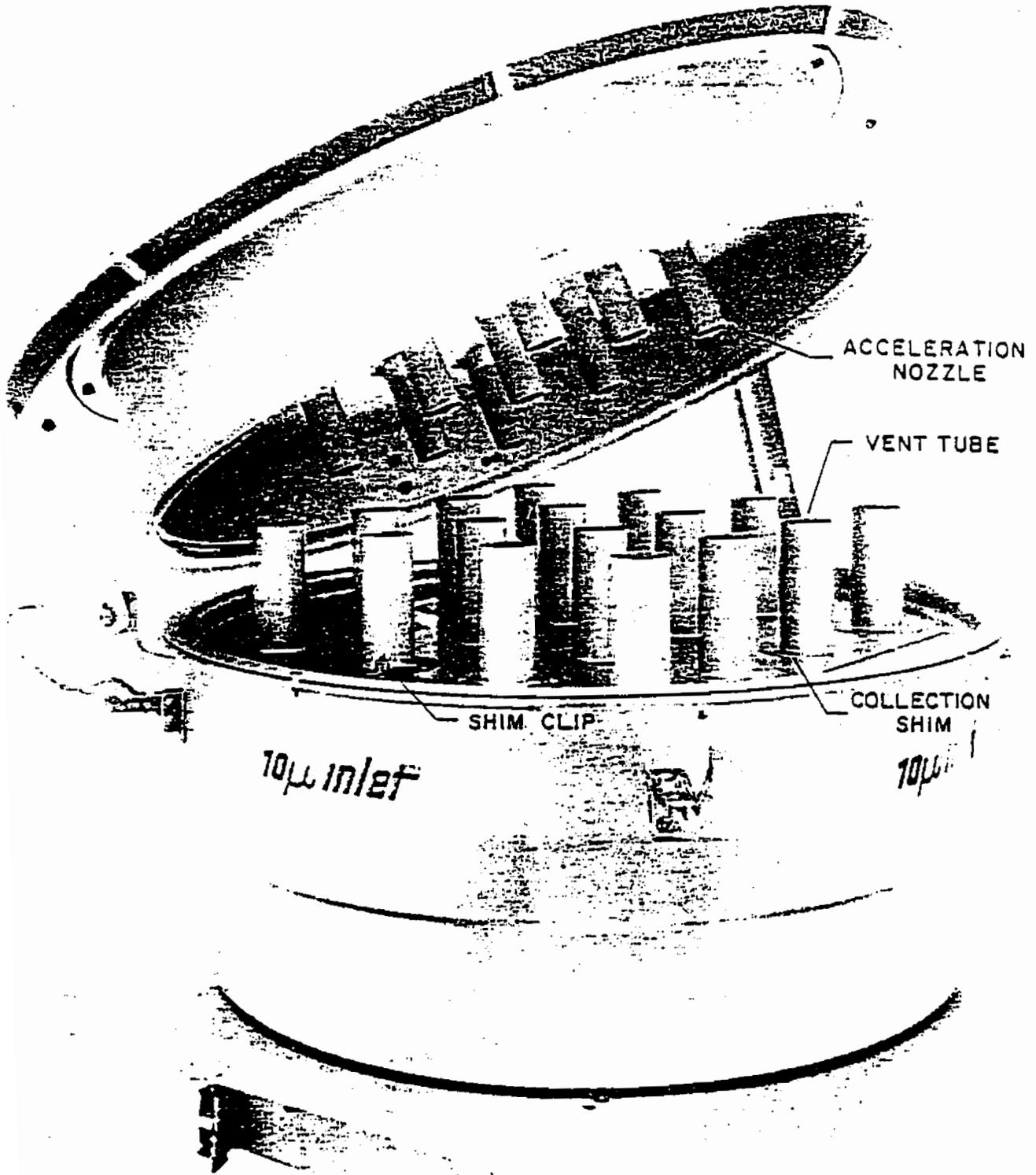


Figure 7.2 Sierra - Andersen/GMW Model 1200 HVPM10 Inlet
Access to Collection Shim

be conducted on future samples. Contact the manufacturer or the analysis laboratory for additional information.

7. Remove the first stage plate by carefully lifting it above the two male centering pins located on each side of the plate. Inspect the TM-bead gasket for wear and replace if necessary (see Step 6) before resuming sampling.
8. Remove the bug screen located beneath the first stage plate. All internal surfaces should be cleaned with a damp cloth and the bug screen inspected for contamination.
9. Reassemble the inlet by reversing steps 6-8. Caution: When replacing the first stage plate, ensure the male pins are aligned with the centering holes. The first stage plate should seat completely on bead-sealing gasket, (PN 1200-21).
10. Re-grease the collection shim. On a clean surface, spray the shim with a thick coating of Dow Silicone #316 (this grease is available from ASI/GMW) . DO NOT SUBSTITUTE ANY OTHER SUBSTANCE WITHOUT CONTACTING THE MANUFACTURER. Particle bounce characteristics within the inlet may be affected by a change in viscosity. Shake the can, and holding it upright 8 to 10-in. away, apply a "generous" amount of the silicone spray. Over-spraying will not affect the performance of the inlet, so when in doubt, apply more spray.
11. Allow 3-5 minutes for drying; the shim should be tacky (not slippery) and slightly cloudy when returned to the inlet.
12. Replace the collection shim in the inlet (oiled-side up) and secure with the shim clips.
13. Close the SSI. It is important to ensure that the male guide pin centers in the clearance hole.

7.2 High Volume Shelter

The HVPM10 sampler shelter should be routinely inspected and maintained as follows:

1. Power cords should be checked for crimps, cracks or exposed junctions each sample day. Do not allow power cords or outlets to be immersed water; if necessary raise the cords above the ground by

taping them to the shelter legs. Interlocking plugs can be purchased from the factory to preclude shock hazards.

2. With reference to Figure 7.3, inspect the filter screen, the filter holder gaskets (PN 3003 and 3005) and the sealing gasket each sample period. Remove any deposits on the filter screen and replace gaskets as necessary.
3. The filter cartridge used to support the sample filter should be checked each time a filter is installed. These gaskets may become warped or cracked due to over-tightening. Replace routinely.
4. Ensure that the continuous recorder pen is still inking each time the sampler is prepared for a sample period. Inspect the tubing to the motor for crimps and cracks. The recorder door should seal completely; replace the gasket as necessary.
5. The MFC (if so equipped) should operate without failure. The probe however, should be cleaned routinely with water followed by isopropyl alcohol. The use of a small camel hair brush is recommended. An electronic schematic of the MFC is presented in Appendix B.

7.3 VFC Motor (PN GBM 2000V) Maintenance Activities:

HVPM10 motors are durable and have a long life if maintained properly. The only routine maintenance required is : 1) inspecting and replacing the motor's neoprene gaskets routinely and 2) replacing the motor's carbon brushes every 300 to 400 hours of operation. The brushes have a higher rate of wear than the brushes used in an MFC motor. It is imperative that the brushes be replaced before the brush shunt touches the motor commutator. If this occurs, contact the manufacturer.

The procedure for motor gasket and brush replacement is as follows:

CAUTION: Ensure all electrical power to the HVPM10 sampler is disconnected prior to opening the motor housing. Unplug the motor power cord from the line voltage source.

1. Open the shelter door. Disconnect the rubber hose that connects the motor housing pressure tap to the continuous recorder.

2. While supporting the motor housing with one hand, loosen the four (4) 1/4-20 x 5/8" hex-head screws that attach the motor to the bottom of the VFC. Inspect the VFC flange gasket for wear. Replace if necessary. To facilitate access to the motor, the filter holder, VFC and motor can be removed from sampler by lifting the assembly through the top of the sampler base.
3. Remove the motor and motor housing from the sampler.
4. Inspect the mounting plate gasket (PN G2001) and replace as necessary (at least twice each year).
5. By looking down through the filter screen, inspect the VFC for any debris or large particles. Disassemble and clean as necessary.
6. Release the power cord by turning the cap of the power cord connector (PN G2010H) counter-clockwise.
7. Carefully let the motor slide from the housing exposing the brushes.
8. Remove each brush holder clamp and release the expended brush.
9. Insert new brush and replace the clamps.
10. Assemble motor after brush replacement by returning the motor to the housing. Do not pinch any motor wires beneath the motor mounting ring (PN G2006).
11. Gently pull the power cord back out of the motor housing and secure it with the connector cap.
12. Return the motor to its position beneath the VFC. Replace the four (4) 1/4-20 x 5/8" hex-head screws and tighten cross-corners simultaneously to ensure an even seal.
14. For proper motor performance and maximum brush life expectancy, it is necessary to seat or "break-in" the brushes. Apply approximately 50% voltage to the motor for at least thirty minutes. A brush miser (PN G900) can be used or simply connect two motors of similar rating in series.

Caution: Direct application of full voltage after changing brush will cause arcing, commutator pitting, and reduce overall life.

15. A leak test is recommended after brush changes, refer to Section 4.0.

7.4 MFC Motor (PN GBM 2000H) Maintenance Activities:

HVPM10 motors are durable and have a long life if maintained properly. The only routine maintenance required is : 1) inspecting and replacing the motor's neoprene gaskets routinely and 2) replacing the motor's carbon brushes every 400 to 500 hours of operation. It is imperative that the brushes be replaced before the brush shunt touches the motor commutator. If this occurs, contact the manufacturer.

The procedure for motor gasket and brush replacement is as follows:

CAUTION: Ensure all electrical power to the HVPM10 sampler is disconnected prior to opening the motor housing. Unplug the motor power cord from the line voltage source.

1. Open the shelter door and disconnect the rubber pressure hose that connects the motor to the continuous recorder.
2. Using both hands, clasp the motor mounting ring and turn counter-clockwise to loosen the ring.
3. Remove the motor and motor housing from the sampler.
4. Inspect the motor housing gaskets and replace as necessary (at least twice a year).
5. Remove the mounting plate motor cover (PN G2002) by removing the four (4) 1/4 20 x 3/8" round-head bolts. This will expose the motor.
6. Release the power cord by turning the cap of the power cord connector (PN G2010H) counter-clockwise.
7. Carefully let the motor slide from the housing exposing brushes.
8. Remove each brush holder clamp and release the expended brush.
9. Insert a new brush and replace the clamps.
10. Assemble motor after brush replacement by returning the motor to the housing. Do not to pinch any motor wires beneath the motor mounting ring (PN G2006).
11. Replace the mounting plate motor cover and bolts.
12. Gently pull the power cord back out of sampler housing and secure it with the connector cap.
13. Return the motor to its mounting ring beneath the filter holder. It is a common error to cross thread the ring or to forget the gasket. Ensure

there is a proper seal and all wires are free from rotating motor parts and the motor frame.

14. For proper motor performance and maximum brush life expectancy, it is necessary to seat or "break-in" the brushes. Apply approximately 50% voltage to the motor for at least thirty minutes. A brush miser (PN G900) can be used or simply connect two motors of similar rating in series.

Caution: Direct application of full voltage after changing brush will cause arcing, commutator pitting, and reduce overall life.

15. A leak test is recommended after brush changes, refer to Section 4.0.

**REPLACEMENT PARTS
ASI/GMW HVPM10 SAMPLERS**

Model 1200 SSI

(numbers refer to parts indicated in Figure 7.1)

Item	Part Number
1. Upper Tub Housing	G12001
2. Lower Tub Housing	G12002
3. First Stage Plate	G12003
4. Acceleration Nozzle	G12004
5. Acceleration Nozzle Plate	SSI-109
6. Shelter	G12006
7. Shelter Draw-Catch	G12007
8. BP-sealing Gasket (16 x 16")	G12008
9. FH-sealing Gasket (8 x 10")	G12009
10. Vent Tube	G12005
11. Brass Bolt Assembly	G120011
12. Shelter Hinge Bracket	G120012
13. Shelter Shoulder Bolt	G120013
14. Inlet Base Plate	G120014
15. Inlet Base Plate Hinge Bracket	G120015
16. Inlet Base Plate Strike	G120016
17. Support Strut	G120018
18. Inlet Base Plate Shoulder Bolt	G120019
19. Bug Screen With Edging	G120020
20. TM-bead Gasket	G120021
21. Inlet Hook-Catch	G120022
22. Inlet Hook	G120024
23. Lower Tub Hinge	G120025
24. Upper Tub Hinge	G120026
25. Collection Shim Plate	G120027
26. Collection Shim Clips	G120028
27. Filter Holder Support Frame	G120029
28. Collection Shim Kit	G120030
29. Nozzle Plate Gasket	SSI-20
30. Hood	SSI-106
31. Nozzle Modification Kit (9.2 μ m)	G120034
32. Shim and Nozzle Modification Kit	G120035
33. Dow Silicone 316 Grease	G10596 or SE290G

Model G3000 Filter Cartridge

Item	Part Number
Filter Cartridge Complete	G3000
Aluminum Cover	G3001
Aluminum Filter Frame	GFH2017
Rubber Filter Gasket	GFH2018
Aluminum Frame with Stainless Steel Screen	G3004
Rubber Frame Gasket	GFH2018
Brass Thumb Nut (2 per set)	G3006

**REPLACEMENT PARTS
ASI/GMW HVPM10 SAMPLERS**

Model GFH2100 Filter Steel Filter Holder

Item	Part Number
Aluminum Filter Holder Complete	GFH2100
Aluminum Hold Down Filter Frame	GFH2017
Rubber Filter Gasket	GFH2018

Model GBM2000V Motor Assembly for VFC units

Item	Part Number
Motor Assembly Complete (does not include filter holder)	GBM2000V
Mounting Plate Gasket	G2001
Male Adapter	G2002
Top Motor Gasket	G2003
110 volt VFC Motor (Note: Different then MFC motor)	G115923
Carbon Motor Brushes, <i>motors purchased after 1/78</i> (set of 2)	GB1
Motor Armature with Bearings	G215276
Motor Cushion Gasket	G2005
Motor Mounting Metal Ring	G2006
Motor Housing	G2007H
Power Cord Retainer	G2010H
Male Power Cord	G2011
Motor Pressure Tap	G2015
Pressure Recorder Tubing	G2016

Model GBM2000H Motor Assembly for MFC units

Item	Part Number
Motor Assembly Complete (does not include filter holder)	GBM2000H
Mounting Plate Gasket	G2001
Male Adapter	G2002
Top Motor Gasket	G2003
110 volt MFC Motor (Note: different than VFC motor.)	G115750
Carbon Motor Brushes, <i>motors purchased</i> <i>after 1/78</i> (set of 2)	GB1
Carbon Motor Brushes, <i>motors purchased</i> <i>before 1/78</i> (set of 2)	GB3
Motor Armature with Bearings	G215276
Motor Cushion Gasket	G2005
Motor Mounting Metal Ring	G2006
Motor Housing	G2007H
Power Cord Retainer	G2010H
Male Power Cord	G2011
Motor Pressure Tap	G2015
Pressure Recorder Tubing	G2016

**REPLACEMENT PARTS
ASI/GMW HVPM10 SAMPLERS**

Model G105 Continuous Recorder (Dickson)

Item	Part Number
Continuous Recorder (complete assembly)	G105
Circular Charts (Box of 100)	G106
Ink Pen Cartridge (Red)	G127
Recorder Chart Motor (115 volts, 60Hz)	G108
Door Gasket	G113
Tube Hose-Barb Fitting	G115
Back Gasket	G123
Pen Arm Lifter	G124
Cartridge Pen Arm	G126
Cartridge Pen Point	G127

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APPENDIX A
CODE OF FEDERAL REGULATIONS

reference conditions, these corrected concentrations sometimes differ substantially from actual concentrations (in micrograms per actual cubic meter), particularly at high elevations. Although not required, the actual PM_{10} concentration can be calculated from the corrected concentration, using the average ambient temperature and barometric pressure during the sampling period.

2.3 A method based on this principle will be considered a reference method only if (a) the associated sampler meets the requirements specified in this appendix and the requirements in Part 53 of this chapter, and (b) the method has been designated as a reference method in accordance with Part 53 of this chapter.

1.0 Range.

3.1 The lower limit of the mass concentration range is determined by the repeatability of filter tare weights, assuming the nominal air sample volume for the sampler. For samplers having an automatic filter-changing mechanism, there may be no upper limit. For samplers that do not have an automatic filter-changing mechanism, the upper limit is determined by the filter mass loading beyond which the sampler no longer maintains the operating flow rate within specified limits due to increased pressure drop across the loaded filter. This upper limit cannot be specified precisely because it is a complex function of the ambient particle size distribution and type, humidity, filter type, and perhaps other factors. Nevertheless, all samplers should be capable of measuring 24-hour PM_{10} mass concentrations of at least $300 \mu\text{g}/\text{std m}^3$ while maintaining the operating flow rate within the specified limits.

4.0 Precision.

4.1 The precision of PM_{10} samplers must be $5 \mu\text{g}/\text{m}^3$ for PM_{10} concentrations below $80 \mu\text{g}/\text{m}^3$ and 7 percent for PM_{10} concentrations above $80 \mu\text{g}/\text{m}^3$, as required by Part 53 of this chapter, which prescribes a test procedure that determines the variation in the PM_{10} concentration measurements of identical samplers under typical sampling conditions. Continual assessment of precision via collocated samplers is required by Part 58 of this chapter for PM_{10} samplers used in certain monitoring networks.

5.0 Accuracy.

5.1 Because the size of the particles making up ambient particulate matter varies over a wide range and the concentration of particles varies with particle size, it is difficult to define the absolute accuracy of PM_{10} samplers. Part 53 of this chapter provides a specification for the sampling effectiveness of PM_{10} samplers. This specification requires that the expected mass concentration calculated for a candidate PM_{10} sampler, when sampling a specified particle size distribution, be within ± 10 percent of that calculated for an ideal sampler whose sampling effectiveness is explicitly specified. Also, the particle size for 50 percent sampling effectiveness is required to be 10 ± 0.5 micrometers. Other specifications related to accuracy apply to flow measurement and calibration, filter media, analytical (weighing) procedures, and artifact. The flow rate accuracy of PM_{10} samplers used in certain monitoring networks is required by Part 58 of this chapter to be assessed periodically via flow rate audits.

6.0 Potential Sources of Error.

6.1 *Volatile Particles.* Volatile particles collected on filters are often lost during shipment and/or storage of the filters prior to the post-sampling weighing³. Although shipment or storage of loaded filters is sometimes unavoidable, filters should be reweighed as soon as practical to minimize these losses.

6.2 *Artifacts.* Positive errors in PM_{10} concentration measurements may result from retention of gaseous species on filters^{4, 5}. Such errors include the retention of sulfur dioxide and nitric acid. Retention of sulfur dioxide on filters, followed by oxidation to sulfate, is referred to as artifact sulfate formation, a phenomenon which increases with increasing filter alkalinity⁶. Little or no artifact sulfate formation should occur using filters that meet the alkalinity specification in section 7.2.4. Artifact nitrate formation, resulting primarily from retention of nitric acid, occurs to varying degrees on many filter types, including glass fiber, cellulose ester, and many quartz fiber filters^{7, 8, 9, 10}. Loss of true atmospheric particulate nitrate during or following sampling may also occur due to dissociation or chemical reaction. This phenomenon has been observed on Teflon[®] filters¹¹ and inferred for quartz fiber filters^{12, 13}. The magnitude of nitrate artifact errors in PM_{10} mass concentration measurements will vary with location and ambient temperature; however, for most sampling locations, these errors are expected to be small.

6.3 *Humidity.* The effects of ambient humidity on the sample are unavoidable. The filter equilibration procedure in section 9.0 is designed to minimize the effects of moisture on the filter medium.

6.4 *Filter Handling.* Careful handling of filters between presampling and postsampling weighings is necessary to avoid errors due to damaged filters or loss of collected particles from the filters. Use of a filter cartridge or cassette may reduce the magnitude of these errors. Filters must also meet the integrity specification in section 7.2.3.

6.5 *Flow Rate Variation.* Variations in the sampler's operating flow rate may alter the particle size discrimination characteristics of the sampler inlet. The magnitude of this error will depend on the sensitivity of the inlet to variations in flow rate and on the particle distribution in the atmosphere during the sampling period. The use of a flow control device (section 7.1.3) is required to minimize this error.

6.6 *Air Volume Determination.* Errors in the air volume determination may result from errors in the flow rate and/or sampling time measurements. The flow control device serves to minimize errors in the flow rate determination, and an elapsed time meter (section 7.1.5) is required to minimize the error in the sampling time measurement.

7.0 Apparatus.

7.1 PM_{10} Sampler.

7.1.1 The sampler shall be designed to:
a. Draw the air sample into the sampler inlet and through the particle collection filter at a uniform face velocity.

Appendix J—Reference Method for the Determination of Particulate Matter as PM_{10} in the Atmosphere

1.0 Applicability.

1.1 This method provides for the measurement of the mass concentration of particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM_{10}) in ambient air over a 24-hour period for purposes of determining attainment and maintenance of the primary and secondary national ambient air quality standards for particulate matter specified in § 50.6 of this chapter. The measurement process is nondestructive, and the PM_{10} sample can be subjected to subsequent physical or chemical analyses. Quality assurance procedures and guidance are provided in Part 58, Appendices A and B, of this chapter and in References 1 and 2.

2.0 Principle.

2.1 An air sampler draws ambient air at a constant flow rate into a specially shaped inlet where the suspended particulate matter is inertially separated into one or more size fractions within the PM_{10} size range. Each size fraction in the PM_{10} size range is then collected on a separate filter over the specified sampling period. The particle size discrimination characteristics (sampling effectiveness and 50 percent cutpoint) of the sampler inlet are prescribed as performance specifications in Part 53 of this chapter.

2.2 Each filter is weighed (after moisture equilibration) before and after use to determine the net weight (mass) gain due to collected PM_{10} . The total volume of air sampled, corrected to EPA reference conditions (25°C , 101.3 kPa), is determined from the measured flow rate and the sampling time. The mass concentration of PM_{10} in the ambient air is computed as the total mass of collected particles in the PM_{10} size range divided by the volume of air sampled, and is expressed in micrograms per standard cubic meter ($\mu\text{g}/\text{std m}^3$). For PM_{10} samples collected at temperatures and pressures significantly different from EPA

b. Hold and seal the filter in a horizontal position so that sample air is drawn downward through the filter.

c. Allow the filter to be installed and removed conveniently.

d. Protect the filter and sampler from precipitation and prevent insects and other debris from being sampled.

e. Minimize air leaks that would cause error in the measurement of the air volume passing through the filter.

f. Discharge exhaust air at a sufficient distance from the sampler inlet to minimize the sampling of exhaust air.

g. Minimize the collection of dust from the supporting surface.

7.1.2 The sampler shall have a sample air inlet system that, when operated within a specified flow rate range, provides particle size discrimination characteristics meeting all of the applicable performance specifications prescribed in Part 53 of this chapter. The sampler inlet shall show no significant wind direction dependence. The latter requirement can generally be satisfied by an inlet shape that is circularly symmetrical about a vertical axis.

7.1.3 The sampler shall have a flow control device capable of maintaining the sampler's operating flow rate within the flow rate limits specified for the sampler inlet over normal variations in line voltage and filter pressure drop.

7.1.4 The sampler shall provide a means to measure the total flow rate during the sampling period. A continuous flow recorder is recommended but not required. The flow measurement device shall be accurate to ± 2 percent.

7.1.5 A timing/control device capable of starting and stopping the sampler shall be used to obtain a sample collection period of 24 ± 1 hr ($1,440 \pm 60$ min). An elapsed time meter, accurate to within ± 15 minutes, shall be used to measure sampling time. This meter is optional for samplers with continuous flow recorders if the sampling time measurement obtained by means of the recorder meets the ± 15 minute accuracy specification.

7.1.6 The sampler shall have an associated operation or instruction manual as required by Part 53 of this chapter which includes detailed instructions on the calibration, operation, and maintenance of the sampler.

7.2 Filters.

7.2.1 *Filter Medium.* No commercially available filter medium is ideal in all respects for all samplers. The user's goals in sampling determine the relative importance of various filter characteristics (e.g., cost, ease of handling, physical and chemical characteristics, etc.) and, consequently, determine the choice among acceptable filters. Furthermore, certain types of filters may not be suitable for use with some samplers, particularly under heavy loading conditions (high mass concentrations), because of high or rapid increase in the filter flow resistance that would exceed the capability of the sampler's flow control device. However, samplers equipped with automatic filter-changing mechanisms may allow use of these types of filters. The specifications given below are minimum requirements to ensure acceptability of the

filter medium for measurement of PM_{10} mass concentrations. Other filter evaluation criteria should be considered to meet individual sampling and analysis objectives.

7.2.2 *Collection Efficiency.* 99 percent, as measured by the DOP test (ASTM-2986) with $0.3 \mu m$ particles at the sampler's operating face velocity.

7.2.3 *Integrity.* $\pm 5 \mu g/m^3$ (assuming sampler's nominal 24-hour air sample volume). Integrity is measured as the PM_{10} concentration equivalent corresponding to the average difference between the initial and the final weights of a random sample of test filters that are weighed and handled under actual or simulated sampling conditions, but have no air sample passed through them (i.e., filter blanks). As a minimum, the test procedure must include initial equilibration and weighing, installation on an isoperstive sampler, removal from the sampler, and final equilibration and weighing.

7.2.4 *Alkalinity.* < 25 microequivalents/gram of filter, as measured by the procedure given in Reference 13 following at least two months storage in a clean environment (free from contamination by acidic gases) at room temperature and humidity.

7.3 *Flow Rate Transfer Standard.* The flow rate transfer standard must be suitable for the sampler's operating flow rate and must be calibrated against a primary flow or volume standard that is traceable to the National Bureau of Standards (NBS). The flow rate transfer standard must be capable of measuring the sampler's operating flow rate with an accuracy of ± 2 percent.

7.4 Filter Conditioning Environment.

7.4.1 Temperature range: 15° to 30° C.

7.4.2 Temperature control: $\pm 3^\circ$ C.

7.4.3 Humidity range: 20% to 45% RH.

7.4.4 Humidity control: $\pm 5\%$ RH.

7.5 *Analytical Balance.* The analytical balance must be suitable for weighing the type and size of filters required by the sampler. The range and sensitivity required will depend on the filter tare weights and mass loadings. Typically, an analytical balance with a sensitivity of 0.1 mg is required for high volume samplers (flow rates $> 0.5 m^3/min$). Lower volume samplers (flow rates $< 0.5 m^3/min$) will require a more sensitive balance.

8.0 Calibration.

8.1 General Requirements.

8.1.1 Calibration of the sampler's flow measurement device is required to establish traceability of subsequent flow measurements to a primary standard. A flow rate transfer standard calibrated against a primary flow or volume standard shall be used to calibrate or verify the accuracy of the sampler's flow measurement device.

8.1.2 Particle size discrimination by inertial separation requires that specific air velocities be maintained in the sampler's air inlet system. Therefore, the flow rate through the sampler's inlet must be maintained throughout the sampling period within the design flow rate range specified by the manufacturer. Design flow rates are specified as actual volumetric flow rates, measured at existing conditions of temperature and pressure (Q_a). In contrast, mass concentrations of PM_{10} are computed using

flow rates corrected to EPA reference conditions of temperature and pressure (Q_r).

8.2 Flow Rate Calibration Procedure.

8.2.1 PM_{10} samplers employ various flow control and flow measurement devices. The specific procedure used for flow rate calibration or verification will vary depending on the type of flow controller and flow indicator employed. Calibration in terms of actual volumetric flow rates (Q_a) is generally recommended, but other measures of flow rate (e.g., Q_{std}) may be used provided the requirements of section 8.1 are met. The general procedure given here is based on actual volumetric flow units (Q_a) and serves to illustrate the steps involved in the calibration of a PM_{10} sampler. Consult the sampler manufacturer's instruction manual and Reference 2 for specific guidance on calibration. Reference 14 provides additional information on the use of the commonly used measures of flow rate and their interrelationships.

8.2.2 Calibrate the flow rate transfer standard against a primary flow or volume standard traceable to NBS. Establish a calibration relationship (e.g., an equation or family of curves) such that traceability to the primary standard is accurate to within 2 percent over the expected range of ambient conditions (i.e., temperatures and pressures) under which the transfer standard will be used. Recalibrate the transfer standard periodically.

8.2.3 Following the sampler manufacturer's instruction manual, remove the sampler inlet and connect the flow rate transfer standard to the sampler such that the transfer standard accurately measures sampler's flow rate. Make sure there are no leaks between the transfer standard and the sampler.

8.2.4 Choose a minimum of three flow rates (actual m^3/min), spaced over the acceptable flow rate range specified for the inlet (see 7.1.2) that can be obtained by suitable adjustment of the sampler flow rate. In accordance with the sampler manufacturer's instruction manual, obtain or verify the calibration relationship between the flow rate (actual m^3/min) as indicated by the transfer standard and the sampler's flow indicator response. Record the ambient temperature and barometric pressure. Temperature and pressure corrections to subsequent flow indicator readings may be required for certain types of flow measurement devices. When such corrections are necessary, correction on an individual or daily basis is preferable. However, seasonal average temperature and average barometric pressure for the sampling site may be incorporated into the sampler calibration to avoid daily corrections. Consult the sampler manufacturer's instruction manual and Reference 2 for additional guidance.

8.2.5 Following calibration, verify that the sampler is operating at its design flow rate (actual m^3/min) with a clean filter in place.

8.2.6 Replace the sampler inlet.

8.0 Procedure.

8.1 The sampler shall be operated in accordance with the specific guidance provided in the sampler manufacturer's instruction manual and in Reference 2.1.

general procedure given here assumes that the sampler's flow rate calibration is based on flow rates at ambient conditions (Q_a) and serves to illustrate the steps involved in the operation of a PM_{10} sampler.

9.2 Inspect each filter for pinholes, particles, and other imperfections. Establish a filter information record and assign an identification number to each filter.

9.3 Equilibrate each filter in the conditioning environment (see 7.4) for at least 24 hours.

9.4 Following equilibration, weigh each filter and record the presampling weight with the filter identification number.

9.5 Install a preweighed filter in the sampler following the instructions provided in the sampler manufacturer's instructional manual.

9.6 Turn on the sampler and allow it to establish run-temperature conditions. Record the flow indicator reading and, if needed, the ambient temperature and barometric pressure. Determine the sampler flow rate (actual m^3/min) in accordance with the instructions provided in the sampler manufacturer's instruction manual. **NOTE.**—No onsite temperature or pressure measurements are necessary if the sampler's flow indicator does not require temperature or pressure corrections or if seasonal average temperature and average barometric pressure for the sampling site are incorporated into the sampler calibration (see step 8.2.4). If individual or daily temperature and pressure corrections are required, ambient temperature and barometric pressure can be obtained by on-site measurements or from a nearby weather station. Barometric pressure readings obtained from airports must be station pressure, not corrected to sea level, and may need to be corrected for differences in elevation between the sampling site and the airport.

9.7 If the flow rate is outside the acceptable range specified by the manufacturer, check for leaks, and if necessary, adjust the flow rate to the specified setpoint. Stop the sampler.

9.8 Set the timer to start and stop the sampler at appropriate times. Set the elapsed time meter to zero or record the initial meter reading.

9.9 Record the sample information (site location or identification number, sample date, filter identification number, and sampler model and serial number).

9.10 Sample for 24 ± 1 hours.

9.11 Determine and record the average flow rate (Q_a) in actual m^3/min for the sampling period in accordance with the instructions provided in the sampler manufacturer's instruction manual. Record the elapsed time meter final reading and, if needed, the average ambient temperature and barometric pressure for the sampling period (see note following step 9.6).

9.12 Carefully remove the filter from the sampler, following the sampler manufacturer's instruction manual. Touch only the outer edges of the filter.

9.13 Place the filter in a protective holder or container (e.g., petri dish, glassine envelope, or manila folder).

9.14 Record any factors such as meteorological conditions, construction

activity, fires or dust storms, etc., that might be pertinent to the measurement on the filter information record.

9.15 Transport the exposed sample filter to the filter conditioning environment as soon as possible for equilibration and subsequent weighing.

9.16 Equilibrate the exposed filter in the conditioning environment for at least 24 hours under the same temperature and humidity conditions used for presampling filter equilibration (see 9.3).

9.17 Immediately after equilibration, reweigh the filter and record the postsampling weight with the filter identification number.

10.8 Sampler Maintenance.

10.1 The PM_{10} sampler shall be maintained in strict accordance with the maintenance procedures specified in the sampler manufacturer's instruction manual.

11.0 Calculations.

11.1 Calculate the average flow rate over the sampling period corrected to EPA reference conditions as Q_{ref} . When the sampler's flow indicator is calibrated in actual volumetric units (Q_a), Q_{ref} is calculated as:

$$Q_{ref} = Q_a \times (P_{ref}/T_{ref})(T_{amb}/P_{amb})$$

where

Q_{ref} = average flow rate at EPA reference conditions, std m^3/min ;

Q_a = average flow rate at ambient conditions, m^3/min ;

P_{amb} = average barometric pressure during the sampling period or average barometric pressure for the sampling site, kPa (or mm Hg);

T_{amb} = average ambient temperature during the sampling period or seasonal average ambient temperature for the sampling site, K;

T_{ref} = standard temperature, defined as 298 K;

P_{ref} = standard pressure, defined as 101.3 kPa (or 760 mm Hg).

11.2 Calculate the total volume of air sampled as:

$$V_{std} = Q_{ref} \times t$$

where

V_{std} = total air sampled in standard volume units, std m^3 ;

t = sampling time, min.

11.3 Calculate the PM_{10} concentration as:

$$PM_{10} = (W_f - W_i) \times 10^6 / V_{std}$$

where

PM_{10} = mass concentration of PM_{10} , $\mu g/std m^3$;

W_f , W_i = final and initial weights of filter collecting PM_{10} particles, g;

10^6 = conversion of g to μg .

Note.—If more than one size fraction in the PM_{10} size range is collected by the sampler, the sum of the net weight gain by each collection filter ($\Sigma(W_f - W_i)$) is used to calculate the PM_{10} mass concentration.

12.0 References.

1. Quality Assurance Handbook for Air Pollution Measurement Systems. Volume I. Principles. EPA-600/9-76-005. March 1976. Available from CERL, ORD Publications, U.S. Environmental Protection Agency, 26 West St. Clair Street, Cincinnati, Ohio 45258.

2. Quality Assurance Handbook for Air Pollution Measurement Systems. Volume II. Ambient Air Specific Methods. EPA-600/4-77-027a. May 1977. Available from CERL, ORD Publications, U.S. Environmental Protection Agency, 26 West St. Clair Street, Cincinnati, Ohio 45258.

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13. Harrell, R.M. Measuring the Alkalinity of Hi-Vol Air Filters. EMSL/RTP-SOP-QAD-534, October 1985. Available from the U.S. Environmental Protection Agency, EMSL/QAD, Research Triangle Park, North Carolina 27711.

14. Smith, F., P.S. Wohlschlegel, R.S.C. Rogers, and D.J. Mulligan. Investigation of Flow Rate Calibration Procedures Associated With the High Volume Method for Determination of Suspended Particulates. EPA-600/4-78-047, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, 1978.

ELECTRONIC MASS FLOW CONTROLLER (MFC)

1.0 Description

An electronic MFC adjust the sampler's motor speed and thus maintains a constant mass flow rate regardless of fluctuating ambient conditions (temperature and barometric pressure) and filter loadings. All ASI/GMW MFC models are designed to control HVPM10 motors with power ratings up to 3/4hp (ASI/GMW motors are rated at 0.6hp) and are available at both 50 and 60Hz, 115 VAC. All models have an adjustable flow range of 0.4 std. m³/min to 1.7 std. m³/min with an accuracy of ± 0.03 std. m³/min when operated in the temperature range of 0°C to 45°C.

An ASI/GMW MFC utilizes a set-screw potentiometer (pot) to adjust the sampler's flow rate. The pot is located (dependent upon the model) either: 1) on the front panel of the MFC, 2) on the printed circuit card (before 1982) behind the front panel or 3) on the front door of the MFC (USEPA units). This pot is adjusted after the sampler's calibration (refer to Section 4.0 of the Operator's Manual) to set the sampler at its seasonally adjusted set point flow rate (SFR).

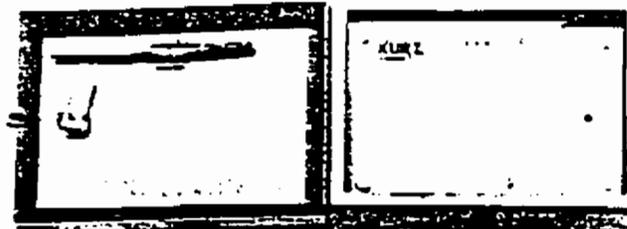
Elapsed time indicators (ETI) are included with all ASI/GMW MFC systems. ETIs are mechanical devices that are activated only when the sampler is energized. Both resettable and non-resettable ETI are available; the purchaser should evaluate the options available and chose the model most useful in their monitoring network. The ETI's mechanical digital totalizer is read in either units of XXXX.X hours or XXXX.X minutes.

ASI/GMW offer a variety of MFC systems to our customers. The following is a brief description of the MFCs and combination MFC/timers provided with ASI/GMW HVPM10 samplers (Figure B-1).

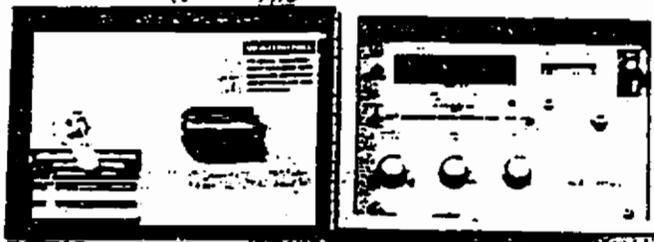
1. Model SA350/G310

This electronic MFC is sold as a single unit and is encased in a steel all-weather enclosure. In HVPM10 samplers, GMW-IP-801 AND GMW-IP-10-8000, it is electronically wired to activate when the master timer energizes the motor.

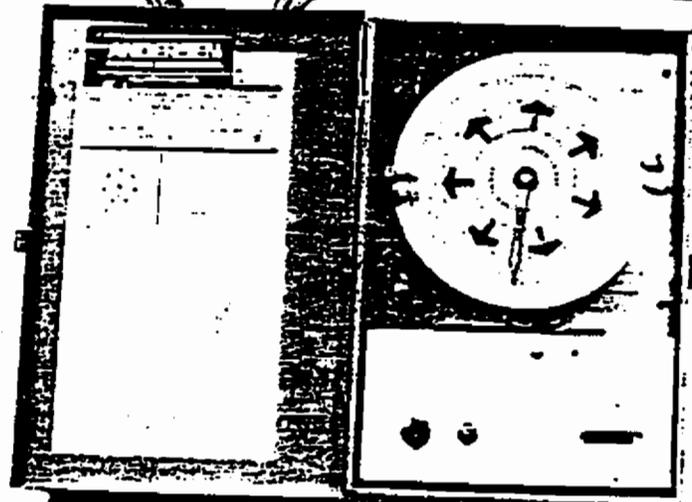
2. Model SA352/G312



- Model 310, 350



- Model 312, 352



- Model 313, 353

Electronic Flow Controllers

This is an MFC that has been mated with a Model 302 electronic digital timer/programmer. These two units are packaged in a single steel all-weather enclosure and are supplied in HVPM10 systems SAUV-10-H and GMW-IP-10.

3. Model SA353/G313

This is an MFC that has been mated with a with Model 70 mechanical 7-day master timer. These two units are packaged together in the enclosure that houses the Model 70 timer. A Model 76 master timer may be substituted for the Model 70 master timer at the user's option. The Model SA353 and G313 are supplied in HVPM10 systems SAUV-11H and GMW-IP-10-70.

Note: All MFC systems must have a minimum of 90VAC to operate correctly. It is recommended that each sampler equipped with a MFC have a separate circuit to preclude low-voltage failure. Due to amperage fluctuations, the use of portable generators for power supplies is strongly discouraged.

2.0 Theory of Operation

The electronic MFC is designed to control the sampler's mass flow rate over the range of 0.4 to 1.7 std. m³/min. Since mass flow rates are always expressed in terms of standard conditions, and an HVPM10 sampler must be operated in terms of actual conditions, ASI/GMW calibration procedures use the MFC as a device to set the sampler's operational flow rate to a "centered" (in respect to the required design flow rate) seasonally adjusted flow rate. For further information, please refer to Section 4.0, "Calibration Procedures."

Simply stated, the MFC controls the sampler's flow rate by increasing or decreasing the motor speed by adjusting the input voltage to the motor. The MFC ability to operate correctly, is therefore dependent upon line voltage and to a lesser extent, the motor's power rating. A separate power circuit for each MFC sampler is recommended and a minimum of 90VAC is required.

Each MFC consists of two basic components: 1) a temperature differential sensor and a feedback control circuit that varies the voltage input into the motor. The temperature differential sensor is a short (4-in) metal-covered glass probe that is inserted into the throat of the sampler's filter holder. (Note: At one time, ASI/GMW also manufactured a long-probe model MFC that was compatible with HVPM10 samplers equipped with plastic filter holders.

These long probe MFC and plastic filter holders are no longer in production, please contact the factory for additional information.)

The temperature differential probe consists of a gas temperature sensor and constant temperature hot-wire anemometer. Gas passing the temperature sensor (the open area on the probe) has a cooling effect that is proportional to the pressure, temperature, and velocity of the gas. The anemometer, a heated, metal covered tungsten wire, provides a reference temperature. The ratio of temperature change between the temperature sensor and the anemometer determines the voltage input into the sampler's motor.

The probe and related electronic circuitry produce an output signal that is proportional to the mass of the gas flowing past the probe. The feedback control circuit contains the electronics necessary to vary the input voltage to the motor so as to maintain a constant, mass flow rate.

SPECIFICATIONS

Flow Range: 15-60 SCFM, adjustable.

Accuracy: Better than ± 1 SCFM over
-20°C to 55°C temperature
range.

Sensor: Rugged metal-covered type
with temperature compensation.

Motor Type: Compatible with series wound
or universal or split-capacitor
type.

Installation: Electronics enclosure mounted
on Hi-Vol shelter, sensor
inserted into 17/64" dia.
hole in filter holder.

Construction: All solid-state electronics
in a weatherproof enclosure.

Dimensions: Electronics: 6.25" x 9.0" x 3.75"
WLD; Metal-covered sensor: 0.25"
dia. x 3.0" L.

Power: 115 VAC, 50/60 Hz, 10 amp. max.
(200/230 VAC available).

Shpg. Wt: 8 lbs.

Meets all EPA Specifications:
Federal Register, Vol 47, No.
December 6, 1982

MAINTENANCE

The Model 310 requires little maintenance in most cases. If the probe sensor gets contaminated by dust accumulation (e.g. if the 8" x 10" filter breaks and allows dust to be pulled across the sensor), it should be cleaned by brushing with a solvent such as acetone or methanol. Andersen recommends keeping the probe sheathed in its protective cover if it is removed from the throat of the Hi-Vol.

If the probe or electronics enclosure are damaged, call the factory:

ANDERSEN SAMPLERS, INC.
4215-C WENDELL DRIVE
ATLANTA, GEORGIA 30336

TOLL FREE (800) 241-6898
(404) 691-1910

TROUBLE SHOOTING

B-7

Symptom

1. Is J10 running too high or low?

Correction

- a) Is the probe properly lined up?
- b) Are the paper and probe clean?
- c) Is there a leak upstream? (too low) if none then the unit probably needs recalibration.

Symptom

2. Does it oscillate?

Correction

- a) Make sure filter paper is in place! (If there is no filter paper the system oscillates because the time constant of electronics is slower than the change in mass flow rate)

Symptom

3. Can't get full mass flow rate?

Correction

- a) Check Hi-Vol motor first by bypassing J10.
- b) Install brushes.
- c) Change paper and Hi-Vol motor.

Symptom

4. Hi-Vol running full blast?

Correction

- a) Either the diac or triac is bad. (See instruction manual for location) If the triac is bad your unit will run full force with the diac out of the system. (replace)
- b) If not then diac is bad.

Symptom

5. Unit does not come on at all.

Correction

- a) Check to see if the transformer primary or secondary leads have broken loose. If so resolder or replace transformer. Calibration procedures are outlined in the instruction manual. **CAUTION DO NOT REMOVE PROBE WITH POWER APPLIED OR YOU WILL DESTROY IT.** (The circuit sees infinite resistance and turns the Op Amp all the way on and with no current limit it burns up one of the sensors. Pay close attention to proper wiring as improper wiring of probe also can destroy one of the sensors. See instruction manual before attempting

Trouble Shooting

component replacement on the circuit board. Check with the factory for proper procedures.

Symptom

6. Flow probe dirty?

Correction

- a) Disconnect all power plugs from the unit.
- b) Remove flow probe.
- c) Clean with water using camels hair brush.
- d) Clean again in alcohol.
- e) Re-install in Hi-Vol being certain not to re-connect power cords until operation is complete.

NOTE:

When returning the 310 to the factory.

- a) Wrap the probe in a protective covering being certain it cannot be damaged in transit. In all cases the probe must be returned with the Model 310 as both are balanced and calibrated together.

Model 310, 310B, and 310A

COMPONENT PARTS LIST

<u>ITEM</u>	<u>DESCRIPTION</u>	<u>QUANTITY</u>	
B1	PRINTED CIRCUIT BOARD	1	
B2	TERMINAL STRIP 6 (1-6)	1	
B3	TERMINAL STRIP 6 (7-12)	1	
C1	CAPACITOR .022 MFD	4	
C2	CAPACITOR 220 MFD @ 35V	1	
C3	CAPACITOR 100 MFD @ 10V	1	
C4	CAPACITOR 3300 MFD @ 25V	1	
C5	CAPACITOR .47 MFD @ 200 V	1	
D1	EROXY BRIDGE RECTIFIER VE08 <i>SK3105</i>	1	
D2	DIODE <i>1N914 (Replaced with Jumper)</i>	1	
D3	DIODE ZENER 1N823	1	
D4	DIODE ZENER 1N5242	1	
D5	DIODE ZENER 1N5242	1	
P1	PHOTO RESISTOR <i>VTL9A10</i>	1	
R1	RESISTOR 5 WATT 30.1 ohms	1	
R2	RESISTOR RN60D	1	
R3	RESISTOR RN60D	1	
R4	RESISTOR RN60D	1	
R5	RESISTOR RN60D	1	
R6	RESISTOR RN60D 9.09K ohms	1	
R7	RESISTOR RN60D 20K ohms	1	
R8	RESISTOR VARIABLE 2K ohms	1	
R9	RESISTOR CARBON 270 ohms	1	
R10	RESISTOR CARBON 820 ohms	1	
R11	RESISTOR RN60D factory selected <i>7K 1/4 Watt 5%</i>	1*	
R12	RESISTOR RN60D 10K ohms	1*	
R13	RESISTOR RN60D 9.09K ohms	1*	
R14	RESISTOR RN60D 9.09K ohms	1*	
R15	RESISTOR RN60D factory selected <i>24.9K 1/4 Watt 5%</i>	1*	
R16	RESISTOR CARBON 36K ohms (75K ohms in 220 VAC version)	1*	
R17	<i>0-5% 1/2 5 pins 6 pins</i>	{ RESISTOR VARIABLE, 25T, 2K ohms (<i>5 pins</i>) RESISTOR VARIABLE, 25T, 2K ohms (<i>2 pins</i>)	1*
R18			1*
R19	RESISTOR CARBON 270 ohms 10%	1	
R20	RESISTOR VARIABLE, 25T, 2K ohms	1	
R20A	RESISTOR VARIABLE 10T, 2K ohms PANEL MOUNT	1***	
T	TRANSFORMER, TRIAD F-40X, or Equiv.	1	
Q1	OPERATIONAL AMPLIFIER, 741HC	1	
Q2	OPERATIONAL AMPLIFIER, 741HC	1	
Q3	TRANSISTOR, MJE 520	1	
Q4	OPERATIONAL AMPLIFIER, 741HC	1*	
Q5	OPERATIONAL AMPLIFIER, 741HC	1*	
Q6	TRIAC 8 AMP ISOLATED TAB SC 142D	1	
Q7	TRIGGER DIAC 1N5761	1	
HS	HEAT SINK	1	
M	METER READOUT, 310R	1**	
N3001	FLOW PROBE ASSEMBLY	1	
-	ENCLOSURE	1	

* FOR 310B
 ** FOR 310R
 *** REMOTE FLOW ADJ.

COMPONENT PARTS LIST

B-11

TERMINAL STRIP NOMENCLATURE:

<u>NO.</u>	<u>DESCRIPTION</u>
1	+ OUTPUT FOR 0-5 VDC SIGNAL .
2	- OUTPUT FOR 0-5 VDC SIGNAL (GROUND)
3	TRANSDUCER OUTPUT
4	RED LEAD TO PROBE
5	BLACK LEAD TO PROBE
6	SILVER LEAD TO PROBE (GROUND)
7	AC OUTPUT, TO HI-VOL MOTOR
8	AC COMMON (GROUND)
9	AC OUTPUT, TO HI-VOL MOTOR
10	AC LINE VOLTAGE
11	AC GROUND
12	AC LINE VOLTAGE

SERIES 350 FLOW CONTROLLER
PARTS LIST

<u>PART NUMBER</u>	<u>DESCRIPTION</u>	<u>REFERENCE DESIGNATION</u>
350-001	Probe, 20ohm/160ohm	R1, R2
350-002	Resistor, 30.1 ohms, 3W, 1%	R3
350-003	Resistor(pair), Factory Selected	R4
350-004	Resistor(pair), Factory Selected	R5
350-005	Resistor, 80-100K, 1/2W 1% selected	R9
350-006	Resistor, 200K, 1/2W, 1%	R26
350-007	Resistor, 8.2K, 1/2W, 5%	R6, 7, 13, 17, 19, 21
350-008	Resistor, 820ohms, 1/2W, 5%	R10
350-009	Resistor, 240ohms, 1/2W, 5%	R36
350-010	Resistor, 100K, 1/2W, 1%	R27
350-011	Potentiometer, miniature, 10K 25 turn, 1%	R11
350-012	Resistor, 30.1K, 1/2W, 1%	R8, 12, 15, 34
350-013	Resistor, 2.7K, 1/2W, 1%	R16, 24, 33, 37
350-014	Resistor, 33 ohms, 1/2W, 5%	R18
350-015	Resistor, 1.8K, 1/2W, 5%	R20
350-016	Resistor, 330ohms, 1/2W, 5%	R21
350-017	Resistor, 47 ohms, 1/2W, 5%	R22
350-018	Potentiometer, 10K, Ten Turn 1% Panel Mount	R30
350-019	Resistor, 15K, 1/2W, 1%	R14, 28
350-020	Resistor, 7.5K, 1/2W, 1%	R29
350-021	Resistor, 5.1K, 1/2W, 1%	R25
350-022	Potentiometer, Miniature, 10K Single Turn, 1%	R31, 32
350-023	Resistor, 1K, 1/2W, 5%	R35
350-024	Diode, 1N914	CR1, 2, 4, 5, 9, 10, 11
350-025	Diode, 1N4002	CR6, 7, 8, 13, 14, 15
350-026	Diode, Zener, 1N753A	CR3 (discontinued)
350-027	IC, Zener, LM329BZ	CR3
350-028		
350-029	Capacitor, 10mf, 16V elect.	C1, 2
350-030	Capacitor, .33mf, 50V Tant.	C3
350-031	Capacitor, 2200mf, 35V elect.	C4
350-032	Capacitor, .1mf, 400V	C5
350-033	Capacitor, .1mf, 630V (for 230 VAC version)	C5
350-034		
350-035		
350-036	Bracket, Transformer	BKT-1
350-037	Transformer, PC-24-450	T1
350-038	Transformer, DPC-24-450 (for 230 VAC version)	T1
350-039	Transformer, PE-5760	T2
350-040	Screw, 6-32x1/2, T1 Hold down	4 each
350-041	Nut, Keps, 6-32, T1 Hold down	4 each
350-042		
350-043	IC, LM324N, Quad Op-Amp	U1
350-044		
350-045	Transistor, 2N2907	Q3
350-046	Regulator, LM317LZ	Q8

PAGE TWO
 SERIES 350 FLOW CONTROLLER
 PARTS LIST

<u>PART NUMBER</u>	<u>DESCRIPTION</u>	<u>REFERENCE DESIGNATION</u>
350-047	Transistor, MJES20, NPN	Q1
350-048	Transistor, 2N3906, PNP	Q2
350-049	Transistor, 2N3904, NPN	Q4,5,7
350-050	Transistor, 2N4871, UJT	Q6
350-051	Triac, SC142D Q601525	TH-1
350-052	Dome Washer, Q1 Mounting Hardware	WW-1
350-053	Insulator, Mica	IN-1
350-054	Socket, DIP, 14 pin	
350-055	Connector, Ribbon Cable assy.	
350-056	Header, Connector, P.C.B	
350-057	Relay, PC mount, 12VDC	RY1 (K-1)
350-058	Screw, 6-32x3/8, TH-1 Mtg. Hdwre.	1 each
350-059	Nut, Keps, 6-32, TH-1 Mtg. Hdwre.	1 each
350-060	Fuse clip, 2 each	FC-1
350-061	Fuse, 8 Amp, slo-blo 314-008	FU-1
350-062		
350-063		
350-064	Heat Sink	HS-1
350-065	Screw, 4-40x1/4, Q1 Mtg.Hdwre	1 each
350-066	Nut, Keps, 4-40 Q1 Mtg. Hdwre	1 each
350-067	Terminal Block, 9 Terminal	TB-1
350-068	Thermal Grease	Sn-1
350-069	Printed Circuit Board	PC-1
350-070	Box - Short	B-1
350-071		
350-072	Front Panel, Model 352	P-1
350-073	Shaft lock, for 350-018	SL-1
350-074	Stand-off, 1 1/4", assy.	SO-1,4
350-075	Stand-off, 1 3/8", assy.	SO-2,3
350-076	Strain Relief, Pwr. Cord Set	SR-1,2
350-077	Strain Relief, Probe	SR-3
350-078	Cord Set, Male & Female	C-1
350-079		
350-080	Latch, Enclosure	L-1
350-081		
350-082	Model 302 Clock P.C.B. Assembly	PCB302-1
350-083		
350-084	Elapsed Time Indicator, 115VAC/60hz	ETI-1
350-085		
350-086	Circuit Breaker/Switch	CB-1
350-087		
350-088	Meter Movement, 1mA	Read-1
350-089		
350-090	Washer, 60 duro, retrofit	} See I.M.
350-091	Bulkhead fitting, retrofit	
350-092	15° Block, 2 part, retrofit	

APPENDIX C
CONTINUOUS FLOW RECORDER

CONTINUOUS FLOW RECORDER

1.0 Description

Each ASI/GMW continuous flow recorder (PN#G105) comes equipped with a pen cartridge (PN# G107), a box of 100 recorder charts (PN# G106) and connecting tubing. The flow recorder is a borden-gauge unit which responds to changes in plenum pressure caused by either flow restriction during the sampler's calibration, or changes in flow rate during the sample period. It also provides a hard-copy of the sampler's flow rate stability and indicates any interruption of the sample period (i.e. power or motor failures).

The flow recorder is supplied with a female AC receptacle power cord. The recorder can be wired to be on continuously or only when the master timer energizes the HVPM10 sampler.

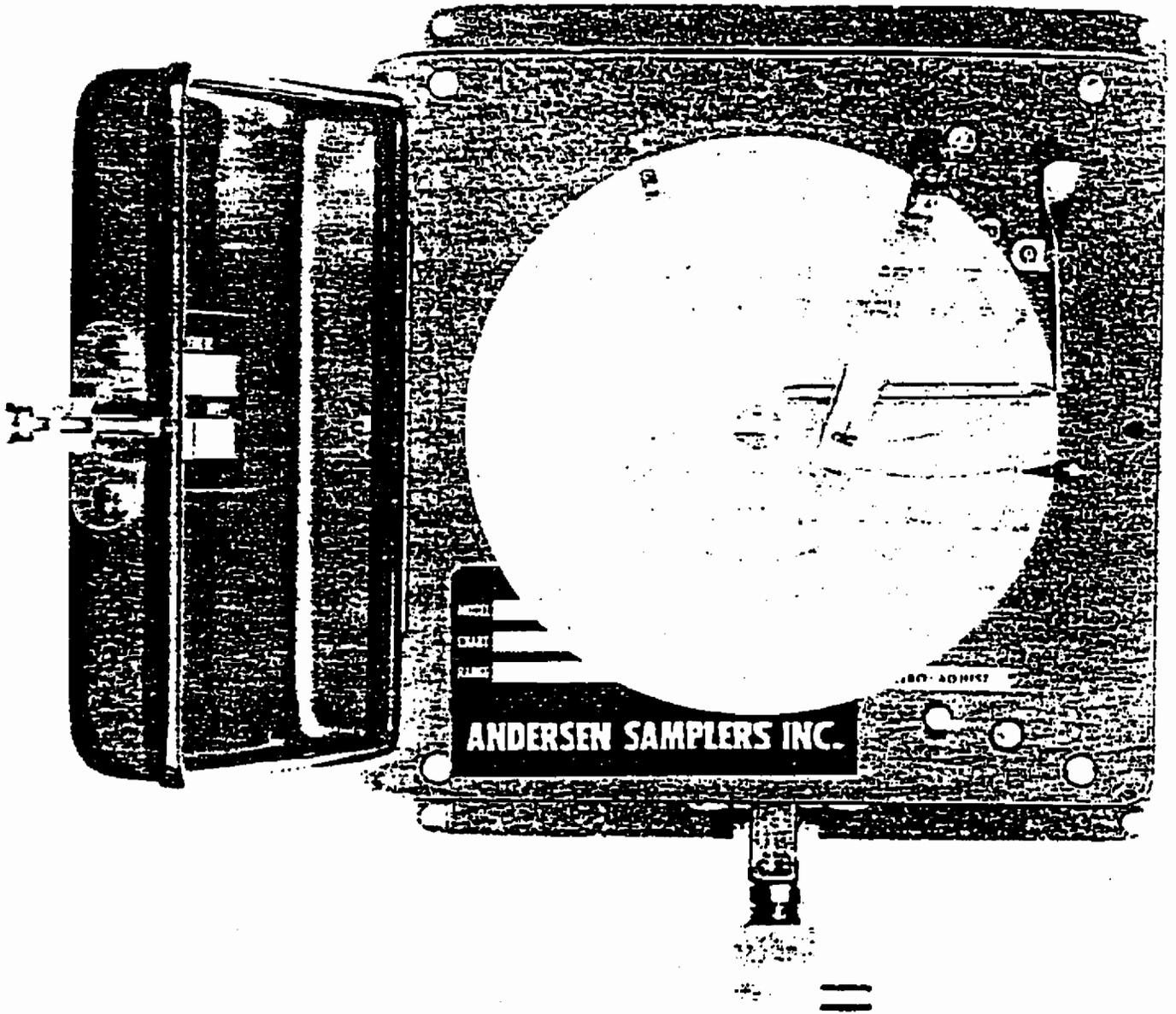
2.0 Theory of Operation:

The sampler calibration procedure presented in this Operator's Manual (Section 4.0) relates known flow rates (as determined by a calibrated transfer standard orifice device) with the ratio of atmospheric to plenum pressure. The plenum is the area within the motor housing (aft of the motor unit) in which pressures exceed atmospheric. To measure the plenum pressure, ASI/GMW equips all their HVPM10 samplers with a continuous flow recorder (Figure B-1) that is connected to the motor pressure tap by a length of rubber tubing.

The sampler's operator must install a clean recorder chart for each sample period. To install a chart, the following procedure should be followed:

1. Open the recorder door. Raise the pen arm by gently pressing against the flat portion of the pen lifter. Never energize the sampler while the pen arm is raised; this will result in a warp of the pen arm and possibly damage the spring inside the flow recorder.
2. Slip a clean recorder chart beneath the pen arm and over the slotted chart drive. Make sure that the chart is held by the two chart clips located on the face of the recorder.

Note: During periods of inclement weather, or when the sampler is being operated in a humid environment, two recorder charts can be installed simultaneously. This practice will prohibit the



Flow Event Recorder

sample chart from becoming adhered to the recorder face and not advancing throughout the sample period.

3. Lower the pen arm. Ensure that the recorder is properly zeroed (the pen rests on the inner-most circle of the chart). Adjust the set screw (located on the bottom right corner of the recorder face) as necessary. Advance the chart to check the zero and to ensure that the pen is inking.
4. If the recorder is wired to operate continuously (e.g. plugged directly into line voltage) turn the slotted drive clockwise until the correct time is indicated by the pointed chart clip. If the recorder is plugged into a Master Timer, set the time for the beginning of the next sample period.
5. Close the recorder door and engage the locking mechanism. Inspect the connecting tubing for crimps or cracks.
6. The recorder is now ready for the next sample period.

Caution must always be exercised to ensure that the tubing does not become pinched in the shelter door.

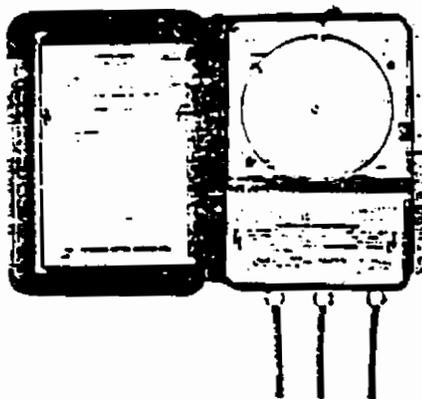
The pressure recorder is supplied with an pen cartridge that requires no filling. When operated in an arid environment, the pens may dry out before the ink is exhausted. If this occurs, place the pens in a sealed plastic bag with a damp cloth or Kimwipe. Pens have a life of approximately 3 to 6 months (dependent on the sample frequency) and should be replaced routinely as part of a preventative maintenance schedule. To replace the pen, follow the procedure presented below:

1. Lift the pen arm by pressing gently on the flat portion of the pen lifter.
2. Slide the old cartridge off the pen arm, being careful not to bend the arm.
3. Lay the new cartridge on the pen arm with the tip centered in the Vee cut.
4. With the forefinger and thumb, deflect the hinged retainer, and snap it into the engaged position around the pen arm.

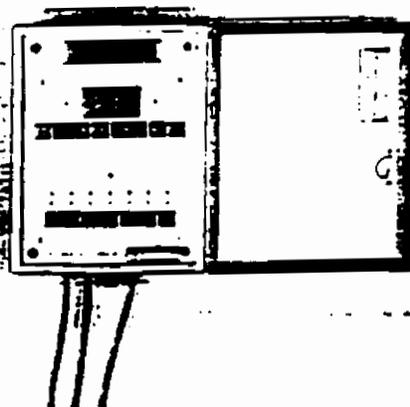
The circular chart paper is time marked and logarithmically scaled. The flow rates printed on the chart are only for reference purposes; the sampler must

be calibrated to determine operational flow rates. The continuous recorder is not designed as a direct readout instrument.

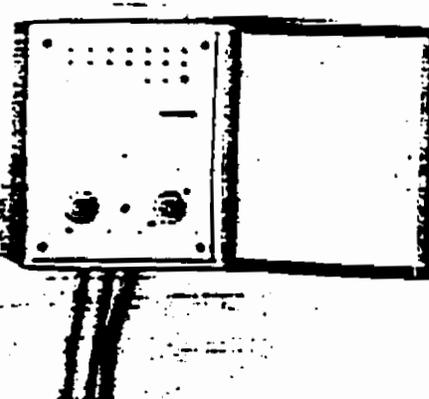
APPENDIX D
TIMING DEVICES



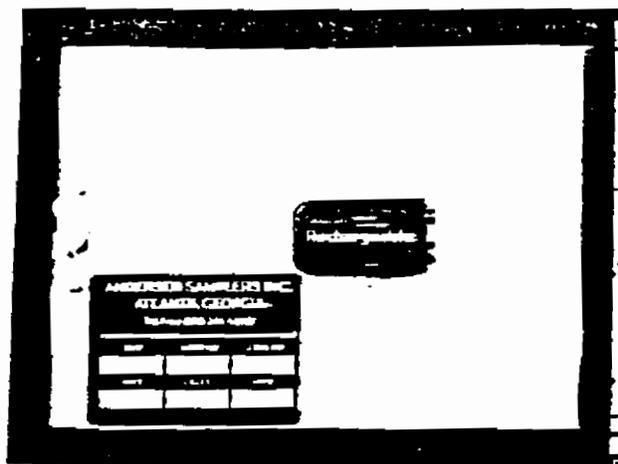
Model 76



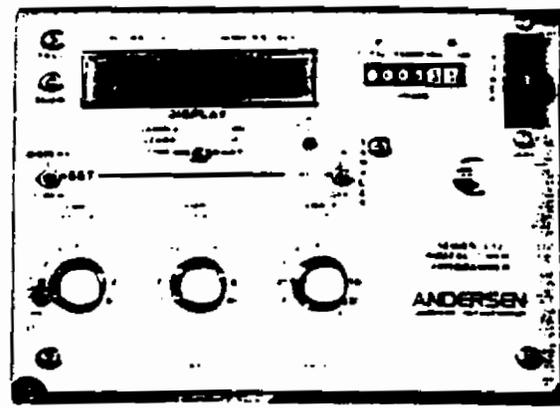
Model 3000



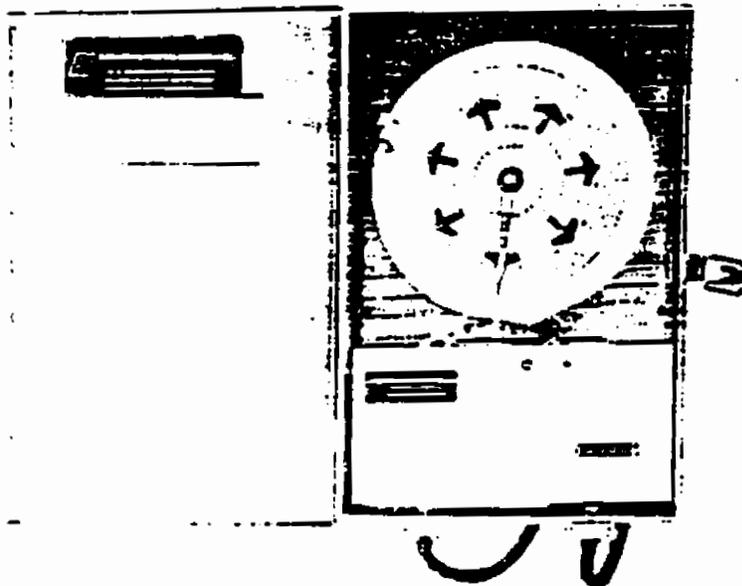
Model 801



ANDERSEN SAMPLES INC.	
ATLANTA, GEORGIA	
Tel. Area 404-526-4400	



Model 302



Master Timers

sample duration (up to 24-h) to the discretion of the operator. A digital, non-resettable elapsed time indicator is included. The Model 801 provides three distinct programming modes: 24-h, episode, and 6-day sampling schedules.

5. Model 8000: Solid State Timer/Programmer

Provides the same programming capability of the Model 801 but includes additional features, including an auxiliary battery for clock operation in the event of power failure. When primary power is restored, the timer will cycle as originally programmed. The "power failure" indicator lamp continues flashing to signal that failure has occurred. By comparing the elapsed time with the programmed sampling time; it can be determined if the sampling period was affected. Model 801 provides three distinct programming modes: 24-h, episode, and 6-day sampling schedules. Changing from program modes or sample duration is achieved by simple manipulation of a thumb wheel. The actual and total elapsed times are verified and displayed on command.

2.1 Operating Procedures:

2.1.1 Models 70 and 76, Mechanical 7-Day and 6-Day Skip Timers, respectively

1. Place the timer's ON/OFF "Flipper" switch (located on the bottom of the timer wheel) in the OFF position.
2. Plug the male power cord of the timer into the line voltage and connect the remaining electrical components of the HVPM10 sampler.
3. Set the trippers by placing the "A", or bright trippers, at the sample start time. Place the "B", or dark trippers, at the sampler stop time. Place the "Flipper" switch to its ON position.
4. The timer will now turn off and on the sampler automatically.

Note: For manual operation, use the timer's "Flipper" switch exclusively. Manual operation over-rides the automatic settings.

2.1.2 Model 302 Digital Timer/Programmer

1. Open the cover of the timer enclosure. Turn the sampler's main power switch to OFF.
2. Plug the male cord into line voltage (115 VAC for Model 302, 220VAC for Model 302X)
3. Plug the female cord into the sampler.

4. Press the "Power" switch to ON. The pump will not energize. If an optional battery is used, connect battery at this time. Note: When programming, the digits will flash until set.
5. Set present "Time of Day": Set "Display" switch to "Time of Day". Hold DOWN the "fast/slow" switch as necessary to set. The "Time of Day" is a 24-h format.
6. Set the "Sample Start Time": Set "Display" switch to "Sample Start Time". Hold DOWN the "fast/slow" switch as necessary to set.

NOTE: The "Sample Start Time" must be at least 30 minutes after the present "Time of Day". The "Display" switch must not be in the "Sample Start Time" mode within 10 minutes of the initiation of the sample period.

7. To use the "Delay Start" programming capability (Sample after X days, 0-8 days, maximum), set the "Sample After" switch to the number of days to be skipped before the next sample period. Position "0" will initiate the first sampling period as soon as the time of day matches the sample start time. Or in other words, no days will be skipped. Position 1, the timer will skip one day, Position 2, two days, etc.
8. To use the "Skip Timer" (sample every X days, 1-9 days), set the "Sample Every" switch to initiate one sample every X days. Position 1 samples daily, Position 2, every second day, etc.
9. To set sample duration (sample for X hours, 1-24-h), set the "Sample For" switch for the number of hours that the sampler is to remain energized.
Note: The switches referred to in steps 7-9 are positive detent switches that provide exact timing. If the switch is not in the detent, it is not useable.
10. Set the timer by pressing the "Set" switch DOWN to the "Timer" position momentarily. Place the "Sampler" switch in the "Timer" position.

Notes:

- Flashing time display indicates AC and battery power failure.
- AC Power Fail light indicates failure of AC power during sample period.

- Display may be left on. Battery life however, may be shortened to approximately 24-h if AC power fails.
- The ETI records the total time sample is left on. AC power failure stops ETI until power is restored.
- The power switch uses a circuit breaker. When circuit is broken, the ON button pops UP. If more than 15 amps are drawn, the circuit breaker will trip even if the button is held in. Reset is accomplished by pressing the ON button.

2.1.3 Model 801 Sixth Day, Timer Programmer

Model 801 provides three distinct programming modes: 24-h, episode, and 6-day sampling schedules. For all modes discussed below, the real time clocks, "A" and "B" are set to the actual time of day. Both clocks rotate clockwise together with the top position of the power switch.

The white ON and black OFF tabs of clock "A" are set at midnight. The function of clock "A" is to sequentially advance the indicator light every 24-h. The tabs are secured together under the clock face and must be moved together. The OFF tab of clock "A" must never be permitted to swing around in front of the ON tab. This will result in a burn out of the stepping mechanism coil.

The ON and OFF tabs of clock "B" are needed only while in the episode sampling mode. The function of clock "B" is to act as a series switch to the output, according to the setting of the ON and OFF tabs. The series switch of clock "B" can be brought into the circuit by placing the toggle switch between the two clocks in the right hand position.

The indicator lights are wired in parallel and indicate the day or position of the stepping mechanism. As a result, it is possible for more than one indicator light to glow when the timer output is activated. To reset the indicator light, all seven day switches must be in the DOWN position.

The timer is arranged with three power cords extending down from the bottom of the unit. The male cord is plugged into line voltage, the left-hand female cord is the timed output and should be plugged into the motor, the right-hand cord is an auxiliary output that is not timed.

24-H Sampling Schedule:

1. Set all seven "Day" switches and the "6-day Sample" switch in the DOWN position.

2. Reset the indicator light to the present day by pressing the "Day Reset" switch.
3. Set the toggle switch between clocks "A" and "B" to its left-hand position.
4. Place the desired "Sampling Day(s)" switch(es) in the UP position. The sampler will activate at midnight.

Episode Sampling:

1. Set all seven "Day" switches and the "6-day Sample" switch in the DOWN position.
2. Reset the indicator light to the present day by pressing the "Day Reset" switch.
3. Set the toggle switch between clocks "A" and "B" to its right-hand position.
4. Place the desired "Sampling Day(s)" switch(es) in the UP position.
5. Set the ON and OFF tabs of clock "B" for the sample start and stop time.

6-Day Sampling Schedule:

Note: When programming for 6-day operation, disregard the names of the sample days. The days of the week should be referred to as positions and not as Monday, Tuesday, etc.

1. Set all seven "Day" switches in the DOWN position.
2. Reset the indicator light to the fifth from the left position (Thursday) by pressing the "Day Reset" switch.
3. Place the "6-Day Sample" switch in the UP position.
4. Place the sixth from the left switch (Friday) in the UP position.
5. Set the toggle switch between clocks "A" and "B" to its left-hand position.

The sample period is from midnight to midnight the following day or position, and every 6-days thereafter.

2.1.4 Model 8000 Solid State Timer /Programmer

1. Remove the battery compartment cover to expose the battery and loose battery clip. Attach the clip to the battery and replace the cover. This battery should be checked every six months and replaced annually (subject to frequency and duration of any power failures). This battery should be disconnected when the timer is in transit or storage to preclude unnecessary power drain.

2. Plug the male cord into line voltage. The left hand female cord is the timed output to be connected to the sampler motor; the right-hand cord is an auxiliary output that is not timed.
3. Press the "Display On/Total Time" button to activate the time display. Set the correct time (military time, 0000 hours) using the fast/slow time buttons. This display will remain on for seven minutes unless reset by repeating this step. If bright sunlight makes seeing the display or indicators difficult, close the door to partially block the sunlight and darken the power.
4. Reset the power failure indicator by pressing the "Power Failure Reset" button.
5. Manually activate the sampler to ensure that the motor is operating correctly. Press the ON button, the sampler should energize. Press the OFF button to turn off the sampler. No accumulated time results when using these manual controls. It is not possible however, to turn the sampler off within the first minute of programmed operation using these controls.
6. Reset the "Day Indicator" lamp (top row of lamps) to the present day by pressing the "Set Day" button.
7. Select the start and stop times on the thumb wheel switches (in military time). For a midnight to midnight sample, set both at 0000 hours.
8. Set the "Day Mode" thumb wheel to the frequency of sampling desired. Position 1 will sample every day, Position 2, every other day, etc. When using Position 7, more than one sample day can be selected and the sampler will activate on the same day(s) each week.
9. To check the elapsed time after a sample, press the "Display On/Total Time" button. To reset the total elapsed time, simultaneously press the "Display On/Total Time" and "Display Test" buttons. Note: If the power failure indicator blinks indicating loss of power, the failure could have occurred during a non-sampling period. Press the "Display On/Total Time" button and compare the elapsed time with the sampling time indicated on the thumb wheel switches. If the readouts are identical, the failure occurred during the non-sampling period. If a discrepancy exists, subtract the elapsed time to determine the sample's duration.

APPENDIX E
RETRO-FIT INSTRUCTIONS
SIZE SELECTIVE INLET
MODEL 321-A TO 321-B

RETRO-FIT INSTRUCTIONS,
SIZE SELECTIVE INLET
MODEL 321-A TO 321-B

1.0 Background:

The original SSI's were developed by Dr. A.R. McFarland of Texas A&M University (TAMU) under an U.S.Environmental Protection Agency (EPA) grant to meet a potential 15 micron (μm) ambient Inhalable Particulate (IP) standard. After research and field studies, the EPA reconsidered this particulate indicator and decided that an indicator based on the concentration of Thoracic Particulates (those particles that can be entrained in the respiratory system, $<10\mu\text{m}$ aerodynamic diameter (a.d.) provided a better indication of the potential health effects from particulate pollution.

Dr. McFarland modified the single stage, $15\mu\text{m}$ SSI to obtain a $10.2\mu\text{m}$ cut point under funding from Andersen Samplers, Inc. (ASI). This inlet was sold by ASI and General Metal Works (GMW) from March, 1982 until May, 1984 under a Model 321 designation.

Although the Model 321 inlet met all of the prevailing performance specifications for PM₁₀ inlets, Dr. McFarland developed an improved SSI, the two stage Model 321-A. During subsequent EPA field performance evaluations however, it was determined that a greased collection surface was required (within the SSI) to prevent a potential "carry-through" of large particles ($>20\mu\text{m}$) at PM₁₀ monitoring sites subject to high winds.

Later TAMU data analysis determined that the of $10.2\mu\text{m}$ inlet cut point (original design of Model 321 and 321-A inlets) could be modified to a cut point of $9.7\mu\text{m}$ by using a smaller diameter acceleration nozzle. A $9.7\mu\text{m}$ cut point meets not only all Federal Reference Method (FRM) inlet specifications (inlet cut point of $10\mu\text{m} \pm 0.5\mu$) but also results in lower mass concentration measurements. Hence, the development of greased shim and nozzle insert retro-fit kits for both the 321 and 321-A inlets.

Once modified with a greased collection surface, the 321 and 321-A inlets are designated Reference Methods (RFPS-1287-065 and RFPS-1287-064, respectively) and are referred to as Model 321-C and 321-B, respectively. Note: Nozzle inserts for Model 321-A inlets are not required for FRM designation, they are however, recommended by the manufacturer. Please refer to Table 1.1.

Reference Method Designation Number	Model Number	Inlet Description
RFPS-1287-064	Model 321-B	Modified 321 -A inlet <ol style="list-style-type: none"> 1. Two Acceleration Nozzle Stages 2. 9.7μm, 50% cut point 3. Greased collection shim on first stage 4. Inlet hood removable for cleaning
RFPS-1287-065	Model 321-C	Modified 321-Inlet <ol style="list-style-type: none"> 1. Single Acceleration Nozzle Stage 2. 9.7μm, 50% cut point 3. Greased collection shim 4. Inlet hood removable for cleaning
RFPS-1287-063 Noz-	Model 1200	<ol style="list-style-type: none"> 1. Single Acceleration Nozzle Stage 2. 9.7μm, 50% cut point 3. Greased collection shim 4. Inlet body hinged for cleaning

Table 1.1 ASI/GMW Inlet Description

2.0 Description of Modification Kits

Each Greased Shim and Nozzle Modification Kit (PN#G 120035) consists of the following components and is offered free to all ASI/GMW customers who have purchased Model 321 or 321-A inlets. As indicated below, individual items can be ordered and purchased separately.

1. Collection Shim Kit: PN# G120030
 - a. Collection Shim Plate: PN # G120027
 - b. Collection Shim Clips: PN# G120028
 - c. Dow Silicon #316 Grease PN# G10544 or SE290G
2. Nozzle Modification Kit (9.2µm): PN# G120034
 - a. RTV adhesive: PN# G10596
 - b. Nozzle Plate Gasket PN# SSI-20

Note: ASI/GMW will exchange any Model 321 or 321-A inlet for a new, hinged body Model 1200 SSI. The exchange price is 450.00 per unit plus freight. Please contact the factory.

3.0 Shim and Nozzle Modification Kit Installation Procedures

Note: The installation procedures presented below are applicable only to the Model 321-A SSI (Figure 1) . Contact the manufacturer for modification instructions for the Model 321.

1. Gather the following tools:
 - ° Flat Head Screwdriver
 - ° Power Drill with 7/32" Drill Bit
 - ° Crescent Wrench
2. Remove the inlet hood by removing all of the spacer bolts that affix the hood to the inlet body. Lift the hood carefully and place it on the floor or a workbench, dome-side-down to avoid warping. The acceleration nozzle plate will now be visible.
- 3.. Remove the twelve (12) bolts that attach the acceleration nozzle plate (PN#SSI-109) to the inlet housing. Gently lift the plate and place it on the floor or a workbench, nozzle-side-up to avoid contaminating or damaging the nozzies.
4. Discard the nozzle plate gasket (PN# SSI-20) that forms a seal between the acceleration nozzle plate and the inlet housing.

5. Remove the first stage collection plate by loosening the four (4) bolts and lifting over the inlet housing. Carefully place the collection plate onto a level, sturdy surface, top-side-up.
6. Using a power drill with a metal 7/32" drill bit, drill two holes in the collection plate at the locations shown in Figure 2. While drilling, exercise caution to avoid bending the plate.
7. Mount the two shim clips (PN# G120028) as shown in Figure 3.
8. Clean all interior surfaces of the SSI using a clean cloth or Kimwipe. Inspect all nozzles and vent tubes and clean with a bottle brush as necessary. Ensure that the collection plate is completely clean; remove any metal shavings or residual debris.
9. Return the collection plate to the sampler inlet. Replace and tighten the four (4) retaining bolts.
10. Place the collection shim (PN# G120027) on a clean, flat surface at some distance from the rest of the inlet. Spray the shim with a thick coating of Dow Silicone #316 (PN# SE209G) Do not substitute any other substance without contacting the manufacturer. Shake the can, and holding it upright 8 to 10-in. away, apply a "generous" amount of silicone spray. Over spraying will not affect the performance of the inlet, so when in doubt, apply more spray.
11. Allow 3 to 5 minutes for drying; the shim should be tacky (not slippery) and have a slightly cloudy appearance before placing it in the inlet.
12. Lift the greased collection shim by the edges and place it on the collection plate, greased-side-up.
13. Rotate the two (2) shim clips 90° so that they are placed over the edge of the greased collection shim.
14. Inspect the acceleration nozzles and clean as necessary using a soft clean cloth or Kimwipe.
15. Install a new nozzle plate gasket (PN#SSI-20).
16. Reversing step 3, install the acceleration nozzle plate.
17. Place a small bead of RTV (silicone caulking) adhesive on the bottom lip of an acceleration nozzle insert (Figure 4). Press the nozzle insert firmly into an existing nozzle. Repeat for the remaining eight (8) inserts.
18. Remove any excess adhesive from the edges of the nozzle inserts.
19. Replace the inlet hood by reversing the procedures presented in step 2.

20. Attach the enclosed gummed label to the outside of the SSI. This label provides notice that the inlet has been modified to become a Model 321-B

4.0 Maintenance Activities:

The SSI hood should be inspected every sample period for dents or irregularities in the inlet gap. Contact the manufacturer if dents exceeding 1/2" are noted.

In general, ASI/GMW recommends a thorough cleaning of the SSI after 15 days of sampling; which, on a 6 day schedule would correspond to 3 calendar months. If the TSP can be estimated from historical data to the site, it is recommended that the schedule shown be used.

AVERAGE ESTIMATED TSP AT SITE STD. $\mu\text{g}/\text{m}^3$	<u>MAINTENANCE FREQUENCY</u>	
	NUMBER OF SAMPLING DAYS	INTERVAL, ASSUMING 6-DAY SAMPLING SCHEDULE
40	30	6 months
75	15	3 months
150	10	2 months
200	5	1 months

Procedures for cleaning and maintaining the Model 321-B inlet are as follows:

1. Inspect the four shelter draw-catches for proper tension. Adjust as necessary by the first loosening the lock-nut on the hook-catch rod. To shorten the catch length, turn the rod clockwise; counter-clockwise to loosen. After adjustments are complete, re-tighten the lock-nut. Do not over-tighten, distortion in the inlet housing can result.
2. Remove the hood (reverse assembly procedure presented in section 3.0, step 2) and clean the nine (9) acceleration nozzles with a small bottle brush. Wipe all internal surfaces with a damp cloth or Kimwipe.
3. Remove the acceleration nozzle plate according to procedures presented in section 3.0. Clean the twelve (12) acceleration nozzles with a bottle brush or clean cloth.
4. Inspect the collection shim pattern. A normal greased shim pattern is indicated by a circular pattern of particle collection directly beneath the acceleration nozzles. An overloaded shim can be identified by bars or stripes of deposit between the margins of the circular deposits.

5. Re-grease the collection shim by following procedures in section 3.0, steps 10 and 11.

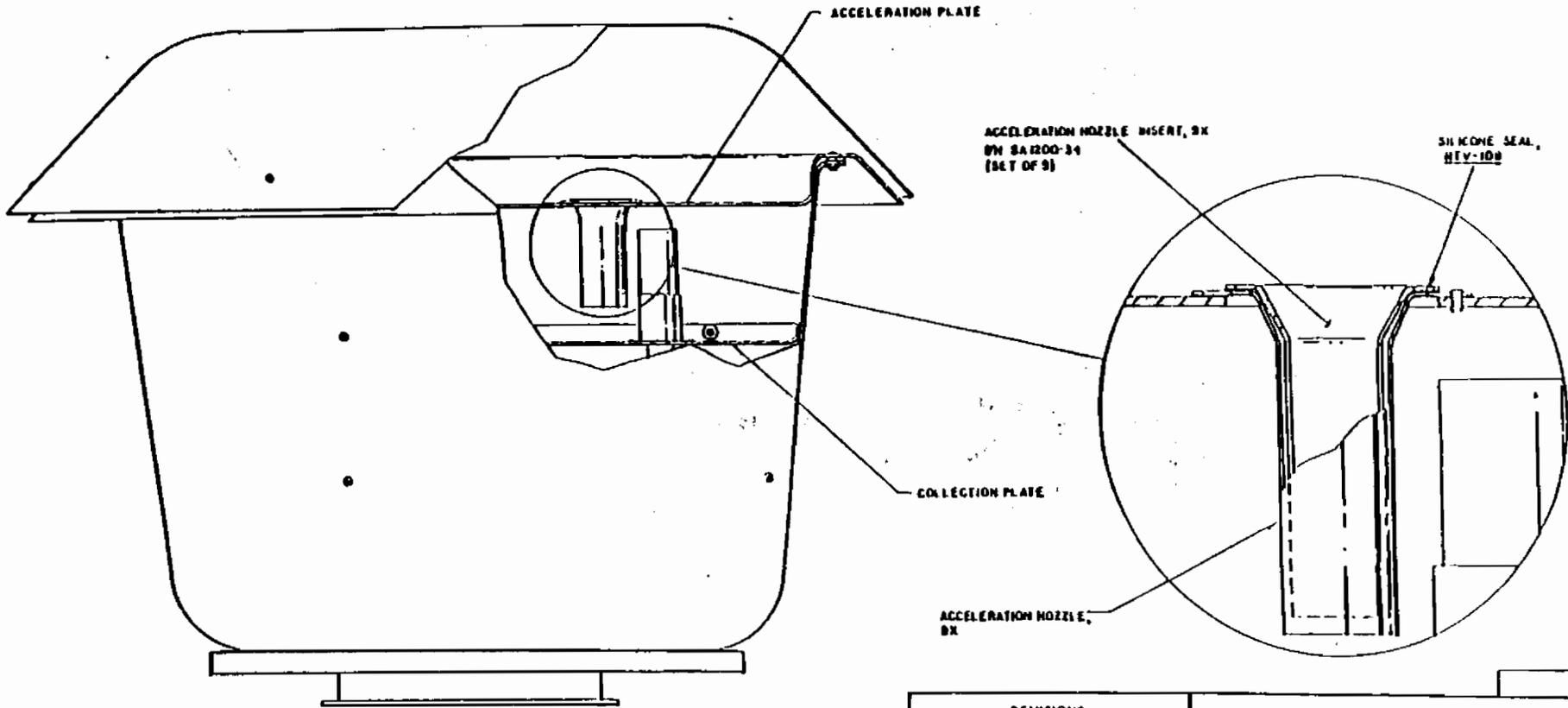


fig D

REVISIONS			ACCELERATION NOZZLE MODIFICATION, 1200 - 34			
DESCRIPTION	DATE	BY	ANDERSEN		DATE	BY
			SAMPLERS CORPORATION		12 1986	SY
			CHK BY T.A.	APPD BY	DRAWING NUMBER	
			SCALE	PPAC TOLL.	1200 - 34	
			DEC. TOL.	AND TOLL.	REV	
			CONCENTRICITY			
			MATERIAL			
			FINISH			