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Groundwater Monitoring Plan

for

Portsmouth Naval Shipyard

Kittery, Maine

Northern Division

Naval Facilities Engineering Command

Contract Number N62472-90-D-1298

Contract Task Order 0148

March 1994

Halliburton NUS
CORPORATION

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GROUNDWATER MONITORING PLAN
FOR
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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1.0 GROUNDWATER MONITORING PLAN

1.1 INTRODUCTION

This plan has been prepared to implement a groundwater monitoring program for Solid Waste Management Units (SWMUs) of concern at the Portsmouth Naval Shipyard (NSY Portsmouth) and thereby assess facility-wide water quality. For the NSY Portsmouth, a RCRA monitoring program with modified analyses is proposed for several reasons. First, the RCRA Facilities Investigation (RFI) Report and addenda addressing regulatory comments (McLaren Hart 1992) indicate that contamination has already migrated from several SWMUs. Additionally, the future status of the NSY Portsmouth is uncertain. Although currently operating under a RCRA permit issued by the Environmental Protection Agency (EPA) in March of 1989, the NSY Portsmouth was proposed for the National Priorities List (NPL) on June 23, 1993. Finally, the current RCRA permit specifies that a Corrective Measures Study (CMS) be conducted by the Navy as part of an effort to achieve Media Protection Standards, which are currently being developed. As a result, source and groundwater remediation may be occurring in the next several years which would impact the groundwater monitoring program. The approach, then, is to determine the SWMUs continuing impact on the quality of groundwater in the aquifer and its impact on State waters.

1.2 APPROACH

Typically, a RCRA groundwater monitoring plan for a surface impoundment, landfill or land treatment facility serves two purposes: (1) Detect contaminants migrating from the SWMU, and/or (2) ensure compliance with contaminant-specific concentration limits. To serve these purposes, a baseline condition is established based on EPA Primary Drinking Water Standards, Maine Maximum Exposure Guidelines as well as indicator parameters for groundwater quality (chloride, iron, manganese, phenols, sodium, and sulfate) and indicator parameters for groundwater contamination (pH, specific conductance, total organic carbon [TOC], and total organic halogen [TOX]). Typically, upgradient and downgradient monitoring wells are installed and sampled/analyzed according to a schedule established in the plan (at least semiannually for a detection monitoring program. Replicate sampling is required for the indicator parameters to allow statistical interpretation. After baseline conditions are established, future sampling and analysis focuses on indicator parameters only; if and when a statistically significant deviation occurs, compliance monitoring begins (focusing on an expanded suite of analytical parameters), and corrective action may be warranted.

Two monitoring events (first event, second event) to establish baseline conditions, followed by semi-annual sampling is planned for the NSY Portsmouth. There are 55 existing monitoring wells installed as part of an initial RFI conducted in 1991 (McClaren Hart 1992). An additional 17 monitoring wells will be installed in early 1994 as part of the RFI Data Gap investigation (Halliburton NUS 1994). The subject long-term groundwater monitoring program considers all these monitoring wells, as necessary. Note that one round of analysis is already planned for the RFI Data Gap investigation (Halliburton NUS 1994). This RFI Data Gap analytical data will satisfy some of the long-term groundwater monitoring program requirements, resulting in a reduced number of facility wells to be addressed by the subject long-term groundwater monitoring program to establish baseline conditions (first event). The following groundwater monitoring approach is proposed for the NSY Portsmouth:

(1) Establish baseline conditions for all 55 existing monitoring wells installed as part of the initial RFI and an additional 17 monitoring wells to be installed during the RFI Data Gap investigation planned for spring of 1994. Conduct two rounds of sampling - three months apart for the existing RFI wells. For the new RFI Data Gap wells, one round of sampling is included with the RFI Data Gap investigation, so only one additional round of sampling is required for these monitoring wells. All monitoring wells will be analyzed for full TCL organics/TAL inorganics which is consistent with the analytical methods used for the RFI and proposed for the RFI Data Gap investigation. Also, indicator parameters are included but without replicate sampling since the sampling/analysis program includes full TCL organics/TAL inorganics, resulting in less reliance on indicator parameters.

(2) Conduct subsequent groundwater monitoring for selected monitoring wells.

- Two background wells for the facility will be selected for subsequent monitoring following establishment of background conditions.

- At the DRMO (SWMU #6), where groundwater flow direction is known, two upgradient wells and five shallow and two bedrock wells located at the downgradient DRMO perimeter will be monitored. No further downgradient wells can be installed since this SWMU borders the Piscataqua River.

- At the JILF Landfill (SWMU #8), where groundwater flow direction appears to be in several directions, perimeter wells will be monitored. Nineteen shallow and eight bedrock wells will be monitored.

- The Mercury Burial Sites (SWMU #9) are located within the JILF Landfill and therefore can be included with the landfill, creating a RCRA Corrective Action Management Unit (CAMU). Therefore, monitoring will be in accordance with the JILF Landfill perimeter monitoring program. Of note, additional sampling and analysis is being conducted for Mercury Burial Site II as part of the RFI Data Gap investigation. The inclusion of SWMU #9 within the JILF Landfill for groundwater monitoring does not preclude remediation activities specific to SWMU #9.

- The Former Waste Oil Tanks (SWMU #11) also are located within the JILF Landfill and therefore can be considered part of a larger RCRA CAMU. Therefore, monitoring will be in accordance with the JILF perimeter monitoring program. Of note, additional sampling and analysis is being conducted for SWMU # 11 as part of the RFI Data Gap investigation. The inclusion of SWMU #11 within the JILF Landfill for groundwater monitoring does not preclude remediation activities specific to SWMU #11.

- At the Fuel Oil Spillage Area (SWMU #27), all six existing shallow wells will be monitored. No additional investigation of the Fuel Oil Spillage Area is occurring as part of the RFI Data Gap investigation.

Groundwater samples will be analyzed for full TCL organics/TAL inorganics which is consistent with the analytical methods used for the RFI and proposed for the RFI Data Gap investigation. Also, indicator parameters are included but without replicate sampling since full TCL organics/TAL inorganics analysis is planned, resulting in less reliance on indicator parameters. Sampling/analysis will be conducted on a semi-annual basis.

(3) Revise the monitoring program on a yearly basis, as necessary. Currently, monitoring is planned to continue throughout the active life of the facility, and for disposal facilities, during the post-closure care period and until final closure of the facility or until approval is given by the Regional Administrator to suspend monitoring activities based on an absence of groundwater impacts and

a likelihood of no future impacts. If site remediation occurs, selected wells will be monitored prior to, during, and following remediation. It is the intent of the Navy to conduct sampling and analyses only as necessary. Therefore, after the baseline conditions are established, analytes which are not expected and not detected will be deleted from the analytical program for subsequent years. Similarly, different analytical methods may be requested.

(4) Water levels for both existing RFI monitoring wells and proposed RFI Data Gap wells will first be measured facility wide, as part of the RFI Data Gap investigation (Halliburton NUS 1994). For the second event to establish baseline conditions, and for all subsequent sampling, water-level measurements will occur for only those wells being sampled and analyzed at the time. Both high tide and low tide measurements will take place.

2.0 BACKGROUND INFORMATION

2.1 GEOLOGY/HYDROGEOLOGY

2.1.1 Site Location and Description

Situated within the town of Kittery, Maine, the Portsmouth Naval Shipyard (NSY Portsmouth) is composed of four islands located in the Piscataqua River. The Piscataqua River is a tidal estuary which forms the southern boundary between New Hampshire and Maine.

The shipyard is engaged in the conversion, overhaul, and repair of submarines for the U.S. Navy. The shipyard has a long history dating back to 1690 when the first warship launched in North America, the *Falkland*, was built. The shipyard was first established as a government facility in 1800. The shipyard served as a repair and building facility for ships during the Civil War. The first government-built submarine was designed and built at the shipyard during World War I and a large number of submarines were designed and constructed at the yard from 1917 to the present. The shipyard has continued servicing submarines to this day.

As the workload at the shipyard expanded, fill material was used to create man-made-land adjacent to the original islands. Today the shipyard is composed of 376 buildings on 278 acres of continuous land surface that extends between three of the original four islands. Much of the shipyard is built on fill overlying former tidal flats as shown in Figure 2-1.

2.1.2 Physiography

The NSY Portsmouth is located on Seavey Island in the Piscataqua River immediately south of the town of Kittery, Maine. The location of the shipyard is shown in Figure 2-2. The shipyard is built on an area comprising Dennet's, Seavey, Jamaica, and Clark's Islands, as well as man-made-land between these islands. Approximate elevations on-site range from sea level to a maximum of sixty feet above MSL. Two-thirds of the site is high-density industrial area containing 376 buildings, while the remaining areas are flat-lying to gently sloping grass-covered fields. Minor wooded areas exist on the east side of Jamaica Island.

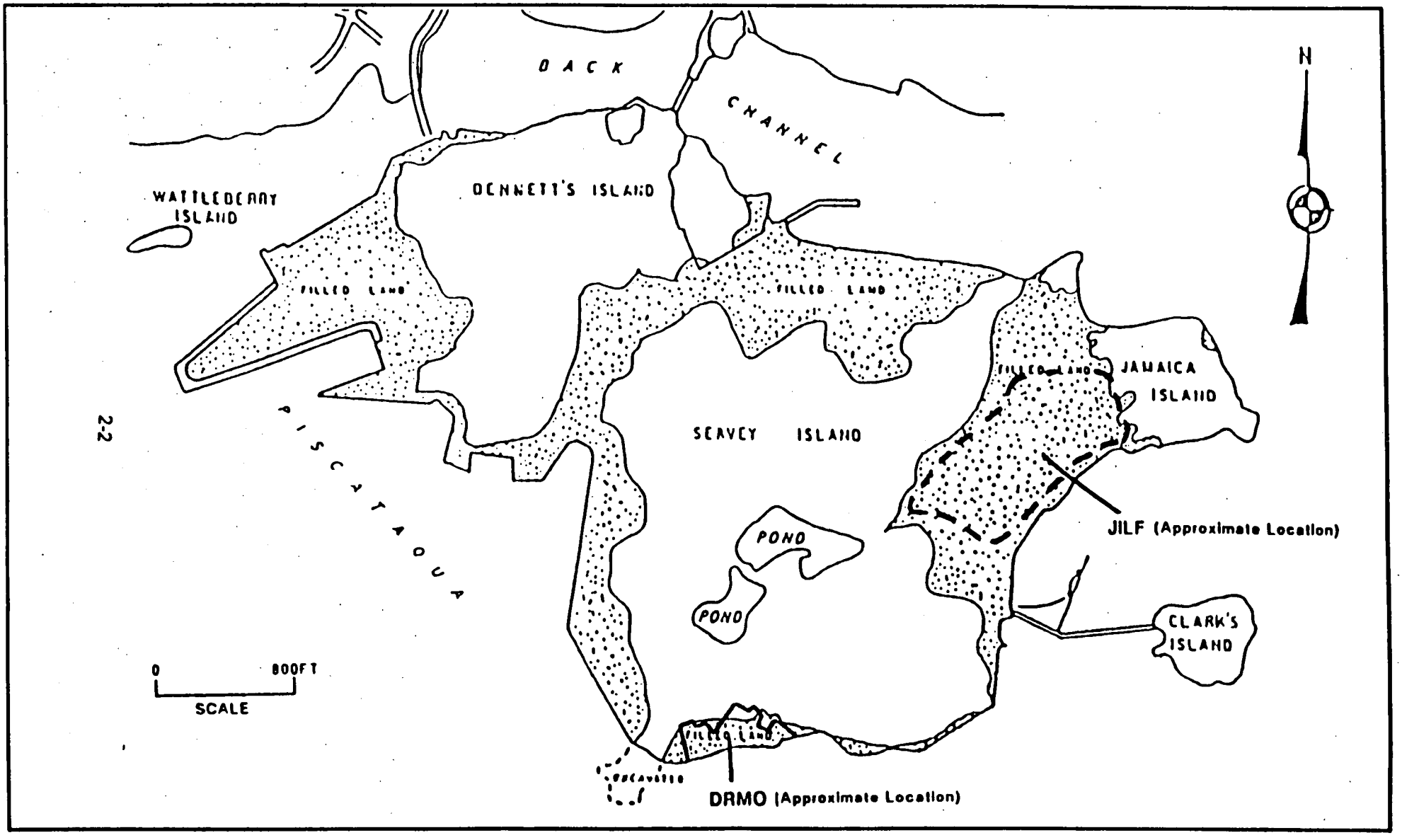

FIGURE 2-1

PORTSMOUTH NSY LAND MAP
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

HALLIBURTON NUS CORPORATION

FIGURE 2-2

LOCATION MAP
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

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The shoreline in the Portsmouth area is described as an embayed coast produced by partial submergence of a fluvially eroded land mass (Strahler, 1971). This type of shoreline is closely associated with the drowned river valley type estuary. The Great Bay Estuary would be classed as a drowned river valley in a geomorphological classification (Duxbury, 1971). Valleys show some degree of straightening and deepening by ice; hilltops are blunted by ice erosion; and deposits of till block smaller valleys in the Maine version.

2.1.3 Surface Water

The Piscataqua River hydrology is not characteristic of traditional inland fluvial hydrology. Figure 2-1 shows the Piscataqua River, Little Bay and Great Bay, and the seven converging rivers that form the Great Bay Estuary.

Seavey Island is located in the mouth of the Great Bay Estuary, commonly referred to as the Portsmouth Harbor. The harbor's main channel is approximately 75 feet deep (mean low water) and the back channel is approximately 20 feet deep (mean low water) in the vicinity of Seavey Island (NOAA Chart, 1988).

Additional surface water information can be found in the RCRA Facilities Investigation Report (McLaren/Hart 1992).

2.1.4 Geology and Stratigraphy

The islands composing the NSY Portsmouth are formed on bedrock highs with thin veneers of glacial till, recent alluvium, and/or fill materials. Bedrock consists of tectonically deformed Middle Ordovician volcanic rocks and highly fractured, metamorphosed sandstones, shales, and siltstone of Silurian age belonging to the Kittery Formation (Hussey, 1985). Metamorphism has destroyed original interparticle porosity in the sedimentary rocks. Therefore, groundwater flow is controlled by fractures.

The bedrock of this area has undergone at least three periods of deformation; the Taconic Orogeny (440 million years before present(mybp)), Acadian (360 mybp), and the Appalachian (260 mybp)), resulting in multiple rock cleavages, planes of foliation, faults of various ages and types, and varied fold orientations and geometries. The resulting bedrock fracture pattern therefore is highly complex.

Additional geologic information can be found in the RCRA Facilities Investigation Report (McLaren/Hart, 1992).

2.1.5 Hydrogeology

Groundwater is encountered within both the unconsolidated materials and bedrock at the facility. In general, the unconsolidated materials appear to be moderately to highly permeable. Bedrock permeability is expected to generally be less than that of the unconsolidated materials.

Groundwater levels at the NSY Portsmouth are shallow and likely controlled by the bedrock surface topography and by the thickness of glacial till and fill material overlying bedrock or former tidal flat areas. Groundwater flow directions on-site vary considerably depending on the thickness and composition of overburden, bedrock-overburden contact-surface dip, and tidal influence, but overall are from interior portions of the facility toward the island coastline. Recharge to groundwater is derived from local precipitation and tidal effects, and possible deep-seated recharge from further inland areas.

Kittery's potable water supply originates from surface reservoirs located in the vicinity of York, Maine. The shipyard is not currently using groundwater on-site.

Additional information can be found in the RCRA Facility Investigation Report (McLaren/Hart 1992). Hydrogeology is not currently fully understood and is being further investigated as part of the RFI Data Gap investigation scheduled for spring of 1994.

2.1.6 Topography

Detailed topographic maps of the DRMO (SWMU #6) and JILF Landfill (SWMU #8) can be found in the RCRA Facility Investigation Report (McLaren/Hart 1992). The DRMO is currently undergoing interim remediation measures in the form of a liner and gravel cap; the DRMO has been graded flat as part of this operation.

3.0 GROUNDWATER MONITORING SYSTEM

3.1 MONITORING WELL LOCATION

The location of all existing and new/proposed wells can be found on the enclosed Figure 3-1. Additional information about the location of existing RFI monitoring wells can be found in Sections 4.0 and 5.0 of the RCRA Facility Investigation Report (McLaren/Hart 1992). Additional information about the location of RFI Data Gap wells can be found in the RFI Data Gap Work Plan (Halliburton NUS 1994).

3.2 MONITORING WELL INSTALLATION AND CONSTRUCTION

3.2.1 RFI Data Gap Monitoring Wells

The 17 proposed RFI Data Gap monitoring wells (both overburden and bedrock) will be constructed of 2-inch-diameter PVC well screen and casing. The well screens (20 slot by 10 to 15 feet long) will be installed across the desired monitoring/fracture zone interval, then a sand pack will be installed around and to approximately 2 feet above the screen. A bentonite seal will then be installed immediately above the sand and the remaining borehole annulus will be backfilled with cement-bentonite grout, to ground surface. Table 3-1 summarizes RFI Data Gap monitoring well installation and construction.

Steel protective casings (4-inch minimum diameter) equipped with locking caps will be installed around most RFI Data Gap monitoring wells. These casings are to be cemented a minimum of 3 feet into the ground and have at least one drain hole positioned approximately 0.5 feet above the ground surface. A 0.5-foot thick concrete apron measuring 2 feet by 2 feet is to be constructed equally portioned around the casing of each well. Remaining RFI Data Gap monitoring wells are to be completed as flush-mounted installations. At flush-mounted installations the well riser pipe is to be cut off immediately below surface grade and provided with a locking, packer-type cap. A steel flush-mounted protective casing is to be cemented in place over the riser pipe. The protective casing will be installed flush with the ground surface. Flush-mounted covers will identify the location as a "Monitoring Well". All protective casings will be secured with Master locks and keyed alike.

TABLE 3-1
RFI DATA GAP PROPOSED MONITORING WELL INSTALLATION AND CONSTRUCTION DETAILS
NSY PORTSMOUTH, KITTERY, MAINE

Well ID Number (a,b)	Riser		Screen				
	Material	Diameter	Type	Material	Length	Diameter	Slot Size
MW-08	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
MW-09	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
MW-10	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
DI-01B	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
DI-01DB	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
FA-01	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
FA-01B	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
FA-01DB	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
SI-01B	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
SI-01DB	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
DW-07B	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
JW-13DB	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
WOT-01	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
WOT-02	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
WOT-03	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
WOT-04	PVC	2"	Slotted	PVC	10-15'	2"	0.020"
WOT-05	PVC	2"	Slotted	PVC	10-15'	2"	0.020"

(a) Wells designated as "B" are shallow bedrock wells and are to be installed approximately 20 to 25 feet into bedrock.
Wells designated as "DB" are deep bedrock wells and are to be installed approximately 80 to 100 feet into bedrock.
All other monitoring well installations are shallow overburden wells and are to be installed to approximately 10 feet below the water table.

(b) MW = Mercury Burial Site II area wells.
SI = Seavey Island area wells.
WOT = Waste Oil Tank area wells
DI = Dennet's Island area wells.
DW = DRMO area wells.
FA = Fill Area wells.
JW = JILF area wells.

3.2.2 RFI Monitoring Wells

A summary of the installation and construction of the 55 existing monitoring wells is shown in Table 3-2. Additional information on existing well installation and construction can be found in Section 5.0 (and Appendix IV) of the RCRA Facility Investigation Report (McLaren/Hart 1992).

3.3 DECONTAMINATION

The equipment involved in field sampling activities will be decontaminated prior to and during drilling and sampling activities. This equipment includes drilling rigs, downhole tools, augers, well casing and screens (if any new wells are installed in the future); and all sampling equipment. Since dedicated disposable bailer will be used at each well location, no decontamination water will be generated.

3.3.1 Major Equipment

All downhole drilling equipment (if any new wells are installed in the future) and sampling tools shall be steam cleaned prior to beginning work, between well borings, any time the drilling rig leaves the site prior to completing a boring, and at the completion of the drilling program. In addition, well casing and screens shall be steam cleaned prior to being installed into the borings.

These decontamination operations will consist of washing the equipment using a high-pressure steam wash. All decontamination activities will take place at a location determined during mobilization.

3.3.2 Sampling Equipment

If, in the future, nondedicated sampling equipment is used for collecting groundwater samples, the equipment will be decontaminated both prior to beginning field sampling and between samples. The following decontamination steps will be taken:

- Potable water rinse
- Alconox or Liquinox detergent wash
- Potable water rinse
- Nitric acid rinse

TABLE 3-2
RFI MONITORING WELL INSTALLATION AND CONSTRUCTION DETAILS
NSY PORTSMOUTH, KITTERY, MAINE

Well ID Number (a)	Riser		Screen					Elevation (b)			
	Material	Dia.	Type	Material	Length	Dia.	Slot Size	Ground	Top of Riser	Top of Screen	Bottom of Screen
DW-1	PVC	2"	Slotted	PVC	5'	2"	0.010"	109.42	111.44	102.42	97.42
DW-1B	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	109.53	111.36	92.53	87.53
DW-2	PVC	2"	Slotted	PVC	5'	2"	0.010"	108.84	108.34	98.34	93.34
DW-2B	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	109.93	111.77	88.93	83.93
DW-3	PVC	2"	Slotted	PVC	10'	2"	0.010"	108.48	110.69	98.48	88.48
DW-4	PVC	2"	Slotted	PVC	5'	2"	0.010"	110.16	109.69	100.16	95.96
DW-5	PVC	2"	Slotted	PVC	5'	2"	0.010"	109.09	111.14	102.09	97.09
DW-6	PVC	2"	Slotted	PVC	7'	2"	0.010"	100.17	112.06	102.17	95.17
DW-7	PVC	2"	Slotted	PVC	10'	2"	0.010"	109.93	111.52	99.93	89.93
DW-7B	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	110.41	112.33	82.41	77.41
DW-8	Teflon	2"	Slotted	Teflon	10'	2"	0.010"	107.38	109.86	97.38	87.38
DW-8B	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	107.39	109.03	58.69	53.69
DW-9	Teflon	2"	Slotted	Teflon	10'	2"	0.010"	108.42	110.14	98.42	88.42
DW-10B	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	111.62	112.83	98.62	93.62
FW-1	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	•	•	••	••
FW-2	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	•	••	••	••
FW-3	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	••	••	••	••
FW-4	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	••	••	••	••
FW-5	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	••	••	••	••
FW-6	Teflon	2"	Slotted	Teflon	10'	2"	0.010"	••	••	••	••
JW-3	Teflon	2"	Slotted	Teflon	10'	2"	0.010"	108.46	110.09	103.09	93.09

TABLE 3-2 (CONT.)
RFI MONITORING WELL INSTALLATION AND CONSTRUCTION DETAILS
PORTSMOUTH NSY, KITTERY, MAINE

DRAFT

Well ID Number (a)	Riser		Screen					Elevation (b)			
	Material	Dia.	Type	Material	Length	Dia.	Slot Size	Ground	Top of Riser	Top of Screen	Bottom of Screen
JW-4	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	106.13	105.80	98.80	93.80
JW-5	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	106.96	106.74	96.96	91.96
JW-6	Teflon	2"	Slotted	Teflon	10'	2"	0.010"	108.31	107.78	97.28	87.28
JW-7	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	107.14	108.94	100.34	95.34
JW-7B	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	107.32	108.87	89.32	84.32
JW-8	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	111.06	112.73	102.06	97.06
JW-8B	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	111.12	114.00	91.12	86.12
JW-9	Teflon	2"	Slotted	Teflon	8'	2"	0.010"	104.5*	106*	97.5*	89.5*
JW-9B	Teflon	2"	Slotted	Teflon	10'	2"	0.010"	105*	106.5*	80.5*	70.5*
JW-10	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	106.5*	108.5*	99.5*	94.5*
JW-12S	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	109*	111*	102*	97*
JW-12D	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	109*	111*	92*	87*
JW-12B	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	109*	111*	75*	70*
JW-13S	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	110*	112*	102*	97*
JW-13D	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	110*	112*	96*	91*
JW-13B	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	110*	112*	79*	74*
JW-14	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	106*	108*	93*	88*
JW-14B	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	106*	108*	83*	78*
JW-15	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	107.5*	107*	100.5*	95.5*
JW-15B	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	107.5*	107*	86.5*	81.5*
JW-16	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	107*	106.5*	102.5*	97.5*
JW-16B	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	107*	106.5*	93.5*	88.5*
JW-17B	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	107.5*	107*	86*	81*

TABLE 3-2 (CONT.)
RFI MONITORING WELL INSTALLATION AND CONSTRUCTION DETAILS
PORTSMOUTH NSY, KITTERY, MAINE

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Well ID Number (a)	Riser		Screen					Elevation (b)			
	Material	Dia.	Type	Material	Length	Dia.	Slot Size	Ground	Top of Riser	Top of Screen	Bottom of Screen
JW-18	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	107*	106.5*	100*	95*
JW-18B	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	•	•	•	•
JW-19	Teflon	2"	Slotted	Teflon	10'	2"	0.010"	111.5*	113*	100*	90*
JW-19B	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	111.5*	111*	44.5*	39.5*
MW-2	PVC	2"	Slotted	PVC	10'	2"	0.010"	115.98	118.15	106.33	96.33
MW-3	PVC	2"	Slotted	PVC	10'	2"	0.010"	116.41	116.14	106.80	96.80
MW-4	PVC and Teflon	2"	Slotted	Teflon	10'	2"	0.010"	111.45	113.08	102.53	92.53
MW-5	PVC	2"	Slotted	Teflon	10'	2"	0.010"	111.57	113.45	101.31	91.31
MW-6	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	116.50	116.17	95.83	90.83
MW-7	Teflon	2"	Slotted	Teflon	5'	2"	0.010"	111.66	113.86	93.79	88.79

• Information not available.

* Elevations interpolated from (McLaren/Hart, 1992) Well Cross Section diagrams.

(a) MW = Mercury Burial Site II area wells. DI = Dennet's Island area wells. FA = Fill Area wells.
SI = Seavey Island area wells. DW DRMO area wells. JW = JILF area wells.
WOT = Waste Oil Tank area wells.

(b) Elevation 100.00' Mean High Tide NSY Portsmouth system is equal to 3.804' USGS system.

- Analyte-free water rinse
- Methanol rinse
- Analyte-free water rinse
- Air dry

3.4 WELL DEVELOPMENT

For any new wells, the monitoring wells will be developed no sooner than 24 hours after installation to remove fines from the area around the monitored interval of the well. Wells will be developed by use of a small submersible pump. Wells will be developed until the water is visibly clear of sediment or until approved by the field representative. Additionally, development will proceed until the variation between turbidity meter readings is less than 10 percent; however, development will not exceed two hours per well. Other development methods may be used with permission by Halliburton NUS.

3.5 AQUIFER TESTING

Insitu hydraulic conductivity testing (slug tests) has been performed in all existing monitoring wells. Slug testing will be performed on the new RFI Data Gap wells after they have been developed and the water levels have returned to static. Pressure transducers and data loggers will be used for data collection to obtain sufficiently accurate field data.

The following minimum information will be collected for each well during the performance of aquifer tests:

- Well number/depth/screened interval/ inside diameter of screen/ diameter of sand pack
- Static water level
- Method of inducing water level change
- Time/recovery data
- Total time of test

Data generated during the tests will be documented on the appropriate data sheets and analyzed, using the most appropriate evaluation technique for the existing hydrogeologic conditions. Data generated during the slug tests will be recorded on the appropriate forms.

3.6 SURVEYING

All monitoring well locations have been surveyed. Existing survey monuments from the previous RFI surveying event will be utilized as reference points for the RFI Data Gap monitoring well locations. Monitoring well horizontal locations are surveyed to the nearest 0.10 foot. Vertical elevations are referenced to the 1929 North American Datum. Monitoring well elevations are surveyed to the nearest 0.01 foot at the measuring point where the uncapped riser pipe is notched. Ground surface elevations at the well locations are surveyed to the nearest 0.10 foot.

3.7 RESIDUE MANAGEMENT

Two types of potentially contaminated residues are expected to be generated during the groundwater monitoring program, namely Personal Protective Equipment (PPE) and purge water. Based on the activities and types of contaminants present, none of these residues are expected to represent a significant risk to human health or the environment if properly managed. Planned management of each of these residues is provided below.

PPE - Halliburton NUS will place PPE in the trash receptacles at the facility.

Purge Water - Disposal of purge water is the responsibility of NSY Portsmouth. It is recommended that purge water be containerized in large plastic/polyethylene tanks staged near the industrial treatment plant. Groundwater generated during monitoring well sampling will be containerized and stored until analytical results are received.

- If analytical results indicate that purge water concentrations for any constituent in the container exceed MCLs but are less than RCRA hazardous waste concentrations, the contents could be discharged to the on-base industrial wastewater treatment plant.

- If analytical results indicate that purge water concentrations for any constituent exceed RCRA TCLP criteria, then treatment at an offsite treatment facility is warranted.

- If, in the future, a dedicated groundwater treatment system is installed for treatment of groundwater, any purge water produced would preferentially be discharged to the front end of the groundwater treatment system.

4.0 SAMPLING AND ANALYSIS

4.1 EXISTING DATA

4.1.1 Available Groundwater Monitoring Data

Available groundwater monitoring data is included in Section 5.0 (and Appendix IX) of the RCRA Facilities Investigation Report (McLaren/Hart 1992). The following summarizes the known nature and extent of contamination:

DRMO (SWMU #6)

Elevated concentrations of metals were consistently detected in groundwater samples from the DRMO wells. For the most part, metals were detected primarily in the unfiltered groundwater samples but not in the filtered samples, indicating that the metals were in the particulate, rather than the dissolved, form. Pesticides and PCBs were detected at the DRMO, but not consistently.

Volatile organic compounds (VOCs) and semi-volatile compounds were detected at relatively low levels at the DRMO. Bis(2-ethylhexyl)phthalate was the typical and many times only semi-volatile compound detected. Petroleum products were also detected at several locations. Herbicides were not detected in any DRMO groundwater samples.

Jamaica Island Landfill (SWMU #8)

Elevated levels of VOCs and semi-volatiles are present in several JILF Landfill monitoring wells. Additional investigation of organics in JILF groundwater is included in the RFI Data Gap Work Plan (Halliburton NUS 1993). Additionally, elevated groundwater concentrations of metals have been detected. For the most part, metals were detected primarily in the unfiltered groundwater samples but not in the filtered samples, indicating that the metals were in the particulate, rather than the dissolved, form. Petroleum product encountered has been attributed to the former waste oil storage tanks (SWMU #11), located within the JILF Landfill; additional investigation is included in the RFI Data Gap Work Plan (Halliburton NUS 1994).

Pesticides and PCBs were detected generally in low concentrations. Herbicides were not detected in any JILF groundwater samples.

Mercury Burial Sites (SWMU #9)

VOCs and semi-volatiles detected in wells located near Mercury Burial Site II are associated with petroleum. It is possible that a former gas station upgradient of this area is the source area or the contamination could be a result of contaminated fill. Additional investigation of groundwater in this area is included in the RFI Data Gap Work Plan (Halliburton NUS 1994). Additionally, elevated groundwater concentrations of metals have been detected. For the most part, metals were detected in the unfiltered groundwater samples, indicating that the metals were in the particulate, rather than the dissolved, form. The Phase IV groundwater sample from MW-6 was the only sample to contain concentrations of mercury equalling or exceeding the proposed Federal Action Level and NPDWR.

Pesticides and PCBs were not consistently detected in the groundwater samples. Herbicides were not detected in any Mercury Burial site groundwater samples.

Fuel Oil Spillage Area (SWMU #27)

Trichloroethene (TCE), detected at one well, is the only VOC that exceeds regulatory standards. Fuel oil and lube oil was detected and identified in a different well. Additionally, elevated groundwater concentrations of metals have been detected. For the most part, metals were detected in the unfiltered groundwater samples, indicating that the metals were in the particulate, rather than the dissolved, form.

Semi-volatiles, pesticides, PCBs, and cyanide were not detected.

4.1.2 Available Groundwater Level Data

Refer to Section 4.0 and Appendix VIII of the RCRA Facility Investigation Report (McLaren/Hart 1992). Note that groundwater levels at numerous wells are impacted by tidal variations.

4.1.3 Source Contamination

Source area contamination will be addressed in the upcoming Corrective Measures Study. Media Protection Standards for soil will be the basis of Corrective Measures.

4.2 SELECTION OF MONITORING WELLS FOR SAMPLING AND ANALYSIS

4.2.1 Baseline Groundwater Monitoring - First Two Events Sampling

Baseline conditions will be established for all 55 existing monitoring wells installed as part of the RFI and an additional 17 monitoring wells to be installed during the RFI Data Gap investigation planned for the spring of 1994. Two rounds of sampling will be conducted - three months apart for the existing RFI wells. For the new RFI Data Gap wells, one round of sampling is included with the RFI Data Gap investigation, so only one additional round of sampling is required for these monitoring wells. Analysis consists of full TCL organics/TAL inorganics which is consistent with the analytical methods used for the RFI and proposed for the RFI Data Gap investigation. Also indicator parameters will be analyzed; however replicate sampling will not be conducted, since sampling/analysis includes full TCL organics/TAL inorganics, resulting in less reliance on indicator parameters.

Refer to Table 4-1 for a summary of specific parameters of concern to be sampled to establish baseline conditions. Table 4-1 also includes analytical methods, containers, preservation, and holding times for each parameter. Tables 4-2 and 4-3 present the anticipated number of samples, including QA/QC samples for establishing baseline conditions for the first and second event sampling event, respectively.

4.2.2 Subsequent Groundwater Monitoring

Following establishment of baseline groundwater monitoring conditions, subsequent groundwater monitoring will be conducted for selected monitoring wells, as follows:

- Two shallow background wells will be monitored. Selection of these wells will be determined upon completion of the baseline conditions monitoring.

TABLE 4-1
SAMPLE CONTAINERS, PRESERVATION METHODS, AND HOLDING TIMES
NSY PORTSMOUTH, KITTERY, MAINE

Method	Parameter	Container Material	Sample Volume	Preservation	Holding Time (a)
GROUNDWATER					
CLP OLM01.8	TCL Volatiles	Glass, Teflon-lined septa	(2) 40 ml	4 C; 4 drops HCl, pH < 2	14 days
CLP OLM01.8	TCL Semi-volatiles	Glass, Teflon-lined septum	2,500 ml	Cool, 4 C	Extract 7 days; Analyze 40 days
CLP ILM02.1	TAL Metals (Total)	Plastic, glass	1 liter	4 C; HNO_3 to pH < 2	6 months Hg- 28 days
CLP ILM02.1	TAL Metals (Dissolved)	Plastic, glass	1 liter	4 C; HNO_3 to pH < 2	6 months Hg- 28 days
EPA 415.1 SW 9020	Total Organic Carbon (TOC) Total Organic Halogen (TOX)	Polyethylene	500 ml	H_2SO_4 to pH<2	28 days
EPA 325.3 EPA 375.3 EPA 150.1 EPA 120.1	Chloride Sulfate pH Specific Conductance	Polyethylene	1 liter	Cool, 4 C	28 days
EPA 200.7	Iron Manganese Sodium	Polyethylene	1 liter	HNO_3 to pH<2 Cool, 4 C	6 months
EPA 420.1	Phenols	Amber glass	1 liter	H_2SO_4 to pH<2 Cool, 4C	28 days

(a) Holding times are measured from time of collection.

Note: Additionally Oxidation Reduction Potential (ORP) will be measured in the field.

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TABLE 4-2
GROUNDWATER MONITORING ANALYTICAL PROGRAM
BASELINE CONDITIONS - FIRST EVENT
NSY PORTSMOUTH, KITTERY, MAINE

Media	Analysis	Method	No. Samples	Trip Blank(1)	Rinsate Blank(2)	Field Blank(3)	Duplicate(4)	Total Samples
Groundwater	TCL volatiles	CLP OLM01.8	55	11	-	-	6	72
	TCL semi-volatiles	CLP OLM01.8	55	-	-	-	6	61
	TAL metals(5) (Total)	CLP ILM02.1	55	-	-	-	6	61
	TAL metals(6) (Dissolved)	CLP ILM02.1	55	-	-	-	6	61
	Total organic carbon (TOC)	EPA 415.1	55	-	-	-	6	61
	Total organic halogen (TOX)	SW9020	55	-	-	-	6	61
	Chloride	EPA 325.3	55	-	-	-	6	61
	Sulfate	EPA 375.3	55	-	-	-	6	61
	pH	EPA 150.1	55	-	-	-	6	61
	Specific Conductance	EPA 120.1	55	-	-	-	6	61
	Iron	EPA 200.7	55	-	-	-	6	61
	Manganese	EPA 200.7	55	-	-	-	6	61
	Sodium	EPA 200.7	55	-	-	-	6	61
	Phenols	EPA 420.1	55	-	-	-	6	61

(1) Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organic (VOA) samples. One trip blank per each cooler containing volatile organics.
(2) Rinsate Blank - Samples obtained by pouring analyte-free water over sample collection equipment (bailer, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis. Number of samples reflects the number of actual laboratory analyses performed. Only samples from every other day will be analyzed.
(3) Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event/media.
(4) Duplicates - A single sample split into two portions during a single act of sampling. Assess the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.
(5) Total Metals - For the determination of total metals the sample is not filtered before acidification.
(6) Dissolved Metals - For the determination of dissolved metals the sample is filtered to 0.45μ before acidification.

Note: Additionally, Oxidation Reduction Potential (ORP) will be measured in the field.

TABLE 4-3
GROUNDWATER MONITORING ANALYTICAL PROGRAM
BASELINE CONDITIONS - SECOND EVENT
NSY PORTSMOUTH, KITTERY, MAINE

Media	Analysis	Method	No. Samples	Trip Blank(1)	Rinsate Blank(2)	Field Blank(3)	Duplicate(4)	Total Samples
Groundwater	TCL volatiles	CLP OLM01.8	72	14	-	-	8	94
	TCL semi-volatiles	CLP OLM01.8	72	-	-	-	8	80
	TAL metals(5) (Total)	CLP ILM02.1	72	-	-	-	8	80
	TAL metals(6) (Dissolved)	CLP ILM02.1	72	-	-	-	8	80
	Total organic carbon (TOC)	EPA 415.1	72	-	-	-	8	80
	Total organic halogen (TOX)	SW9020	72	-	-	-	8	80
	Chloride	EPA 325.3	72	-	-	-	8	80
	Sulfate	EPA 375.3	72	-	-	-	8	80
	pH	EPA 150.1	72	-	-	-	8	80
	Specific Conductance	EPA 120.1	72	-	-	-	8	80
	Iron	EPA 200.7	72	-	-	-	8	80
	Manganese	EPA 200.7	72	-	-	-	8	80
	Sodium	EPA 200.7	72	-	-	-	8	80
	Phenols	EPA 420.1	72	-	-	-	8	80

(1) Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organic (VOA) samples. One trip blank per each cooler containing VOAs.

(2) Rinsate Blank - Samples obtained by pouring analyte-free water over sample collection equipment (bailer, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis. Number of samples reflects the number of actual laboratory analyses performed. Only samples from every other day will be analyzed.

(3) Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event/media.

(4) Duplicates - A single sample split into two portions during a single act of sampling. Assess the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

(5) Total Metals - For the determination of total metals the sample is not filtered before acidification.

(6) Dissolved Metals - For the determination of dissolved metals the sample is filtered to 0.45μ before acidification.

Note: Additionally, Oxidation Reduction Potential (ORP) will be measured in the field.

- At the DRMO (SWMU #6), where groundwater flow direction is certain, two upgradient wells and five shallow/two bedrock wells located at the DRMO perimeter will be monitored. True downgradient wells cannot be installed since this SWMU borders the Piscataqua River. The nine wells to be monitored include DW-4, DW-10B, DW-6, DW-8/DW-8B, DW-2, DW-9, and DW-7/DW-7B. Figure 3-1 presents the monitoring well locations.

- At the JILF (SWMU #8), where groundwater flow direction appears to be in several directions, perimeter wells will be monitored. Eighteen shallow/seven bedrock wells will be monitored. The 25 wells to be monitored include JW-6, JW-17B, JW-15/JW-15B, JW-5, JW-4, JW-3, JW-14/JW-14B, MW-4, MW-7, JW-13S/JW-13B, JW-12S/JW-12B, JW-10, JW-9/JW-9B, MW-8, MW-6, MW-10, JW-8/JW-8B, and JW7/JW-7B. Figure 3-1 presents monitoring well locations.

- The Mercury Burial Sites (SWMU #9) are located within the JILF Landfill and so can be considered a RCRA Corrective Action Management Unit (CAMU). Therefore, monitoring will be in accordance with the JILF perimeter monitoring program. Of note, additional sampling and analysis is being conducted for Mercury Burial Site II as part of the RFI Data Gap investigation.

- The Former Waste Oil Tanks (SWMU #11) also are located within the JILF Landfill and so can be considered a RCRA CAMU. Therefore, monitoring will be in accordance with the JILF perimeter monitoring program. Of note, additional sampling and analysis is being conducted for SWMU #11 as part of the RFI Data Gap investigation.

- At the Fuel Oil Spillage Area (SWMU #27), all six existing wells will be monitored, including FW-1, FW-2, FW-3, FW-4, FW-5, and FW-6.

Samples will be analyzed for full TCL organics/TAL inorganics which is consistent with the analytical methods used for the RFI and proposed for the RFI Data Gap investigation. Data will be reviewed and a revised analytical suite will be proposed if appropriate. Also, indicator parameters will be included; however, no replicate sampling will be conducted. Sampling/analysis will occur on a semi-annual basis.

Refer to Table 4-1 for a summary of specific parameters of concern to be sampled. Table 4-1 also includes analytical methods, containers, preservation, and holding times for each parameter. Table 4-4 presents the anticipated number of samples for groundwater sampling/analysis, following the establishment of baseline conditions. Table 4-4 assumes that no analyses will be deleted from the program following establishment of baseline conditions.

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TABLE 4-4
GROUNDWATER MONITORING ANALYTICAL PROGRAM
SUBSEQUENT MONITORING
NSY PORTSMOUTH, KITTERY, MAINE

Media	Analysis	Method	No. Samples	Trip Blank(1)	Rinsate Blank(2)	Field Blank(3)	Duplicate(4)	Total Samples
Groundwater	TCL volatiles	CLP OLM01.8	42	8	-	-	5	55
	TCL semi-volatiles	CLP OLM01.8	42	-	-	-	5	47
	TAL metals(5) (Total)	CLP ILM02.1	42	-	-	-	5	47
	TAL metals(6) (Dissolved)	CLP ILM02.1	42	-	-	-	5	47
	Total organic carbon (TOC)	EPA 415.1	42	-	-	-	5	47
	Total organic halogen (TOX)	SW9020	42	-	-	-	5	47
	Chloride	EPA 325.3	42	-	-	-	5	47
	Sulfate	EPA 375.3	42	-	-	-	5	47
	pH	EPA 150.1	42	-	-	-	5	47
	Specific Conductance	EPA 120.1	42	-	-	-	5	47
	Iron	EPA 200.7	42	-	-	-	5	47
	Manganese	EPA 200.7	42	-	-	-	5	47
	Sodium	EPA 200.7	42	-	-	-	5	47
	Phenols	EPA 420.1	42	-	-	-	5	47

(1) Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organic (VOA) samples. One trip blank per each cooler containing VOAs.
(2) Rinsate Blank - Samples obtained by pouring analyte-free water over sample collection equipment (bailer, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis. Number of samples reflects the number of actual laboratory analyses performed. Only samples from every other day will be analyzed.
(3) Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event/media.
(4) Duplicates - A single sample split into two portions during a single act of sampling. Assess the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.
(5) Total Metals - For the determination of total metals the sample is not filtered before acidification.
(6) Dissolved Metals - For the determination of dissolved metals the sample is filtered to 0.45μ before acidification.

Note: Additionally, Oxidation Reduction Potential (ORP) will be measured in the field.

4.3 SAMPLING AND ANALYSIS PROCEDURES

Refer to the RFI Data Gap Work Plan QAPP and HASP for supplemental information concerning sample collection and analysis (Halliburton NUS 1994). Also, refer to Appendix C of the Groundwater Monitoring Plan for the Analytical Laboratory NEESA Quality Assurance Manual for PACE New England, Inc.. PACE New England has been selected to perform the analytical services for the RFI Data Gap activity and long-term groundwater monitoring.

4.3.1 Inspection of Existing Monitoring Wells

Prior to sampling of a given monitoring well, a brief onsite inspection will be conducted, consisting of the following elements:

- Condition of the protective casing
- Condition of the cement seal surrounding the protective casing
- Presence of any standing water around the protective casing
- Physical characteristics and composition of the inner casing or riser
- Presence of grout between the riser and outer casing, and the presence of drain holes in the outer casing
- Presence of dedicated sampling equipment
- Determination of static water level
- Determination of total depth of well, including a check to determine if well is obstructed
- Well security evaluation

Comparisons will be made between original and sampling date conditions to determine if significant changes have occurred which may indicate well damage. A record of all field observations will be recorded in a field log book.

4.3.2 Water-Level Measurement

Two comprehensive rounds of water level measurements will be conducted for each event to provide semi-annual information regarding groundwater flow patterns and flow gradients across the NSY Portsmouth facility. Note that for the establishment of baseline conditions (first event), this activity has been

completely addressed for all facility monitoring wells under the RFI Data Gap investigation (Halliburton NUS 1994) planned for spring of 1994. Water levels will be obtained from all monitored wells; one round during mean high tide and one round during mean low tide. Each set of water level measurements will be obtained within an 2-hour period, and no sooner than 24 hours after a significant precipitation event, to minimize the precipitation effects, on the data sets.

Measurements will be taken with an M-Scope (electrical water-level indicator) using the top of the inner well casing as the reference point for determining depths to water. This well casing shall be notched and marked so that the same point will be referenced for all measurements. Water level measurements will be recorded to the nearest 0.01 foot in the field logbook and on a groundwater level measurement form, attached in Appendix A. Section 5.0 of SOP-GH-2.5 (refer to Appendix B) provides a description of Water Level Measurement procedures.

4.3.3 Well Purging

Prior to obtaining samples, water levels will be measured and the wells will be purged using a dedicated bailer or a 2-inch submersible pump. Three to six well volumes will be purged. If the wells are purged dry with less than three volumes removed, the water in the well will be allowed to recover at least 70 percent, then a sample will be collected. In the event that recovery is slow, samples will be collected within 24 hours of purging. Field measurements of pH, temperature, and specific conductance will be taken after each well volume is purged. Stabilization of the above parameters is defined as follows: temperature ± 1.0°C, pH ± 0.1 units, specific conductance ± 5 percent. If these parameters do not stabilize after 3 volumes, up to 6 volumes maximum will be removed. Section 5.0 of SOP-SA-1.1 and SOP-SF-1.1, attached in Appendix B, provide a description of Groundwater Sample Acquisition.

Purging/sampling of wells located near the island shoreline will be performed during low tide, to minimize the potential for samples to be affected by surface water influx.

Purge water will be containerized, labelled, and properly disposed of by NSY Portsmouth personnel. Refer to Section 3.7 of this groundwater monitoring plan concerning residue management.

4.3.4 Sampling of Wells

Teflon bailers with dedicated polyethylene rope as bailing line will be used for sample collection. The sample will be poured directly from the bailer into the appropriate sample bottles for analysis. Samples to be analyzed for volatile constituents shall be taken first and immediately sealed in a container so that no head space exists.

4.3.5 Sample Identification System

Each sample collected will be assigned a unique sample tracking number. The sample tracking number will consist of a two-segment, alpha-numeric code that identifies the sample medium and location, and sample round identifier (in the case of groundwater samples). Any other pertinent information regarding sample identification will be recorded in the field log books.

The alpha-numeric coding to be used in the sample system is explained in the diagram and the subsequent definitions:

(AAAA[N])	-	**(AANN)**	-	**(AANN)**
(Site ID)		(Location)		(Medium & Round Identifier)

Character Type:

A	=	Alpha
N	=	Numeric

Site ID:

JILF	=	Jamaica Island Landfill
MBS1	=	Mercury Burial Site 1
MBS2	=	Mercury Burial Site 2
DI	=	Dennets Island
SI	=	Seavey Island
FA	=	Fill Area
DRMO	=	DRMO Facility
WOT	=	Waste Oil Tanks

Sample Location:

Groundwater sample = Monitoring well number

Medium:

GW = Groundwater from monitoring well

Sample Round Identifier:

For all samples = sampling round

- Baseline Conditions, first event, Round 7
- Baseline Conditions, second event, Round 8
- Subsequent Sampling, Round 9, 10, etc.

For example, a groundwater sample collected from monitoring well 13DB at Jamaica Island Landfill during establishment of second event baseline conditions would be designated as: JILF-13DB-GW07-8

Field quality control (QC) samples are described in Section 4.3.8. They will be designated using a different coding system. The QC code will consist of a two-segment, alpha-numeric code that identifies the sample medium (for duplicates only), QC type, and date. The same sample medium codes will be used as for the standard environmental samples (GW, SW, SD, and SO). The QC types are identified as:

FB = Field Blanks
RB = Rinsate Blanks
TB = Trip Blanks
FD = Field Duplicates

Matrix Spike and Matrix Spike Duplicate (MS/MSD) samples will be designated on the field documentation forms and sample labels. MS/MSDS are collected at a frequency of 1 per 20 samples per matrix and double or triple volumes of sample are required.

For example, a duplicate of a groundwater sample obtained on February 3, 1994 would be designated as: GWFD-020394

The sampling time recorded on the chain-of-custody form for duplicate and matrix spike/matrix spike duplicate samples will be 00:00 so that the samples are "blind" to the laboratory. Notes detailing the

sample number, time, date, and type will be recorded in the field log book.

4.3.6 Sample Handling

Sample handling includes the field related considerations connected with the selection of sample containers, preservatives, allowable holding times, and analyses requested. Table 4-1 provides a summary of all sample handling considerations. Section 5.0 of SOP-SF-1.2, attached in Appendix B, provides a description of Sample Preservation Requirements.

4.3.7 Chain-of-Custody

Sample custody procedures are designed to provide documentation of preparation, handling, storage, and shipping of all samples collected. An example of the chain-of-custody form, which will be used during this investigation, is included in Appendix A. A copy of the procedure is included in Appendix B.

Integrity of the samples collected during the site investigation will be the responsibility of identified persons from the time they are collected until they, or their derived data, are incorporated into the final report. Stringent chain-of-custody procedures will be followed to document sample possession.

Field Custody

- The FTL is responsible for the care and custody of the samples collected until they are delivered to the analyzing laboratory or entrusted to a carrier.

- Sample logs or other records will be signed and dated.

- Chain-of-custody sample forms will be completed to the fullest extent possible prior to sample shipment. They will include the following information: project name, sample number, time collected, source of sample and location, description of sample location, matrix, type of sample, grab or composite designation, preservative, and name of sampler (see attached form).

These forms will be filled out in a legible manner, using waterproof ink, and will be signed by the sampler. Similar information will be provided on the sample label which will be securely attached to the sample bottle. The label will also include the general analyses to be conducted. In addition, sampling forms will be used to document collection, filtration, and preparation procedures. Copies of all forms used during field activities are provided in Appendix A.

Transfer of Custody and Shipment

The following procedures will be used when transferring custody of samples:

- Samples will be accompanied by a chain-of-custody record. When transferring samples, the individuals relinquishing and receiving them will sign, date, and note the time of the chain-of-custody record. This record documents the sample custody transfer from the sampler to the laboratory, often through another person or agency (common carrier). Upon arrival at the laboratory, internal sample custody procedures will be followed.

- Prior to shipment to the laboratory for analysis, samples will be properly packaged. Individual custody records will accompany each shipment. Shipping containers will then be sealed for shipment to the laboratory. The methods of shipment, courier name, and other pertinent information, will be entered in the remarks section of the custody record.

- All shipments will be accompanied by the chain-of-custody record identifying the contents. The original record will accompany the shipment; and a copy will be retained by the field sampler.

- Proper documentation will be maintained for shipments by common carrier.

Sample Shipment Procedures

The following procedures will be followed when shipping samples for laboratory analysis:

- Samples requiring cooling to 4°C will be promptly chilled with ice or Blue Ice and will be

packaged in an insulated cooler for transport to the laboratory. Ice will be sealed in containers to prevent leakage of water. Samples will not be frozen.

- Only shipping containers that meet all applicable state and Federal standards for safe shipment will be used.

- Shipping containers will be sealed with nylon strapping tape, custody seals will be signed, dated, and affixed, in a manner that will allow the receiver to quickly identify any tampering that may have occurred during transport to the laboratory.

- The field chain-of-custody document will be placed inside the shipping container in a sealed plastic envelope.

- Shipment will be made by a public courier. After samples have been taken, they will be sent to the laboratory within 24 hours.

Field Documentation Responsibilities

It will be the responsibility of the FTL to secure all documents produced in the field (e.g., sampling logs, calibration forms) at the end of each work day. A copy of all forms used during field activities are included in Appendix A. Copies of all field logbooks will be sent to NORTHDIV monthly, to the attention of Rich Fini.

The possession of all records will be documented; however, only the project FTL or designee may remove field data from the site for reduction and evaluation.

Laboratory Sample Custody

To ensure the integrity of a sample from collection through analysis, it is necessary to have an accurate, written record that traces the possession and handling of the sample. This documentation is referred to as the sample chain-of-custody.

A sample is under custody if

- The sample is in the physical possession of an authorized person.
- The sample is in view of an authorized person after being in his/her possession.
- The sample is placed in a secure area by an authorized person after being in his/her possession.
- The sample is in a secure area, restricted to authorized personnel only.

Sample custody during collection and shipping is discussed in Section 5.3 of Halliburton NUS SOP SA-6.1, attached in Appendix B. Laboratory sample custody is discussed in the following sections.

When samples are received, the shipping manifest is signed and dated to acknowledge sample receipt. The sample custodian must examine the shipping containers and verify that the correct number of containers was received. The shipping containers are then opened and the enclosed sample paperwork is removed. Samples are removed from the shipping containers and the bottle condition must be noted. The information on the chain-of-custody, the airbill, the containers, and the laboratory request is reviewed to note any discrepancies.

All samples received by the laboratory must be stored at 4°C until analysis. Laboratory holding times are specified by the contract and are presented in Table 4-1.

4.3.8 Quality Control Samples

Field Blanks

Field blanks are not anticipated for the long-term monitoring program unless new monitoring wells are installed or non-dedicated bailers are used for sampling. Field blanks are obtained by sampling the water(s) used in decontamination during the field investigation activities. Samples consist of the source water used in: (1) steam cleaning of large equipment and (2) analyte-free water used for decontamination of sampling equipment. Field blanks will be used to confirm the effectiveness of decontamination procedures, and to determine if the analyte-free water or the potable water (used for steam cleaning) may

be contributing to sample contamination. Field blanks will be collected for each type of water used for decontamination and will be submitted at a frequency of one per sampling event. Field blanks will be obtained during the early days of the sampling activities.

Rinsate Blanks

Equipment rinsate blanks are not anticipated for the long-term monitoring program unless new monitoring wells are installed or non-dedicated bailers are used for sampling. Equipment rinsate blanks are obtained under representative field conditions by running analyte-free water through sample collection equipment (bailer, split-spoon, corer, etc.) after decontamination and placing it in the appropriate sample containers for analysis. Equipment blanks will be used to assess the effectiveness of decontamination procedures. Equipment blanks will be collected for each type of non-dedicated sampling equipment used and will be submitted at a frequency of one per day per media. Equipment blanks, however, will only be analyzed every other day unless positive detections are recorded in the prior rinsate blank. For dedicated or precleaned equipment, rinsate blanks will be collected and analyzed at a frequency of one per lot for a specific equipment type. It will be the responsibility of the FTL to communicate to the laboratory whether an equipment blank is, or is not, to be analyzed as stated above.

Field Duplicates

Field duplicates are two samples collected: (1) independently at a sampling location in the case of groundwater or surface water, or (2) a single sample split into two portions in the case of soil or sediment. Duplicates are obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis program. Ten percent of all samples for each media shall be field duplicates. Duplicates shall be analyzed for the same parameters in the laboratory and will be labeled so as to make the identity of the duplicate unknown to the laboratory.

Trip Blanks

Trip blanks are samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organic analysis samples (such as TCL volatiles). One trip blank will be collected per each cooler containing volatile organics. Trip blanks are only analyzed for the volatile constituents that are being shipped in a given cooler.

5.0 PREPARATION, EVALUATION, AND RESPONSE FOR GROUNDWATER MONITORING

5.1 DATA VALIDATION

Although no formal data validation will be conducted, limited analytical data evaluation will be conducted to ensure that only true data points are considered for decision-making purposes. Limited data validation will consist of the following:

- Analytical holding time compliance review
- Gross calibration deficiency review to determine if gross false negatives potentially exist
- Evaluation of laboratory and field blank contamination

In the performance of limited data evaluation, only informal deliverables consisting of data evaluator's notes to file are generated; that is, no detailed memoranda comparable with full-scale data validation are generated.

5.2 PROCEDURES FOR DETERMINING SIGNIFICANT INCREASES FOR MONITORED CONTAMINANTS AND INDICATOR PARAMETERS

Compliance criteria will be in accordance with the Media Protection Standards, which are currently under development and review. In the future, if there is an exceedence, the NSY Portsmouth may resample within one month and repeat the analysis for those compounds that exceed the criteria, to confirm the elevated concentration.

Upon evaluation of the analytical data, statistical evaluation will be utilized if determined to be necessary. Variance among samples will be performed using tolerance levels based on the normal distribution. With this method, a tolerance interval is established for the background well(s) for each monitored constituent of concern. Sample analyses from downgradient wells are then compared to the established tolerance interval, with those values falling above the upper limit of the tolerance interval being considered statistically significant evidence of contamination. A coverage of the tolerance interval of 95% will be used, with tolerance coefficient of 95%. This combination results in a 95% certainty that the results from a well

unaffected by the unit operations will not exceed the upper 95% tolerance limit. The procedure for applying this statistical method to the monitoring data is as follows:

(1) Calculate the mean (M) and standard deviation (SD) of the background data set, for each monitored constituent.

(2) Calculate the upper tolerance limit (TL) as follows: TL=M+ (SD)(K), where K is the one sided tolerance factor found in Table 5, Appendix B of EPA's "Guidance Document for Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities" (EPA/530SW89-026).

(3) Compare the data from the downgradient wells to the tolerance limit for each constituent.

Until baseline conditions are established, background ranges of values for monitored constituents have not been established yet. Tolerance limits will be determined after the collection of four rounds of water quality data from the monitoring wells.

The results of each sampling round, along with the applicable data evaluation information, will be forwarded to the appropriate EPA and MEDEP personnel for evaluation. The sampling data for each well will be provided in a table format, with the tolerance limit also presented for each constituent (where statistical evaluation is warranted) for comparative purposes. Downgradient well samples that exhibit statistically significant increases in monitored constituents will be identified and the constituent exceedence levels identified. A project file and computer database will also be kept by the NSY Portsmouth with all of the groundwater monitoring data and statistical evaluations.

5.3 PROCEDURES FOR ANNUAL DETERMINATION OF AQUIFER FLOW RATE AND DIRECTION

All monitoring wells have been or will be measured for hydraulic conductivity via rising-head or falling-head slug tests. Water levels will be measured twice during each sampling round (to represent high tide and low tide conditions) to determine groundwater flow directions and assess seasonal fluctuations in the water table. Overall average groundwater flow directions and gradients will be established during the RFI Data Gap investigation. Additionally, based on semi-annual water level elevations, potentiometric surface or groundwater maps will be prepared on an annual basis.

5.4 CORRECTIVE ACTION

A Corrective Measures Study (CMS) is planned to address any corrective action to alleviate existing contamination problems. If future sampling results reveal evidence of significant contaminant increases in any of the monitored wells, the regulatory authorities will be notified in writing as to:

(1) Identification and concentrations of contaminants of concern

(2) Any proposed changes to the groundwater monitoring system at the facility

(3) Any proposed additions or changes to the monitoring frequency, sampling and analysis procedures or methods

(4) Notice of intent to seek an alternate concentration limit

(5) Within 180 days submit all data necessary to justify an alternate concentration limit and submit an engineering feasibility plan for a corrective action program

(6) If applicable, demonstrate that a source other than a regulated unit caused the contamination or that the detection is an artifact caused by an error in sampling, analysis or natural variation in the groundwater. In any case, the Navy will continue to monitor in accordance with the established monitoring program.

If the number, location, or depth of monitoring wells needs to be modified or evaluation of analytical data is required (e.g., risk assessment calculations), the necessary modifications will be made to bring the groundwater monitoring system into compliance with this requirement. If vertical migration of contaminants is suspected to be a problem, existing deep bedrock monitoring wells DW-7DB at the DRMO and JW-13D, JW-13DB, and JW-12D will be added to the monitoring program.

If warranted in the future, analytes which are not expected and not detected will be deleted from the analytical program, upon written request by the Navy and approval by the regulatory authorities. Similarly, written request and approval will be obtained in the future prior to switching to other analytical methods which are less expensive, yet include the primary contaminants of concern. One particular modification

that could be considered following completion of the base-line monitoring may be the replacement of TAL metals with the less expensive list of the eight RCRA metals list.

6.0 RECORDKEEPING

6.1 RECORDKEEPING

Records to be maintained throughout the site closure include boring logs, well construction logs, well purging/sampling forms, groundwater sample forms, chain-of-custody forms, laboratory analysis results, and static water level records. These records will be maintained by the NSY Portsmouth, at the Department of Natural Resources and Environmental Affairs.

Field personnel will use bound logbooks for the maintenance of all field records pertaining to well drilling and installation (if additional wells are required in the future) and sampling activities. These records will be maintained onsite and will document all visual observations, calculations and equipment adjustments. Every entry will be dated, and the time for each entry will be noted. The logbooks are controlled documents that will be properly maintained and retained as part of the project files.

Field notes will be maintained in the following manner:

- Entries into the field notebook will be legibly written in indelible ink.
- A new page will be used at the beginning of each day's activities. This page will identify the date, time, location, onsite personnel, and observed weather conditions.
- Sketches or maps will be included to identify well, sample and/or photograph locations. Maps should include a north arrow and scale.
- Information for water-level measurements will include a well number, date, time, and weather conditions at the time.
- Upon sample completion, notes will include date, time, sample locations, and sample ID numbers.
- None of the documents are to be destroyed or thrown away, even if they are illegible or contain inaccuracies.

6.2 DATA MANAGEMENT AND REPORTING

Appropriate data sheets will be used by the laboratory to record analysis data. Records of the groundwater analytical data will be kept in a computer database. A project file will also be kept which will include a copy of the groundwater monitoring data.

The following information will be reported to the EPA and the Maine Department of Environmental Protection (MEDEP):

- During the first two sampling events when baseline conditions are being established, and for subsequent sampling/analysis events, concentrations of the analytical parameters for each well will be reported within 30 days after receiving analytical results. In addition, any parameters that exceed the established Media Protection Standards will be identified. The data will be presented in tabular form and for each analyte the detection limit will also be presented.

- If applicable, the Navy will request in writing that certain analytes be deleted from subsequent sampling/analysis events.

- Groundwater contour maps will be produced from each round of water level measurements and submitted to the regulatory agencies on an annual basis. Water levels will be measured twice during each sampling round (to represent high tide and low tide conditions) to determine groundwater flow directions and assess seasonal fluctuations in the water table.

Groundwater monitoring reports will be presented in the following format:

1.0 Introduction
- 1.1 Purpose
- 1.2 Project Organization and Responsibilities
- 1.3 Scope of Work

2.0 Groundwater Sampling Procedures
- 2.1 Sample Locations and Analytical Methods
- 2.2 Sample Collection Procedures
- 2.3 Water Level Measurement

3.0 Results and Data Evaluation
3.1 Analytical Results
3.1.1 Analytical Results
3.1.2 Statistical Evaluations
3.2 Groundwater Flow Directions
3.2.1 Current Groundwater Flow Directions
3.2.2 Comparison with Previous Results
4.0 Recommendations

Appendix A - Chain of Custody Forms
Appendix B - Raw Analytical Data
Appendix C - Summary of Limited Data Validation
Appendix D - Statistical Calculations

7.0 SCHEDULE

Two baseline conditions monitoring events followed by semi-annual sampling is planned. The RFI Data Gap monitoring well installation is scheduled to occur in spring of 1994. Upon installation, the wells will be sampled in accordance with the RFI Data Gap planning documents (Halliburton NUS 1994). The existing RFI monitoring wells will be sampled in or about the same time in accordance with the requirements of the subject groundwater monitoring plan. In combination, this will comprise the establishment of baseline conditions - first event sampling event. For the establishment of baseline conditions -second event sampling event, both RFI and RFI Data Gap wells will be sampled/analyzed concurrently in accordance with the subject groundwater monitoring plan. Following establishment of baseline conditions, two quarters will elapse, then subsequent sampling/analyses will take place in accordance with the subject groundwater monitoring plan.

REFERENCES

Environmental Protection Agency (EPA), 1989; "Guidance Document for Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities", Table 5, Appendix B (EPA/530SW89-026).

Halliburton NUS, February 1994; RFI Data Gap Work Plan (Draft), Portsmouth Naval Shipyard.

McLaren Hart, August 1991; RCRA Facility Investigation Work Plan, Portsmouth Naval Shipyard, U.S. Department of the Navy, Naval Facilities Engineering Command, Philadelphia, PA

McLaren Hart, July 1992; RCRA Facility Investigation Report, Portsmouth Naval Shipyard, U.S. Department of the Navy, Naval Facilities Engineering Command, Philadelphia, PA

DRAFT

APPENDIX A
FIELD INVESTIGATION FORMS

HALLIBURTON NUS
Environmental Corporation

EQUIPMENT CALIBRATION LOG

Instrument (Name/Model No./Serial No.): _____

Manufacturer _____ Date Purchased _____

Calibration Date	Initial Settings	Standard/Gas Used	Procedure	Adjustments Made	Final Settings	Signature	Comments

GROUNDWATER LEVEL MEASUREMENT SHEET

HALLIBURTON NUS

Project Name: _____ Location: _____
Project No.: _____ Weather Conditions: _____
Personnel: _____ Measuring Device: _____
Date: _____ Remarks: _____
Tidally Influenced: Yes _____ No _____ _____

Well or Piezometer Number	Date/Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Correction Factor	Adjusted Depth (Feet)*	Groundwater Elevation (Feet)*

CAD: 1049\GW-LEVEL.DWG 3/18/91 WJJ

HALLIBURTON NUS
Environmental Corporation

SAMPLE LOG SHEET

☐ Monitoring Well Data
☐ Domestic Well Data
☐ Other _____

Page _____ of _____

Case # _____

By _____

Project Site Name _____ Project Site Number _____

NUS Source No. _____ Source Location _____

Total Well Depth:	Purge Data				
Well Casing Size & Depth:	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level:					
One Casing Volume:					
Start Purge (hrs.):					
End Purge (hrs.):					
Total Purge Time (min.):					
Total Amount Purged (gal.):					
Monitor Reading:					
Purge Method:					
Sample Method:					
Depth Sampled:					

Sample Date & Time:	Sample Data			
	pH	S.C.	Temp. (°C)	Color & Turbidity
Sampled By:				

Signature(s):

Observations / Notes:

Type of Sample

☐ Low Concentration
☐ High Concentration
☐ Grab
☐ Composite
☐ Grab - Composite

Analysis:	Preservative				

HALLIBURTON NUS
Environmental Laboratories
5350 CAMPBELLS RUN ROAD
PITTSBURGH, PA. 15205

NUS SAMPLE #

Client Name _____

Date Sampled _____ Time _____

Client Sample # _____

Sample Source _____

_____

HALLIBURTON NUS
Environmental Corporation

CUSTODY SEAL

Date

Signature

HALLIBURTON NUS
Environmental Corporation

CUSTODY SEAL

Date

Signature

CHAIN-OF-CUSTODY SEAL

HALLIBURTON NUS Envir nmental
C rporation and Subsidiaries

CHAIN OF CUSTODY RECORD

PROJECT NO.:	SITE NAME:
SAMPLERS (SIGNATURE):	

STATION NO.	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CON-TAINERS							REMARKS

RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED BY(SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE / TIME:	RECEIVED FOR LABORATORY BY (SIGNATURE):	DATE / TIME:	REMARKS:	

NUS 440 REVISED 0891

APPENDIX B

STANDARD OPERATING PROCEDURES (SOPS)

Hydrogeology

GH-2.5, Section 5.0: Water Level Measurement/Contour Mapping

Sampling

SA-1.1, Section 5.0: Groundwater Sample Acquisition

SA-6.1, Section 5.0: Sample Identification and Chain-of-Custody

SA-6.2, Section 5.0: Sampling Packaging and Shipping

SA-6.3, Section 5.0: Site Logbook

Support Field Methods

SF-1.1, Section 5.0: On-Site Water Quality Testing

SF-1.2, Section 5.0: Sample Preservation

SF-2.3, Section 5.0: Decontamination of Chemical Sampling and Field Analytical Equipment

5.0 PROCEDURES

5.1 GENERAL

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well evacuation or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the geologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment A), along with the date and time of the reading. The total depth of the well shall be measured and recorded, if not already known. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and bariometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. The reference point shall be noted in the field notebook. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater if required.

Water level readings shall be taken regularly, as required by the site hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map shall be made in the shortest practical time to minimize affects due weather changes, and at least during the same day.

5.2 WATER LEVEL MEASURING TECHNIQUES

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the onsite hydrogeologist.

In most instances, preparation of accurate potentiometric surface requires that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, the Chalked Tape or Electrical Water Level Indicator methods have been found best, and thus are the most often utilized. Other, less precise methods, such as the Popper or Bell Sound or Bailer Line methods, may be appropriate for developing preliminary estimates of hydraulic conditions. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use the Float Recorder or Pressure Transducer methods. When conditions in the well limit readings (i.e., turbulence in the

water surface or limited access through small diameter tubing), less precise, but appropriate, methods such as the Air Line or Capillary Tubing methods can be used.

5.2.1 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment as required.

2. Record all information specified below in the geologist's field notebook or on the Groundwater Level Measurement Sheet.

   a. Well number.
   b. Record water level to the nearest 0.01 foot (0.3 cm). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing.
   c. Record the time and day of the measurement.

Water level measuring devices with permanently marked intervals shall be used when possible. If water level measuring devices marked by metal or plastic bands clamped at intervals along the measuring line are used, the spacing and accuracy of these bands shall be checked frequently as they may loosen and slide up or down the line, resulting in inaccurate reference points (see Section 5.2.3).

5.2.2 Water Level Measuring Devices

Chalked Steel Tape

The water level is measured by chalking a weighted steel tape and lowering it a known distance (to any convenient whole foot mark) into the well or borehole. The water level is determined by subtracting the wetted chalked mark from the total length lowered into the hole.

The tape shall be withdrawn quickly from the well because water has a tendency to rise up the chalk due to capillary action. A water finding paste may be used in place of chalk. The paste is spread on the tape the same way as the chalk, and turns red upon contacting water.

Disadvantages to this method include the following: depths are limited by the inconvenience of using heavier weights to properly tension longer tape lengths; ineffective if borehole/well wall is wet or inflow is occurring above the static water level; chalking the tape is time consuming; difficult to use during periods of precipitation.

Electric Water Level Indicators

These devices consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, the probe shall be lowered slowly into the well. The electric tape is marked at the measuring point where contact with the water surface was indicated. The distance from the mark to the nearest tape band is measured using an engineer's folding ruler or steel tape and added to the band reading to obtain the depth to water. If band is not a permanent marking band, spacing shall be checked periodically as described in Section 5.2.3.

Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

Float Recorder

A float or an electromechanically actuated water-seeking probe may be used to detect vertical changes of the water surface in the hole. A paper-covered recording chart drum is rotated by the up and down motion of the float via a pulley and reduction gear mechanism, while a clock drive moves a recording pen horizontally across the chart. To ensure continuous records, the recorder shall be inspected, maintained, and adjusted periodically. This type of device is useful for continuously measuring periodic water level fluctuations, such as tidal fluctuations or influences of pumping wells.

Air Line

An air line is especially useful in pumped wells where water turbulence may preclude the use of other devices. A small-diameter weighted tube of known length is installed from the surface to a depth below the lowest water level expected. Compressed air (from a compressor, bottled air, or air pump) is used to purge the water from the tube, until air begins to escape the lower end of the tube, and is seen (or heard) to be bubbling up through the water in the well. The pressure needed to purge the water from the air line multiplied by 2.307 (feet of water for 1 psi) equals the length in feet of submerged air line. The depth to water below the center of the pressure gauge can be calculated by subtracting the length of air line below the water surface from the total length of the air line.

The disadvantages to this method include the need for an air supply and lower level of accuracy (unless a very accurate air pressure gauge is used, this method cannot be used to obtain water level readings to the nearest 0.01 ft).

Capillary Tubing

In small diameter piezometer tubing, water levels are determined by using a capillary tube. Colored or clear water is placed in a small "U"-shaped loop in one end of the tube (the rest of the tube contains air). The other end of the capillary tube is lowered down the piezometer tubing until the water in the loop moves, indicating that the water level has been reached. The point is then measured from the bottom of the capillary tube or recorded if the capillary tube is calibrated. This is the best method for very small diameter tubing monitoring systems such as Barcad and other multilevel samples. Unless the capillary tube is calibrated, two people may be required to measure the length of capillary tubing used to reach the groundwater. Since the piezometer tubing and capillary tubing usually are somewhat coiled when installed, it is difficult to accurately measure absolute water level elevations using this method. However, the method is useful in accurately measuring differences or changes in water levels (i.e., during pumping tests).

Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost-effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

Bailer Line Method

Water levels can be measured during a bailing test of a well by marking and measuring the bailer line from the bottom of the bailer (where water is first encountered) to the point even with the top of the well casing. This is a useful technique during bailing tests (particularly if recovery is rapid) if the bailer is heard hitting the water. However, it is not recommended for measuring static water levels because it is not usually as accurate as some of the other methods described above.

5.2.3 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the geologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements shall be measured from a known reference point. The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point shall be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

5.2.4 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells.

Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy periodically. A water level indicator calibration sheet shall be completed each time the measuring device is checked. A water level indicator calibration form is shown in Attachment A. The "actual reading" column on the sheet is the actual length of the interval from the end of the indicator to the appropriate marked depth interval. In many cases, these measurements are different b cause the water lev l m asuring device is connected to the end of the measuring tape or line, and may extend beyond "0" feet on the measuring line.

5.3 POTENTIOMETRIC SURFACE MAPPING

5.3.1 Selection of Wells

All wells used to prepare a flow net in a plan or map view should represent the same hydrogeologic unit, be it aquifer or aquitard. All water level measurements used shall be collected on the same day.

Before mapping, review the recorded water levels and monitoring-well construction data, site geology and topographic setting to ascertain that the wells are completed in the same hydrogeologic unit and to determine if strong vertical hydraulic gradients may be present. Such conditions will be manifested by a pronounced correlation between well depth and water level, or by a difference in water level between two wells located near each other but set to different depths or having different screen lengths. Professional judgment of the hydrogeologist is important in this decision. If vertical gradients are significant, the data to be used must be limited vertically, and only wells finished in a chosen vertical zone of the hydrogeologic unit can be used.

At least three wells must be used to provide an estimation of the direction of groundwater flow, and many more wells will be needed to provide an accurate contour map. Generally, shallow systems require more wells than deep systems for accurate contour mapping.

5.3.2 Construction of Equipotential Lines

Plot the water elevations in the chosen wells on a site map. Other hydrogeologic features associated with the zone of interest -- such as seeps, wetlands, and surface-water bodies -- should also be plotted along with their elevations.

The data should then be contoured, using mathematically valid and generally accepted techniques. Linear interpolation is most commonly used, as it is the simplest technique. However, quadratic interpolation or any technique of trend-surface analysis or data smoothing is acceptable. Computer-generated contour maps may be useful for large data sets. Contour lines shall be drawn as smooth, continuous lines which never cross one another.

Inspect the contour map, noting known features, such as pumping wells and site topography. The contour lines must be adjusted in accordance with these, utilizing the professional judgment of the hydrogeologist. Closed contours should be avoided unless a known sink exists. Groundwater mounding is common under landfills and lagoons; if the data imply this, the feature must show in the contour plot.

5.3.3 Determination of Groundwater-Flow Direction

Flow lines shall be drawn so that they are perpendicular to equipotential lines. Flow lines will begin at high head elevations and end at low head elevations. Closed highs will be the source of additional flow lines. Closed depressions will be the termination of some flow lines. Care must be used in areas with significant vertical gradients to avoid erroneous conclusions concerning gradients and flow directions.

5.4 HEALTH AND SAFETY CONSIDERATIONS

Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a Health/Safety hazard which must be considered. Initial monitoring of the well headspace and breathing zone

concentrations using a PID (HNU) or FID (OVA) and combustible gas meters shall be performed to determine required levels of protection.

6.0 REFERENCES

Freeze, R. A. and J. A. Cherry, 1979. Groundwater. Prentice-Hall, Englewood Cliffs, New Jersey, 604 pp.

Cedergren, H. R., 1977. Seepage, Drainage and Flow Nets (2nd edition). John Wiley and Sons, New York.

Fetter, C. W., 1980. Applied Hydrogeology. Me , Columbus, Ohio, 488 pp.

7.0 ATTACHMENTS

Attachment A - Groundwater Level Measurem neet

Attachment B - Water Level Indicator Calibration Sheet.

- Other sampling equipment - Bailers and monofilament line with tripod-pulley assembly (if necessary). Bailers shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.

- Pails - Plastic, graduated.

- Decontamination solutions - Distilled water, Alconox, methanol, acetone.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cl aned, sterilized, and reused, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well flushing and sample collection.

5.3 CALCULATIONS OF WELL VOLUME

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the field logbook and on the field data form (Attachment A):

- Obtain all available information on well construction (location, casing, screens, etc.).

- Determine well or casing diameter.

- Measure and record static water level (depth below ground level or top of casing reference point).

- Determine depth of well (if not known from past records) by sounding using a clean, decontaminated weighted tape measure.

- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

- Calculate one static well volume in gallons ($V = 0.163Tr^2$).

  where:

V	=	Static volume of well in gallons.
T	=	Thickness of water table in the well measured in feet, i.e., linear fe t of static water.
r	=	Inside radius of well casing in inches.
0.163	=	A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Determine the minimum amount to be evacuated before sampling.

5.4 EVACUATION OF STATIC WATER (PURGING)

5.4.1 General

The amount of flushing a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pump d until the parameters such as temperature, electrical conductance, and pH have stabilized. Onsite measurements of these parameters shall be recorded on the field data form.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce significant groundwater flow from other areas. Generally three to five well volumes are considered effective for purging a well.

The site hydrogeologist, geochemist and risk assessment personnel shall define the objectives of the groundwater sampling program in the Work Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment B provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

5.4.2.1 Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist f a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and fav red, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- There is minimal outgassing of volatile organics while the sample is in the bail r.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use f bailers is physically demanding, especially in warm temperatures at protecti n lev is above Level D.

1.0 PURPOSE

The purpose of this procedure is to provide general reference information on the sampling of groundwater wells. The methods and equipment described are for the collection of water samples from the saturated zone of the subsurface.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Hydrogeologist or Geochemist - responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, documenting these in the Project Operations Plan (POP), and properly briefing the site sampling personnel.

Site Geologist - The Site Geologist is primarily responsible for the proper acquisiti n of the groundwater samples. When appropriate, such responsibilities may be performed by other qualified personnel (engineers, field technicians).

Site Manager - The Site Manager is responsible for reviewing the sampling procedures used by the field crew and for performing in-field spot checks for proper sampling procedures.

5.0 PROCEDURES

5.1 GENERAL

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of testing in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the scre n d s ction will remain is lated and bec me stagnant. To safeguard against collecting non-representative stagnant water in a sample, the foll wing approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation f three to five volumes is recommended for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the scre ned section, evacuation prior to sample withdrawal is not as critical.

2. For wells that can be purged to dryness with the sampling equipment being used, the well shall be evacuated and allowed to recover prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is preferred.

3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of th following techniques shall be used to minimize this possibility:

- A submersible pump, intake line of a surface pump or bailer shall be placed just bel w the water surface when removing the stagnant water and lowered as the water level decreases. Three to five volumes of water shall be removed to provide reasonabl assurance that all stagnant water has been evacuated. Once this is accomplished a bailer may be used to collect the sample for chemical analysis.

- The inlet line of the sampling pump (or the submersible pump itself) shall be placed n ar the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a rate equal to the well's recovery rate.

Stratification of contaminants may exist in the aquifer formation, both in terms of a concentration gradients due to mixing and dispersion processes in a homogeneous layer, and in layers of variable permeability into which a greater or lesser amount of the contaminant plume has flowed. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point, and thus result in the collection of a non-representative sample.

5.2 SAMPLING, MONITORING, AND EVACUATION EQUIPMENT

Sample containers shall conform with EPA regulations for the appropriate contaminants.

The following equipment shall be on hand when sampling ground water wells:

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate packing containers and filler, ice, labels and chain-of-custody documents.

- Field tools and instrumentation - Thermometer; pH paper/meter; camera and film; tags; appropriate keys (for locked wells); engineers rule; water-level indicat r; wher applicable, specific-conductivity meter.

- Pumps

  - Shallow-well pumps—Centrifugal, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.

  - De p-well pumps—submersibl pump and electrical power generating unit, or air-lift apparatus wher applicabl .

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record and maintaining custody of samples until they are relinquished to another custodian, to the shipper, or to the common carrier.

Remedial Investigation Leader - Responsible for determining that chain-of-custody procedures have been met by the sample shipper and analytical laboratory.

5.0 PROCEDURES

5.1 OVERVIEW

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is what it is represented to be. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom and, secondly, provide security for the evidence as it is moved and/or passes from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain of possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

5.2 SAMPLE IDENTIFICATION

The method of identification of a sample depends on the type of measurement or analysis performed. When in-situ measurements are made, the data are recorded directly in bound l gbooks or other field data records, with identifying information.

5.2.1 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling Plan. Each sample container is identified by a sample label (see Attachment B). Sample labels are provided by the PMO. The information recorded on the sample label includes:

- **Project:** EPA Work Assignment Number (can be obtained from the Sampling Plan).
- **Station Location:** The unique sample number identifying this sample (can b obtain d from the Sampling Plan).
- **Date:** A six-digit number indicating the day, month, and year of sample collection; e.g., 12/21/85.
- **Time:** A f ur-digit number indicating the 24-h ur tim f collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).

  Medium: Water, s il, sediment, sludge, waste, etc.

- **Concentration:** The expected concentration (i.e., low, medium, high).
- **Sample Type:** Grab or composite.
- **Preservation:** Type of preservation added and pH levels.
- **Analysis:** VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- **Sampled By:** Printed name of the sampler.
- **Case Number:** Case number assigned by the Sample Management Office.
- **Traffic Report Number:** Number obtained from the traffic report labels.
- **Remarks:** Any pertinent additional information.

Using just the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing analysis fr m knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previ us work on the site).

5.2.2 Sample Identification Tag

A Sample Identification Tag (Attachment F) must also be used for samples collected for CLP (Contract Laboratory Program) analysis. The Sample Identification Tag is a w ², waterproof paper label, approximately 3-by-6 inches, with a reinforced eyelet, and string or w or attachment to th neck of the sample bottle. The Sample Tag is a controlled document, and i. ovided by the regional EPA office. Following sample analysis, the Sample Tag is retained by the la. atory as evidence of sampl receipt and analysis.

The following information is recorded on the tag:

- **Project Code:** Work Assignment Number.
- **Station Number:** The middle portion of the Station Location Number, (betw n th hyphens).
- **Month/Day/Year:** Same as Date on Sample Label.
- **Time:** Same as Time on Sample Label.
- **Designate - Comp/Grab:** Composite or grab sample.
- **Station Location:** Same as Station Location on Sample Label.
- **Samplers:** Sam as Sampled By on Sample Label.
- **Preservative:** Yes r N .
- **Analyses:** Check appropriate b x(es).

- **Remarks:** Same as Remarks on Sample Label (make sure the Case Number and Traffic Report numbers are recorded).

- Lab Sample Number: For laboratory use only.

The tag is then tied around the neck of the sample bottle.

If the sample is to be split, it is aliquoted into similar sample containers. Identical information is completed on the label attached to each split.

Blank, duplicate, or field spike samples shall not be identified as such on the label, as they may compromise the quality control function. Sample blanks, duplicates, spikes, and splits are defined in Procedure SA-6.6.

5.3 CHAIN-OF-CUSTODY PROCEDURES

After collection, separation, identification, and preservation, the sample is maintain d under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed of.

5.3.1 Field Custody Procedures

- Samples are collected as described in the site-specific Sampling Plan. Care must be taken to record precisely the sample location and to ensure that the sample number n the label matches the sample log sheet and Chain-of-Custody Record exactly.

- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation pr cedur , the name of the photographer, date, time, site location, and site description are ent red sequentially in the site logbook as photos are taken. Once developed, the photographic prints shall be serially numbered, corresponding to the logbook descriptions.

- Sample labels shall be completed for each sample, using waterproof ink unless pr hibited by weather conditions, e.g., a logbook notation would explain that a pencil was used to fill out the sample label because a ballpoint pen would not function in freezing w atn r.

5.3.2 Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. Chain-of-Custody Record Forms used in EPA Regions I-IV are shown in Attachments A through D. The appropriate form shall b obtain d from the EPA Regional Office. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as follows:

- Enter header information (project number, samplers, and project name -- project name can b obtained from the Sampling Plan).

  Sign, date, and ent r the tim under "Relinquished by" entry.

- Enter station number (the station number is the middle portion of the stati n location number, between the hyphens).
- Check composite or grab sample.
- Enter station location number (the same number as the station location on the tag and label).
- Enter the total number of containers per station number and the type of each bottle.
- Enter either the inorganic traffic report number, the organic traffic report number, or th SAS number for each station number in the remarks column.
- Enter the tag number from the bottom of the sample identification tag in the remarks column for each station location.
- Make sure that the person receiving the sample signs the "Received by" entry, or enter the name of the carrier (e.g., UPS, Federal Express) under "Received by." Receiving laborat ry will sign "Received for Laboratory by" on the lower line and enter the date and time.
- Enter the bill-of-lading or Federal Express airbill number under "Remarks," in the bottom right corner, if appropriate.
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in th appropriate sample shipping package. Retain the pink copy with field records.
- Sign and date the custody seal, a 1- by 3-inch white paper label with black lettering and an adhesive backing. Attachment G is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they hav been collected in the field. Custody seals are provided by ZPMO on an as-needed basis.
- Place the seal across the shipping container opening so that it would be broken if the container is opened.
- Complete other carrier-required shipping papers.

The custody record is completed using black waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Rec rd Forms; this necessitates packing the record in the sample container (enclosed with other documentation in a plastic zip-lock bag). As long as custody forms are sealed inside the sample container and th custody seals are intact, commercial carriers are not required to sign off on the custody form.

If sent by mail, the package will be registered with return receipt requested. If sent by common carrier or air freight, proper documentati n must b maintained.

The lab ratory representative who accepts the incoming sampl shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then th laboratory's responsibility to maintain internal logbooks and custody records through ut sample preparati n and analysis.

5.3.3 Receipt for Samples Form

Whenever samples are split with a private party or government agency, a separate Receipt for Samples Record Form is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the party or agency shall require the signature of a representative of the appropriate party acknowledging receipt of the samples. If a representative is unavailable or refuses to sign, this is noted in the "Received by" space. When appropriate, as in the case where the representative is unavailable, the custody record shall contain a statement that the samples were delivered to the designated location at the designated time. This form must be completed and a copy given to the owner, operator, or agent-in-charge even if the offer for split samples is declined. The original is retained by the Field Operations Leader.

6.0 REFERENCES

U.S. EPA, 1984. User's Guide to the Contract Laboratory Program, Office of Emergency and Remedial Response, Washington, D.C.

7.0 ATTACHMENTS

Attachment A - Chain-of-Custody Record Form for use in Region I
Attachment B - Chain-of-Custody Record Form for use in Region II
Attachment C - Chain-of-Custody Record Form for use in Region III
Attachment D - Chain-of-Custody Record Form for use in Region IV
Attachment E - Sample Label
Attachment F - Sample Identification Tag
Attachment G - Chain-of-Custody Seal

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Reportable Quantity (RQ) - A parenthetical note of the form "(RQ-1000/454)" following an entry in the DOT Hazardous Materials table (49 CFR 172.101) indicates the reportable quantity of the substance in pounds and kilograms. If a spill of that amount or more of the substance occurs during transit or storage, a report must be filed with DOT according to ¶171.15-15 concerning hazardous materials incidents reports. If the material spilled is a hazardous waste, a report must always be filed, regardless of the amount, and must include a copy of the manifest. If the RQ notation appears, it must be shown either immediately before or after the proper shipping name on the shipping paper (or manifest). Most shipping papers and manifests will have a column designated "HM" which may be used for this purpose.

4.0 RESPONSIBILITIES

Field Operations Leader or Team Sampling Leader - responsible for determining that samples are properly packaged and shipped.

Sampling Personnel - responsible for implementing the packaging and shipping requirements.

5.0 PROCEDURES

5.1 INTRODUCTION

Samples collected for shipment from a site shall be classified as either environmental or hazardous material (or waste) samples. In general, environmental samples are collected off-site (f r example from streams, ponds, or wells) and are not expected to be grossly contaminated with high lev is f hazardous materials. On-site samples (for example, soil, water, and materials from drums or bulk storage tanks, obviously contaminated ponds, lagoons, pools, and leachates from hazardous waste sites) are considered hazardous. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples. If there is any doubt, a sample shall be considered hazardous and shipped accordingly.
- Protect the health and safety of laboratory personnel receiving the samples. Special precautions are used at laboratories when samples other than environmental samples are received.

5.2 ENVIRONMENTAL SAMPLES

5.2.1 Packaging

Environmental samples may be packaged following the procedures outlined in Secti n 5.4 f r samples classified as "flammable liquids" or "flammable solids." Requirements for marking, labeling, and shipping papers do not apply.

Environmental samples may also be packed without being placed inside metal cans as required for flammable liquids or solids.

- Place sample container, properly identified and with a sealed lid, in a polyethylene bag, and seal the bag.
- Place sample in a fiberboard container or metal picnic cooler which has been lined with a large polyethylene bag.
- Pack with enough noncombustible, absorbent, cushioning materials to minimize the possibility of the container breaking.
- Seal large bag.
- Seal or close outside container.

5.2.2 Marking Labeling

Sample containers must have a completed sample identification tag and the outside container must be marked "Environmental Sample." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling are required.

5.2.3 Shipping Papers

No DOT shipping papers are required. However, the appropriate chain-of-custody forms must be included with the shipment.

5.2.4 Transportation

There are no DOT restrictions on mode of transportation.

5.3 DETERMINATION OF SHIPPING CLASSIFICATION FOR HAZARDOUS MATERIAL SAMPLES

Samples not determined to be environmental samples, or samples known or expected to contain hazardous materials, must be considered hazardous material samples and transported according to the requirements listed below.

5.3.1 Known Substances

If the substance in the sample is known or can be identified, package, mark, label and ship according to the specific instructions for that material (if it is listed) in the DOT Hazardous Materials Table, 49 CFR 172.101.

Unz and Company have published the following steps to help in locating a proper shipping name from the Hazardous Materials Table, 49 CFR 172.101.

1. Look first for the chemical or technical name of the material, for example, ethyl alcohol. Note that many chemicals have more than one technical name, for example, perchloroethylene (not listed in 172.101) is also called tetrachloroethylene (listed 172.101). It may be useful to consult a chemist for all possible technical names a material can have. If your material is not listed by its technical name then. . . . . .

2. Look for the chemical family name. For example, pentyl alcohol is not listed but the chemical family name is: alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed then. . . . . .

3. Look for a generic name based on end use. For example, Paint, n.o.s or Fireworks, n.o.s. if a generic name based on end use is not listed then. . . . . .

4. Look for a generic family name based on end use, for example, drugs, n.o.s. or cosmetics, n.o.s. Finally, if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazardous classes, then. . . . . .

5. You will have to go the the general hazard class for a proper shipping name. For example, Flammable Liquid, n.o.s, or Oxidizer, n.o.s.

5.3.2 Unknown Substances

For samples of hazardous substances of unknown content, select the appropriate transportation category according to the DOT Hazardous Materials Classification (Attachment A), a priority system of transportation categories.

The correct shipping classification for an unknown sample is selected through a process of elimination, utilizing Attachment A. Unless known or demonstrated otherwise (through the use of radiation survey instruments), the sample is considered radioactive and appropriate shipping regulations for "radioactive material" followed.

If a radioactive material is eliminated, the sample is considered to contain "Poison A" materials (Attachment B), the next classification on the list. DOT defines "Poison A" as extremely dangerous poisonous gases or liquids of such a nature that a very small amount of gas, or vapor of the liquids, mixed with air is dangerous to life. Most Poison A materials are gases or compressed gases and would not be found in drum-type containers. Liquid Poison A would be found only in closed containers; however,all samples taken from closed drums do not have to be shipped as Poison A, which provides for a "worst case" situation. Based upon information available, a judgment must be made whether a sample from a closed container is a Poison A.

If Poison A is eliminated as a shipment category, the next two classifications are "flammable" or "nonflammable" gases. Since few gas samples are collected, "flammable liquid" would be the next applicable category. With the elimination of radioactive material, Poison A, flammable gas, and nonflammable gas, the sample can be classified as flammable liquid (or solid) and shipped accordingly. These procedures would also suffice for shipping any other samples classified below flammable liquids in the DOT classification table (Attachment A). For samples containing unknown materials, categories listed below flammable liquids/solids on Attachment A are generally not used because showing that these materials are not flammable liquids (or solids) requires flashpoint testing, which may be impractical and possibly dangerous at a site. Thus, unless the sample is known to consist of materials listed as less hazardous than flammable liquid (or solid) on Attachment A, it is considered a flammable liquid (or solid) and shipped as such.

For any hazardous material shipment, utilize the shipping checklist (Attachment C) as a guideline to ensure that all sample-handling requirements are satisfied.

5.4 PACKAGING AND SHIPPING OF SAMPLES CLASSIFIED AS FLAMMABLE LIQUID (OR SOLID)

5.4.1 Packaging

Applying the word "flammable" to a sample does not imply that it is in fact flammabl . The w rd prescribes the class of packaging according to DOT regulations.

1. Collect sample in the prescribed container with a nonmetallic, Teflon-lined screw cap. To prevent leakage, fill container no more than 90 percent full.

2. Complete sample label and sample identification tag and attach securely to sample container.

3. Seal container and place in 2-mil thick (or thicker) polyethylene bag, one sample per bag. Position sample identification tag so that it can be read through bag. Seal bag.

4. Place sealed bag inside metal can and cushion it with enough noncombustible, absorbent material (for example, vermiculite or diatomaceous earth) between the bottom and sides of the can and bag to prevent breakage and absorb leakage. Pack one bag per can. Use clips, tape, or other positive means to hold can lid securely, tightly and permanently. Mark can as indicated in Paragraph 1 of Section 5.4.2, below.

5. Place one or more metal cans (or single 1-gallon bottle) into a strong outside container, such as a metal picnic cooler or a DOT-approved fiberboard box. Surround cans with noncombustible, absorbent cushioning materials for stability during transp rt. Mark container as indicated in Paragraph 2 of Section 5.4.2.

5.4.2 Marking/Labeling

1. Use abbreviations only where specified. Place the following information, either hand-printed or in label form, on the metal can (or 1-gallon bottle):

   - Laboratory name and address.

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."

Not otherwise specified (n.o.s) is not used if the flammable liquid (or solid) is identified. Then th name of the specific material is listed before the category (for example, Acetone, Flammable Liquid), followed by its appropriate UN number found in the DOT Hazardous Materials table (49 CFR 172.101).

2. Place all information on outside shipping container as on can (or bottle), specifically:

   - Proper shipping name.
   - UN or NA number.
   - Proper label(s).
   - Addressee and sender.

   Place the following labels on the outside shipping container: "Cargo Aircraft Only" and "Flammable Liquid" (or "Flammable Solid"). "Dangerous When Wet" label shall be used if the solid has not been exposed t a wet envir nm nt. "Laborat ry Samples" and "THIS SIDE UP" r "THIS END UP" shall also be marked n the top f the outside c ntainer, and upward-pointing arrows shall be placed n all four sides of the container.

5.4.3 Shipping Papers

1. Use abbreviations only where specified. Complete the carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form, see Attachment D). Provide the following information in the order listed (one form may be used for more than one exterior container).

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."
   - "Limited Quantity" (or "Ltd. Qty.").
   - "Cargo Aircraft Only."
   - Net weight (wt) or net volume (vol), just before or just after "Flammable Liquid, n.o.s." or "Flammable Solid, n.o.s.," by item, if more than one metal can is inside an exterior container.
   - "Laboratory Samples" (if applicable).

2. Include Chain-of-Custody Record, properly executed in outside container.

3. "Limited Quantity" of "Flammable Liquid, n.o.s." is limited to one pint per inner container. For "Flammable Solid, n.o.s.," net weight of inner container plus sample shall not exceed one pound; total package weight shall not exceed 25 pounds.

5.4.4 Transportation

1. Transport unknown hazardous substance samples classified as flammable liquids by rented or common carrier truck, railroad, or express overnight package services. Do not transport by any passenger-carrying air transport system, even if they have cargo-only aircraft. DOT regulations permit regular airline cargo-only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that only carry cargo.

2. For transport by government-owned vehicle, including aircraft, DOT regulations do not apply. However, procedures described above, with the exception of execution of the bill of lading with certification, shall still be used.

6.0 REFERENCES

U.S. Department of Transportation, 1983. Hazardous Materials Regulations, 49 CRF 171-177.

NUS Standard Operating Procedure SA-6.1 - Sample Identification and Chain-of-Custody

NUS Standard Operating Procedure SA-1.2 - Sample Preservation

NUS Standard Operating Procedure SF-1.5 - Compatibility Testing

1.0 PURPOSE

This procedure describes the process for keeping a site logbook.

2.0 SCOPE

The site logbook is a controlled document which records all major on-site activities during a Remedial Investigation/Feasibility Study. At a minimum, the following activities/events shall be recorded in the site logbook:

- Arrival/departure of site visitors
- Arrival/departure of equipment
- Sample pickup (chain-of-custody form numbers, carrier, time)
- Sampling activities/sample logsheet numbers
- Start or completion of borehole/trench/monitoring well installation or sampling activities
- Health and Safety issues

The site logbook is initiated at the start of the first on-site activity (e.g., initial reconnaissance surv y). Entries are made for every day that on-site activities take place which involve RI/FS contractor personnel. One current site logbook is maintained per site.

The site logbook becomes part of the permanent site file maintained in the RI contract r's office. Because information contained in the site logbook may be admitted as evidence in cost rec very r other legal proceedings, it is critical that this document be properly maintained.

3.0 GLOSSARY

Site Logbook - The logbook is a bound notebook with consecutively numbered pages that cann t be removed. Upon entry of data, the logbook requires signature by the responsible site l ader (see Section 5.1).

4.0 RESPONSIBILITIES

The site logbook is issued by the Regional Manager (or his designee) to the Site Manager for th duration of the project. The Site Manager releases the site logbook to the Field Operati ns Leader or other person responsible for the direction of on-site activities (e.g., Reconnaissance Survey Team Leader, Sampling Team Leader). It is the responsibility of this person (or his designee) to keep the site logbook current while in his possession, and return it to the Site Manager or turn it over t another field team. Following the completion of all fieldwork, the site logbook is returned to the Site Manager for inclusion in the permanent site files.

5.0 PROCEDURES

5.1 GENERAL

The cover of each site logbook contains the following informati n:

- Project Name
- NUS Pr ject Number
  RI/FS Contractor and Site Manager's Nam
  Sequential Book Number

- Start Date
- End Date

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded:

- Date
- Start time
- Weather
- All field personnel present
- Any visitors present

During the day, a summary of all site activities and level of personal protection shall be recorded in the logbook. The information need not duplicate that recorded in other field notebooks (e.g., sample logbook, Site Geologist's notebook, Health and Safety Officer's notebook, etc.), but shall summarize the contents of these other notebooks and refer to the page locations in these notebooks for detailed information. An example of a site logbook page is shown in Attachment A.

The sample logsheet for each sample collected (see Procedure SA-6.6) must be referenced. If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the notebook and page number(s) on which they are recorded (see Attachment A).

All entries shall be made in black pen. No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook must be signed. It must also be signed by the Field Operations Leader or responsible site leader at the end of each day.

5.2 PHOTOGRAPHS

When movies, slides, or photographs are taken of a site or any monitoring location, they are numbered to correspond to logbook entries. The name of the photographer, date, time, site location, site description, and weather conditions are entered in the logbook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook. If possible, such techniques shall be avoided, since they can adversely affect the admissibility of photographs as evidence. Chain-of-custody procedures depend upon the subject matter, type of film, and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Adequate logbook notation and receipts may be used to account for routine film processing. Once processed, the slides of photographic prints shall be serially numbered and labeled according to the logbook descriptions.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A - Typical Site Logbook Entry

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: _____ DATE: _____

SITE LEADER: _____

PERSONNEL:

NUS	DRILLER	EPA
_____	_____	_____
_____	_____	_____
_____	_____	_____

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.

2. Drilling activities at well _____ resumes. Rig geologist was _____. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4 inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and w ll construction details for well _____.

3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _____.

4. Well _____ :rilled. Rig geologist was _____. S e Geologist's Notebook, No. 2, page _____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.

5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. Th well was then pumped using the pitcher pump for 1 hour. At the end of the h ur, water pumped from well was "sand free."

6. EPA remedial project manger arrives on-site at 14:25 hours.

7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _____.

8. Test pit _____ dug with cuttings placed in dump truck. Rig geologist was _____. See Geologist's Notebook, No. 1, page 32, for details f test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit _____ resulted in a very soft and wet area. A mound was developed and the area roped off.

9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel offsite, gate locked.

_____
Field Operations Leader

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5.0 GUIDELINES

5.1 MEASUREMENT OF pH

5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base n utralizati n, water softening, and corrosion control, is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Measurements of pH can also be used to check the quality and corrosivity of soil and s lid waste samples. However, these samples must be immersed in water prior to analysis, and specific techniques are not described.

Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicat r paper is used when only a rough estimate of the pH is required, and the pH meter wh n a m r accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, coll idal r suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity r basicity of the solution with the indicator compound on the paper. Depending on the indicat r and th pH range of interest, a variety of differen colors can be used. Typical indicators are weak acids or bases, or both. Process chemistry and molecular transformations leading to the color change are variable and complex.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement reli s on establishment of a potential difference across a glass or other type of membrane in response to hydrogen ion concentration across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference pr portional to hydrogen ion concentration can be generated and measured.

5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Accumet 150 portable pH meter, or equivalent.
- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitabl electrode inputs.
- pH indicator paper, such as Hydrion r Alkacid, t c ver the pH range 2 through 12.
- Buffer solutions f pH 4, 7 and 10, or ther buffers which bracket the expected pH range.

5.1.4 Measurement Techniques for Field Determination of pH

1. pH Meter

The following procedure is used for measuring pH with a pH meter (Standardization is according to manufacturers instructions):

a. The instrument and batteries shall be checked and calibrated prior to initiation f the field effort.

b. The accuracy of the buffer solutions used for field and laboratory calibration shall be checked. Buffer solutions need to be changed often due to degradation upon exposure to the atmosphere.

c. Immerse the tip of the electrodes in water overnight. If this is not possible due to field conditions, immerse the electrode tip in water for at least an hour before use. The electrode tip may be immersed in a rubber or plastic sack containing buffer soluti n for field transport or storage. This is not applicable for all electrodes as some must be stored dry.

d. Make sure all electrolyte solutions within the electrode(s) are at their proper lev ls and that no air bubbles are present within the electrode(s).

e. Immerse the electrode(s) in a pH-7 buffer solution.

f. Adjust the temperature compensator to the proper temperature (on models with automatic temperature adjustment, immerse the temperature probe into the buffer solution). Alternately, the buffer solution may be immersed in the sample and all wed to reach temperature equilibrium before equipment calibration. It is best to maintain buffer solution at or near expected sample temperature before calibration.

g. Adjust the pH meter to read 7.0.

h. Remove the electrode(s) from the buffer and rinse well with demineralized water. Immerse the electrode(s) in pH-4 or 10 buffer solution (depending on the expected pH f the sample) and adjust the slope control to read the appropriate pH. For best results, the standardization and slope adjustments shall be repeated at least once.

i. Immerse the electrode(s) in the unknown solution, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues t drift, the sample temperature may not be stable, a chemical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.

j. Read and record the pH of the solution, after adjusting the temperature compensat r to the sample temperature. pH shall be recorded to the nearest 0.1 pH unit. Also record the sample temperature.

k. Rinse th electrode(s) with deionized wat r.

l. Keep th electrode(s) immersed in dei nized water when not in use.

The sample used for pH measurement shall never be saved for subsequent conductivity or chemical analysis. All pH electrodes leak small quantities of electrolytes (e.g., sodium or potassium chloride) into the solution. Precipitation of saturated electrolyte solution, especially at colder temperatures, or in cold water, may result in slow electrode response. Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

2. pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper.

5.2 MEASUREMENT OF SPECIFIC CONDUCTANCE

5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in th water and the temperature at which the measurement is made. The mobility of each of the vari us dissolv d ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, while the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Convers ly, organic compounds such as sucrose or benzene, which do not disassociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength f the aqueous solution to be tested, a potential difference is d veloped across the cell which can be c nverted directly or indirectly (depending on instrument type) t a measurement of specific conductance.

5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- YSI Model 33 portable conductivity, meter, or equivalent
- Probe for above meter

A variety of conductivity meters are available which may also be used to monitor salinity and temperatures. Probe types and cable lengths vary, so equipment may be obtained t meet the specific requirement of the sampling program.

5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturers instructions):

- Check batteries and calibrate instrument before going into the field.
- Calibrate the instrument daily when used. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used. Attachment A may be used for guidance.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity. Adjust the temperature setting to the sample temperature.
- Read and record the results in a field logbook or sample log sheet.

If the specific conductance measurements become erratic, or inspection shows that any platinum black has flaked off the electrode, replatinization of the electrode is necessary. See the manufacturer's instructions for details.

Note that specific conductance is occasionally reported at temperatures other than ambient.

5.3 MEASUREMENT OF TEMPERATURE

5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood f biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.3.2 Equipment

T mperature m asurements may be taken with alcohol-toluene, mercury filled r dial-type thermometers. In addition, various meters such as specific conductance r dissolved xygen met rs, which have temperature m asurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements f temperature at great depths can be performed.

5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used on a collected water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.

- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is to be used, the instrument shall be calibrated according to manufacturer's recommendations with an approved thermometer before each measurement or group of closely spaced measurements.

5.4 MEASUREMENT OF DISSOLVED OXYGEN CONCENTRATION

5.4.1 General

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process contr l. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time if the sample is not adequately preserved.

The method monitoring discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and are free from interf rence caused by color, turbidity, colloidal material or suspended matter.

5.4.2 Principles of Equipment Operation

Dissolved oxygen probes are normally electrochemical cells that have two solid metal electrodes f different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeabl membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false l w readings are obtained. It is therefore necessary to stir the sample (or the probe) c nstantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vig rous that additional oxygen is introduced through the air-water interface at the sample surface. To av id this possibility, some probes are equipped with stirrers to agitate the soluti n near the probe, but to leav the surface of the solution undisturbed.

Dissolved oxygen probes are relativ ly free of interferences. Interferences that can occur are reactions with xidizing gases (such as chlorine) or with gases such as hydrogen sulfide which are not

easily depolarized from the indicating electrode. If the gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also caus interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- YSI Model 56 dissolved oxygen monitor or equivalent.
- Dissolved oxygen/temperature probe for above monitor.
- Sufficient cable to allow the probe to contact the sample.

5.4.4 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentrati n:

- The equipment shall be calibrated and have its batteries checked in the laboratory befor going to the field.

- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.

- The instrument shall be calibrated in the field before each measurement or group of closely spaced measurements by placing the probe in a water sample of known dissolved oxygen concentration (i.e., determined by Winkler method) or in a freshly air-saturated water sample of known temperature. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment B).

- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane, either by stirring the sample, or placing the probe in a flowing stream. Probes without stirrers placed in wells can be moved up and down.

- Record the dissolved oxygen content and temperature of the sample in a field logbook r sample log sheet.

- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This however, may not always be practical. Be sure to record whether the liquid was analyzed in-situ, or if a sample was taken.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen solubilization and positive test interferences.

5.5 MEASUREMENT OF OXIDATION-REDUCTION POTENTIAL

5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendence of organic or inorganic compounds to exist in an oxidized state. The technique therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of oxidized to reduced species in the sample.

5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is devel ped at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and will be dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

5.5.3 Equipment

The f llowing equipment is needed for measuring the oxidation-reduction potential of a solution:

- Accumet 150 portable pH meter or equivalent, with a millivolt scale.
- Platinum electrode to fit above pH meter.
- Reference electrode such as a calomel, silver-silver chloride, or equivalent.

5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The f llowing procedure is used for measuring oxidation-reduction potential:

- The equipment shall be calibrated and have its batteries checked before going to the field.

- Check that the platinum probe is clean and that the platinum bond or tip is unoxidized. If dirty, polish with emery paper or, if necessary, clean the electrode using aqua regia, nitric acid, or chromic acid, in accordance with manufacturer's instructions.

- Thoroughly rinse the electrode with demineralized water.

- Verify the sensitivity of the electrodes by noting the change in millivolt reading when th pH of the test solution is altered. The ORP will increase when the pH of the test soluti n decreases and the ORP will decrease if the test solution pH is increased. Place the sampl in a clean glass beaker and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added, the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions. If the ORP does not respond as above when the caustic is added, the electrodes shall be cleaned and the abov procedure repeated.

- After the assembly has been checked for sensitivity, wash the electrodes with three changes of water or by means of a fl wing stream f water from a wash bottle. Place th sample in a clean glass beaker r sample cup and insert the electrodes. Set temperature

compensator throughout the measurement period. Read the millivolt p tential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful ORP. Record all results in a field logbook, including ORP (to nearest 10 mV), sample temperature and pH at the time of measurement.

5.6 SPECIFIC ION ELECTRODE MEASUREMENTS

5.6.1 General

Use of specific ion electrodes can be beneficial in the field for determining the presence and concentration of dissolved inorganic species which may be associated with contaminant plumes or leachate. Thus, electrodes can be used for rapid screening of water quality and determination of water migration pathways.

This procedure provides generic information for specific ion electrodes comm nly used in groundwater quality monitoring programs and describes the essential elements f a field investigation program. Analytical methods using some specific ion electrodes have n t been approved by the USEPA. In addition, calibration procedures and solutions, interfer nces and conditions and requirements for use for various electrodes vary greatly. Consequently, review f manufacturer's literature is mandatory prior to use.

5.6.2 Principles of Equipment Operation

All specific ion electrode measurements involve the use of a reference electrode, a pH meter, and a specific ion electrode (SIE). When the SIE and the reference electrode are immersed in a soluti n of the ion to be measured, a potential difference is developed between the two electrodes. This potential can be measured by a pH meter and related to the concentration of the ion of interest through the use of standard solutions and calibration curves.

Several different types of SIEs are in use: glass, solid-state, liquid-liquid membrane, and gas-sensing. All of the electrodes function using an ion exchange process as the potential determining mechanism. Glass electrodes are used for pH measurement. The glass in the tip of the electrode actually acts as a semi-permeable membrane to allow solution. Solid-state electrodes replace the glass membrane with an ionically-conducting membrane, (but act in essentially the same manner) while liquid-liquid membrane electrodes have an organic liquid ion exchanger contained in the pores of a hydrophobic membrane. Maintenance of the conducting interface, in combination with a reference electrode, allows completion of the electrical circuit and subsequent measurement of the potential difference. Gas-sensing electrodes have a membrane that permits the passage of gas only, thus all wing for the measurement of gas concentration. Regardless of the mechanism involved in the electrode, most SIEs are easy to use under field conditions. The sensitivity and applicable concentration range f r van us membranes and electrodes will vary.

5.6.3 Equipment

The following equipment is required for performing quantitative analyses using a specific ion electrode:

- A pH meter with a millivolt scale, or equivalent.
- The specific ion electrode for the parameter to be measured. A partial list of ions which can be measured includes cyanide, sulfide, ammonia, lead, fluoride and chloride.
- A suitable reference electrode to go with the above SIE.

Specific electrodes for other ions have also been developed, but are not widely used for field investigation efforts at this time. Note that of the specific electrodes referenced above, only fluoride and ammonia have analytical methods approved by the U.S. EPA.

5.6.4 Measurement Techniques for Inorganic Ions Using Specific Ion Electrodes

Different types of electrodes are used in slightly different ways and are applicable for different concentration ranges. Following the manufacturer's instructions, the general steps given below are usually followed:

- Immerse the electrode in water for a suitable period of time prior to sample analysis.

- Standardize the electrode according to the manufacturer's instructions, including necessary chemical additions for ionic strength adjustment, etc. Standard solutions normally differ by factors of ten in concentration. Constant stirring is needed for accurate readings.

- Immerse the electrode in the sample. Allow the reading to stabilize and record the results in a site logbook. Stir the sample at the same rate as the standards. Air bubbles near the membrane shall be avoided, since this may cause interference in millivolt readings.

(NOTE: Each SIE has substances which interfere with proper measurement. These may be eliminated using pretreatment methods as detailed by the manufacturer. It is important to know if interferences are present so that suspect readings may be noted as such.)

- If the pH meter does not read out directly, plot millivolts versus concentration for the standards and then determine sample concentration.

6.0 REFERENCES

American Public Health Association, 1980. Standard Methods for the Examination of Water and Wastewater, 15th Edition, APHA, Washington, D.C.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.

U.S. Geological Survey, 1984. National Handbook of Recommended Methods for Water Data Acquisition, Chapter 5: Chemical and Physical Quality of Water and Sediment. U.S. Department of the Interior, Reston, Virginia.

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1.0 PURPOSE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped offsite for chemical analysis.

2.0 SCOPE

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, while many organic chemicals may dissolve various types of plastic containers. It is therefore critical to select the correct container in order to maintain the quality of the sample prior to analysis.

Many water and soil samples are unstable, and therefore require preservation when the time interval between field collection and laboratory analysis is long enough to produce changes in either th concentration or the physical condition of the constituent(s) requiring analysis. While complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that inevitably take place after the sample is collected.

Preservation techniques are usually limited to pH control, chemical addition(s) and refrigerati n/ freezing. Their purpose is to (1) retard biological activity, (2) retard hydrolysis of chemical compounds/complexes, (3) reduce constituent volatility, and (4) reduce adsorption effects.

3.0 GLOSSARY

HCl - Hydrochloric Acid
H_2SO_4 - Sulfuric Acid
HNO_3 - Nitric Acid
NaOH - Sodium Hydroxide

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing one gram-atom of replaceable hydrogen or its equival nt. Thus, a one molar solution of HCl, containing one gram-atom of H, is "one-normal," while a ne molar solution of H_2SO_4 containing two gram-atoms of H, is "two-normal."

4.0 RESPONSIBILITIES

Field Operations Leader - retains overall responsibility for the proper storage and preservati n of samples. During the actual collection of samples, the sampling technician(s) will be directly responsible for the bottling, preservation, labeling, and custody of the samples they collect until released to another party for storage or transport to the analytical laboratory.

5.0 PROCEDURES

5.1 SAMPLE CONTAINERS

F r most samples and analytical parameters either glass or plastic containers are satisfact ry. In general, if the analyte(s) to be determined is organic in nature, the c ntainer shall be made of glass. If the analyte(s) is inorganic, then the container shall be plastic. Since container specification will depend n the analyte and sample matrix types (as indicated in Attachment A) duplicate sampl s shall be tak n when both organic and in rganic analyses are required. C ntainers shall be kept in the

dark (to minimize biological or photooxidation/photolysis breakdown of constituent) until th y reach the analytical laboratory. The sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample is heated during transport (1 liter of water at 4°C expands by 15 ml if heated to 130°F/55°C), however, head space for volatile organic analyses shall be omitted.

For CLP laboratories, containers will be obtained through the CLP Sample Management Office. For Responsible party actions or non-CLP laboratories, the laboratory shall provide containers that hav been cleaned according to U.S. EPA procedures. Sufficient lead time shall be allowed. Shipping containers for samples, consisting of sturdy ice chests, are provided by the laboratory of the remedial investigation contractor.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded; because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are f und to have loose caps or missing Teflon liner (if required for the container) shall be discarded.

General sample container and sample volume requirements are listed in Attachment A. Specific container requirements are listed in Attachment B.

5.2 PRESERVATION TECHNIQUES

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the Field or added in the Field. In general, aqueous samples of low concentration organics (or soil samples of low or medium concentration organics) are cooled to 4°C. Medium concentration aqueous samples and high hazard organics sample are not preserved. Low concentration aqueous samples for metals are acidified with HNO_3, while medium concentrati n and high hazard aqueous metal samples are not preserved. Low or medium concentration s il samples for metals are cooled to 4°C while high hazard samples are not preserved.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

5.2.1 Addition of Acid (H_2SO_4, HCl, or HNO_3) or Base

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade and shall be diluted to the required concentration with d uble-distilled, deionized water in the laboratory, before Field sampling commences:

Acid Base	Concentration	Normality	Amount for Acidificati n*
HCl	1:1 dilution of concentrated HCl	6N	5-10 ml
H_2SO_4	1:1 dilution of concentrated H_2SO_4	18N	2-5 ml
HNO_3	Undiluted concentrated HNO_3	16N	2-5 ml
NaOH	400 grams solid NaOH in 870 ml water	10N	2 ml**

* Amount of acid to add (at the specified strength) per liter of water to reduce the sample pH to less than 2, assuming that the water is initially at pH 7, and is poorly buffered and does not contain particulate matter.

** To raise pH of 1 liter of water to 12.

The approximate volumes needed to acidify one liter of neutral water to a pH of less than 2 (r raise the pH to 12) are shown in the last column of the above table. These volumes are only approximate; if the water is more alkaline, contains inorganic or organic buffers, or contains suspended particles, more acid may be required. The final pH must be checked using narrow-range pH paper.

Sample acidification or base addition shall proceed as follows:

- Check initial pH of sample with wide range (0-14) pH paper.
- Fill sample bottle to within 5-10 ml of final desired volume and add about 1/2 of estimated acid or base required, stir gently and check pH with medium range pH paper (pH 0-6 or pH 7.5-14, respectively).
- Add acid or base a few drops at a time while stirring gently. Check for final pH using narrow range (0-2.5 or 11-13, respectively) pH paper; when desired pH is reached, cap sample bottle and seal.

  Never dip pH paper into the sample; apply a drop of sample to the pH paper using the stirring rod.

5.2.2 <u>Cyanide Preservation</u>

Pre-sample preservation is required if oxidizing agents such as chlorine are suspected to be present. To test for oxidizing agents, place a drop of the sample on KI-starch paper; a blue color indicates the need for treatment. Add ascorbic acid to the sample, a few crystals at a time, until a drop f sample produces no color on the KI-starch paper. Then add an additional 0.6 g of ascorbic acid for each liter of sample volume. Add NaOH solution to raise pH to greater than 12 as described in 5.2.1. If oxidizing agents are not suspected, add NaOH as directed.

5.2.3 <u>Sulfide Preservation</u>

Samples for sulfide analysis must be preserved by addition f 4 drops (0.2 ml) f 2N zinc acetate soluti n per 100 ml sample. The sample pH is then raised to 9 using NaOH. The 2N zinc acetate solution is made by dissolving 220 g of zinc acetate in 870 ml of distilled water t make 1 liter of s lution.

5.2.4 Preservation of Organic Samples Containing Residual Chlorine

Some organic samples containing residual chlorine must be treated to remove this chlorine upon collection (See Attachment A). Test the samples for residual chlorine using EPA methods 330.4 or 330.5 (Field Test Kits are available for this purpose). If residual chlorine is present, add 0.008% sodium thiosulfate (80 mg per liter of sample).

5.2.5 Field Filtration

When the objective is to determine concentration of dissolved inorganic constituents in a water system, the sample must be filtered through a non-metallic 0.45 micron membrane filter immediately after collection. A filtration system is recommended if large quantities of samples must be filtered in the field. The filtration system shall consist of a Büchner funnel inserted into a single-hole rubber stopper, sized to form a seal when inserted into the top of a vacuum filter flask equipped with a single side arm. Heavy-wall Tygon tubing shall be attached to the single side arm of the vacuum filter flask and the suction port of a vacuum pump. The stem of the Büchner funnel shall extend below th level of the side arm of the vacuum filter flask to prevent any solvent from entering the tubing leading to the vacuum pump. Before filtration, the filter paper, which shall be of a size to lay flat n the funnel plate, shall be wetted with the solvent in order to "seal" it to the funnel. Sl wly pour th solvent into the funnel and monitor the amount of solvent entering the vacuum filter flask. When the rate of solvent entering the flask is reduced to intermittent dripping and the added aliqu t of solvent in the funnel has passed through the filter, the used filter paper shall be replaced with n w filter paper. If the solvent contains a high percentage of suspended solids, a coarser-sized nonmetallic membrane filter may be used prior to usage of the 0.45 micron membrane filter. This "prefiltering" step may be necessary to expedite the filtration procedure. Discard the first 20 to 50 ml of filtrate from each sample to rinse the filter and filtration apparatus to minimize the risk of altering the composition of the samples by the filtering operation. For analysis of dissolved metals, the filtrate is collected in a suitable bottle (see Section 5.1) and is immediately acidified to pH 2.0 or less with nitric acid whose purity is consistent with the measurement to be made. Inorganic ani nic constituents may be determined using a portion of the filtrate that has not been acidified.

Samples used for determining temperature, dissolved oxygen, Eh, and pH should not be filter d. Do not use vacuum filtering prior to determining carbonate and bicarbonate concentration becaus it removes dissolved carbon dioxide and exposes the sample to the atmosphere. Pressure filtrati n can be done using water pressure from the well. If gas pressure is required, use an inert gas such as argon or nitrogen.

Do not filter samples for analysis of volatile organic compounds. If samples are to be filtered for analyzing other dissolved organic constituents, use a glass-fiber or metal-membrane filter and collect the samples in a suitable container (see Section 5.1). Because most organic analyses require extraction of the entire sample, do not discard any of it. After filtering, the membrane containing th suspended fraction can be sealed in a glass container and analyzed separately as soon as practicable. Total recoverable inorganic constituents may be determined using a second, unfiltered sampl collected at the same time as the sample for dissolved constituents.

1.0 PURPOSE

The purpose of these procedures is to provide a general methodology, protocol, and reference information on the proper decontamination procedures to be used on chemical sampling and field analytical equipment.

2.0 SCOPE

This procedure addresses chemical sampling and field analytical equipment only, and should be consulted when equipment decontamination procedures are being developed as part of project-specific plans.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Manager - responsible for ensuring that project-specific plans and the implementati n of field investigations are in compliance with these guidelines.

Field Operations Leader - responsible for ensuring that decontamination procedures for all chemical sampling and field analytical equipment are programmed prior to the actual field eff rt and that personnel required to accomplish the task have been briefed and trained to execute the task.

5.0 PROCEDURES

In order to assure that chemical analysis results are reflective of the actual concentrati ns pres nt at sampling locations, chemical sampling and field analysis equipment must be properly decontaminated prior to the field effort, during the sampling program (i.e., between sample p ints) and at the conclusion of the sampling program. This will minimize the potential for cross-contamination between sample points and the transfer of contamination offsite.

This procedure incorporates only those aspects of decontamination not addressed in other procedures. Specifically it incorporates those items involved in decontamination of chemical sampling and field analytical equipment.

5.1 ACCESS FOR SAMPLING

5.1.1 Bailers and Bailing Line

The potential for cross-contamination between sampling points via the use of common bailer, or its attached line, is high unless strict procedures for decontamination are followed. It is preferable, f r the aforementioned reason, to dedicate an individual bailer and its line to each sample point, although this does not eliminate the need for decontamination of dedicated bailers. For non-dedicated sampling equipment, the following conditions and/or decontaminati n procedures should be f llowed.

Before the initial sampling and after each succeeding sampling point, the bail r must be decontaminated. The following steps should be followed if sampling for organic contaminants:

- Potable water rinse
- Alconox or Liquinox detergent wash
- Scrubbing of the line and bailer with a scrub brush may be required if the sampl point if heavily contaminated with heavy or extremely viscous compounds
- Potable water rinse
- Rinse with 10 percent nitric acid solution*
- Deionized water rinse
- Acetone or methanol rinse
- Hexane rinse**
- Distilled/Deionized water rinse
- Air dry

If sampling for organics only, the nitric acid, acetone, methanol, and hexane rinses may be omitted. Contract-specific requirements may permit alternative procedures.

Braided nylon or polypropylene lines may be used with a bailer, however, the same line must n t come in contact with the sample medium, otherwise, the line must be discarded in an appr ved receptacle and replaced. Prior to use, the bailer should be wrapped in aluminum foil or p lyethylene sheeting.

5.1.2 Sampling Pumps

Most sampling pumps are normally low volume (less than 2 gpm) pumps. These include peristaltic, diaphragm, air-lift, pitcher and bladder pumps, to name a few. If these pumps are used for sampling from more than one sampling point, they must be decontaminated.

The procedures to be used for decontamination of sampling pumps compare to those used for a bailer except the 10 percent nitric acid solution is omitted. Each of the liquid factions is t be pumped through the system. The amount of pumping is dependent upon the size of the pump and the length of the intake and discharge hoses. Certain types of pumps are unacceptable for sampling purposes.

An additional problem is introduced when the pump relies on absorption of water via an inlet or outlet hose. For organic sampling, this hose should be Teflon. Other types of hoses leach organics into the water being sampled (especially the phthalate esters) or adsorb organics from the sampled water. For all other sampling, the hose should be Viton, polyethylene, or polyvinyl chloride (in order of preference). Whenever possible, dedicated hoses should be used.

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* Due t the leaching ability f nitric acid, on stainless steel, this step is to be mitted if a stainless steel sampling device is being used and metals analysis is required with detecti n limits less than appr ximately 50 ppb; or the sampling equipment is dedicated.

** If sampling for pesticides, PCBs, or fuels.

5.1.3 Filtering Equipment

Part of the sampling plan may incorporate the filtering of groundwater samples, and subsequent preservation. This should occur as soon after sample retrieval as possible; preferably in the field as soon as the sample is obtained. To this end, three basic filtration systems are most comm nly used - the in-line disposable Teflon filter, the inert gas over-pressure filtration system, and the vacuum filtration system.

For the in-line filter, decontamination is not required since the filter cartridge is disposable, how v r, the cartridge must be disposed of in an approved receptacle and the intake and discharge lines must still be decontaminated.

For the over-pressure and the vacuum filtration systems, the portions of the apparatus which come in contact with the sample must be decontaminated as outlined in the paragraphs describing the decontamination of bailers. (Note: Varieties of both of these systems come equipped from the manufacturer with Teflon-lined surfaces for those that would come into contact with the sample. These filtration systems are preferred when decontamination procedures must be employed.)

5.2 FIELD ANALYTICAL EQUIPMENT

5.2.1 Water Level Indicators

Water level indicators that come into contact with groundwater must be decontaminated using the following steps:

- Rinse with potable water
- Rinse with deionized water
- Acetone or methanol rinse
- Rinse with deionized water

Water level indicators that do not come in contact with the groundwater but may enc unter incidental contact during installation or retrieval need only undergo the first and last steps stated above.

5.2.2 Probes

Probes, e.g., pH or specific ion electrodes, geophysical probes, or thermometers which would com in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise; in those cases, the methods of decontamination must be clearly described in the FSAP. Probes that contact a volume of groundwater not used for laboratory analyses can be rinsed with deionized water. For probes which make no direct contact, e.g., OVA equipment, the probe will be wiped with clean paper-towels or cloth wetted with alcohol.

6.0 REFERENCES

None.

7.0 RECORDS

None.

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APPENDIX C

ANALYTICAL LABORATORY NEESA QUALITY ASSURANCE MANUAL

PACE NEW ENGLAND, INC.

PACE NEW ENGLAND, INC.

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ANALYTICAL LABORATORY
NEESA QUALITY ASSURANCE MANUAL

TITLE: PACE New England, INC. NEESA Laboratory Quality Assurance Manual

Prepared By/Date: Stephanie Beck/Wendy E. Harris October 1993

Approved By/Date:

Stephanie Beck 10·8·93
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Dennis L. McGrath 10/08/93
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1.0 INTRODUCTION

1.1 Purpose and Scope

This manual details the quality assurance program in effect in the PACE NE Analytical Chemistry Laboratory. It is meant to be a teaching tool and source of information for laboratory personnel. The Manual is divided into logical sections, each dealing with a different phase of laboratory operation, yet all sections overlap and function together to form a complete quality assurance program. The Manual is based on Good Laboratory Practices, common sense, and industry-accepted standard analytical practices.

The Manual must be read and understood by all laboratory personnel as part of their training program. The Manual should also be referred to regularly as a source of information. A system of continuous updating is built into the Manual to allow it to change as laboratory conditions change or as new regulations are promulgated. This manual is a controlled document, which means that its identity, development, distribution, and status must be known and traceable at all times. All PACE NE permanent laboratory personnel will be assigned a controlled copy.

Whenever a technician or analyst is in doubt as to proper procedures in a specific circumstance, the Manual should be consulted. Omissions or errors should be immediately reported to the Quality Assurance Officer, for corrective action. **IT IS THE RESPONSIBILITY OF EACH LABORATORY WORKER TO ENSURE THAT THE PROVISIONS OF THIS MANUAL ARE FOLLOWED.** Disagreement with specific requirements or knowledge of changes causing deviation from the procedures should be discussed with the immediate supervisor before further work is completed. Laboratory personnel are encouraged to comment on the Manual and make recommendations for more efficient procedures.

The latest revision of each section of the Manual is the applicable rule. Therefore, revisions will be announced to all laboratory personnel. An uncontrolled copy of the Manual is offered to clients and regulatory agencies as the definitive quality assurance program used at PACE NE.

1.2 QA Policy and Objectives of the Program

PACE NE is committed to quality as priority number one. PACE NE's quality assurance policy is based on the definition of quality as conformance to requirements; and further, on the premise that the requirements are governed by Company policies and standard

operating procedures. This commitment recognizes the need for data to be representative of the environmental conditions under consideration, and for data to be generated within a system of functions that that is designed to meet applicable regulatory compliance criteria. To this end, PACE NE has developed a company-wide Quality Assurance (QA) Plan and maintains an ongoing QA Program. Our Quality Assurance Program contains provisions for establishing, maintaining and executing protocols which lead to results of known, appropriate and acceptable quality; documentation of these activities is an integral part of the QA program. No other concern will be permitted to interfere with the quality of data PACE NE provides to clients.

This manual describes the set of policies and principles which guide day-to-day operations. Specific protocols are included by reference and are contained in a series of volumes cited in Section 8.0 of this document.

1.3 Quality Assurance Documents

1.3.1 QA Manual

This document describes management policies related to operation of the analytical laboratories. It provides overall guidance regarding acceptable practices and discusses each element of the Quality Assurance Program. It functions as the Project QA Manual where no other Quality Assurance Project Plan, Statement of Work or other contractually mandated project plan has been specified. Adherence to the practices described in this manual is required of all employees. This manual may be revised and/or superseded only with the written authority of the PACE NE Regional Director. Copies of this manual are controlled and distribution is administered by the QA Officer.

1.3.2 Standard Operating Procedures Manuals

All procedures related to sample collection, storage, preparation, analysis, disposal, data validation, data reporting and employee training and safety shall be contained in written Standard Operating Procedures Manuals (SOP's). Each SOP shall contain the elements outlined in PACE NE SOP QA-553, Preparation of SOP's. All sections shall be structured in a step-wise manner using numbered sections. All record-keeping requirements shall be described at each step in the SOP. Examples of forms used shall be included as tables or figures and referenced within the text. Preparation of SOP's shall be the responsibility of each Group Supervisor. SOP's shall be assigned a number from the Inventory List for SOP's maintained by the Quality Assurance Department. This number

shall become part of the document control number when the SOP is accepted for implementation by PACE NE management. SOP's shall be reviewed and approved by the Group Supervisor (and Lab Manager for all SOP's related to analytical procedures) and the QA Officer, and submitted by the QA Department to the Technical Directors and the Regional Director for approval prior to implementation.

1.3.3 Project QA Manuals

Project QA Manuals shall be implemented as required. These shall include such documents as Quality Assurance Project Plans (QAPP's). For those projects which require specific QA/QC criteria, a QAPP which has been approved by a regulatory agency, usually the EPA, is provided to PACE NE by the client.

1.3.4 Document Control, Distribution and Revision

In order that this document achieve the goals outlined in Section 1.2, it is necessary that each PACE NE laboratory employee be familiar with the current provisions of this document. It is also necessary that this document represent a consensus among PACE NE Management and operational personnel as to the quality level desired and the means to that end.

Prior to its publication as a controlled document, this manual must be approved by the Quality Assurance Officer, the Laboratory Technical Directors, and the Regional Director. To obtain such approval, the document proceeds through an iterative process of review and revision, involving the affected managers and their designated representatives. The signature page at the beginning of the manual represents acceptance.

Each time a revision is made to this manual, it must also be approved. The Quality Assurance Officer must approve each revision. If the revision constitutes a complete rewrite of the document, then review and approval by the Quality Assurance Officer, the Laboratory Technical Directors, and the Regional Director becomes necessary. The appropriate approval process will be decided in each case by the Quality Assurance Officer.

1.4 Terms and Definitions

Accuracy: The degree of agreement between a measured value and the true or expected value.

Aliquot: A measured portion of a sample taken for analysis.

Analyte: The specific entity an analysis seeks to determine.

Batch: A grouping of samples of similar matrix which are prepared and analyzed together with the same method and the same lots of reagents within the same time frame. A sample may be analyzed in a different analytical batch than the one with which it was prepared.

Blank: A blank is an artificial sample designed to detect and/or monitor the contribution of analyte and non-analyte contamination, instrumental background and sample processing to the measurement system.

Blind Sample: A sample submitted for analysis whose composition is known to the submitter but unknown to the analyst.

Calibration: The process of establishing the relationship between instrument response and known, traceable quantities of analytes of interest.

Comparability: Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. Comparable data are produced through the use of standardized procedures and techniques.

Completeness: Measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct normal conditions.

Continuing Calibration: The process of analyzing standards periodically to verify the maintenance of calibration of the analytical system.

Control Chart: A graphical plot of test results with respect to time or sequence of measurement, together with limits within which they are expected to lie when the system is in a state of statistical control.

Control Limit: A range within which specified measurement results must fall to signify compliance. Control limits may be mandatory, requiring corrective action if exceeded, or advisory, requiring that nonconforming data be flagged.

Detection Limit: The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero.

Dry Weight: The weight of a sample based on percent solids. The weight after drying in an oven.

Duplicate Analysis: A second measurement made on the same sample extract or digestion to assist in the evaluation of precision of analysis.

Duplicate Sample: A second aliquot of the same sample that is treated the same as the original sample in order to determine the precision of the method.

Equipment Blank: Special type of field blank used primarily as a check on equipment decontamination procedures. Laboratory deionized water is passed over sampling equipment after decontamination.

Field Blank: A quality control sample used to assess the contamination effects on accuracy due to the combined activities of sampling and analysis. Typically, it is composed of a reagent and analyte free matrix (deionized water) provided by the laboratory.

Field Sample: A portion of material received by the laboratory to be analyzed, that is contained in single or multiple containers and identified by a unique field ID number.

Holding Time: The elapsed time expressed in days from the date of sample collection by the field personnel until the date of its processing/analysis. For the Contract Laboratory Program, holding times start at the Verified Time of Sample Receipt by the laboratory. Holding time requirements are dictated by the method or QAPjP.

Homogeneity: The degree to which a property or substance is evenly distributed throughout a material.

Instrument Detection Limit: The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero. The instrument detection limit is generally more sensitive than the method detection limit.

Initial Calibration: The process of analyzing standards, prepared at specified concentrations, to define the quantitative response, linearity and dynamic range of the instrument to the analytes of interest. Initial calibration is performed whenever the results of a continuing calibration do not conform to the requirements of the method in use or at a frequency specified in the method.

Internal Standards: Analytes added to every standard blank, matrix spike, matrix spike duplicate, and sample at a known concentration, prior to analysis for the purpose of adjusting the response factor used in quantitating target analytes. Internal standards are used as the basis for quantitation of the target compounds, and are generally applicable to organic analyses.

Lab. Control Sample: A control sample of known composition spiked with known concentration of analytes of interest. Aqueous and solid laboratory control samples are analyzed using the same preparation, reagents, and analytical methods employed for field samples received.

LABUX: The Hewlett-Packard A900 based Laboratory Information Management System. It is used to collect data from instrumentation and preparation laboratories for later combination into final reports. Data is collected a number of ways including direct ports from instrument computers, interactive manual entry direct to the database using HP provided procedures, importing data from spreadsheets, and importing batch data entered manually. Data is combined, calculated, and formatted either by HP provided or custom reporters and stored in directories where it can be printed initially for manager review and later as part of a final report.

LAS: Hewlett-Packards' A900 based 3350a Laboratory Automation System. Its function is to collect, calculate, and present chromatographic data. The system allows the operator to calibrate for, identify and quantitate the data. Requantitation is possible without reinjection of the sample. Typically the data provided to the analyst by the LAS is entered into LABUX for combination with data from the preparation laboratory to generate a final report. Alternatively, the preparation information can be entered into the analysis sequence on the LAS to generate results corrected for preparation volumes, dilutions, and dry weights.

Lot: A quantity of bulk material of similar composition processed or manufactured at the same time.

Matrix: The predominant material of which the sample to be analyzed is composed.

Matrix Spike: Aliquot of sample fortified (spiked) with known quantities of specified compounds and subjected to the entire procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery.

Matrix Spike Duplicate: A second aliquot of the sample that is treated the same as the original matrix spike sample. The relative percent difference between the matrix spike and matrix spike duplicate is calculated and used to assess analytical precision.

Method Blank: An analytical control consisting of all reagents, internal standards and surrogate standards, that is carried through the entire analytical procedure. The method blank is used to define the level of laboratory background contamination in the associated sample batch.

Method Detection Limit: Method Detection Limits may be determined using replicate spike samples The detection limit is calculated using the appropriate student's t-parameter times the standard deviation of a series of spiked samples.

Performance Audit or Evaluation: A process to evaluate the proficiency of an analyst or laboratory by evaluation of the results obtained on known test materials.

Precision: The measurement of agreement of a set of replicate results among themselves without any prior information as to the true result. Precision is assessed by means of duplicate/replicate sample analysis.

Protocol: A stated plan that clearly defines the objectives, methods and procedures for accomplishing a task.

QAPP: A Quality Assurance Project Plan or QAPP is a project specific document that describes the policies, organization, objectives, functional activities, and specific QA and QC activities designed to achieve the data quality goals of a specific project.

Quality Assurance: A system of policies and procedures whose purpose is to ensure, confirm and document that the product or service rendered fulfills the requirements of PACE NE and its client. Quality Assurance includes quality planning, quality control, quality assessment (auditing), quality reporting and corrective action.

Quality Control: A system of checks and corrective measures, integrated with the activities that directly generate the product or service, that serves to monitor and adjust the process to maintain conformance to predetermined requirements.

Replicate Samples: A second, separate sample collected at the same time, from the same place, for the same analysis, as the original sample in order to determine overall precision.

Reporting Limit: The level at which method, permit, regulatory and client specific objectives are met. The reporting limit may never be lower than the statistically determined MDL, but may be higher based on any of the above considerations. Reporting limits are corrected for sample amounts, including the dry weight of solids, unless otherwise specified.

Rounding Rules: If the figure following those to be retained is less than 5, the figure is dropped, and the retained figures are kept unchanged. As an example,

11.443 is rounded off to 11.44. If the figure following those to be retained is greater than 5, the figure is dropped, and the last retained figure is raised by 1. As an example, 11.446 is rounded off to 11.45. If the figure following those to be retained is 5, and if there are no figures other than zeros beyond the five, the figure 5 is dropped, and the last-place figure retained is increased by one if it is an odd number or it is kept unchanged if an even number. As an example, 11.435 is rounded off to 11.44, while 11.425 is rounded off to 11.42. If a series of multiple operations is to be performed (add, subtract, divide, multiply), all figures are carried through the calculations. Then the final answer is rounded to the proper number of significant figures.

Sensitivity: Capability of methodology or instrumentation to discriminate between samples having differing concentrations or containing differing amounts of an analyte.

Split Sample: A portion or subsample of a total sample obtained in such a manner that is not believed to differ significantly from other portions of the same sample.

Standard: A substance or material the properties of which are believed to be known with sufficient accuracy to permit its use to evaluate the same property in a sample.

Standard Blank: An analytical control sample consisting of the same solvent/reagent matrix used to prepare the calibration standards without the analytes. It is used to construct the calibration curve by establishing instrument background.

Standard Operating Procedure: A procedure adopted for repetitive use when performing specific measurement or sampling operation. It may be an industry accepted standard method or one developed by the user.

Surrogates: When employed, these are compounds added to every blank, sample, matrix spike, matrix spike duplicate, and standard prior to any processing or preparation; used to evaluate analytical efficiency by measuring recovery. Surrogate compounds are not expected to be detected in environmental media, but are similar to the analytes of interest. Surrogates are generally utilized for organic analyses.

Systems Audit: An on-site inspection or assessment of a laboratories' quality control system.

Traceability: The ability to trace the source and accuracy of a material (i.e. standard) to a recognized primary reference source such as the National Institute of Standards and Technology (NIST) or USEPA. Also, the ability to independently reconstruct and review all aspects of the measurement system through available laboratory notebooks and documentation and reach the same results.

Trip Blank: This blank is used to detect sample contamination from the container and preservative during transport and storage of the sample. A cleaned sample container is filled with laboratory pure water; any preservative used in the sample is added; and then the blank is stored, shipped, and analyzed with its group of samples.

Validation: The process by which a sample, measurement, method, or piece of data is deemed useful for a specified purpose.

Warning Limits The limits (typically 2 standard deviations either side of the mean) shown on a control chart within which most results are expected to lie (within a 95% probability) while the system remains in a state of statistical control.

2.0 QA ORGANIZATION AND PERSONNEL

It is important for efficient laboratory operation that all laboratory employees understand the operational structure, specific areas of responsibility and lines of authority within the organization.

It is equally important for laboratory personnel to understand that the structures of the Quality Organization may be separate from other laboratory operations but that the quality function is totally integrated into every aspect of laboratory operation. All laboratory personnel are responsible for knowing and following proper methods and standard operating procedures; recording quality control information required by those procedures in the proper location; and suspending analyses when quality control criteria are not met.

The organizational structure of the analytical chemistry laboratory is provided in Figure 2-1. Under the direction of the laboratory technical directors, the technical staff of the laboratory is organized into the following functional groups:

Sample Management (Receipt and Log-in)
Sample Preparation - Organic
Sample Preparation - Metals
Wet Chemistry
Metals Analysis
GC Analysis
GC/MS Volatiles Analysis
GC/MS Semivolatiles Analysis
Reporting
Project Management (Client Services)

Each group is headed by a Group Supervisor who is responsible for operations on a daily basis. Environmental chemists, analysts, laboratory technicians and laboratory assistants report to the Group Supervisors. See Appendix A for resumes of all technical staff employed as of this revision date.

2.1 Laboratory Organization

It is the individual responsibility of each analyst and technician to perform their assigned tasks according to the applicable SOPs, QA Project Plans, Study Protocols, and Work Plans. This includes responsibility for performing quality control analyses as specified in the method SOP and for entering the QC data in the appropriate method control file

system. The analyst shall report out-of-control results to the Group Supervisor.

Group Supervisors shall assure that analysts and technicians are instructed in the requirements of the PACE NE Laboratory QA Manual, study-specific QA Project Plans, SOPs, Protocols, and Work Plans for the analytical method or other procedure. Group Supervisors shall review sample QC data at frequent intervals designed to assure that QC analyses are being performed at the required frequency, that data are documented in the method control file system and that established corrective action procedures for out-of-control situations are followed and the results documented. It is the responsibility of the Group Supervisor to assure that data have been validated and reported to the Laboratory Manager. Group Supervisors shall report to Laboratory Managers.

Laboratory Managers shall be the Technical Directors and shall take overall responsibility for technical conduct, evaluation and reporting of all analytical tasks associated with each study. Laboratory Managers assure that approved procedures are documented and followed, that all data are recorded and verified and that all deviations from approved procedures are documented. Laboratory Managers shall assure that Group Supervisors are instructed in the requirements of the PACE NE Laboratory QA Manual, study-specific QA Project Plans, SOPs, Protocols, and Work Plans. Laboratory Managers approve standards for QC control limits for methods and work with Group Supervisors to bring out-of-control methods back to within established acceptance limits. Laboratory Managers shall report to the Regional Director.

The Quality Assurance Department, under the direction of the Quality Assurance Officer, shall be responsible for conducting systems audits and inspections for compliance with this manual, SOP's and QA Project Plans or other project-specific protocols, maintaining the archives, maintaining historical files of all QA documents, reviewing QC charts, documenting findings and corrective actions, and reporting findings to management. The Quality Assurance Officer shall report directly to the Regional Director of PACE NE.

The PACE NE Regional Director shall designate Laboratory Manager(s)/Technical Director(s) and replace if necessary. The PACE NE Regional Director shall assure that there is a Quality Assurance Department, that personnel and other resources are adequate, that personnel have been informed of their responsibilities, that deficiencies are reported to Laboratory Managers and that corrective actions are taken and documented. Any significant changes to written SOP's shall be authorized in writing by the Regional Director of PACE NE.

2.2 Training and Orientation

Each new permanent employee receives a four part orientation: a human resources orientation, a safety department orientation, a quality assurance department orientation, and a supervisory orientation. The human resources orientation involves matters of immediate personal concern such as benefits, salary, and company policies. The safety department orientation is an in-depth examination of the PACE NE Chemical Hygiene Plan and safety program, which are consistent with the requirements of OSHA's Hazard Communication Program (29 CFR 1910.1200). The Quality Assurance orientation provides the new employee with information on the PACE NE QA program through a brief introduction to the QA manual and SOPs, acceptable recordkeeping practices, and the individuals responsibility. The new employee's group supervisor provides the employee with a basic understanding of the role of the laboratory within the structure of PACE, Inc. and the basic elements of that individual's position within the laboratory. The training of a new employee concentrates on his/her scientific background and work experience to provide the employee with a level of competence so that the individual will be able to function within the defined responsibilities of his/her position ASAP.

Training is a process used to assist laboratory personnel in their professional development. The training techniques utilized include:

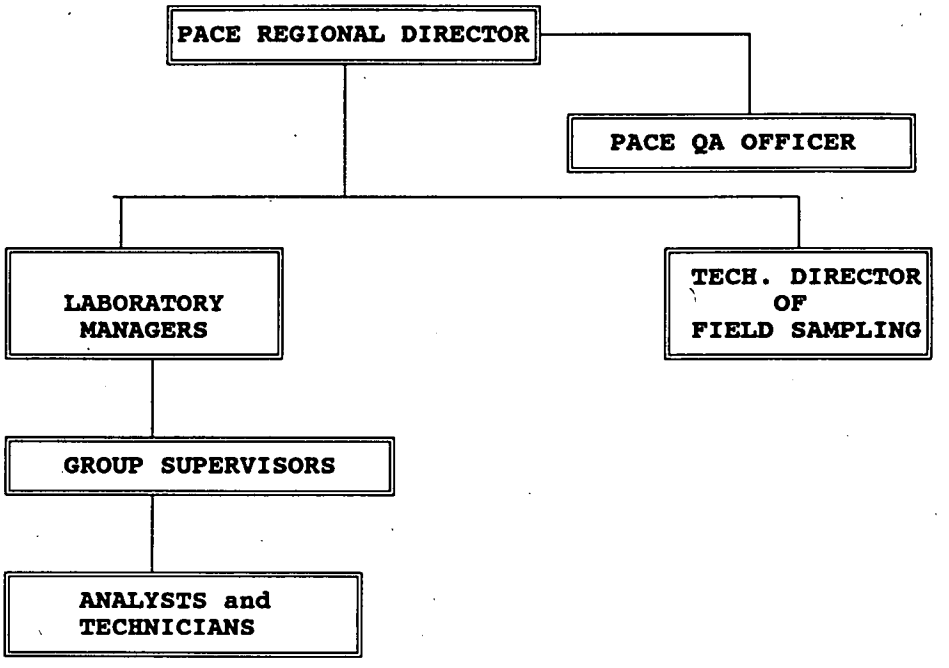
- on-the-job training
- lectures
- programmed learning
- conferences and seminars
- short courses
- specialized training by instrument manufacturers
- participation in check-sample or proficiency sample programs.

Group Supervisors shall be responsible for providing documentation of training and proficiency for each employee under their supervision. The Training Documentation File indicates what procedures (SOPs) a technician is capable of performing either solo or only with supervision. The files shall also include logbook pages and sample reports indicating performance of passing QC samples. The Group Supervisor is responsible for keeping training documentation updated and current. The QA department shall maintain a file for each technical employee. In addition to the training documentation, these files shall include a current CV and proofs of education such as college transcripts or certificates from continuing education coursework or specialized training.

Temporary employees receive the same orientation as permanent staff with the exception of the human resources orientation.

Figure 2-1

PACE New England, Inc.
QUALITY ASSURANCE
ORGANIZATION CHART



APPENDIX A

Resumes For PACE NE Technical Staff
Employed As Of This Revision Date

DEBORAH F. MCGRATH
Regional Director
PACE New England, Inc.

Experience

As Regional Director, Ms. McGrath is responsible for the overall management of PACE New England which includes the oversight and coordination of Laboratory and Field Operations, Quality Assurance, Support Systems, Administrative, and Sales/Marketing departments. In addition, she serves as liaison for PACE NE on behalf of both clients and other laboratories within the PACE network.

Prior to joining PACE NE in 1993, Ms. McGrath served as Vice President and Division Manager of NET Inc., Cambridge Division, in Bedford, MA (formerly Cambridge Analytical Associates, Inc.), from 1989-1993 where her responsibilities included oversight of the technical operations and business development of the division. She was Vice President of Environmental Services for one year and Director of Analytical Services for two while employed by Cambridge Analytical Associates, Inc. from 1986-1989.

Ms. McGrath served in the position of Manager of the Laboratory Analysis Department and Inorganic Section while employed by GCA Technology Division, Bedford, MA from 1981-1986.

Previous to her management positions, Ms. McGrath held the position of analytical chemist at Kennecott Copper Ledgemont Laboratory, Lexington, MA.

Education

B.S. Chemistry, Simmons College, Boston, MA 1971

Publications

Ms. McGrath is the author/co-author of over 15 publications on methods development and comparison studies, waste oil and biota analysis, combustion assessments and waste minimization.

STEPHANIE BECK
Quality Assurance Officer
Pace New England, Inc.

Experience

Ms. Beck is responsible for quality assurance activities at Pace New England, Inc. She is responsible for auditor training and Quality Assurance training for new employees. She performs internal inspections of PACE NE labs and is responsible for the implementation of quality programs at Pace NE, Inc. She reviews data for internal and regulatory compliance. Ms. Beck prepares Quality Assurance Project Plans. She reviews SOPs. Ms. Beck reports to Deborah McGrath, Regional Director.

Prior to joining PACE NE, INC. Ms. Beck worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE NE, INC. in June 1992. Ms. Beck came to PACE NE, INC. with over 4 years laboratory experience performing inorganic chemistry analysis. Ms. Beck has over 2 years experience in the Quality Assurance department (1990 - present) performing the duties to assure management that facilities, equipment, personnel, methods, practices, records, and controls are adequate and in conformance with regulations. She has over 2 years experience reviewing Aquatic Tox. studies and Organic and Inorganic Chemistry data for FIFRA, TSCA, OECD, and FDA compliance as a GLP auditor. She has experience reviewing CLP data packages.

QA Officer, PACE NE, INC., Inc., Hampton, NH 5/92 - Pres

QA Auditor, Resource Analysts, Inc., Hampton, NH 4/90 - 5/92

Education

B.S., Environmental Economics, University of New Hampshire, 1988

Continuing Education

Environmental and Natural Resource Law, 1992 U. of N.H. Durham, NH
Introduction to Computer Validation SQA Annual Meeting 1991, Kansas City, MO
Intro. and Advanced WordPerfect 1991 OMC, Portsmouth NH
Producing Results with Others, 1991 Millipore, Bedford MA
SQA Basic Training GLP SQA Annual Meeting Oct 1990, Orlando FL
Lotus 123, 1990 Millipore, Bedford MA

RICHARD L. WELLMAN
Inorganic Laboratory Director
New England Regional Office

Experience

As Inorganic Laboratory Manager, Mr. Wellman manages the groups providing wet chemistry, metals prep and metals analysis. He reports to Ms. McGrath, Regional Director.

Prior to joining PACE, Mr. Wellman worked in similar capacities for Resource Analysts, Inc. which was acquired by PACE in June 1992. Mr. Wellman joined RAI in 2/88 and worked as the GC Lab Director until 1/91 when his responsibilities changed to managing the Metals Labs and the Reporting/Data Review and Lab Data Services Departments.

Mr. Wellman has extensive experience in the analytical chemistry field as a Consultant and Chemist. Mr. Wellman has over thirteen years of experience in Gas Chromatography, High Pressure Liquid Chromatography, Infrared Spectrophotometry, UV-VIS Spectrophotometry, GPC, and NMR.

Consultant, Medical & Scientific Enterprises, Sudbury, MA Summer 1986

Consultant, Acadia Management, Boston, MA Summer 1986

Systems Specialist, DuPont/NEN Products, Boston, MA 1984 - 1985

Group Leader Analytical Chemistry, DuPont/NEN Products, Boston, MA 1978 - 1984

Education

M.B.A., Business Administration, Boston University, Boston, MA, 1987

B.S., Chemistry, Union College, 1975

Continuing Education

"Environmental Data Requirements", conference, April 25, 1989

"HP RTE System Managers Course", May 22-26, 1989"

"Newest Analytical Methods and Techniques", Hewlett Packard Video Teleconference, April 19, 1990

STEVEN F. RHODE
Organics Laboratory Director
New England Regional Office

Experience

Mr. Rhode manages the Organics Extractions, GC and GC/MS organics laboratories through four laboratory group supervisors. He and his staff conduct standard EPA analyses as well as non-routine GC/MS approaches to special analytical problems. Mr. Rhode is Project Manager for PACE NE, Inc.'s CLP contract work. He is responsible for workflow and technical review and approval of all data generated by the GC and GC/MS organics laboratories. Mr. Rhode reports to Deborah McGrath, Regional Director.

Prior to joining PACE NE, Inc., Mr. Rhode worked for four years for National Environmental Testing, Inc. (NET) managing the CLP GC and organic preparation laboratories. He had two years experience working as a GCMS analyst for Cambridge Analytical Associates using EPA methods and CLP protocol. His experience includes the programming of HP1000 data systems to automate data analysis and also includes management of RTE-6 and RTE-6A series data systems.

Mr. Rhode was a teaching fellow at Boston University Department of Chemistry for four years. There he organized and taught laboratory and discussion sections for graduate and undergraduate courses in instrumental analysis, qualitative analysis and general chemistry.

Education

Ph.D. candidate, Chemistry, Boston University

M.S., Chemistry, University of New Hampshire, 1983

B.S., magna cum laude, Marine Science/Biology/Chemistry, University of Tampa, FL, 1980

ELIZABETH A. DUPERE
Volatiles Group Supervisor
Pace New England, Inc.

Experience

Ms. Dupere is responsible for the supervision of the GC/MS Volatile Organics Laboratory. As a Supervisor-in-Training, she reports to Mr. Rhode, Organics Laboratory Manager, who maintains the ultimate responsibility for work performed by the Volatiles Lab.

Prior to joining PACE NE, INC. Ms. Dupere worked as an analyst for Resource Analysts, Inc. which was acquired by PACE NE, INC. in June 1992. She joined RAI in 1987 as a technician in the Wet Lab. She became a GC operator in 1988 and in 1990 became a GC/MS operator. Ms. Dupere currently has approximately two and a half years experience in volatile organics analysis. While employed in the organics laboratory, Ms. Dupere has received approximately two years' training in gas chromatography. She has experience in the use of detectors, including Hall and ECD, as well as FID, FPD, and NPD. As a Laboratory Technician in the wet lab, she has also received 10 months training in wet chemistry techniques.

Education

B.S., Biochemistry, University of New Hampshire, 1987

Continuing Education

"Use of Widebore Columns", By Restek, Inc., Boston, MA, December, 1989

"Mass Spectral Interpretation", By Bill Rounds, University of New Hampshire, spring, 1990

"Air Analysis Symposium" By Tekmar, Inc., Lexington, MA. May 1991.

"GC/MS Troubleshooting", seminar, Hewlett Packard, Burlington, MA, Spring 1992

LIANE HALL
Semi-Volatiles Group Supervisor
New England Regional Office

Experience

Ms. Hall is responsible for the supervision of the Semi-volatiles laboratory, analysis of environmental samples by GC and GC/MS, performance and documentation of all specified QC measures and instrument maintenance and troubleshooting. Ms. Hall reports to Mr. Rhode, Organics Laboratory Manager.

Prior to joining PACE NE, INC., Ms. Hall worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE NE, INC. in June 1992. Ms. Hall joined RAI in 1989 and worked as an Analytical Chemist until 1/91 when she became Supervisor of the Semivolatiles lab.

Ms. Hall has over 3 years experience, prior to RAI, in the environmental field. As a Research Assistant/Technician for the University of Maine, Ms. Hall was responsible for analyses of microbial processes in marine sediments utilizing GC, HPLC, UV/VIS Spectroscopy and AA. While employed as a Chemist II, GC/MS Operator for the State of Maine, Ms. Hall was responsible for timely VOA and SVO analyses, adherence to QC procedures and accurate report generation utilizing HP 5996 and 5970.

Education

Candidate for Doctor of Philosophy degree, Loyola University of Chicago, 1980 - 1984

M.S., Chemistry, Northwestern University, 1980

B.S., Chemistry, Massachusetts Institute of Technology, 1979

Continuing Education

"GC/MS Operator I" by Jim Stacy, Hewlett Packard, April, 1989

"Aquarius Software" by Jim Stacy/Pam Kelly, Hewlett Packard, May, 1989

"Mass Spectral Interpretation", by Bill Rounds, University of New Hampshire, Spring, 1990

"Capillary Chromatography" by Neil Mosesman/David Shelow, Restek, November, 1990

PETER LEMAY
GC Operator/Group Supervisor
Radiation Safety Officer
New England Regional Office

Experience

Mr. Lemay is responsible for the analysis of PCB's, Pesticides, PNA's, PHC's, DI solvents, and Herbicides and for the supervision of three GC analysts. He reports to Mr. Rhode, Organics Laboratory Manager.

Prior to joining PACE, Mr. Lemay worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE in June 1992. Mr. Lemay joined RAI in 1987. While employed at RAI, Mr. Lemay acquired three and a half year's experience on the following GC's: HP 5890, HP 5880, HP 5840, Tracon and waters dimension GC using the following detectors: ECD, ELCD, NPD, FID, FPD with either packed or capillary columns.

Mr. Lemay served as a chemist for Burgess Analytical Laboratory, North Adams, MA from 1985 to 1987. His duties included performing chemical analyses on a variety of materials, sample preparation, operation of instruments, evaluating and reporting results, and training new employees.

Medical Laboratory Specialist, United States Air Force. 1977 - 1981

Education

B.A., Chemistry, University of Maine, Orono, ME 1985

Continuing Education

Intro to GC/MS - Hewlett Packard, 1988

Occupational and Environmental Radiation Protection, Harvard School of Public Health, Aug 1991

PAUL RAITI
Organics Extractions Lab Supervisor
New England Regional Office

Experience

Mr. Raiti is responsible for the supervision of a staff of technicians performing sample preparation for ABN, PCB, PHC, PNA, pesticide and other organic methods. The Organics Prep Lab is also responsible for the oil and grease and phenol methods which Mr. Raiti oversees. As part of the organics sample preparation process, Mr. Raiti also performs and directs the operation of two GPC/HPLC units for sample clean-up. As supervisor, Mr. Raiti monitors all holding times and schedules daily workflow to ensure timeliness of all extract preparation. He is also responsible for the training of technicians to meet all PACE specific and general method requirements for data quality. As a supervisor-in-training, Mr. Raiti reports to Mr. Rhode, Organics Laboratory Manager, who has the ultimate responsibility for the Extractions Lab.

Prior to becoming the lab supervisor, Mr. Raiti had over two years experience as a Senior Technician in the Organics Prep Lab. He was hired as a Senior Tech by Resource Analysts, Inc. in 8/90 and continued to work in the same capacity after RAI was acquired by PACE in June 1992. Mr. Raiti is fully qualified in all organics sample preparation procedures performed at PACE.

Education

B.S., Plant Science, University of New Hampshire, 1989

A.S., Horticulture, Essex Agricultural and Technical Institute, 1987

Continuing Education

"Laws in Natural Resource and Environment", University of NH, Spring 1991

"Wetland Resource Management", University of NH, Fall 1991

"Analytical Chemistry", University of Massachusetts, 1992

CLIFFORD CHASE
Metals Instrument Group Supervisor
New England Regional Office

Experience

Mr. Chase presently supervises the metals instrument laboratory, and provides operation for the instrumental analyses of metals. Mr. Chase reports to Mr. Wellman, the Inorganics Laboratory Manager.

Prior to joining PACE, Mr. Chase supervised the organic extraction laboratory for Resource Analysts, Inc. which was acquired by PACE in June 1992. Mr. Chase joined RAI in 1988 and worked as an analyst until 1990 when he became Organics Extractions Group Supervisor. Mr. Chase has over three years of supervisory experience and a strong background in instrumentation. He is experienced in the analysis of environmental samples and has 6 months training on the Extrel ELQ-400 GC/MS, the HP 5880 and HP 5840 GC/FID, and the HP 5890/5970 GC/MSD.

During a five year tenure at the University of New Hampshire, Mr. Chase was responsible for analyses, operator training, repair and maintenance of JEOL FX90Q FTNMR, Instrumentation Laboratory Model 951 AA and a Varian Cary 219 UV/VIS.

Education

B.S. Chemistry, University of New Hampshire, 1986

Continuing Education

"Mass Spectral Interpretation", University of New Hampshire, April/May 1988

"Aquarius GC/MS Data System Training Seminar", Hewlett Packard Co., Andover, MA, September 13-14, 1988

"Management Lead Skills Training", Millipore Corp., Bedford, MA, July 17, 24, 31, Aug. 7, 1990

"UV Detector Service Training", Waters Chromatography Division, MILLIPORE Corp., Marlborough, MA, April 20-21, 1992

THERESA I. HENNESSEY
Wet Chemistry Group Supervisor
New England Regional Office

Experience

Ms. Hennessey is responsible for managing and overseeing all Wet Lab workflow, analyses, spreadsheet review, raw data review, data handling and tracking, report generation, review and timely completeness. Ms. Hennessey supervises a staff of 7 - 8 technicians and is responsible for scheduling work hours, vacation and bi-annual performance and salary reviews. Ms. Hennessey reports to Mr. Wellman, Inorganics Laboratory Manager.

Prior to joining PACE, Ms. Hennessey worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE in June 1992. While employed at RAI, Ms. Hennessey gained over six year's experience on the pH meter, Specific Conductance Meter, Zero Headspace Extractors, High Pressure Filtration System, Spectronic 20, Flashpoint Apparatus, Top Loading Balances, Analytical Balance and BTU. Ms. Hennessey has experience in the proper preparation of sample digests for trace metal analysis, including the digestion of tissues, solids, waxes, oils, plastics and polymers as well as the usual soils and water samples. Ms. Hennessey supervised the Metals Digests Lab for two and a half years with a staff of 3. For one year, she managed both the Wet Lab and Metals Digests Lab with a staff of 11-12. She has one year's experience in reviewing final Wet Lab data and reports and one year's experience in the use of Lotus Quattro.

Education

B.S., Environmental Conservation/Resource Economics, UNH 1984

Continuing Education

"General Chemistry" University of New Hampshire, Spring, 1987

"Leadership Skills for Women" March, 1988

"Introduction to Lotus", Millipore Corp., Bedford, MA, Nov. 1990

"Quantatative Analysis", University of New Hampshire 1992

"Organic Chemistry", University of New Hampshire 1992

KATHLEEN LAWSON
Laboratory Technician
New England Regional Office

Experience

As Lead Technician for the Metals Prep Laboratory, Ms. Lawson is reponsible for digestion of samples by EPA methods 3010, 3020, 7060, 3050 (HNO_3), 3050 (HCL) and filtering of samples for ICP and furnace analysis, fluoride distillation, calibration of: hoods, pipettes, extractors, and pH meters. Her Metals Prep responsibilities also include TCLP, EPTOX, and California W.E.T. She is responsible for the wet chemistry tests: Specific conductance, Total Phosphorus, Alkalinity, and BOD. Ms. Lawson reports to Mr. Rick Wellman, Metals Prep Lab Manager.

Prior to joining PACE, Ms. Lawson worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE in June 1992. Ms. Lawson joined RAI in February 1991.

Ms. Lawson was a Cardiac Technician at Sisters of Charity Hospital, Buffalo, NY where she gained 8 years of experience in EKG, Holter monitoring and record keeping in an 800 bed hospital.

Education

H.S. Diploma, Mt. Mercy Academy, Buffalo NY

CHRISTINE PAQUETTE STELZER
Senior Data Validator/Reporter
New England Regional Office

Experience

Ms. Stelzer is primarily responsible for the review, validation, and reporting of organics data as it pertains to special projects. Special projects include those under USEPA CLP protocol, state or government agency protocols, or unique PACE/client contracts. Part of her job involves reviewing Statements of Work, Quality Assurance Plans, and Bid Requests to identify special analytical, QC, or reporting requirements. Findings are communicated to Sales and Analytical staff to help ensure appropriate bidding and compliant analyses. Ms. Stelzer subsequently reviews organics data generated for these jobs to ensure accuracy and scientific defensibility. Ms. Stelzer is responsible for generating special forms and diskettes as required to complete the data package. She is the Project Manager/Data Reporting and Delivery Officer for the EPA CLP Organics Contract 68D20026. Ms. Stelzer reports to Mr. Rhode, Organics Laboratory Manager.

Prior to joining PACE, Mrs. Stelzer worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE in June 1992. Ms. Stelzer joined RAI in 1987. She has worked as a Technician and Analyst in the Volatile Organics and Semivolatiles Lab. She has experience in GC/MS analysis using both packed and capillary columns under USEPA methods 624, 8240, 524.1, 501.3, 625, 8270 and 1988 CLP protocol. She is also experienced with gas chromatographs equipped with FID, PID, and Hall ELCD detectors for methods including 601, 8010, 602, 8020. Ms. Stelzer has thorough familiarity with the HP RTE software used for GC/MS data acquisition and reporting and is proficient in using HP LAS and LIMS data systems. She has a thorough understanding of USEPA CLP requirements for volatiles, semivolatiles, and pesticide/PCB's under 1988 and 1991 protocols.

Laboratory Technician, Environmental Testing Lab, Chicopee, MA. 1986 - 1987

Research Assistant, Elms College, Chicopee, MA. 1985 - 1986

Laboratory Assistant, Chemical Specialties, Springfield, MA. 1984

Education

B.A., Chemistry and Biology, Elms College, Chicopee, MA, Magna cum laude 1986

Continuing Education

"Systems Maintenance and Wastewater Treatment" Springfield Technical Community College, Springfield, MA, 1/19-5/29, 1987

Hewlett Packard RTE-6 Operator School by Hewlett Packard, New Orleans, LA, September 14-18, 1987

"Statistics" Springfield Tech. Comm. College, Springfield, MA, '87

"Custom Reporting", Hewlett Packard class by Hewlett Packard, 1988

Mass Spectral Interpretation Course University of New Hampshire, April 23 - May 18, 1988

Career Track Communication Skills Workshop August 17, 1988

Capillary Chromatography Seminar Restek, 12/11/89

"Train the Trainer", seminar by Maggie Dean, RAI, 4/92

Publications

Wright, M.L., and S.T. Jorey, Y.M. Myers, M.L. Fieldstad, C.M. Paquette, and M.B. Clark, 1988. Influence of Photoperiod, Daylength, and Feeding Schedule on Tadpole Growth and Development. Development Growth and Differentiation, 30, 315-323.

Wright, M.L. et al, 1988. Effect of Changing the Light/Dark Schedule, the Time of Onset of the Light or Dark Period, or the Daylength, on Rhythms of Epidermal Cell Proliferation. Chronobiology International, 5, 317-330.

Wright, M.L. and L.S. Blanchard, S.T. Jorey, C.A. Basso, Y.M. Myers and C.M. Paquette, 1990. Metamorphic Rate as a Function of the Light/Dark Cycle in Rana pipiens Larvae. Comp. Biochem. Physiol., 96A, 215-220.

KERRY HUNTER
Data Validator
New England Regional Office

Experience

Ms. Hunter is responsible for the review, validation and reporting of organics data (specifically pesticide/PCB packages) as it pertains to work conducted under specific protocols such as USEPA CLP protocol, state or government agency protocols or unique PACE/client contracts. Ms. Hunter is responsible for the generation of specific forms and diskette deliverables required to complete a data package. Ms. Hunter reports to Mr. Rhode, Organics Laboratory Manager and Technical Director.

Prior to her position as a Data Validator, Ms. Hunter worked in the Reporting Department where she was responsible for the generation of commercial reports for organic and inorganic analyses. Prior to joining PACE NE, Inc., Ms. Hunter worked in the same capacity for Resource Analysts, Inc. (RAI) which was acquired by PACE NE, Inc. in June 1992. Ms. Hunter joined RAI in 1986 and worked as a GC operator until 1990 when she became an analyst for the Product Registration Group (PRL) of RAI. In this capacity she was responsible for method validation and analysis of samples in support of GLP aquatic toxicology studies. In 1991, she was promoted to Senior Analyst for the PRL. Ms. Hunter has more than four years experience on the HP 5880, HP 5840, HP 5890 Capillary ECD, and the Tracor Hall, 5890 Hall, NPD, TCD, FID, LAS and EPA software, and HPLC experience using the Waters 490, 470, and 430 detectors.

Education

B.S., Biology, University of New Hampshire, 1985

Continuing Education

Laboratory Health and Safety - 1986

Fundamentals of LC - Hewlett Packard - 9/90

Radiation Safety Training course - Dr. George Chabot, Univ. of Lowell - 3/91

Waters service training for 420 and 470 detectors - Millipore Corp. - 4/91

DAVID BUCK
Computer Systems Manager
Pace New England, Inc.

Experience

Mr. Buck is responsible for performing daily, weekly and monthly housekeeping duties on the PACE Network, LAS, and LABUX computer systems. He designs and implements new procedures for data entry and reporting. Mr. Buck is responsible for computer networks and their security. Mr. Buck reports to Ms. Deborah McGrath, Regional Director.

Prior to joining PACE NE, INC. Mr. Buck worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE NE, INC. in June 1992. He joined RAI in 1988 and has had more than four years experience as a Computer Systems Manager and six years training on Hewlett Packard 1000 computers, RTE-A/RTE-6/RTE-IVB. Mr. Buck has converted order tracking systems to database systems and centralized collection of electronic test data.

Computer Analyst, Sprague Electric, Sanford, ME 1987 - 1988

Computer Analyst, Fairchild Semiconductor, South Portland, ME 1985 - 1987

Education

M.B.A., Business Administration, Nasson College, 1987

B.S., Mathematics, University of Maine, 1982

Continuing Education

"Second Annual LIMS Conference", June, 1988

"LABSAM System Manager Course", January, 1989

"Novell System Manager", February 1991

"Unix Basics I and II", December 1991

"Unix System Manager", January 1992

JAMES CUTTER
Senior Technical Specialist
New England Regional Office

Experience

Mr. Cutter is responsible for technical support for all analytical chemistry. This includes instrument operator supervision and training, instrument trouble shooting and maintenance, method development, and analysis of samples. He is responsible for analyses by various methodologies including but not limited to HPLC, GC, and GC/MS. Mr. Cutter reports to Mr. Rhode, Organics Laboratory Director.

Prior to joining PACE, Mr. Cutter worked in a similar capacity for Resource Analysts, Inc. which was acquired by PACE in June 1992. Mr. Cutter joined Envirosystems, Inc., a division of RAI in 10/91 as Product Registration Chemistry Manager. In 3/92 he became Senior Technical Specialist.

Mr. Cutter has more than sixteen years of experience in the areas of environmental and life science analysis and methods development using HPLC, GC, GC/MS, NMR, AAS.

Senior Scientist, ENSECO Inc., Cambridge, MA 10/88 - 10/91

Chromatography Group Leader, ESA Labs, Inc., Bedford, MA 10/86 - 10/90

Chromatography Section Manager, Cambridge Analytical Assoc., Boston, MA 4/86 - 10/86

Chemist II, DuPont/NEN Products, Boston, MA 4/78 - 4/86

Chemist, ESA, Inc., Boston, MA 10/75 - 10/77

Education

B.S., Chemistry, University of Massachusetts, Amherst, MA 1974

Continuing Education

Waters Assoc. training courses in HPLC methods development and maintenance

Axiom Labs training in asbestos analysis (PLM and PCM)

KATHLEEN HUDSON
Project Management/Sample Management Supervisor
New England Regional Office

Experience

Ms. Hudson is responsible for the management of the Sales and Marketing programs and Client Service Department at PACE New England, Inc. Her duties include the development and implementation of marketing strategies and programs, preparation and maintenance of sales forecasts, and supervision of the sales force. The Client Services/Project Management staff also report to Ms. Hudson. Ms. Hudson reports to Ms. McGrath, Regional Director.

Prior to joining PACE NE, INC., Ms. Hudson worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE NE, INC. in June 1992. Ms. Hudson has over seven years of experience in the service industry. She has experience in the environmental, engineering and banking industries.

6/92 - Pres Marketing Manager

8/89 - 6/92 Dir. of Client Svcs., Resource Analysts, Inc., Hampton, N.H.

1/89 - 8/9 Client Services Representative, R.A.I. Hampton, N.H.

1986 - 1987 Commercial Lender, Granite State National Bank, Rochester, N.H.

1985 - 1986 Officer's Assistant/Analyst, Bank of Vermont, Brattleboro, Vt.

Education

B.S. Management Science, Keene State College, Keene, N.H., 1983

M.B.A. New Hampshire College (In Process)

STUART BRONSON
Senior Project Manager
New England Regional Office

Experience

Mr. Bronson serves as a Project Manager for clients who specialize in large scale, complex and on-going site work. He reviews Quality Assurance Project Plans for completeness, applicability and conformance to established protocols. QAPP information is condensed for Laboratory Project Alert Forms. Negotiates project specifications with clients, insures specifications are met by the lab and delivered to the client in the required time frame. Fields questions from a diverse clientele to determine testing needs; issues advice and answers technical questions about the lab, data, methodologies, protocols and procedures. He also maintains communication channels with the Sales Dept. and the Laboratory Staff and serves as the USEPA-CLP contact person for the lab. He gives tours of the Sample Management Dept. to visitors and auditors. Mr. Bronson reports to Ms. Hudson, Project Management/Sample Management Supervisor.

Prior to joining PACE, Mr. Bronson worked as Director of Sample Management for Resource Analysts, Inc. which was acquired by PACE NE, INC. in June 1992. Mr. Bronson joined RAI in 1990.

Mr. Bronson worked at Laucks Testing Laboratory in Seattle, Washington for four years prior to RAI in the capacity of analyst and manager.

Education

B.A. Ecology and Evolutionary Biology, University of Arizona, Tucson, Arizona, 1985.

Coursework towards M.S. in Limnology, University of Washington, Seattle, Washington, 9/89 - 5/90.

Continuing Education

Customer Service Seminar. Dun and Bradstreet, held at Nashua, New Hampshire, May 1991

GRETCHEN FRANZHEIM
Project Manager
New England Regional Office

Experience

Ms. Franzheim currently serves as a Project Manager for clients specializing in large-scale, protocol-specific projects. She reviews Requests For Proposal (RFPs) and Quality Assurance Project Plans (QAPPs) for completeness, applicability and conformance to established protocols. She is responsible for communicating special project requirements to laboratory staff to ensure adherence to protocol or specific client project requirements. Ms. Franzheim serves as primary PACE NE contact with designated clients and is responsible for managing analytical projects from onset to completion. In addition, she fields questions from a diverse clientele to determine testing needs and to answer technical questions regarding protocol, methods, reporting and procedures. Ms. Franzheim reports to Ms. Hudson, Project Management/Sample Management Supervisor.

Previous to her position as a Project Manager, Ms. Franzheim functioned as a Senior Data Reviewer, Ms. Franzheim was responsible for the review of Inorganic CLP data and also served as a backup Organics CLP data reviewer. She is experienced in the review of environmental data for a wide variety of Organic and Inorganic Methods and Protocols including USEPA SAS (Special Analytical Services) projects, NJ ECRA, NYASP, NEESA, and HAZWRAP.

Prior to joining PACE, Ms. Franzheim worked for Resource Analysts, Inc. which was acquired by PACE in June 1992. She joined RAI in 1987 and served in the capacity of Data Review Supervisor until June 1992. Her responsibilities included the tracking of samples and documents through the analytical process while under contract to EPA. She supervised the assembly, review and validation of data for Organics CLP case packages, as well as handling the responsibility of training staff to perform these duties.

Ms. Franzheim has extensive experience in the chemistry field within a variety of areas. Ms. Franzheim gained experience in data review and quality assurance at Aquatec, Inc. and a Chemist at Ladd Research Industries, Inc. From 1977 to 1982, she taught chemistry, biology, physics, and mathematics in public schools.

Education

B.S., Chemistry, St. Lawrence University, 1975

M.S. Candidate, Environmental Studies, U. MASS, Lowell, MA

Continuing Education

"Seminar on CLP Organics", Technical Management Consulting, January, 1988

"Mass Spectral Interpretation", University of New Hampshire, Durham, NH, April - May, 1988

"In Search of Excellence", seminar by Tom Peters, October 18, 1988

"CLP/Superfund Automated Analytical Data Management Caucus", June 28-30, 1989

"Superfund Data Management Caucus", Raleigh, NC, June 12-13, 1990

"Sixth Annual Waste Testing and Quality Assurance Symposium", Washington, D.C., July 16-20, 1990

"Ward CLP Training Class", Ward Scientific, Ltd., Burlington, MA, Aug. 7-8, 1990

"Law of Natural Resources and Environment", University of New Hampshire, Durham, NH, Spring 1991

"Industrial Pretreatment Pollution Prevention", by New England Interstate Environmental Training Center, Westford, MA, February 12, 1992.

"Environmental Law Update 1992", sponsored by Sheehan Phinney Bass + Green Professional Association, Nashua, NH, April 9, 1992.

"Environmental Chemistry Laboratory", University of Massachusetts, Lowell, MA, Fall 1992.

LILLIAN PEPIN
Project Manager
New England Regional Office

Experience

Ms. Pepin is responsible for project management from initiation to completion. Ms. Pepin is the point of client contact for projects, priorities, preliminary data, bottle orders and price quotes for commercial work. Ms. Pepin also serves as liaison for Network projects that New England Regional Office is involved with. Ms. Pepin reports to Ms. Hudson, Project Management/Sample Management Supervisor.

Prior to joining PACE, Ms. Pepin worked in sample management for Resource Analysts, Inc. which was acquired by PACE in June 1992. Ms. Pepin joined RAI in 8/90 and worked in Sample Management where she was responsible for the receiving, handling, storage, and distribution of incoming samples. Her duties also included client contact, data entry, maintenance of sample storage area security, and sample separation for proper disposal.

Ms. Pepin has significant previous experience in the health care industry and has pursued an education in data processing.

Education

Data Processing Certificate, Hesser College, Portsmouth, NH 1989

Nursing Assistant Certificate, State of NH 1985

Continuing Education

"Exceptional Customer Service", Seminar, Dun & Bradstreet, Portland, ME May 1991

MICHAEL K. CAMPBELL
Sample Management Technician
Pace New England, Inc.

Experience

Mr. Campbell is responsible for maintenance of internal custody of samples, preservation of samples, scheduling sample analysis, sample storage, bottle orders, resolving client difficulties, writing SOP's, and documentation of client and sample related information. Mr. Campbell assists in coordinating projects within Sample Management that require special client protocol such as CLP, NEESA, ECRA, and NPDES. He also assists in the supervision of department employees. During periods of high sample volume, Mr. Campbell has assisted in performing certain inorganic analyses. Mr. Campbell reports to Ms. Hudson, Sample Management Supervisor.

Prior to joining PACE NE, INC. Mr. Campbell worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE NE, INC. in June 1992. Mr. Campbell joined RAI in 1990 and worked as Lab Safety Assistant until 1991. His responsibilities as Safety Assistant included managing lab chemical inventories, MSDSs, and hazardous waste shipping manifests. He assisted in implementing the Chemical Hygiene Plan and laboratory safety practices.

Mr. Campbell has experience in customer service, civil engineering, and consumer electronics as well as academic training in the sciences.

Education

B.G.S., Planetary Geology, University of Iowa, 1986

Schoolteacher Certification, State of Maine, Spring 1987.

Intro. to Surveying (20 hours), UNH DCE, Fall, 1988.

Continuing Education

"Hazardous Waste Management in NH", Seminar, BIA/NHDES, March 19, 1992

Excellent Customer Service seminar, Dun & Bradstreet Business Education Services, May 13, 1991

Standard First Aid and Adult CPR Certification, October 15, 1990

"New Hampshire Safety Council Conference & Exhibition", 4/90

3.0 OBJECTIVES

PACE NE is committed to the philosophy that quality operations result from quality planning, design, and work performance by skilled operational personnel. PACE NE's policy is to perform its varied types of technical work in accordance with standard quality assurance practices such as Good Laboratory Practices (GLP) and the EPA Contract Laboratory Program (CLP). PACE NE has a Quality Assurance Officer responsible for maintenance of standard operating procedures, laboratory audits, performance evaluations, federal and state certifications and quality assurance documentation.

Each laboratory worker is responsible for checking standard operating procedures when necessary; following these procedures during routine analyses; recording quality control information required by those procedures in the proper location, and taking appropriate corrective action including suspending analyses when quality control criteria are not met.

Objectives of the quality program are:

- to provide a quality organization independent of the pressures of project performance with the responsibility and authority for auditing and recommending corrective action;
- to provide a quality organization with clear paths of communication with management;
- to perform regularly scheduled audits and thereby document an objective evaluation of quality-related practices;
- to promptly identify variances and implement corrective actions;
- to maintain readily identifiable and retrievable records that provide documentary evidence of the quality of activities performed;
- to provide procedures for implementing project-specific quality plans;
- to define responsibility and authority for developing and implementing quality plans;
- to provide quality reference documentation for each project.

Quality Assurance objectives for measurement data can be expressed in terms of completeness, representativeness, accuracy, precision, comparability and traceability.

3.1 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected. The QA objective for completeness is to maximize the number of valid results. This can be attained by:

- minimizing sample loss and breakage
- performing sufficient QC samples to document control
- documenting all aspects of the analytical system

The laboratory goal for completeness is 95% where:

$$\frac{D}{n} \times 100 = \% \text{ complete}$$

D : number of samples analyzed that met the Data Quality Objectives

n : number of samples recieved for analysis

3.2 Representativeness

Representativeness is the extent to which reported analytical results truly depict the chemistry of the sampled environment. Representativeness is a qualitative objective which is optimized through proper selection of holding times and procedures, through proper sample preservation, and through prompt extraction and analysis. Refer to Table 6.1.

USEPA guidance is followed for sample preservation and field preservation is checked upon sample receipt in the laboratory. Refer to PACE NE SOP QA-400, Sample Receiving and Identification, current revision.

Sample holding times follow EPA recommendations. In cases where no formal recommendation has been made, the holding time for that analyte in a different matrix or a similar analyte in a similar matrix is applied.

3.3 Accuracy and Precision

Accuracy and precision data are optimized through the use of analytical procedures that minimize biases through the use of standard procedures, through the meticulous calibration of analytical equipment and by implementing corrective action whenever measured accuracy and precision exceed pre-established limits.

Accuracy and precision are assessed through the analysis of Laboratory Control Check Samples. Laboratory generated QC samples, such as method blanks and Laboratory Control Spike/Spike Duplicate Samples are used to assess the accuracy and precision of measurements due to laboratory activities. QC Samples, such as surrogate spikes and matrix spike/matrix spike duplicates are used to monitor the effects of the sample matrix on precision and accuracy. QC Check Samples such as field blanks, field duplicates and trip blanks are used to assess the accuracy and precision of both sampling and laboratory activities. Accuracy and precision goals for the laboratory are based on laboratory historical data, specific method requirements and the requirements of each specific project. A more detailed discussion of these goals is provided in Section 11.

3.4 Comparability

Comparability is the extent to which comparisons among different measurements of the same quantity or quality will yield valid conclusions. Comparability is a qualitative objective that will be attained by utilizing standard techniques for sample analysis and by reporting analytical data in appropriate units. Comparability between PACE NE analytical results and those obtained by other researchers will be ensured through the use of EPA, ASTM, and other recognized methods.

3.5 Traceability

Traceability is the extent to which results can be substantiated by hard-copy documentation. Traceability documentation exists in two forms: that which links final numerical results to authoritative measurement standards, and that which explicitly describes the history of each sample from collection to analysis. Refer to Sections 6 and 10 for more specifics on PACE NE procedures.

4.0 STANDARD PRACTICES

4.1 Laboratory Safety

Sample receiving areas and laboratories shall be equipped with suitable hoods, respirators, protective clothing and eye wear, gloves, barrier creams and other measures to prevent or minimize staff contact with hazardous substances. Safety equipment such as eyewash stations, drench showers, spill adsorbents and neutralizers, fire extinguishers, first aid materials, and breathing oxygen shall be available.

As a matter of policy, PACE NE shall not accept known initiator explosives, known dioxin-contaminated materials or unusual biohazard materials. PACE NE shall accept only those radioactive materials for which the isotope and emissions are clearly identified, and are in compliance with the terms and conditions of any and all applicable license(s). PACE NE shall accept nitroaromatics and nitroamines providing that the client makes provisions for disposal of samples with a positive explosive identification.

A laboratory staff member shall be designated as Safety Manager by the Regional Director. The Safety Manager prepares and maintains safety-related SOP's, conducts safety and occupational health orientation, training and review sessions as required, and maintains up to date familiarity with safety and occupational health issues pertinent to the laboratory.

The Safety Manager prepares and maintains educational programs as required to comply with state and federal "right to know" legislation.

The Safety Manager or his designee shall conduct an orientation session with each new staff member to familiarize him/her with routine and emergency safety procedures and equipment. Generally, the first one to three days shall be devoted primarily to health and safety concerns. Eye protection and a lab coat shall be issued to the employee. A respirator will be issued, as required, after respiratory protection training. Refer to PACE NE NE SOP QA-607, Respiratory Protection. A tour of the laboratory shall be conducted. During the tour, needs for eye, skin, and respiratory protection shall be discussed as well as the use of safety glasses, face shields, goggles, partial and full-face respirators, ventilated work areas, fume hoods, gloves, barrier creams, and Tyvek coveralls. The location of eye wash stations, drench showers, fire extinguishers, and first aid equipment shall be shown to the employee and their use shall be described or demonstrated. Fire and spill notification, emergency procedures, and evacuation stations shall be taught during this session. Refer to PACE NE NE SOP QA-602, Employee Training Safety Tours. The orientation concludes with an introduction to potential

chemical hazards and the Material Safety Data Sheets (MSDS). MSDS shall be made available for review.
Employees shall be responsible for their own safety. Laboratory Managers and Group Supervisors may require that certain levels of protective equipment be worn when in their judgement it is appropriate. Failure of an employee to wear required protective equipment will result in immediate disciplinary action.

4.2 Training

Laboratory Manager(s) shall be responsible for staff training programs, which may be administered by the Laboratory Managers and Group Supervisors.

Training shall be conducted for each individual on each procedure that he or she is to perform.

No individual shall conduct any analysis, experimental procedure or other professional function without continuous direct supervision until training in that procedure has been completed and the individual's ability to produce acceptable results has been documented.

Training Documentation Forms and written records of training activities shall be generated and maintained by the Laboratory Managers or Group Supervisors.

Records of attendance at professional development seminars, conferences, courses and the like shall be kept by the Quality Assurance Department in individual training files maintained for all technical staff. Refer to PACE NE SOP QA-556, Training Files.

4.3 Security and Confidentiality

Three tiers of security shall be maintained within all PACE NE, Inc. facilities with the purpose of controlling external influences on samples, analytical processes, and data. This helps assure the completeness, representativeness, accuracy, and precision of analytical results.

The first tier of security maintained shall be controlled access to laboratory buildings. Exterior doors to laboratory buildings shall remain either locked or continuously monitored by a PACE NE, Inc. staff member. Keyless door-lock combinations shall be changed every time an employee terminates employment at PACE NE. Posted signs shall direct visitors to the reception office and mark all other areas as off limits to unauthorized personnel. All visitors to the facilities must sign the Visitors' Logbook maintained by the receptionist. All visitors shall be accompanied by a staff member during the duration of their stay on the premises. The staff member shall escort the

visitor back to the reception area at the end of their visit where they shall sign out in the Visitor's Logbook. Prior to departure of the last staff member at the close of each day, all windows shall be locked and all doors checked and locked by the last staff member.

The second security level shall be within the facility and may be designated as required by the Laboratory Managers in consultation with the Regional Director. Individual Laboratory Managers or Group Supervisors may close specific areas under their responsibility to entry by unauthorized persons. A list of authorized persons shall be prepared and signed by the Regional Director. "Closed Areas" shall be designated by prominent postings at all points of access.

The final tier of security shall be comprised of specific secure areas for sample, data and client report storage which shall be lockable within the facilities, and to which access shall be limited to specific individuals or their designees. Security of sample storage areas shall be the responsibility of the Sample Manager. Refer to PACE NE SOP QA-401, Sample Storage. Security of samples and data during analysis and data reduction shall be the responsibility of Group Supervisors and Laboratory Managers. Security of client report archives shall be the responsibility of the Quality Assurance Officer. Refer to PACE NE SOP QA-550, Data Archives. These secure areas will be locked whenever these individuals or their designees are not present in the facility.

Designated laboratory sample storage locations are designed to limit access to authorized personnel only, and provisions for lock and key access shall be provided. No samples are to be removed without authorization, which consists of having a worklist requesting analysis on an aliquot and without filling out the associated chain-of-custody records.

Standard business practices of confidentiality shall apply to all documents and information regarding client analyses. Specific protocols for handling confidential documents are described in PACE NE SOP QA-557. Additional protocols for internal identification of samples and data by number only shall be implemented as required under contract-specific Quality Assurance Project Plans.

4.4 Traceability of Standards, Instrumentation, and Data

Since standard solutions used for analytical method calibration affect all data derived from the method, the importance of quality and traceability shall be paramount.

Laboratory staff may order only materials of certified purity from reputable suppliers. Records of reference material purchased shall be maintained by the appropriate department.

PACE NE strives to purchase only the highest quality materials. To that end, reference materials shall be NIST traceable, EPA certified (CRADA), or American Association for Laboratory Accreditation certified whenever possible.

If assayed materials are unavailable, the material of highest purity available shall be obtained and assayed in-house before use.

Reference material containers shall be identified with the standard serial reference number and dated upon receipt.

Bound laboratory notebooks shall be used by analysts and technicians to record preparation of working standards from identified reference material. The following information shall be recorded:

date of preparation
analyst's initials
source of reference material
amounts used
final volume
serial reference number and expiration date of the stock standard used
expiration date of the working standard made

All standards containers shall be labelled with, at minimum (as on small glass ampules), the standard serial reference number; when possible, the name, concentration, date of preparation and expiration date of the stock standard.

All diluted working standards not consumed during an analytical session shall be labelled fully, including the serial reference number of any stock standard used in its preparation.

Instrumentation used shall be as prescribed in the SOP for the analytical method.

All instruments used to collect samples, generate sample results and/or reduce data shall be designated by a unique alphanumeric identifier. This instrument identifier shall appear on the instrument, in the analysts' notebooks, instrument logbooks and/or computer-generated hardcopy for all sample analyses.

Preventive maintenance shall be provided for all instruments and equipment as specified by the manufacturer, or as established by the Laboratory Manager (or Group Supervisor), whichever is more frequent. Preventive maintenance shall be conducted in order to assure timely, accurate and reproducible analytical processes in a safe laboratory or field environment.

All maintenance activities shall be recorded in either the instrument run log or a separate logbook unique to the instrument.

All data generated in and/or reported from the laboratory shall include reference to the person(s) who performed the analysis, the date of analysis, the method used, the identification of the instrument and the acceptability of the results in the context of the QC system.

The Laboratory Control Sheet issued to laboratory departments shall be used to initiate a laboratory data file for the project.

All data pertinent to sample preparation shall be recorded by the laboratory staff in bound notebooks with numbered pages, on preprinted bench sheet forms and/or in LABUX. If bench sheets are used, the original forms will be retained in a 3 ring binder and a true copy will be forwarded to the reporting group for inclusion with the archived report package. During the sample preparation process, a preparation sheet shall be prepared for the project by the preparation specialist. It shall contain the following information:

Sample identification numbers
Date of preparation
Method reference
Analyst's initials
Preparation weights and/or volumes
Relevant blank
Spike and surrogate data including the serial reference number and the instrumental analysis to be performed on each extract.

The preparation sheet shall be filed with the Laboratory Control Sheet in the Laboratory Project File.

At the time of sample analysis, the laboratory identification number, amount injected or otherwise analyzed, any dilution of the original sample and/or extract and other relevant sample data shall be entered into either an analyst's notebook or instrument logbook, or if possible into the instrument header.

All data relevant to the calculations should, where possible, be entered onto the instrument header including sample weight or volume, final volume, dilution, and spike level.

4.5 Accountability

All areas of the laboratory in which samples are received, stored, processed, or analyzed shall be kept in a condition that minimizes the risk of samples becoming lost or accidentally destroyed, contaminated, degraded, misidentified, improperly handled or otherwise compromised. The following practices shall be followed to assure that data reported represent results on the sample as submitted to the facility.

All employees shall be responsible for the cleanliness and order of their work areas. The Laboratory Manager(s) shall routinely tour the facilities noting major and minor infractions. These shall be brought to the attention of the respective group supervisors who formulate and institute corrective action through their staff.

Each sample, defined as a unit of matrix enclosed by a single container, shall be assigned a Laboratory Control Number by the Sample Management staff member who receives the sample. Provisions to identify field replicates and additional sample volume shall be incorporated into this procedure as described in PACE NE SOP QA-400, Sample Receiving and Identification.

Cross-referencing of Laboratory Control Numbers and Client Sample ID's shall be implemented in Sample Management documents as described in PACE NE SOP QA-400, Sample Receiving and Identification.

Sample analyses shall be identified by Laboratory Control Number in analysts' notebooks or instrument logbooks, which shall consist of bound laboratory notebooks with prenumbered pages or on pre-printed benchsheets.

Transfers of samples in and out of storage shall be recorded in Internal Custody Records maintained by the Sample Manager.

Standards shall be stored separately from samples and extracted samples.

Computerized systems for data generation designed in house shall be validated prior to implementation and shall contain provisions for password access and additional security measures as required.

Where commercial computer software is used for data generation within PACE NE, the software producer is responsible for validation of their system.

4.6 Sample Analysis

Samples shall be analyzed within holding times as specified in Table 6.1, unless a more restrictive holding time is prescribed under a contract-specific QA Project Plan.

Samples shall be analyzed and experimental procedures conducted following written Standard Operating Procedures (SOP's) which have been approved in writing by management. Where PACE NE SOPs differ from EPA or Standard Methods, these differences will be noted in the SOP. Refer to Section 8.0, Analytical Procedures. Substantial changes to established procedures shall be authorized in writing by management via an SOP revision process as described in PACE NE SOP QA-553, Preparation of SOP's.

Departures from SOP's need management approval prior to implementation and shall be recorded in the raw data and on an SOP Deviation Form obtained from the QA Department (Figure 12-1). A copy of the form should be filed with the associated report file.

Laboratory Managers shall assure that samples are scheduled for analysis in compliance with the analytical request as issued by the Sample Manager in the form of a Laboratory Control Sheet(s).

A written Worklist System approved by the Technical Director shall be used to assign work to preparatory and instrumentation lab staff members.

4.7 Data Validation

Each department shall have written procedures for data validation which incorporate the quality assurance goals of traceability, accountability completeness, precision and accuracy.

No written reports shall be issued which have not undergone the data validation process.

4.8 Documentation

All information related to the quality assurance practices outlined in this manual shall be contained in records. This shall include, but not be limited to, standard operating procedures, study protocols, results of instrument calibrations, analysis of quality control samples, analysis of samples, sample custody and disposal, preparation of standards, corrective action reports, audits and inspections.

The Quality Assurance Office shall keep written inventories of quality-related documents.

5.0 MATERIALS AND APPARATUS

5.1 Reagents, Solvents and Gases

Chemical reagents, solvents, gases, and standards, supplied by reputable chemical suppliers, are used in the laboratory. All chemical reagents used for analyses shall be at least "Analytical Reagent Grade". Individual method references may indicate specific reagent requirements.

Materials are dated upon receipt in the laboratory. Solvents are checked for purity before use (Section 5.2.2, Solvent Lot Checks). Filters are placed on gas lines supplying instruments as an extra precaution.

All solvents and gases used shall be chosen to assure compliance with specific method and SOP requirements.

5.2 Laboratory Equipment

5.2.1 Refrigerator/Freezer Temperature Logs

Refrigerators and freezers are checked every weekday to ensure that they are operating properly and within established temperature ranges. All information is recorded on monthly data sheets taped to the door of each unit. Routine maintenance such as defrosting is performed as needed. Refer to PACE NE SOPs QA-800 and QA-801. Responsibility for performing the checks is assigned within the laboratory section where the units are located. The QA Department is responsible for ascertaining that checks have been performed and that necessary corrective actions have been instituted when needed. The QA Department is responsible for maintaining all historical temperature logsheets.

5.2.2 Solvent Lot Checks

Solvents are checked for trace contaminants on a lot-by-lot basis. When a new lot is opened, the chromatogram for the blank associated with the first samples extracted using this new lot is checked for any contamination. All information relevant to the check is recorded and maintained in a Solvent Check File. Responsibility for performing the checks and maintaining the records is assigned to the Extractions Laboratory Group Supervisor.

5.3 Glassware

All glassware used in the laboratory is maintained in good condition, cleaned, properly stored, and separated according to its specific laboratory application. Cracked, excessively chipped or otherwise defective glassware is either discarded or repaired. PACE NE's analytical laboratory purchases the majority of glassware from recognized commercial laboratory glassware suppliers such as Fisher Scientific and Baxter. All volumetric glassware utilized is class "A" certified.

Each laboratory maintains its own set of glassware, completely independent from the other laboratories. Cleaning of glassware is performed in each preparation laboratory to ensure that the glassware remains within each laboratory.

5.4 Glassware Cleaning

Laboratory glassware is scrupulously cleaned prior to use. Different cleaning procedures exist for different types of analyses and glassware. Refer to PACE NE SOP QA-802 (inorganics), QA-805 (metals preparation), and QA-804 (general organics).

5.5 Sample Preservation and Storage

Samples are preserved according to the EPA's recommendations (refer to Table 6.1) unless otherwise instructed, and stored to minimize sample contamination. To keep samples of differing levels of contamination separate, samples are segregated when high levels of contamination are known to be present. The laboratory must rely upon information supplied by the sampling team to document any known hazards. If there are samples that are suspected of having contaminants at high levels, they are unpacked in a hood. For Log-In procedures and supporting documentation, see Section 6 and PACE NE SOPs QA-400 and QA-401.

A holding blank comprised of DI water is placed into the volatiles storage refrigerators in the sample Receiving Area to monitor the potential of cross contamination. The holding blank is created daily for volatiles and analyzed whenever the associated jobs are analyzed.

5.6 Instruments

Laboratory instrumentation used shall be as specified in the protocol for the analytical method. Table 5-1 is a listing of major analytical instrumentation present in this laboratory.

Preventive maintenance is performed for each instrument by analysts and technicians on an ongoing basis and the activities documented in a bound instrument maintenance logbook or in the analysts runlogs.

Corrective maintenance shall be provided as required for all instruments and equipment and documented in appropriate logbooks. Factory replacement parts, trained service technicians and first quality materials shall be used whenever available. It is PACE NE's policy to conduct repairs at the lowest level of complexity necessary and to obtain parts directly from primary manufacturers whenever possible. The purpose of this policy is to maintain efficiency, economy and reliability of quality maintenance.

TABLE 5-1

ANALYTICAL INSTRUMENTATION

ITEM	QTY.	DESCRIPTION
GC/MS & GC SYSTEMS:		
GC/MS/DS	2	HP 5970 on RTE A900 HP-1000
GC/MS/DS	2	HP 5970 on RTE A900 HP-1000
GC/MS/DS	2	HP 5970 on RTE 600 HP-1000
GC/MS/DS	1	Extrel, ELQ 400 on Digital PDP-11
GC/(2ECD)	2	HP 5890
GC(2ECD)	1	HP 5880
GC(FID, FPD)	1	HP 5890
GC(NPD, ECD)	1	HP 5890
GC(FID, ECD)	2	HP 5840, HP 5890
GC(FID, TCD)	1	HP 5880 dual channel
GC(PID, HECD)	1	Tracor 540
GC(HECD,ELCD)	2	HP 5890
GC(FID)	1	HP 5890
GC(NPD-FID)	1	Waters Dimension 1
GC(Hall-PID)	1	Waters Dimension 1
Auto Sampler	9	HP 7673A
Auto Sampler	1	Tekmar ALS 2016
Auto Sampler	5	Tekmar ALS
Purge & Trap	2	Tekmar LSC 2000
Purge & Trap	5	Tekmar LSC 2
Dynamic Headspace Concentrator	1	Tekmar 4000/4200
Thermal Desorber	1	Century ATD
Auto Sampler	2	HP 7672A
Auto Sampler	1	Varian 8050
Auto Sampler	2	Dynatech PTA-30
HPLC SYSTEMS:		
LC System-Auto Sampler	6	Waters Assoc. 48 position 712 WISP
LC System-Chromatography Pumps	5	Waters Assoc. 510
LC System-Conductivity Detector	1	Waters Assoc. 431
LC System-Fluorescence Detector	1	Waters Assoc. 420
LC System-Pump Controller	3	Waters Assoc. 680
LC System-RI Detector	1	Waters Assoc. 410
LC System-UV Spectrophotometer	2	Waters Assoc. 490E
LC System-UV Spectrophotometer	1	Waters Assoc. 441
LC System-Chromatography Pump	1	Waters Assoc. 590

TABLE 5-1 - CONTINUED

ANALYTICAL INSTRUMENTATION

ITEM	QTY.	DESCRIPTION
HPLC SYSTEMS - CONTINUED:		
LC System-Fraction Collector	1	ISCO - "Foxy"
LC System-Fraction Collector	1	Waters Assoc.
Post Column Derivatization System	1	Waters Assoc.
LC System-WAVS	1	Waters Assoc. Auto. Valve Station
Ion Chromatograph	1	Dionex 2000i
LC System-UV Detector	1	LDC Spectromonitor II
LC System-Scanning Fluorescence Detector	2	Waters Assoc. 470
LC System-Tunable Absorbance Detector	2	Waters Assoc. 484
LC System Controller & Pump	1	Waters Assoc. 600E
LC System Temperature Control Module	1	Waters Assoc. TCM
METALS INSTRUMENTATION:		
ICP	1	Thermo Jarrell Ash ICAP 61
ICP	1	Leeman Labs Plasma Spectrophotometer
AA Spectrophotometer	1	Hitachi Z9000 Zeeman (4 channel)
AA Spectrophotometer	1	Varian Spectra AA 20AA
AA Spectrophotometer	1	Perkin-Elmer 5100 Zeeman Furnace
AA Spectrophotometer	1	Perkin-Elmer 3100
Vapor Generation Accessory	1	Varian VGA-76
Auto Sampler	1	Varian PS-56
Auto Sampler	1	Perkin-Elmer AS90
Auto Sampler	1	Perkin-Elmer AS60/70
Furnace Atomizer	1	Perkin Elmer HGA 600
Mercury/Hydride System	1	Perkin-Elmer FIAS 200
DATA MANAGEMENT EQUIPMENT:		
Lab Automation System (LAS)	1	HP 3350 on RTE A900 HP-1000
Lab Information System (LABSAM)	1	HP on RTE A900 HP-1000
Tape Backup System (LABSAM, LAS)	1	HP 35401
Tape Data Archival (GC/MS)	2	HP 7970B
Tape Data Archival (GC/MS)	2	HP 7974
LAS/LABSAM Terminals	22	HP B&W/Color/150 Terminals
Personal Computers	85	NEC, CompuAdd & Compaq
Organic CLP Software	-	Finnigan Formaster
Inorganic CLP Software	-	Telecations

TABLE 5-1 - CONTINUED

ANALYTICAL INSTRUMENTATION

ITEM	QTY.	DESCRIPTION
OTHER INSTRUMENTATION:		
Autoanalyzer	1	Lachat QuickChem AE
IR Spectrophotometer	1	Perkin Elmer 1420
Total Organic Carbon Analyzer	1	Astro 2001
Total Organic Halide Analyzer	1	Dohrman
Liquid Scintillation Counter	1	LKB Wallac 1214 Rackbeta
UV-Vis Spectrophotometer	1	Bausch & Lomb Spectronic 601
Visable Spectrophotometer	2	Milton Roy 301
Analytical Balance	2	Mettler AE200
Analytical Balance	1	Mettler H31AR
Analytical Balance	1	American Sci. Prod. SP182
Top-loading Balance	1	American Sci. Prod. Z3000
Top-loading Balance	1	American Sci. Prod. Z410
Top-Loading Balance	1	Mettler PJ400
Top-Loading Balance	1	AND EK-1200A
pH Meter	1	Beckman 43
pH Meter	1	Beckman 11
pH Meter	1	Jenco Electronics 6071
Conductivity Meter	1	YSI Scientific Model 32
Rotary Extractors	4	Associated Design Model 3740-12-BRE

6.0 SAMPLE CUSTODY

Chain-of-Custody encompasses three major elements: field sampling, laboratory analysis and final data file. A Chain-of-Custody (COC) document may be the means in some types of legal proceedings by which evidence of custody of samples from time of receipt to completion of analysis is proved in the courts. PACE NE has implemented standard operating procedures to ensure that sample custody objectives of traceability and responsibility are achieved for every project. This section covers quality related activities from the receipt of samples at the laboratory through the issuance of final analytical data and the storage of data in its final data file.

6.1 Chain-of-Custody

The National Enforcement Investigations Center (NEIC) of EPA defines evidence of custody in the following manner:

1. It is in your actual possession, or
2. It is in your view, after being in your physical possession, or
3. It was in your possession and then you locked or sealed it up to prevent tampering, or
4. It is in a secure area.

Samples may be physical evidence and should be handled according to certain procedural safeguards. Field personnel or Client representatives complete a Chain-of-Custody Form for all samples. Samples are received by the laboratory accompanied by these forms.

The sampler should provide the following information:

- Client project name
- Project location
- Field sample number/identification
- Date and time sampled
- Sample type

- Preservative
- Analysis requested
- Sampler signature
- Signature of person relinquishing samples
- Date and time relinquished
- Sampler remarks
- Custody Seal Number

The record is filled out completely and legibly. Errors are corrected by drawing a single line through and initialing and dating the error. The error is also "error coded" to explain the reason for the correction (refer to Table 9-1). The correct information is then recorded with indelible ink. All transfers of samples except to and from commercial couriers must be recorded on the Chain-of-Custody via the "relinquished" and "received by" sections. All information except signatures may be printed.

When samples are received into the laboratory (refer to Section 6.3), Sample Management Personnel sign the Chain-of-Custody, verify their integrity as they are unpacked and explicitly state in the receipt records whether the Chain-of-Custody seal is intact, whether the sample is received intact or broken, and whether the sample is appropriately identified. This information is documented on the Sample Receipt Condition Report (SRCR) and the client is contacted if any discrepencies or problems are found. If the integrity requirements are met or when any discrepancies are resolved, the sample is assigned a laboratory identification number, the sample is stored in the appropriate refrigerator and the pertinent information is entered into the Laboratory Information Management System (LIMS). Once samples are in the laboratory, an Internal Custody Record is generated to track the transport and status of each sample within the laboratory. After sample log-in, a project file is started by the Sample Management Group Supervisor which includes the Chain-of-Custody record and all sample receipt documentation. Further detail on internal laboratory custody procedures is provided in subsequent subsections.

6.2 Sampling Kits

In general, sampling kits comprise the following:

- Sampling containers
- Preservatives (upon request) and appropriate MSDSs
- Chain-of-Custody forms
- Custody Seals (upon request)
- Sample labels
- Packing Material
- Shipping containers
- Ice Packs

Sample kit requests are received by the laboratory personnel (generally the Sample Manager) from a Project Manager or sampling team members via telephone request, memo, or facsimile.

Based upon the specific request, the Sample Manager or Project Manager determines the appropriate containers, preservatives and the necessary volume/quantity to specify for the analysis. This information is outlined in Tables 6-1. Refer to PACE NE SOP QA-402, Bottle Orders and QA-403.

6.2.1 Sample Containers

VOA vials (40 mL) are purchased pre-cleaned from Industrial Glassware.

Sample bottles for all analyses other than VOA are purchased from Fisher Scientific. All glass and plasticware is purchased in lots of about 15-50 cases per size and type of bottle.

An internal lot number is assigned to each batch of bottles purchased so that each batch may be tracked and tested for cleanliness. One or two bottles per batch per type of analysis is taken at random and tested. PACE NE tests its glassware for cyanide, 23 metals, acid/base/neutrals, pesticides, PCBs, and volatile organics as follows:

Table 6-1

Sampling and Preservation Requirements

Parameter	Method	Required Volume & Containers [3]	Preservation [7]	Holding Time (in days)
Organics:				
Drinking water GC/MS VOA	EPA 524.1/524.2	3 x 40 ml Glass vial	HCl; 4°C [2]; No headspace	14
Wastewater GC/MS VOA	EPA 624/SW846 8240	2 x 40 ml Glass vial	HCl; 4°C [2]; No headspace	14
Purgeable Halocarbons	EPA 601/SW846 8010	2 x 40 ml Glass vial	HCl: 4°C [2]; No headspace	14
Aromatics	EPA 602/SW846 8020	2 x 40 ml Glass vial	HCl; 4°C [2]; No headspace	14
Acrolein, Acrylonitrile	EPA 603/SW846 8030	2 x 40 ml Glass vial	pH 4-5;4°C [2]; No headspace	14
TOX (Total Organic Halides)	subcontracted	250 ml Glass,amber	H_2SO_4; 4°C; No headspace	7
Acids/Base Neutrals	EPA 625/SW846 8270	1000 ml/30 g Glass,amber	4°C [2]	7(14)/40
Pesticides/PCB's	EPA 608/SW846 8080	1000 ml/30 g Glass	NaOH,H_2SO_4,pH 5-9;4°C [2]	7(14)/40
Carbamate Pesticides	EPA 531.1	120 ml Glass	3.6 ml Monochloroacetic acid buffer pH 3; Freeze	28
Herbicides (SDWA)	SM 509A/SW846 8150	1000 ml/30 g Glass	4°C [2]	7(14)/40
Petroleum Hydrocarbons-GC/FID	ASTM D-3328-78	1000 ml/30 g Glass	H_2SO_4; 4°C	7(14)/40 [6]
Petroleum Hydrocarbons-IR	EPA 418.1	1000 ml/30 g Glass	H_2SO_4; 4°C	28
Polynuclear Aromatics	EPA 610/SW846 8100	1000 ml/30 g Glass,amber	4°C [2]	7(14)/40
Oil & Grease - Gravimetry	EPA 413.1	1000 ml/30 g Glass	1+1 HCl; 4°C	28
Oil & Grease - IR	EPA 413.2	1000 ml/30 g Glass	1+1 HCl; 4°C	28
NM2P	EPA 625/SW846 8270	1000 ml/30 g Glass	4°C	7(14)/40
Total Phenolics	EPA 420.3	200 ml/30 g Glass,amber	H_2SO_4; 4°C	28
Dioxins	subcontracted	1000 ml/100 g Glass	4°C [2]	7(14)/40
Metals:				
Mercury	245.1/7470 (7471)	50 ml/10 g	HNO_3	28
Arsenic & Selenium	EPA 200/7000 Series	50 ml/10 g	HNO_3	180
Lead, Thallium, Antimony	EPA 200/7000 Series	50 ml/10 g	HNO_3	180
All other metals (ICP metals)	EPA 200.7/SW 6010	50 ml/10 g	HNO_3	180
plus Hardness	SM 314A/EPA 200.7	(Included)	HNO_3	180

The following elements can be analyzed by ICP: Al, Ag, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mo, Mn, Si, Sr, Sn, Na, Ni, Pb, Ti, V and Zn in water, wastewater, and digested solids. As, Pb (water), Se, Tl and other metals normally analyzed by furnace may be determined by ICP but only with reduced sensitivity and therefore higher detection limits. Hg is analyzed by cold vapor.

NOTE: If duplicates and spikes are required, triple the sample volume for water samples.

EPTOX	SW846 1310	250 grams	N/A	N/A
TCLP	Fed.Reg.Vol. 55 Nov. 24, 1992 Rules and Reg.	250 grams (2 X 250 g containers if VOAs are required)	4°C	See Below

TCLP PARAMETER	FROM COLLECTION TO TCLP EXTRACTION	FROM TCLP EXTRACTION TO PREPARATIVE EXT'N	FROM PREP EXT'N TO ANALYSIS
VOLATILES	14	N/A	14
SEMIVOLATILES	14	7	40
MERCURY	28	N/A	28
METALS EXCEPT MERCURY	180	N/A	180
PESTs/HERBs	14	7	40

Table 6-1, continued
Sampling and Preservation Requirements

Parameter	Method	Required Volume & Containers [3]	Preservation [7]	Holding Time (in days)
Inorganics:				
Acidity	EPA 305.1	125 ml/ 2 g	4°C	14
Alkalinity	EPA 310.1	125 ml/ 2 g	4°C	14
Asbestos	subcontracted	1000 ml Glass	4°C	
Bromide	EPA 300.0	10 ml/20 g	4°C	28
BOD	EPA 405.1	250 ml	4°C	2
BTU	ASTM D 240	5 ml/ 2 g	4°C	N/A
Chloride	EPA 300.0 or 325.1	10 ml/20 g	4°C	28
Chlorine upon Combustion (oil)	ASTM D 129-64/300.0	20 g	4°C	N/A
Chlorine, Residual	APHA 4500-CLG	200 ml		Field Test
COD	EPA 410.4	50 ml/ 5 g	H_2SO_4; 4°C	28
Coliform Bacteria	subcontracted	125 ml sterile	4°C [2]	24(6) Hours [5]
Color	EPA 110.2	100 ml	4°C	2
Conductance	EPA 120.1	100 ml	4°C	28
Cyanide, Total	EPA 335.2/SW 9010	1000 ml/25 g	NaOH; 4°C [1]	14
Cyanide, Ammenable	EPA 335.1/SW 9010	1000 ml/25 g	NaOH; 4°C [1]	14
Flashpoint	ASTM D 93-77	80 ml/80 g	4°C	N/A
Fluoride	EPA 340.1/340.2	100 ml (NPDES=500ml) Plastic	4°C	28
Formaldehyde	NIOSH 3500 mod	20 ml/20 g	4°C	N/A
Grain size (dry sieving)	EPA/CE-81-1	100 g		N/A
Hexavalent Chromium	SW846 7196	125 ml/20 g	4°C	1
Ignitability	SW846 1010	50 ml/25 g	4°C	N/A
MBAS (Surfactants)	EPA 425.1	150 ml	4°C	2
Nitrogen - Ammonia	EPA 350.1 or .3	200 ml/ 5 g	H_2SO_4; 4°C	28
" - Nitrate	EPA 300.0 or 353.2	25 ml/20 g	4°C	2
" - Nitrite	EPA 300.0 or 354.1	25 ml/20 g	4°C	2
Nitrogen - Nitrate+nitrite	EPA 353.2	25 ml/20 g	H_2SO_4; 4°C	28
" - TKN	EPA 351.3	200 ml/ 5 g	H_2SO_4; 4°C	28
" - TON (NH_4 & TKN)	EPA 350.3/351.3	250 ml/ 5 g	H_2SO_4; 4°C	28
Ortho Phosphate-P	EPA 365.1 or .3	100 ml	4°C	2
Particle size (wet digestion)	EPA/CE-81-1	100 g	4°C	N/A
pH	EPA 150.1	25 ml		Field Test
Phosphorus, Total	EPA 365.3 or .4	100 ml/ 5 g	H_2SO_4; 4°C	28
Radiology - R, U, Alpha,Beta,Gamma	subcontracted	3000 ml	HNO_3; 4°C	180
Radon	subcontracted	2 x 40 ml Glass	4°C	2
Reactivity- Sulfide Spot Test	SM 427.3C	10 ml/10 g	4°C	N/A
Reactivity- Cyanide Spot Test	SM 412J	10 ml/10 g	4°C	N/A
Reactivity- Releasable Cyanide	SW 846,Sec.7.3.3.2	10 g	No Headspace, 4°C	N/A
Reactivity- Releasable Sulfide	SW 846,Sec.7.3.4.1	10 g	No Headspace, 4°C	N/A
Silicate, Reactive	EPA 370.1	100 ml/ 2 g Plastic	4°C	28
Solids, Settleable	EPA 160.5	1000 ml	4°C	2
Solids, Total (TS)	EPA 160.3	100 ml [4]	4°C	7
Solids, Total Suspended (TSS)	EPA 160.2	100 ml [4]	4°C	7
Solids, Total Dissolved (TDS)	EPA 160.1	100 ml [4]	4°C	7
Solids, Total Volatile (TVS)	EPA 160.4	100 ml [4]	4°C	7
Solids, Total Suspended Volatile	EPA 160.4 or .2	100 ml [4]	4°C	7
% Solids (% moisture)	APHA 2540G	30 g	4°C	N/A
Specific Gravity	EPA/CE 1981	30 ml	4°C	N/A
Sulfate	EPA 300.0 or 375.2	10 ml/20 g	4°C	28
Sulfide	EPA 376.2	250 ml	ZnAc;NAOH,pH>9; 4°C	7
Sulfite	EPA 377.1	100 ml		Field Test
Tannins and Lignins	APHA 5550B	100 ml	4°C	N/A

Table 6-1, continued
Sampling and Preservation Requirements

Parameter	Method	Required Volume & Containers[3]	Preservation[7]	Holding Time (in days)
Inorganics:				
TIC (Total Inorganic Carbon)	EPA 415.1 mod	60 ml/ 2 g	4°C	28
TOC	EPA 415.1	60 ml/ 2 g	No Headspace H_2SO_4; 4°C	28
Turbidity	EPA 180.1	100 ml	4°C	2
Viscosity	ASTM D-445	300 ml	4°C	N/A

References:

EPA = 40 CFR 136
SW846 = Test Methods for Evaluating Solid Waste Physical/Chemical Methods, US EPA SW846, 3rd edition, 1986
SM = Standard Methods For The Examination of Water and Wastewater, 16th ed., 1985
APHA = Standard Methods For The Examination of Water and Wastewater, 17th ed., 1989
ASTM = American Society for Testing and Materials

[1] .006% ascorbic acid if residual chlorine is present.
[2] .008% sodium thiosulfate if residual chlorine is present.
[3] Plastic or glass jars are suitable unless otherwise indicated.
[4] TSS, TDS and TSVS are performed on the same 100 ml sample. TS & TVS are performed on the same 100 ml sample.
[5] "Holding time is not to exceed six hours if the data is to be used in litigation."
[6] No holding time is published - these times are suggested/borrowed from the ABN hold time.
[7] Acid preservations (H_2SO_4, HNO_3, HCl) are adjusted to pH < 2, base preservations (NaOH) are adjusted to pH > 12 unless otherwise noted.

Cyanide: Fill a one liter plastic bottle with DI water and preserve with NaOH. Analyze the water according to normal laboratory procedures.

Metals: Fill a 500 mL poly bottle with 100 mL of 2% nitric acid solution from the metals instrumentation room. Shake. Analyze for metals.

ABNs, Pesticides, PCBs: Submit an empty 1 L glass jar to the Organics Extractions Laboratory for testing with instructions for special extraction procedures to be employed as follows - Add 60 mL $MeCL_2$, shake for 2 minutes, KD to appropriate test volume and analyze under normal laboratory procedures.

VOA: Submit an empty 120 mL jar to the volatiles laboratory with instructions to fill the jar with VOA-free DI water. Let stand for 24 hours and analyze under normal laboratory procedures.

If any analyses indicate contamination, the affected lot is washed according to one of the following protocols and a random sample is retested.

Cleaning Procedure 1 (Extractable Organics)

- wash glass bottles, teflon* liner and caps in hot tap water with laboratory grade non-phosphate detergent
- rinse with tap water
- rinse with 10% HCl (metals-grade HCl in ASTM deionized water)
- rinse three times with ASTM type 1 deionized water
- rinse with hexane
- rinse with pesticide grade methylene chloride
- air dry or oven dry at 125°C
- place liners in lids and cap containers

Procedure 1 is used for amber and clear glass wide mouth jars, amber and clear glass Boston round, and amber and clear glass jugs.

Cleaning Procedure 2 (Purgeable Volatile Organics)

- bake opened jars and lids in a 125°C oven for 30 minutes
- cool
- cap

Procedure 2 is used for 40 ml glass vials, amber and clear, open and closed top, and 8 oz. amber Boston round with septa top.

Cleaning Procedure 3 (Metals, Cyanide)

- wash polyethylene bottles and caps in hot tap water with laboratory grade non-phosphate detergent
- rinse with tap water
- rinse with 10% HNO_3 (metals-grade HNO_3 in ASTM deionized water)
- rinse with deionized water
- invert and air dry in contaminant-free environment
- cap bottle

Procedure 3 is used for HDPE modern round bottles and cubitainers.

6.2.2 Assembling Kits

All glass containers are to be surrounded with packing material to prevent damage.

All preservatives are stored in 10 - 20 ml plastic squeeze bottles, contained within 250 ml plastic wide mouth jars which are appropriately labelled.

The appropriate number of labels and COC's are affixed to the ziplock plastic bag that the sample is stored in.

All the above contents are to be placed inside a cooler with ice packs (if requested) and secured for shipment using styrofoam (packing peanuts or other appropriate packing materials).

Sample kits are delivered to the sampling team via Federal Express, UPS, courier, or personally picked up by the sampling team.

6.3 Sample Receipt and Log-In

Refer to PACE NE SOP QA-400, Sample Receiving and Identification.

Typically, samples are received by the laboratory during normal business hours (8:00 am to 6:00 pm), Monday through Friday and 8:00 am to noon on Saturday.

Shipments for after hours and Sunday delivery are prearranged with laboratory personnel to ensure that personnel will be available to sign the airbill, record the date and time of sample receipt and to place the cooler in the sample management area under refrigeration until the next business day.

Upon sample receipt, the coolers are inspected for the general condition of the Custody Seal, if present. The coolers are then opened and each sample is inspected for damage. The sample containers are removed from the packing material and identities are verified against the Chain-of-Custody. All information regarding sample condition upon receipt is documented on the Sample Receipt Condition Report (SRCR). The report documents:

- Name of person if hand delivered
- Presence/Absence of COC forms and custody seals
- Condition of the custody seals, if present
- Discrepancies noted
- Holding times and preservatives
- Proper sample containers
- Appropriate sample volume

The Sample Receipt Condition Report is completed by signing and recording the date and time. If there are any discrepancies or problems with the samples or documentation, the sample custodian immediately notifies the client or the appropriate PACE NE project manager.

The samples are logged into the laboratory system. Each sample group is assigned a unique five digit laboratory number. This number is preprinted on the SRCR sheets. A unique number is assigned to each sample in the group during the receiving process. This Laboratory Number consists of the PACE NE Laboratory Number followed by a numerical suffix serialized to account for the number of samples in a sample group. This laboratory ID is also recorded on the Chain-of-Custody form.

All of this paper work is then used to log the samples into the PACE NE Laboratory Information Management System (LIMS), a computerized management and tracking system. The LIMS generates laboratory worklists of all samples in the system.

6.4 Initiation of Testing Program

Once samples are received and logged into the laboratory system, the Chain-of-Custody, Sample Receipt Condition Report, and any memo or other documentation is placed into a project file created by sample management. If a sample group is a priority or if samples have a short holding time, sample management will immediately provide notification to the appropriate laboratory personnel that samples have arrived and are ready for processing or will deliver the samples directly to the lab. Otherwise, the LIMS automatically produces a daily worklist for each laboratory section listing all samples in the system which need to be processed, the type of quality control samples required, the priority status, holding time and test(s) required.

There is a system for tracking the status and internal chain-of-custody of samples within the laboratory once sample processing begins. The system documents the movement of samples from sample receiving to sample preparation and back and also the movement of processed sample extracts from sample preparation through analysis. The Internal Custody Record is used by sample preparation personnel to locate samples in the sample management storage areas. The transfer from storage to preparation is documented on this sheet. It also serves to document:

- Who removed the sample from storage

  When

- Which samples are associated with a Lab Number
- If the entire sample was entirely consumed
- When and by whom the remainder of sample was returned to storage

The original Internal Custody Record is maintained by Sample Management until the sample disposal date is recorded on it. After sample disposal, the Internal Custody Record is forwarded to the QA department for archiving.

The second system for tracking samples is the LIMS generated worklist. The worklist is generated every night and lists the status for each sample batch/project and for each analytical section. The worklist is distributed to each laboratory section. When the section personnel completes the particular task, they log into the LIMS and complete the information for that batch of samples.

6.5 Sample Disposal

After completion of sample analysis and submission of the analytical report, unused portions of samples are retained by the laboratory for a minimum of 2 weeks. After 2 weeks, samples will be disposed of according to the nature of the samples. The Hazardous Waste Manager receives a copy of the data report and uses that information to select the appropriate waste steam for the samples. The samples are considered hazardous waste and are handled by state and federally licensed hazardous waste disposal firms.

Upon disposal of samples, a computer spreadsheet is maintained by the Hazardous Waste Manager listing the sample number, inherent waste stream and date disposed. This data file is updated on a weekly basis and is kept on file by the Hazardous Waste Manager and Sample Management.

6.6 Subcontracting Analytical Services

Every effort is made to perform chemical analyses for PACE NE clients within the PACE NE laboratory. There are, however, instances where subcontracting of analytical services is necessary. Currently, the following analyses are subcontracted:

- Bacteriological
- Asbestos
- Dioxins
- Radiological
- Total Organic Halides
- NPDES Tin (furnace method 282.1 and 282.2)

When subcontracting becomes necessary, a preliminary verbal communication with an appropriate laboratory is undertaken. Work involving NEESA samples may be subcontracted only to NEESA approved laboratories. Approval must be obtained from the prime contractor before work may be sent out. The contact and preliminary arrangements and terms of agreement are made between the PACE NE Project Manager and the appropriate subcontract laboratory personnel (i.e., laboratory manager, customer services contact, or the appropriate laboratory section manager). The specific terms of the subcontract laboratory agreement should include (when applicable):

- Method (EPA or otherwise) of analysis
- Number and type of samples expected
- Project specific QA/QC requirements
- Deliverables required
- Applicable laboratory certification status
- Price per analysis
- Turn around time requirements

Chain-of-Custody forms must be generated for samples which require subcontracting to other laboratories. The sample management personnel repackage the samples for shipment, create a transfer chain-of-custody form and record the following information:

- PACE NE Laboratory Number
- Matrix
- Requested analysis

  Special instructions (quick turn around, required detection limits, anything unusual known about the samples or analytical procedure).

- Signature in "Relinquished By"

All subcontracted sample data reports are sent to the PACE NE Project Manager. The Project Manager sends the report to the appropriate PACE NE laboratory manager for review.

Any PACE NE work sent to other labs within the PACE, Inc. network is handled as subcontracted work. All of the conditions and considerations noted in Section 6.6 above apply.

7.0 CALIBRATION PROCEDURES AND FREQUENCY

All instruments and equipment used in the laboratory must follow a well defined calibration routine. Calibration may be accomplished by laboratory personnel using certified reference materials traceable to NIST or EPA certified materials or by external calibration agencies or equipment manufacturers. The discussion presented here is general in nature because the requirements for calibration are instrument (or equipment) and method specific. Details of calibrations can be found in PACE NE Standard Operating Procedures, analytical methods; and operations manuals.

7.1 Standards and Traceability

Analytical standards are prepared from pure compounds or are purchased prepared from reputable vendors. They are used to prepare serial dilutions that are used as calibration and spiking standards. Each laboratory section is responsible for the preparation, storage and disposal of its standards. The preparation information is recorded into section specific Standards Notebooks. The notebooks are where the preparer records all information needed to maintain proper traceability.

Each standard is given an internal identification number. In some instances, particularly with pre-mixed organic standards, the identification number is the solution lot number followed by an PACE NE assigned letter. The preparation of all stock standards shall be documented in a Standards Notebook which is used to record the date of preparation, the analyst, the source of the reference material, amounts used, final volume, etc. and the serial reference number of that stock solution. All standards shall be labelled with the standard serial reference number (small glass ampules), and with the name, concentration, date of preparation and expiration date of the stock standards. All diluted working standards not consumed during an analytical session shall be labelled fully, including the serial reference number of any stock standard used in its preparation.

If no expiration date has been assigned by the manufacturer, then an expiration date of one year from the date of preparation (or the date first opened in the case of sealed ampules) is reported unless degradation prior to this date is observed. To help determine if a standard has degraded, one must note inconsistencies. For instance, very poor recoveries from newly prepared quality control spikes or abnormally low instrument response to a specific standard are indications of possible standard degradation. However, for some standards, degradation is more easily noted. For instance, DDT breaks down to form DDD and DDE. Here one can visually note, on a chromatogram, the degradation of DDT by the increased concentrations of DDD and DDE. If

degradation is observed before the default expiration date, it should be noted in the Standard Notebook for that standard and the standard removed from service. Standards can be held past assigned expiration dates only if it can be demonstrated, by using NIST procedures and a standard from a separate source, that there has been no degradation.

Before any set of non-CRADA standards can be utilized in a calibration curve they must be verified by a secondary means:

- Analysis of an EPA QC Check Sample, or
- Analysis of an independently prepared check standard.

7.2 General Calibration Procedures

Calibration standards for each parameter are chosen to bracket the expected concentrations of those parameters in the sample, and to operate within the linear response range of the instrument. Samples that fall outside of the calibration range are diluted until bracketed by the calibration standards. Calibration standards are prepared typically at a minimum of three concentration levels, usually chosen at two times, three to five times, and five to ten times the estimated method detection limit plus a calibration blank, with the exception of most organic analyses which do not require a calibration blank. Either an internal standard or external standard quantification technique can be utilized.

Calibration standards are prepared from materials of the highest available purity. To establish instrument calibration, working standards are prepared from more concentrated working stock solutions. All organic standards are refrigerated or frozen. Inorganic standards are refrigerated as necessary. Data regarding their preparation is recorded in the each laboratory sections' Standards Notebook.

Instrumental responses to calibration standards for each parameter are subjected to an appropriate statistical test of fitness (least squares linear regression, quadratic equation, or relative standard deviation of response factors) or as required by the method or QAPP. The calibration must reflect an acceptable correlation of data points or linearity to be acceptable. In cases where the calibration data are outside of these criteria, the analyst must rerun the calibration standards (meeting the same criteria), changing instrumental conditions as necessary.

For analyses which are performed frequently and for which substantial calibration data is available, a complete recalibration is not required each time an analysis is performed providing that the following criterion is met: one calibration standard is analyzed at the

beginning of the analysis which may vary from the expected response (based on the initial, most recent calibration curve) by no more than ±25% or as specified by the method, SOP or QAPP. If this criterion is not met, a complete recalibration is necessary.

During the course of analysis, calibration standards are routinely analyzed to ensure that the instrumental response has not changed. Again the criterion stipulated in each method, or SOP for expected response is used by the analyst to determine whether the instrument must be recalibrated or the instrument conditions further optimized.

The accuracy of prepared standards is periodically checked by comparison with a standard from an independent source.

Certain pieces of equipment such as balances, pH meters, and turbidity meters are normally calibrated with NIST traceable standard reference material.

7.2.1 Analytical Balances

Every six months, calibration of the entire analytical range shall be checked by a qualified service technician. The calibration of each balance is checked each day of use using weights traceable to the National Institute of Standards and Technology (NIST). Calibration weights are Class S or better and are recertified every two years. If balances are calibrated by an external agency, verification of their weights shall be provided. All information pertaining to balance maintenance and calibration is found in the individual balance logbook.

7.2.2 Thermometer

Certified, or reference, thermometers are maintained for checking calibration of working thermometers. Reference thermometers are provided with NIST traceability for initial calibration and are recertified every year with equipment directly traceable to the NIST.

Working thermometers are compared with the reference thermometers every 12 months. Each thermometer is tagged and individually numbered. In addition, working thermometers are visually inspected by laboratory personnel prior to use.

Calibration temperatures and acceptance criteria are based upon the working range of the thermometer and the accuracy required for its use. Laboratory thermometer inventory and calibration data is found in the thermometer logbook.

7.2.3 pH/Electrometer

The meter is calibrated before use each day, and once after each four hours of use using buffer solutions as required by PACE NE SOP QA-800, Use, Calibration, and Maintenance of Equipment - Inorganics Lab.

7.2.4 Spectrophotometer

During use, spectrophotometer performance is checked against CCVs and ICVs. The instrument operating capability is also evaluated every six months by an outside service (QC Services).

7.2.5 Titrimetric Methods

Reagents are standardized when newly prepared and every six months following. If the stability of a solution is known to be less than six months it is checked more frequently. Check standards are run with each batch of samples to demonstrate the integrity of the reagents and that the technique employed has not been comprimised over time.

7.2.6 Oven Calibration

Oven temperature is monitored prior to use and daily once in use by calibrated thermometers.

7.2.7 Refrigerator Calibration

Refrigerator temperature is monitored two times on a daily basis by calibrated thermometers.

7.3 GC/MS Calibration Procedures

All volatile and semivolatile analyses by GC/MS performed in support of NEESA shall follow current CLP methodologies (EPA CLP SOW OLM01.8). The following operations should be performed routinely in the laboratory:

- Documentation of GC/MS mass calibration and abundance pattern
- Documentation of GC/MS response factor stability
- Internal standard response and retention time

Prior to initiating data collection, it is necessary to establish that a given GC/MS meets the standard mass spectral abundance criteria. This is accomplished through the analysis of decafluorotriphenylphosphine (DFTPP) for base/neutral and acid (BNA) compounds or p-bromofluorobenzene (BFB) for volatile compounds. The ion abundance criteria for each calibration compound should be met before any samples, blanks, or standards can be analyzed.

Each GC/MS system used for the analysis of semivolatile organic compounds by EPA methods must be tuned to meet method specific abundance criteria for a 50 nanogram (ng) injection of DFTPP. This criteria must be demonstrated every twelve (12) hours. Documentation of the calibration must be provided in the form of a bar graph plot and as a mass listing.

Each GC/MS system used for the analysis of volatile organic compounds by EPA methods must be tuned to meet method specific abundance criteria, typically for a 50 ng injection of BFB. The criteria must be demonstrated every twelve (12) hours. Documentation of the calibration should be provided in the form of a bar graph and a mass listing.

Prior to the analysis of samples and after tuning criteria have been met, the GC/MS system must be initially calibrated with a minimum of five concentrations of each compound being analyzed to determine the linearity of response. USEPA criteria specify both the concentration levels for initial calibration and the specific internal standard to be used on a compound-by-compound basis for quantification. The response factor (RF) for each compound at each concentration level is calculated using the following Equation 7.1:

$$RF = \frac{A_x}{A_{is}} * \frac{C_{is}}{C_x} \qquad (7.1)$$

where:

A_x = area of the characteristic ion for the compound to be measured.

A_{is} = area of the characteristic ion for the specific internal standards.

C_{is} = concentration of the internal standard (ng/ul).

C_x = concentration of the compound to be measured (ng/ul)

Using the RF from the initial calibration, the percent relative standard deviation (%RSD) for compounds identified as Calibration Check Compounds is calculated using Equation 7.2:

$$\%RSD = \frac{s}{\bar{x}} \times 100 \qquad (7.2)$$

where:

RSD = relative standard deviation
s = standard deviation of initial five response factors (per compound).
$\bar{x}$ = mean of initial five response factors (per compound).

The %RSD for each individual CCC should be <u>less</u> than 25 % or as specified by the method. This criteria must be met for the initial calibration to be valid.

A calibration standard containing all compounds of interest as well as all required surrogates, is performed each day of analysis. The RF data from the standards is compared each day against the average RF from the initial calibration for a specific instrument. If the response to a calibration check standard differs from the initial calibration by more than ±25% or as specified by the method, then investigation and corrective action must be performed, including a complete recalibration if necessary.

7.4 Gas Chromatography Calibration Procedures

Calibration of a gas chromatograph (GC) for volatiles analyses is similar to GC/MS calibration procedures. Initially, a five point calibration curve, consisting of all compounds of interest at five different concentrations plus a calibration blank, is established to define the linear range of the instrument. The curve is determined to be linear if the correlation coefficient is ≥ 0.99. Linearity may also be determined using response factors. Response factors are calculated for each compound at each concentration level. These RF will be averaged to generate the mean daily RF for each compound over the range of the standard curve. The mean response factor will be used to calculate the sample concentration of the compound of interest. When sample responses exceed the range of the standard curve, the sample will be diluted to fall within the range of the standard curve and be reanalyzed. The results of the daily GC standardization will be tabulated and filed with the corresponding sample analyses. Daily full calibration is not necessary if a calibration check standard validates the initial

calibration curve. If the response to a calibration check standard differs from the initial calibration by more than ±15% for any analyte being quantitated or as specified by the method, then investigation and corrective action will be performed, including complete recalibration, if necessary.

Initial Calibration of a GC for semivolatile compound analyses (pesticides/herbicides) typically involves a five point calibration curve, consisting of all compounds of interest at five different concentrations to define the working range. Using analyte peak height or peak area, a quadratic curve is applied and extrapolated through the origin. A correlation coefficient of the calibration data should be 0.99 or better for the calibration to be used for quantitation. Continuing Calibration is checked every ten samples or 24 hours, whichever comes first after the initial calibration by analyzing mid-point calibration standards. Each analyte of interest in the continuing calibration must be within 15% of the peak height observed in the initial calibration. For certain multi-peak compounds, the average result for 5 peak heights must be within 15% of the average of the same 5 peak heights observed in the initial calibration.

7.5 Calibration of Inductively Coupled Argon Plasma Spectrophotometer (ICP) and Atomic Absorption Spectrophotometer (AAS)

The ICP and AAS are standardized for the metal of interest by the analysis of a set of calibration standards prepared by diluting a stock solution of known concentration. Working standards are prepared by dilution of the stock standard. For the AAS, the concentration of the calibration standards is chosen so as to cover the working range of the instrument. For ICP, a standard is analyzed as a sample to determine the upper limit of the calibration. Subsequently, all sample measurements are made within this working range. Once the working standards are prepared, they are analyzed on the ICP or AAS and the instrument response is calibrated to provide a direct readout in concentration.

The calibration is accomplished by entering the metal concentration equivalent to the readout in absorbance units (or emission intensity) during analysis of the working standards.

Once the instrument has been initially calibrated, the analysis of the working standards is repeated during sample analysis to standardize instrument response during analysis and to confirm the calibration settings. A typical analysis sequence is presented below.

- Working standards are prepared by dilution of a stock standard solution of the metal of interest.

- A calibration curve within the working range of the instrument is established by analysis of three to five working standards.

- An independent standard is analyzed to confirm the calibration settings. If the calibration settings are not confirmed, the instrument is recalibrated.

- The samples are analyzed for the metal of interest.

- During sample analysis, a check standard is analyzed to monitor instrument stability. If the analysis indicates that instrument calibration has changed by more than $\pm 10\%$ for ICP or more than $\pm 20\%$ for AAS, the instrument is recalibrated and the analysis is repeated.

- Following completion of the sample analyses, the check standard is reanalyzed to confirm calibration settings. If calibration settings are confirmed, the analysis is completed. However, if the calibration settings are not confirmed, the problem is corrected, and the analyses are repeated.

Written records of all calibrations shall be kept in the appropriate instrument logbook.

8.0 ANALYTICAL PROCEDURES

PACE NE Laboratories are capable of analyzing the full range of environmental samples from all media, including surface and groundwater, soil, sediment, tissue, and waste. Refer to Table 8-2 for a listing of specific PACE NE analytical capabilities. The methodologies generally employed constitute the most recent guidance from agencies such as EPA, ASTM, USGS, NIOSH and in certain instances, state regulatory agencies. In some situations, PACE NE develops and validates methodologies which are more applicable to a specific problem or objective.

Analytical procedures are detailed descriptions of any and all processing, preparation and analysis of samples in the laboratory. In some instances, data format, presentation and delivery are also described. All analytical procedures shall be conducted in strict adherence with written Standard Operating Procedures manuals which have been reviewed and approved by the Laboratory Manager(s)/Technical Director(s), the PACE NE QA Officer and the PACE NE Regional Director. Documents from which SOPs are developed include the references listed in Table 8-1. Additional SOPs may be adapted from other sources or generated in-house as project needs require.

8.1 Analytical Methods

Numerous sources of information are available to offer guidance in analytical methods. Selection of the appropriate method is dependent upon data usage and the regulatory requirements during the analysis. Table 8-1 describes the analytical references routinely used by PACE NE Laboratories. PACE NE may modify existing methods based on the following considerations: 1) in order to meet project specific objectives; 2) in order to incorporate modifications or improvements in analytical technology; 3) in order to comply with changing regulations and requirements; 4) in order to address unusual matrices not covered in available methods.

PACE NE will make every effort to disclose to its clients any instances in which modified methods are being used in the analysis of samples and shall obtain permission from the appropriate prime contractor prior to using any modified methods for NEESA-related work.

8.2 Method Validation

When an established method is first used by the laboratory or when the laboratory develops a method, the laboratory establishes the validity of the method prior to applying it to client samples. Method validity is established by meeting certain criteria for precision and accuracy.

The design of the validation study will vary with the nature of the matrix, parameters and requirements of the client. However, in all cases, the laboratory demonstrates that adequate and reproducible recoveries are attainable. The precision of the test method is measured as the relative standard deviation for a minimum of four (4) replicate analyses of the lowest concentration recovery sample.

Accuracy of the test method is established as the relative standard deviation of the average measurement of each recovery sample (at a specific concentration). Design of validation studies incorporates several recovery samples at each concentration level. Thus, it is feasible to determine the test method accuracy at each concentration level, if significant variances occur with concentration.

8.3 Method Detection Limits (MDLs)

When an analytical procedure does not detect a parameter of interest, it is important to know what the lower limit of detection is for that particular method and sample matrix. The laboratory endeavors to prevent matrix interferences from substantially reducing analytical sensitivity, thereby raising the analytical detection limit. When matrix interferences are present, various clean-up techniques may be employed to reduce or eliminate them.

Method detection limit studies are performed for each method in use at least annually and after any procedural or configurational change.

Method detection limits may be determined using replicate spiked laboratory water samples. A minimum of seven aliquots of a sample spiked for the purpose are processed through the entire analytical method. The concentration of the detection limit sample should be between 2 and 5 times the anticipated detection limit.

The laboratory calculates the detection limit as 3.143 times the standard deviation of replicate measurements of the spiked samples. The reader is referred to 40 CFR Part 136, Appendix B for further discussion.

IT IS IMPERATIVE TO NOTE THAT METHOD DETECTION LIMITS LISTED IN THE CITED METHODS ARE FOR GUIDANCE AND MAY NOT ALWAYS BE ACHIEVABLE.

PACE NE may report results of analyses based on Reporting Limits which are the method detection limits adjusted for practical limitations such as sample size, matrix interferences and dilutions. Reporting Limits may never be lower than the statistically determined MDL.

8.4 Compliance

8.4.1 Definition - Compliance is the proper execution of recognized, documented procedures which are either approved or required. Adherence to these procedures is required in order to provide data products acceptable to a regulatory body of competent jurisdiction in a specific regulatory context. Compliance is separate from, but not inconsistent with, technical scientific quality. PACE NE accepts compliance as part of the PACE corporate definition of quality: "Quality is the *fulfillment of expectations and needs* in all activities, demonstrated by the satisfaction of those we serve." PACE NE understands that the expectations of our clients commonly include the assumption that data and reports will satisfy a regulatory purpose and will be found acceptable *and compliant* with regulatory requirements for the performance of tests and generation of data.

8.4.2 Understanding the Regulatory Framework - Compliance is not likely to be achieved in the absence of an understanding of the regulatory framework. PACE NE will attempt to ascertain, prior to beginning a project, what regulatory jurisdiction (USEPA, NJDEPE, etc.) pertains to a project; within the regulatory jurisdiction, what body of regulation is meant to be satisfied (RCRA, SDWA, ECRA, 21E, etc.); and finally, within this context, what protocols are required/expected (CLP, AFCEE, NEESA, ASP, etc.). PACE NE will work with its clients to come to a mutual understanding of all requirements.

8.4.3 Commitment - Clients may, but often do not, fully understand their compliance needs. Clients may sometimes fail to communicate their compliance requirements to PACE NE. Nevertheless, PACE NE, Inc., in defining quality as in 8.4.1 above, has accepted much responsibility for compliance.

PACE NE makes the following commitments to its clients:

1) PACE NE will proactively attempt to identify and understand the regulatory context of clients' needs.

2) PACE NE will strive to be expert in understanding and executing the regulatory requirements for compliance.

3) PACE NE will identify and disclose to clients instances of non-compliance in a forthright fashion.

8.4.4 Resolving Compliance Cantradictions and Hierarchies - It is a common occurrence that multiple regulatory juristictions overlap in a specific case. This causes uncertainty or even contradictions to arise in a work plan. PACE NE will make every effort to detect such inconsistencies, and will communicate them to clients so that an informed decision can be made by the client regarding execution of the project. Similarly, methods and protocols will often be prescribed in a scope of work or QAPP which either will not achieve stated or implied DQOs or which are in conflict with the regulatory requirements. PACE NE will attempt to detect these inconsistencies, and upon detection, disclose same to our client. PACE NE voluntarily accepts a responsibility to provide advice to clients, however, **the primary responsibility for this issue remains with the client.**

8.4.5 Disclosure of Noncompliance - As stated previously, it is PACE NE policy to disclose in a forthright manner any detected noncompliance that may effect the usability of data produced by PACE NE. It is not within our expertise to predict the manner in which a specific regulator or regulatory body will interpret the rules governing analysis; PACE NE is unable to guarantee compliance. It is PACE NE policy that our responsibility begins with a bona fide and competent attempt to evaluate potential compliance issues and ends with disclosure of any findings that may be useful to our client in their making the final judgement.

TABLE 8-1

ANALYTICAL PROTOCOLS

- "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act." Federal Register, 40 CFR Part 136, October 26, 1984.
- "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods." SW-846. 3rd edition, 1986, and Update I, Office of Solid Waste and Emergency Response, U.S. EPA.
- "Methods for Chemical Analysis of Water and Wastes", EPA 600/4-79-020, 1979 Revised 1983, U.S. EPA.
- U.S. EPA Contract Laboratory Program Statement of Work for Organic Analysis, SOW OLM01.8, 8/91.
- U.S. EPA Contract Laboratory Program Statement of Work for Inorganic Analysis, SOW ILM03.0.
- "Standard Methods for the Examination of Water and Wastewater", 15th, 16th and 17th editions, 1980, 1985, 1989. APHA-AWWA-WPCF.
- "Annual Book of ASTM Standards", Section 4: Construction, Volume 04.04: Soil and Rock; Building Stones, American Society for Testing and Materials, 1987.
- "Annual Book of ASTM Standards", Section 11: Water and Environmental Technology, American Society for Testing and Materials, 1987.
- "NIOSH Manual of Analytical Methods", Third Edition, 1984, U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health.
- "Methods for the Determination of Organic Compounds in Finished Drinking Water and Raw Source Water", U.S. EPA, Environmental Monitoring and Support Laboratory - Cincinnati (September 1986).
- New York State Department of Environmental Conservation. Analytical Services Protocol, September, 1989.

TABLE 8-2

PACE NE ANALYTICAL CAPABILITIES
ORGANIC ANALYSES

Analyte	EPA Methods	
Volatile Organic Compounds		
GC/MS	624	8240
GC/MS + 15 Peaks*	624	8240
CLP Volatiles Analysis and Deliverables	3/91 SOW	3/91 SOW
GC/MS Low Detection Limits	624	8240
GC/MS Drinking Water Volatiles	524.1	NA
GC/MS Drinking Water VOA (Extended List)	524.2	NA
GC Drinking Water Halogenated Compounds	502.1	NA
GC Drinking Water Aromatic Compounds	503.1	NA
GC Drinking Water VOA(Combined 502.1 & 503.1)	502.2	NA
Purgeable Halocarbons	601	8010
Purgeable Aromatics	602	8020
Combined Purgeables	601 & 602	8010 & 8020
Acrolein, Acrylonitrile	603	8030
Non-halogenated Volatiles (Partial List)	8015	8015
Base Neutral/Acid Extractables (HSL)	625	8270
Base Neutral/Acid Extractables + 25 Peaks*	625	8270
Acid Extractables Only (HSL)	625	8270
Acid Extractables Only + 10 Peaks*	625	8270
Base Neutral Extractables Only (HSL)	625	8270
Base Neutral Extractables Only + 15 Peaks*	625	8270
CLP Semivolatiles Analysis and Deliverables	3/91 SOW	3/91 SOW
Polynuclear Aromatics (PNA) GC/MS	625	8270
Polynuclear Aromatics (PNA) GC	610	8100

* Tentative identification via computer search of specified number of non-target peaks.

TABLE 8-2, continued

ORGANIC ANALYSES (continued)

Analyte	EPA Methods	
Organochlorine Pesticides & PCBs	608	8080
CLP Organochlorine Pesticides & PCBs	3/91 SOW	3/91 SOW
Organochlorine Pesticides & PCBs (Tissue)	608	8080
Organophosphorus Pesticides	614	8140
Chlorinated Phenoxy Herbicides	8150	
PCBs in oils	ASTM	
PCBs wipes/filters	ASTM	
Petroleum Hydrocarbons, Extractables (water/soil, tissues)	Capillary GC/FID	
Petroleum Hydrocarbons, Purgeables	Modified 8015	
Gasoline Hydrocarbons BTEX(+MTBE)	602	8020
Compositing		

TABLE 8-2, continued

WASTE CHARACTERIZATION

Analyte		EPA Methods
EP Toxicity	Extraction	1310/1330
	Metals in Extract	
	Arsenic	6010
	Barium	6010
	Cadmium	6010
	Chromium	6010
	Lead	6010
	Mercury	7470
	Selenium	6010
	Silver	6010
	Pesticides in Extract	8080
	Endrin	
	Lindane	
	Methoxychlor	
	Toxaphene	
	Herbicides in Extract	8150
	2,4-D	
	2,4,5-TP	
Corrosivity	pH	9040/9045
Reactivity	Releasable Cyanide	SW 846 7.3.3.2
	Releasable Sulfide	SW 846 7.3.4.1
	Releasable Cyanide & Sulfide	
	Water Reactivity	N/A
Ignitability		1010

TABLE 8-2, continued

TCLP ANALYSES

Quality Assurance section of the method requires that a matrix spike be performed for each sample type. A determination as to whether a spike is needed must be made prior to submitting the sample. Matrix spikes are made at five times the method detection limit or at the regulatory limit unless other levels are specified in advance.

Matrix spike for pesticides requires that single component pesticides be analyzed separately from multicomponent pesticides (toxaphene). Therefore, two matrix spikes are required and are reflected in the matrix spike analysis.

Samples containing free liquid that is not miscible with the TCLP extract require that both the free liquid and the extract be analyzed separately and that the results be combined mathematically. An additional charge is required for the analysis of the free liquid or of multiple phases. If a matrix spike is required, only the TCLP extract is spiked.

Analyte		EPA Methods
Extraction for Volatiles (ZHE)		1311
Extraction for Metals, Semivolatiles, Pesticides & Herbicides		1311
Volatiles	benzene	8240
	carbon tetrachloride	
	chlorobenzene	
	chloroform	
	1,2-dichloroethane	
	1,1-dichloroethylene	
	methyl ethyl ketone	
	tetrachloroethylene	
	trichloroethylene	
	vinyl chloride	

TABLE 8-2, continued

TCLP ANALYSES (continued)

Analyte		EPA Methods
Semi-Volatiles	*pyridine*	8270
	m-cresol (3-methyl phenol)	
	o-cresol (2-methyl phenol)	
	p-cresol (4-methyl phenol)	
	1,4-dichlorobenzene	
	2,4-dinitrotoluene	
	hexachloro-1,3-butadiene	
	hexachlorobenzene	
	hexachloroethane	
	nitrobenzene	
	pentachlorophenol	
	2,4,5-trichlorophenol	
	2,4,6-trichlorophenol	
Pesticides	chlordane	8080
	endrin	
	heptachlor	
	heptachlor epoxide	
	lindane	
	methoxychlor	
	toxaphene	
Herbicides	2,4-dichlorophenoxyacetic acid	8150
	2,4-5-trichlorophenoxypropionic acid	
Metals	As, Ba, Cd, Cr, Pb, Se, Ag	6010
	Hg	7470

TABLE 8-2, continued
METALS ANALYSES

Analyte	Required Digest	EPA Methods
Aluminum	3010/3050	200.7 or 6010
Antimony	3010/3050	200.7 or 6010
Antimony (furnace)	3010/3050	204.2 or 7041
Arsenic (furnace)	7060/3050	206.2 or 7060
Barium	3010/3050	200.7 or 6010
Beryllium	3010/3050	200.7 or 6010
Boron	3010/3050	200.7 or 6010
Cadmium	3010/3050	200.7 or 6010
Cadmium (furnace)	3020/3050	213.2 or 7131
Calcium	3010/3050	200.7 or 6010
Chromium	3010/3050	200.7 or 6010
Chromium (furnace)	3020/3050	218.2 or 7191
Cobalt	3010/3050	200.7 or 6010
Copper	3010/3050	200.7 or 6010
Iron	3010/3050	200.7 or 6010
Lead	3010/3050	200.7 or 6010
Lead (furnace)	3020/3050	239.2 or 7421
Magnesium	3010/3050	200.7 or 6010
Manganese	3010/3050	200.7 or 6010
Mercury (cold vapor)	7470/7471	245.1 or 7470/7471
Molybdenum	3010/3050	200.7 or 6010
Nickel	3010/3050	200.7 or 6010
Potassium	3010/3050	200.7 or 6010
Selenium (furnace)	7740/3050	270.2 or 7740
Silver	3010/3050	200.7 or 6010
Sodium	3010/3050	200.7 or 6010
Strontium	3010/3050	200.7 or 6010
Thallium (furnace)	3020/3050	279.1 or 7841
Tin	3010/3050	200.7 or 6010
Titanium	3010/3050	200.7 or 6010
Vanadium	3010/3050	200.7 or 6010
Zinc	3010/3050	200.7 or 6010

Packages Available

CLP Deliverables-23 Metals
13 Priority Pollutant Metals
8 Safe Drinking Water Act Metals
23 HSL Metals-Commercial Deliverables

Digestions

Water	3010,3020,7060,7740
Soil/ICP	3050
Soil/GFAA	3050
Tissues/ICP	3050 Modified
Tissues/GFAA	3050 Modified
Mercury-water/soil	7470/7471

Dissolution (Oils) 3040

TABLE 8-2, continued

INORGANIC ANALYSES

Analyte	Methods
Acidity	EPA 305.1
Alkalinity	EPA 310.1
Bromide	EPA 300.0
Biochemical Oxygen Demand	EPA 405.1
Bicarbonate	APHA 2320
Carbonate	APHA 2320
Bicarbonate & Carbonate	APHA 2320
Carbon - Total Inorganic (water)	EPA 415.1
- Total Organic (water)	EPA 415.1
- Total (soil)	
- Total Organic (soil)	
Cation Exchange Capacity (soil)	EPA 9080
Chemical Oxygen Demand	
Detection limit of 20 mg/L	EPA 410.4
Detection limit of 5 mg/L	EPA 410.4/410.2
Chloride	EPA 300.0 or 325.1
Chlorine, Total Residual	APHA 4500-CLG.
Coliform Bacteria - Total	APHA 9222B
- Fecal	APHA 9222D
Color	EPA 110.2
Chromium - Hexavalent	SW846 7196
Cyanide - Total	EPA 335.2
Cyanide - Total & Ammenable	EPA 335.1
Cyanide, WAD	APHA 4500-CNI.
Density	
Fluoride EPA 340.2	
Formaldehyde	NIOSH 3500
Hardness (Ca, Mg by calculation)	EPA 200.7 and SM 314 B
Calculation only	
Halides, Total Organic (TOX) - Water	9020
- Solids/Oils	
Lime Equivalence	AOAC 1.004-6
Nitrogen - Ammonia	EPA 350.1 or 350.3
- Nitrate plus Nitrite Nitrogen (combined)	EPA 353.2
- Nitrate	EPA 300.0 or 353.2
- Nitrite	EPA 300.0 or 353.2
- Total Kjeldahl	EPA 351.2 or 353.3
- Total Organic-Calculation Fee (requires analysis of TKN & NH3)	

TABLE 8-2, continued

INORGANIC ANALYSES (continued)

Analyte	Methods
Oil & Grease (Gravimetric or IR)	EPA 413.1/413.2
Oxidation Reduction Potential	
Free Liquid Content (Paint Filter Test)	EPA 9095
Total Petroleum Hydrocarbon IR	EPA 418.1
pH	EPA 150.1
Phenols - Total	EPA 420.3
Phosphorus - Total	EPA 365.3 or 365.4
- Ortho	EPA 365.1 or 365.3
Silicate - Reactive	EPA 370.1
Solids - Total	EPA 160.3
- Suspended	EPA 160.2
- Dissolved	EPA 160.1
- Volatile	EPA 160.4
- Suspended Volatile	EPA 160.2 or 160.4
- Settleable	EPA 160.5
Specific Conductance	EPA 120.1
Specific Gravity	EPA/COE 1981
Sulfate	EPA 300.0 or 375.2
Sulfide	EPA 376.2
Sulfite	EPA 377.1
Surfactants - MBAS	EPA 425.1
Tannins and Lignins (as tannic acid)	APHA 5550B
Turbidity	EPA 180.1
Sample Prep:	
Compositing	
Filtration	APHA 3030B

TABLE 8-2, continued

APPENDIX NINE ANALYSES

Appendix IX is derived from Appendix VIII Hazardous Constituents. These parameter lists are intended to apply to groundwater monitoring at hazardous waste storage and disposal sites and are applied to uncontrolled site investigations and remediations.

Analyte	EPA Methods
Volatile Organics (extended list 19 Compounds)	8240
Acrolein and Acrylonitrile	8030
Acid and Base Neutrals (extended list 48 Compounds)	3550/8270
Dioxins/2378 TCDDD	8280
Pesticides and PCB's	3540/8080
Herbicides	8150
Total Cyanide	9010
Hydrogen Sulfide	376.1
pH	150.1
17 Metals	
Arsenic	7060
Antimony	6010
Barium	6010
Beryllium	6010
Cadmium	6010
Cobalt	6010
Chromium	6010
Copper	6010
Mercury	7470
Nickel	6010
Lead	7421
Selenium	7740
Silver	6010
Tin	6010
Thallium	7841
Vanadium	6010
Zinc	6010
Metals Digest	3010,3020,7060,7470

TABLE 8-2, continued

FORM 2C ANALYSES FOR NPDES PERMITS

Analyte	Methods
Part A	
Biochemical Oxygen Demand	EPA 405.1
Chemical Oxygen Demand	EPA 410.4
Total Organic Carbon	EPA 415.1
Total Suspended Solids	EPA 160.1
Ammonia as Nitrogen	EPA 350.2/350.3 or 350.2/350.1
pH	EPA 150.1
Part B	
Total Residual Chlorine	EPA 330.5
Color	EAP 110.2
Fecal Coliform	APHA 9222D
Fluoride	EAP 340.1/340.2
Nitrate	EPA 353.2 or 300.0
Nitrite	EPA 353.2 or 300.0
Total Organic Nitrogen	350.2/350.3/351.3 or 350.2/350.1/351.2
Oil and Grease	EPA 413.1 or 413.2
Total Phosphorus	EPA 365.1 or 365.4
Alpha	
Beta	
Radium	
Sulfate	EPA 300.0
Sulfide	EPA 376.1
Sulfite	EPA 377.1
Surfactants	EPA 425.1
Aluminum	EPA 200.7
Barium	EPA 200.7
Boron	EPA 200.7
Cobalt	EPA 200.7
Iron	EPA 200.7
Magnesium	EPA 200.7
Molybdenum	EPA 200.7
Manganese	EPA 200.7
Tin	EPA 200.7
Titanium	EPA 200.7
Metals Digestion	(3010)

TABLE 8-2, continued

FORM 2C ANALYSES FOR NPDES PERMITS (continued)

Analyte	Methods
Part C	
Antimony	EPA 200.7
Arsenic	EPA 206.2
Beryllium	EPA 200.7
Cadmium	EPA 200.7
Chromium	EPA 200.7
Copper	EPA 200.7
Lead	EPA 239.2
Mercury	EPA 245.1
Nickel	EPA 200.7
Selenium	EPA 270.2
Silver	EPA 200.7
Thallium	EPA 279.1
Zinc	EPA 200.7
Total Cyanide	EPA 335.2 or 335.3
Total Phenols	EPA 420.3
Dioxin	EPA 8280
Volatile Organic Compounds	EPA 624
Acid and Base Neutral Compounds	EPA 625
Pesticides and PCB's	EPA 608
Metals Digestions	(3010,3020,7060)

TABLE 8-2, continued

NON-ROUTINE ANALYSES

PACE New England has the capability to perform the following analyses upon request. Turnaround time is subject to instrument availability and prices are quoted based on analyst and instrument time required and quantity of samples submitted.

Analysis	Methods
BTU	ASTM D 240
Chlorine (%)	ASTM D 129-64
Sulfur (%)	ASTM D 129-64
HalogenS	ASTM D 808
Viscosity	ASTM D 445
Flash point	ASTM D 93-77
API Gravity	ASTM D 287
Ash Content	ASTM D 482-87
pH	SW846 9045
Free Liquids	(Paint Filter)
% Moisture	APHA 2540G
% Sand, Silt, Clay	EPA/CE-81-1
Sieve Analysis (6 fractions >8mm to <2mm)	EPA/CE-81-1
Particle Size (19 fractions >8mm to .02mm)	EPA/CE-81-1
Diquat, Paraquat by HPLC	EPA 549
Carbamate Pesticides by HPLC	EPA 531
PNA by HPLC	EPA 8310
Ethylene Glycol by HPLC	
Nitrogen-Phosphorus Pesticides by GC	EPA 507
EDB & DBCP by GC	EPA 504
GC Direct Inject for Alcohols	
Volatile Air Analysis in Tedlar Bags by GC or GC/MS	
Calibrated Volatile Non-target Compounds by GC/MS	
Method Development for any Organic Compounds by HPLC, GC/MS, or GC	
Non-routine Furnace or ICP Metals	
Bromide by Ion Chromatagraph	EPA 300.0
Formaldehyde by HPLC	EPA 8315
Nitroaromatic Explosives by HPLC	EPA 8330

APPENDIX B

Representative Method Detection Limits
For Parameters and Methods Performed by PACE NE

PACE, INC.

Metals Instrumentation Laboratory Method Detection Limits 3-93

ICP-3010 ELEMENT	REP.1	REP.2	REP.3	REP.4	REP.5	REP.6	REP.7	MEAN	S.D.	DETECT. LIMIT	TRUE VALUE	ANALYSIS DATE
ALUMINUM	135	130	130	134	136	140	151	136.6	6.72	21.1	100	01/11/93
ANTIMONY	33	27	22	29	32	30	29	28.9	3.36	10.5	40	01/18/93
ARSENIC	193	174	195	185	177	177	174	182.1	8.25	25.9	200	01/11/93
BARIUM	2	1	1	3	1	1	1	1.4	0.73	2.3	1	01/18/93
BERYLLIUM	0.7	0.8	0.6	0.6	0.8	0.7	0.8	0.71	0.08	0.3	1	01/18/93
BORON	49	18	13	19	14	26	81	31.43	23.22	72.9	21	01/11/93
CADMIUM	9	9	10	9	11	11	10	9.86	0.83	2.6	10	01/11/93
CALCIUM	126	128	136	209	139	174	138	150	28.2	88.7	51	01/11/93
CHROMIUM	25	24	25	26	26	24	23	24.7	1.03	3.2	21	01/11/93
COBALT	9	0	10	10	10	10	9	8.29	3.41	10.7	10	01/11/93
COPPER	10	10	10	9	10	10	10	9.9	0.35	1.1	10	01/11/93
IRON	289	231	244	229	259	229	237	245.4	20.37	64.0	200	03/19/93
LEAD	106	94	101	99	102	106	105	101.9	4.05	12.7	100	01/11/93
MAGNESIUM	97	96	106	99	109	101	109	102.4	5.12	16.1	101	01/11/93
MANGANESE	4	5	5	5	5	5	5	4.9	0.35	1.1	5	01/11/93
NICKEL	50	52	55	57	50	53	48	52.1	2.90	9.1	51	01/11/93
POTASSIUM	1540	1640	1560	1620	1760	1640	1550	1616	70.9	222.7	1500	01/11/93
SELENIUM	196	190	209	192	191	167	180	189.3	12.12	38.1	201	01/11/93
SILVER	1	1	2	1	1	1	2	1.3	0.45	1.4	4	01/18/93
SODIUM	100	68	80	81	93	110	224	108.0	49.1	154.2	52	01/11/93
THALLIUM	149	201	186	175	170	173	166	174.3	15.0	47.2	199	01/11/93
TIN	64	57	62	57	60	58	60	59.7	2.43	7.6	50	01/11/93
VANADIUM	2	2	3	2	3	1	4	2.4	0.90	2.8	2	01/18/93
ZINC	29	29	34	37	34	34	30	32.4	2.87	9.0	21	01/11/93
MOLYBDENUM	87	101	113	104	114	102	101	103.1	8.34	26.2	100	03/23/93
STRONTIUM	98	95	99	94	99	90	97	96.0	3.02	9.5	100	03/23/93
TITANIUM	95	95	99	92	99	91	98	95.6	3.02	9.5	100	03/23/93
GFAA-7060												
ARSENIC	5.28	5.64	4.94	5.2	5.15	5.4	5.24	5.3	0.20	0.63	5	01/08/93
SELENIUM	4.2	4.3	4.2	4.3	4.3	4.1	4	4.2	0.11	0.3	5	01/18/93
GFAA-3020												
LEAD	4.95	4.55	4.95	4.95	4.8	4.75	4.45	4.8	0.19	0.6	5	02/02/93
THALLIUM	4.33	2.68	4.99	4.4	3.94	3.58	3.73	4.0	0.68	2.1	5	01/15/93
CVAA-7470												
MERCURY	0.61	0.63	0.58	0.61	0.61	0.64	0.53	0.60	0.034	0.11	0.5	01/08/93

All values are in ug/L (ppb).

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
INORGANICS WET LAB PARAMETERS
JAN. 93

TEST	METHOD	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	STD DEV	MDL mg/L	MEAN	SPIKE LEVEL
TOTAL CYANIDE	335.3	0.0435	0.0460	0.0435	0.0430	0.0415	0.0425	0.0440	0.0014	0.004	0.043	0.04
TOTAL ORGANIC CARBON	415.1	5.00	5.06	5.10	4.90	5.29	5.34	5.00	0.1609	0.51	5.10	5.0
CHEMICAL OXYGEN DEMAND HIGH	410.1	75.76	78.28	75.76	73.23	73.23	75.76	78.28	2.0617	6.47	75.76	75
CHEMICAL OXYGEN DEMAND LOW	410.1	10.10	9.40	9.90	9.50	9.70	6.80	9.30	1.1133	3.50	9.24	10
SULFATE	300.0	2.04	1.77	1.96	1.60	1.63	1.76	1.79	0.1604	0.50	1.79	1
BROMIDE	300.0	1.97	1.78	1.88	1.67	1.79	1.80	1.88	0.0957	0.30	1.82	1
FORMALDEHYDE	P&CAM 125	0.54	0.52	0.53	0.51	0.52	0.51	0.54	0.0127	0.04	0.52	0.5
ORTHO PHOSPHATE	365.2	0.045	0.046	0.046	0.047	0.047	0.046	0.047	0.0008	0.002	0.05	0.05
ALKALINITY	310.0	4.4	4.9	5.3	4.3	4.6	4.5	4.7	0.3402	1.07	4.67	5.58
SPECIFIC CONDUCTANCE	120.1	5.08	4.97	4.52	4.46	4.37	4.35	4.29	0.3165	0.99	4.58	1.68
SILICA	370.1	0.54	0.49	0.47	0.47	0.49	0.49	0.47	0.0248	0.08	0.49	0.5
AMMONIA	350.1	0.103	0.105	0.103	0.106	0.105	0.099	0.101	0.0025	0.008	0.103	0.1
NITRITE + NITRATE	353.2	0.270	0.250	0.259	0.259	0.253	0.257	0.263	0.0066	0.021	0.259	0.20
NITRATE	353.2	0.126	0.098	0.116	0.115	0.106	0.112	0.114	0.0087	0.027	0.112	0.10
NITRITE	353.2	0.144	0.152	0.144	0.144	0.147	0.145	0.149	0.0031	0.010	0.146	0.10
HEXAVALENT CHROMIUM	7196	0.0532	0.0532	0.0546	0.0546	0.0546	0.0532	0.0532	0.0007	0.0023	0.0538	0.05
TURBIDITY	180.1	0.44	0.43	0.42	0.43	0.42	0.43	0.42	0.0076	0.02	0.43	0.4
SULFITE	377.1	4.00	3.90	3.75	3.90	3.85	3.75	3.50	0.1618	0.51	3.81	10
TOTAL PHOSPHORUS	365.2	0.052	0.046	0.048	0.047	0.048	0.047	0.050	0.0021	0.006	0.048	0.05
CHLORIDE	325.1	4.370	5.052	4.918	5.124	4.664	4.710	4.708	0.2588	0.813	4.792	5.0
TOTAL KJELDAHL NITROGEN	351.3	1.11	1.08	1.09	1.15	1.05	1.08	1.09	0.0309	0.10	1.09	1.0
SULFIDE	376.1	4.18	3.35	3.05	4.00	4.04	3.53	3.31	0.4348	1.37	3.64	3.55
TOTAL DISSOLVED SOLIDS	160.1	40.2	38.5	35.2	34.7	37.1	39.2	36.1	2.0860	6.55	37.29	32.96
TOTAL SUSPENDED SOLIDS	160.2	20.8	21.3	18.4	18.8	18.4	16.8	20.8	1.6640	5.23	19.33	27.9
TOTAL SOLIDS	160.3	66.0	65.3	59.2	56.2	54.2	64.6	59.8	4.6547	14.62	60.76	56.8
TOTAL ORGANIC CARBON(%)	WALKLEY BLACK	0.039	0.042	0.040	0.042	0.039	0.040	0.039	0.0013	0.004	0.040	0.04
BOD	405.1	1.5	0.94	1.8	1.5	1.4	1.5	1.5	0.2566	0.81	1.45	2.0
TANNINS-LIGNINS	SM513	0.995	1.00	1.00	1.02	1.04	1.02	1.02	0.0160	0.05	1.01	1.0
FLUORIDE	340.2	0.043	0.045	0.038	0.044	0.036	0.043	0.039	0.0034	0.01	0.04	0.05
WADCN	412H	0.0365	0.0395	0.0375	0.0375	0.0345	0.0350	0.0380	0.0017	0.01	0.04	0.04

PACE, INC.

METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 524.2 DMS WATERS
8/93

COMPOUND (1 ppb, exceptions noted)	>D6760 CONC. ug/L	>D6765 CONC. ug/L	>D6764 CONC. ug/L	>D6763 CONC. ug/L	>D6755 CONC. ug/L	>D6759 CONC. ug/L	>D6756 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
CHLOROMETHANE	0.76	0.8	0.9	0.95	1.03	0.87	0.76	0.1016	0.32	0.87
BROMOMETHANE	1.01	0.97	1.11	1.12	1.02	1.15	0.88	0.0959	0.30	1.04
DICHLORODIFLUOROMETHANE	1.04	1.08	1.37	1.25	1.12	1.24	0.99	0.1353	0.42	1.16
CHLOROETHANE	0.98	1.23	1.27	1.08	1.18	1.35	1.07	0.1292	0.41	1.17
VINYL CHLORIDE	1.19	1.3	1.41	1.35	1.26	1.26	1.05	0.1163	0.37	1.26
METHYLENE CHLORIDE	0.77	0.62	0.45	0.59	0.76	0.59	0.98	0.1719	0.54	0.68
ACETONE (5 PPB)	7.07	7.39	6.26	7.31	7.59	7.29	5.86	0.6487	2.04	6.97
CARBON DISULFIDE	1.00	1	1.1	1.03	0.96	1.01	0.99	0.0439	0.14	1.01
TRICHLOROFLUOROMETHANE	0.95	1.05	0.44	1.02	1.08	1.01	0.99	0.2219	0.70	0.93
1,1-DICHLOROETHENE	1.04	1.11	1.2	1.09	1.08	1.09	1.12	0.0493	0.15	1.10
BROMOCHLOROMETHANE	0.97	1.09	1.06	1.01	1.43	1.05	1.01	0.1556	0.49	1.09
1,1-DICHLOROETHANE	0.98	1.02	0.97	1	1.02	1.04	1.1	0.0434	0.14	1.02
1,2-DICHLOROETHENE (CIS)	1.04	1.02	0.95	0.94	0.99	0.95	1.09	0.0559	0.18	1.00
1,2-DICHLOROETHENE(TRANS)	0.94	1.02	1.06	1	1.02	0.99	1.02	0.0368	0.12	1.01
CHLOROFORM	1.01	1.01	0.98	0.96	0.96	1.01	1.04	0.0299	0.09	1.00
2-BUTANONE	5.33	5.66	5.46	5.45	6.73	5.79	6.78	0.6127	1.92	5.89
BENZENE	1.00	1.02	1.04	1.01	1.01	1.02	1.06	0.0206	0.06	1.02
TOLUENE	1.07	1.03	0.97	0.99	0.94	1.06	1.09	0.0561	0.18	1.02
DIBROMOMETHANE	1.08	1.02	1	0.92	1.08	1.03	1.1	0.0618	0.19	1.03
1,2-DICHLOROETHANE	0.98	1.03	0.93	1.01	1.12	1.05	1.11	0.0680	0.21	1.03
2,2-DICHLOROPROPANE	1.04	1.07	1.08	1.07	1.09	1.09	1.11	0.0219	0.07	1.08
1,1,1-TRICHLOROETHANE	0.98	1.01	0.99	0.98	1.03	1.03	1.07	0.0330	0.10	1.01
CARBON TETRACHLORIDE	0.94	1.03	1.03	0.98	1.13	1	1.04	0.0593	0.19	1.02
BROMODICHLOROMETHANE	1.02	1	0.97	0.98	1.07	1.04	1.1	0.0476	0.15	1.03
1,2-DICHLOROPROPANE	1.07	1.03	1	1.02	1.03	1.1	1.15	0.0528	0.17	1.06
1,1-DICHLOROPROPENE	0.92	1.01	1.01	0.97	1.05	1	1.03	0.0426	0.13	1.00
CIS-1,3-DICHLOROPROPENE (.5 ppb)	0.98	0.94	0.96	0.91	0.98	1	0.99	0.0315	0.10	0.97
TRICHLOROETHENE	1.00	1.01	1.04	0.99	1.04	0.96	1.07	0.0369	0.12	1.02
1,1,2-TRICHLOROETHANE	0.95	0.96	0.96	0.93	0.97	0.97	1	0.0214	0.07	0.96
1,3-DICHLOROPROPANE	0.96	0.97	0.92	0.96	0.99	0.91	1.08	0.0560	0.18	0.97
TRANS-1,3-DICHLOROPROPENE (.6 ppb)	1.03	1.01	0.98	1.02	1.08	1.08	1.12	0.0489	0.15	1.05
4-METHYL-2-PENTANONE (5 PPB)	4.46	4.45	4.35	4.47	4.89	4.66	5.65	0.4538	1.42	4.70
2-HEXANONE (5 PPB)	4.86	4.75	4.56	4.43	5.22	4.95	6.02	0.5300	1.66	4.97
TETRACHLOROETHENE	0.99	0.91	0.91	0.87	0.91	0.91	0.99	0.0454	0.14	0.93
CHLOROBENZENE	1.04	1.05	1.09	1.07	1	1.03	1.07	0.0300	0.09	1.05
ETHYLBENZENE	1.13	1.04	1.09	1.03	1	1.11	1.08	0.0467	0.15	1.07
BROMOBENZENE	1.03	1.03	1.07	1.02	1.02	1.05	1.03	0.0181	0.06	1.04
ISOPROPYLBENZENE	1.06	1.06	1.08	1.05	1.03	1.08	1.06	0.0173	0.05	1.06
O-XYLENE	1.01	1.02	1.07	1.03	1.02	1.06	1.08	0.0279	0.09	1.04
M,P-XYLENES (2 PPB)	2.13	2.17	2.2	2.08	2.06	2.14	2.11	0.0489	0.15	2.13
STYRENE	1.00	1.02	1.04	1.04	1.01	1.02	1.03	0.0150	0.05	1.02
N-PROPYLBENZENE	1.06	1.05	1.14	1.09	1.03	1.08	1.09	0.0355	0.11	1.08
TERT-BUTYLBENZENE	1.02	1.01	1.09	1.07	1.04	1.04	1.04	0.0276	0.09	1.04
2-CHLOROTOLUENE	1.05	1.12	1.17	1.19	0.99	1.11	1.08	0.0689	0.22	1.10
4-CHLOROTOLUENE	1.11	0.97	1.05	0.98	1.07	1	1.09	0.0555	0.17	1.04
SEC-BUTYLBENZENE	1.08	1.09	1.15	1.13	1.04	1.12	1.09	0.0365	0.11	1.10
DIBROMOCHLOROMETHANE	1.07	1.02	0.99	1.03	1.04	1.03	1.14	0.0479	0.15	1.05
1,2-DIBROMOETHANE	1.13	1.01	1.08	1.1	1.13	1.15	1.14	0.0486	0.15	1.11
1,3-DICHLOROBENZENE	1.07	1.02	1.04	1.05	0.98	1.06	1.07	0.0324	0.10	1.04
1,2-DICHLOROBENZENE	1.08	1	1.01	1.05	1.01	1.06	1.07	0.0327	0.10	1.04

PACE, INC.

(continued)

METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 524.2 DMS WATERS
8/93

COMPOUND (1 ppb, exceptions noted)	>D6760 CONC. ug/L	>D6765 CONC. ug/L	>D6764 CONC. ug/L	>D6763 CONC. ug/L	>D6755 CONC. ug/L	>D6759 CONC. ug/L	>D6756 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
1,4-DICHLOROBENZENE	1.05	1.01	1.05	1.11	0.99	1.08	1.09	0.0431	0.14	1.05
P-ISOPROPYLTOLUENE	1.07	1.05	1.15	1.12	1.01	1.05	1.08	0.0469	0.15	1.08
1,3,5-TRIMETHYLBENZENE	1.05	1.01	1.14	1.06	0.96	1.01	1.05	0.0560	0.18	1.04
BROMOFORM	1.04	1.01	0.98	1.05	0.96	1.06	1.07	0.0420	0.13	1.02
1,1,1,2-TETRACHLOROETHANE	1.00	1.01	1.02	0.98	1.02	1.07	1.1	0.0418	0.13	1.03
1,1,2,2-TETRACHLOROETHANE	1.15	1.07	1.02	1.06	1.13	1.12	1.17	0.0541	0.17	1.10
1,2,3-TRICHLOROPROPANE	1.14	0.95	1.05	1	1.16	0.73	1.13	0.1507	0.47	1.02
N-BUTYLBENZENE	1.08	1.06	1.16	1.11	0.99	1.03	1.03	0.0568	0.18	1.07
1,2,4-TRIMETHYLBENZENE	1.03	1.06	1.12	1.05	0.94	1.02	1.05	0.0540	0.17	1.04
1,2,4-TRICHLOROBENZENE	1.02	1.01	1.16	1.11	0.93	1.02	1.13	0.0814	0.26	1.05
1,2,3-TRICHLOROBENZENE	1.12	1.03	1.14	1.1	1.07	1.06	1.07	0.0378	0.12	1.08
NAPHTHALENE	1.08	0.89	1.11	1.1	0.95	1.03	1.12	0.0887	0.28	1.04
1,2-DIBROMO-3-CHLOROPROPANE	0.68	0.83	0.92	0.87	1.27	1.24	0.69	0.2400	0.75	0.93
HEXACHLOROBUTADIENE	1.14	1.06	1.19	1.12	1.04	1.12	1.13	0.0503	0.16	1.11

PACE, INC.

METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 524.2 GMS WATERS
4/93

COMPOUND (1 ppb, exceptions noted)	>G5034 CONC. ug/L	>G5035 CONC. ug/L	>G5036 CONC. ug/L	>G5037 CONC. ug/L	>G5038 CONC. ug/L	>G5042 CONC. ug/L	>G5043 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
HLOROMETHANE	0.97	1.24	0.97	1.04	1.05	1.10	1.10	0.0930	0.29	1.07
BROMOMETHANE	1.14	1.54	1.39	1.31	1.45	1.30	1.42	0.1287	0.40	1.36
ICHLORODIFLUOROMETHANE	1.01	1.19	1.07	0.98	0.97	0.93	0.98	0.0869	0.27	1.02
HLOROETHANE	0.59	0.64	0.67	0.62	0.62	0.60	0.54	0.0410	0.13	0.61
VINYL CHLORIDE	0.97	1.01	0.94	1.08	1.04	1.02	1.00	0.0456	0.14	1.01
METHYLENE CHLORIDE	0.98	1.09	1.04	1.02	1.11	1.16	1.09	0.0606	0.19	1.07
CETONE (5 PPB)	4.78	5.57	4.80	5.52	4.93	5.03	5.58	0.3689	1.16	5.17
ARBON DISULFIDE	0.99	0.97	0.97	1.03	0.89	1.78	0.94	0.3110	0.98	1.08
TRICHLOROFLUOROMETHANE	0.95	1.08	1.07	1.02	0.98	1.01	1.03	0.0462	0.15	1.02
1-DICHLOROETHENE	0.91	1.07	1.01	0.94	1.04	1.00	0.92	0.0619	0.19	0.98
ROMOCHLOROMETHANE	0.89	1.16	0.96	0.93	1.02	1.04	0.95	0.0898	0.28	0.99
1,1-DICHLOROETHANE	0.94	1.12	1.04	0.85	0.99	0.99	0.97	0.0834	0.26	0.99
2-DICHLOROETHENE (cis)	1.01	1.09	1.03	0.95	1.07	1.05	0.99	0.0482	0.15	1.03
2-DICHLOROETHENE(trans)	1.03	1.09	1.04	0.98	1.12	1.09	1.06	0.0467	0.15	1.06
HLOROFORM	0.91	1.02	1.04	0.96	1.05	1.02	0.99	0.0495	0.16	1.00
2-BUTANONE (5 PPB)	6.21	7.01	5.54	4.79	5.74	4.67	4.00	1.0202	3.20	5.42
NZENE	0.97	1.02	0.93	0.98	0.99	0.98	0.94	0.0304	0.10	0.97
LUENE	0.94	0.98	1.02	0.89	0.99	1.00	0.97	0.0432	0.14	0.97
DIBROMOMETHANE	1.01	1.13	1.15	1.23	1.19	1.24	1.14	0.0774	0.24	1.16
2-DICHLOROETHANE	1.00	1.09	1.11	1.03	1.10	1.05	1.06	0.0399	0.13	1.06
2-DICHLOROPROPANE	1.01	1.06	0.98	0.91	0.98	0.92	0.89	0.0608	0.19	0.96
1,1,1-TRICHLOROETHANE	0.99	1.07	0.96	0.97	0.98	1.02	0.96	0.0399	0.13	0.99
CARBON TETRACHLORIDE	0.96	1.00	1.01	0.94	1.05	0.93	1.02	0.0446	0.14	0.99
ROMODICHLOROMETHANE	0.95	1.00	1.02	0.96	0.98	1.00	0.93	0.0320	0.10	0.98
2-DICHLOROPROPANE	0.91	1.22	0.96	0.97	1.07	0.95	0.99	0.1047	0.33	1.01
1,1-DICHLOROPROPENE	0.92	1.09	0.94	0.89	0.94	0.90	0.94	0.0668	0.21	0.95
IS-1,3-DICHLOROPROPENE	0.87	0.94	0.98	0.92	0.93	0.85	0.93	0.0439	0.14	0.92
RICHLOROETHENE	0.91	0.92	1.01	0.96	1.01	0.93	0.95	0.0408	0.13	0.96
1,1,2-TRICHLOROETHANE	0.73	1.05	0.88	0.86	0.87	0.91	0.92	0.0948	0.30	0.89
3-DICHLOROPROPANE	0.93	1.14	1.01	1.00	0.97	1.05	0.85	0.0914	0.29	0.99
RANS-1,3-DICHLOROPROPENE	0.91	1.10	0.88	0.92	1.01	0.95	0.95	0.0739	0.23	0.96
4-METHYL-2-PENTANONE (5 PPB)	4.67	4.51	4.46	4.50	4.94	4.35	4.55	0.1899	0.60	4.57
2-HEXANONE (5 PPB)	4.85	5.45	5.37	5.08	4.56	4.66	4.74	0.3495	1.10	4.96
ETRACHLOROETHENE	0.95	1.23	1.06	0.97	1.02	1.04	0.99	0.0934	0.29	1.04
HLOROBENZENE	0.99	1.02	1.00	0.95	1.06	0.99	1.04	0.0364	0.11	1.01
ETHYLBENZENE	0.98	0.93	1.04	0.97	0.97	0.98	0.99	0.0327	0.10	0.98
ROMOBENZENE	0.99	1.03	0.95	1.02	1.07	0.97	1.03	0.0410	0.13	1.01
SOPROPYLBENZENE	0.94	0.91	0.96	0.95	0.95	0.97	1.01	0.0305	0.10	0.96
o-XYLENE	0.88	0.94	0.98	0.83	0.92	0.98	0.97	0.0567	0.18	0.93
m,p-XYLENES (2 PPB)	2.12	2.27	2.21	2.04	2.05	2.20	2.32	0.1070	0.34	2.17
TYRENE	0.86	0.85	0.88	0.85	0.91	0.83	0.93	0.0359	0.11	0.87
-PROPYLBENZENE	1.00	0.93	0.98	0.98	0.99	0.99	1.02	0.0276	0.09	0.98
tert-BUTYLBENZENE	1.00	0.90	0.95	0.97	0.97	1.01	1.04	0.0454	0.14	0.98
-CHLOROTOLUENE	0.86	0.88	0.86	0.85	0.86	1.01	1.00	0.0704	0.22	0.90
-CHLOROTOLUENE	0.93	0.90	0.99	0.97	0.72	0.84	0.96	0.0944	0.30	0.90
sec-BUTYLBENZENE	1.05	0.94	1.02	1.00	1.04	1.02	1.11	0.0516	0.16	1.03
IBROMOCHLOROMETHANE	1.10	1.13	1.02	0.93	1.13	1.02	1.07	0.0725	0.23	1.06
,2-DIBROMOETHANE	1.09	1.16	1.17	1.03	1.05	1.09	1.02	0.0596	0.19	1.09
1,3-DICHLOROBENZENE	0.96	0.99	0.99	0.94	0.98	0.94	0.98	0.0219	0.07	0.97
1,2-DICHLOROBENZENE	1.00	1.08	0.98	1.05	1.02	0.98	1.05	0.0386	0.12	1.02
,4-DICHLOROBENZENE	0.96	0.99	0.95	0.94	0.98	0.94	0.98	0.0206	0.06	0.96

PACE, INC.

(continued)
VOLATILE ORGANIC COMPOUNDS
METHOD 524.2 GMS WATERS
4/93

COMPOUND (1 ppb, exceptions noted)	>G5034 CONC. ug/L	>G5035 CONC. ug/L	>G5036 CONC. ug/L	>G5037 CONC. ug/L	>G5038 CONC. ug/L	>G5042 CONC. ug/L	>G5043 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
p-ISOPROPYLTOLUENE	0.94	0.91	1.02	0.96	0.99	1.01	1.10	0.0622	0.20	0.99
1,3,5-TRIMETHYLBENZENE	1.08	0.97	1.03	1.02	0.97	1.02	1.08	0.0450	0.14	1.02
BROMOFORM	0.85	1.23	0.96	1.05	0.97	1.01	0.91	0.1215	0.38	1.00
1,1,1,2-TETRACHLOROETHANE	1.06	1.13	1.04	1.06	1.12	1.10	1.09	0.0336	0.11	1.09
1,1,2,2-TETRACHLOROETHANE	1.04	1.20	1.19	1.03	0.97	1.11	1.13	0.0860	0.27	1.10
1,2,3-TRICHLOROPROPANE	1.12	1.74	1.04	1.32	1.46	1.40	1.04	0.2573	0.81	1.30
n-BUTYLBENZENE	0.98	0.93	0.99	1.00	0.97	1.02	1.03	0.0334	0.10	0.99
1,2,4-TRIMETHYLBENZENE	1.00	0.93	1.03	1.01	0.97	0.89	1.08	0.0634	0.20	0.99
1,2,4-TRICHLOROBENZENE	1.01	1.03	1.05	1.07	1.06	1.03	1.15	0.0457	0.14	1.06
1,2,3-TRICHLOROBENZENE	0.99	0.93	0.98	0.97	1.07	0.94	1.05	0.0526	0.17	0.99
NAPHTHALENE	0.94	1.05	0.99	0.99	1.00	0.94	0.96	0.0389	0.12	0.98
1,2,-DIBROMO-3-CHLOROPROPANE	0.68	1.09	0.60	0.81	0.85	0.73	0.99	0.1727	0.54	0.82
HEXACHLOROBUTADIENE	0.96	0.87	0.93	0.91	0.93	0.96	1.02	0.0469	0.15	0.94

PACE, INC.

METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 624 DMS WATERS – megabore column
3/93

COMPOUND (5 ppb, exceptions noted)	>D4719 CONC. ug/L	>D4726 CONC. ug/L	>D4724 CONC. ug/L	>D4725 CONC. ug/L	>D4727 CONC. ug/L	>D4728 CONC. ug/L	>D4730 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
CHLOROMETHANE	7.63	6.83	6.23	6.24	6.68	5.33	5.75	0.7524	2.36	6.38
BROMOMETHANE	4.82	4.42	4.12	4.21	4.30	4.18	4.13	0.2475	0.78	4.31
VINYL CHLORIDE	4.22	4.01	3.97	4.36	3.60	4.03	4.44	0.2819	0.89	4.09
CHLOROETHANE	5.23	4.36	4.74	4.65	5.05	4.74	5.33	0.3454	1.08	4.87
METHYLENE CHLORIDE	4.63	4.78	4.56	4.79	4.54	4.25	4.34	0.2045	0.64	4.56
ACETONE	4.04	3.71	4.28	3.88	4.68	4.74	4.85	0.4532	1.42	4.31
CARBON DISULFIDE	4.41	4.48	4.07	3.78	4.43	4.42	4.45	0.2649	0.83	4.29
TRICHLOROFLUOROMETHANE	5.05	5.25	4.82	5.05	4.15	4.66	5.35	0.4075	1.28	4.90
1,1-DICHLOROETHENE	4.85	4.71	4.12	4.67	4.60	3.86	4.13	0.3767	1.18	4.42
TETRAHYDROFURAN	4.85	2.13	4.44	4.24	5.16	3.85	2.06	1.2498	3.92	3.82
1,1-DICHLOROETHANE	5.11	4.50	4.31	4.41	4.50	4.16	4.60	0.3002	0.94	4.51
1,2-DICHLOROETHENE(cis)	4.39	4.20	3.84	3.84	4.15	3.59	3.92	0.2707	0.85	3.99
1,2-DICHLOROETHENE(trans)	5.91	5.93	5.50	4.88	5.91	5.17	6.17	0.4706	1.48	5.64
CHLOROFORM	3.62	3.47	3.22	3.33	3.31	3.24	3.33	0.1402	0.44	3.36
2-BUTANONE	3.75	3.37	3.29	3.39	3.38	3.53	3.12	0.1963	0.62	3.40
1,2-DICHLOROETHANE	5.04	4.74	4.37	4.60	4.79	4.49	4.72	0.2181	0.68	4.68
DIOXANE	5.68	5.03	4.54	4.33	5.20	4.62	4.89	0.4561	1.43	4.90
1,1,1-TRICHLOROETHANE	4.79	4.69	4.86	4.71	4.71	4.76	4.66	0.0683	0.21	4.74
CARBON TETRACHLORIDE	5.13	5.19	5.12	5.02	4.84	5.30	5.23	0.1516	0.48	5.12
VINYL ACETATE	4.27	4.00	4.04	4.27	3.80	3.94	3.91	0.1787	0.56	4.03
BROMODICHLOROMETHANE	5.08	4.98	4.95	5.05	5.07	5.03	4.93	0.0596	0.19	5.01
1,2-DICHLOROPROPANE	5.14	4.65	4.73	4.95	4.92	4.91	4.56	0.2000	0.63	4.84
CIS-1,3-DICHLOROPROPENE	4.87	4.43	4.18	4.44	4.33	4.43	4.19	0.2313	0.73	4.41
TRICHLOROETHENE	4.86	4.67	4.61	4.57	4.75	4.90	4.42	0.1685	0.53	4.68
DIBROMOCHLOROMETHANE	4.89	5.01	4.79	5.43	4.94	5.44	5.06	0.2573	0.81	5.08
1,1,2-TRICHLOROETHANE	5.27	4.97	4.79	4.91	4.89	5.14	4.87	0.1688	0.53	4.98
BENZENE	4.99	4.67	4.73	4.69	4.54	4.73	4.48	0.1634	0.51	4.69
TRANS-1,3-DICHLOROPROPENE	5.27	4.72	4.50	4.76	4.62	4.77	4.15	0.3369	1.06	4.68
2-CHLOROETHYLVINYLETHER	5.15	4.59	4.93	4.93	4.67	4.88	4.51	0.2263	0.71	4.81
BROMOFORM	4.83	5.28	5.16	5.10	5.34	5.17	4.98	0.1742	0.55	5.12
4-METHYL-2-PENTANONE	5.09	4.38	4.50	4.63	4.66	4.40	4.35	0.2583	0.81	4.57
2-HEXANONE	4.43	4.05	4.21	4.26	4.46	4.11	3.87	0.2096	0.66	4.20
TETRACHLOROETHENE	5.28	5.08	4.90	5.25	5.59	5.20	5.13	0.2122	0.67	5.20
1,1,2,2-TETRACHLOROETHANE	4.94	4.75	4.66	4.65	4.70	4.72	4.34	0.1786	0.56	4.68
TOLUENE	4.88	4.61	4.44	4.69	4.88	4.68	4.50	0.1703	0.53	4.67
CHLOROBENZENE	4.90	5.04	4.60	5.04	5.07	4.87	4.69	0.1835	0.58	4.89
ETHYLBENZENE	4.85	4.30	4.49	4.67	4.69	4.66	4.13	0.2510	0.79	4.54
STYRENE	4.59	4.38	4.28	4.53	4.46	4.50	4.13	0.1600	0.50	4.41
XYLENE(O)	4.43	4.37	4.38	4.35	4.54	4.52	4.22	0.1088	0.34	4.40
XYLENE (total) (10 ppb)	9.51	9.41	8.98	9.38	9.67	9.62	8.70	0.3559	1.12	9.32

PACE New England, Inc.
MATRIX DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 624 DMS WATERS - packed column
1/93

COMPOUND (10 ppb, exceptions noted	>D384 CONC ug/L	>D384 CONC ug/L	>D385 CONC ug/L	>D385 CONC ug/L	>D385 CONC ug/L	>D385 CONC ug/L	>D3854 CONC ug/L	STD DEV ====	X 3.14 MDL ug/L ===	MEAN =====
CHLOROMETHANE	8.40	10.18	10.98	10.89	10.00	11.56	10.84	1.0266	3.22	10.41
BROMOMETHANE	9.15	9.67	10.92	10.37	9.96	11.07	10.46	0.6840	2.15	10.23
VINYL CHLORIDE	9.87	11.08	11.44	11.01	10.94	11.48	11.68	0.5969	1.87	11.07
CHLOROETHANE	9.97	10.79	11.59	11.63	10.66	11.61	11.46	0.6426	2.02	11.10
METHYLENE CHLORIDE	10.70	10.44	11.35	11.93	10.58	11.27	11.48	0.5463	1.72	11.11
ACETONE	9.48	9.12	8.86	10.72	12.93	9.13	8.41	1.5531	4.88	9.81
CARBON DISULFIDE	10.95	10.52	11.98	11.39	11.14	12.09	11.16	0.5580	1.75	11.32
TRICHLOROFLUOROMETHANE	10.01	10.59	11.60	10.50	10.71	11.58	11.01	0.5825	1.83	10.86
1,1-DICHLOROETHENE	11.18	10.81	11.05	10.31	10.40	11.27	10.20	0.4411	1.39	10.75
TETRAHYDROFURAN	5.79	4.25	5.01	4.53	7.10	4.61	6.29	1.0554	3.31	5.37
1,1-DICHLOROETHANE	9.77	10.31	11.29	10.50	10.30	10.39	10.10	0.4663	1.46	10.38
1,2-DICHLOROETHENE(total) (20 pp	20.27	20.75	22.10	21.25	20.58	22.01	21.22	0.6969	2.19	21.17
CHLOROFORM	9.79	10.17	11.26	10.66	10.16	11.10	10.95	0.5545	1.74	10.58
2-BUTANONE	10.45	7.87	9.83	9.64	7.47	9.53	8.99	1.0811	3.39	9.11
1,2-DICHLOROETHANE	9.02	10.05	10.93	10.39	10.34	10.88	10.76	0.6640	2.08	10.34
MTBE	9.76	10.24	10.92	10.12	9.88	11.06	10.91	0.5399	1.70	10.41
1,1,1-TRICHLOROETHANE	9.59	10.20	10.37	9.66	9.55	10.26	9.53	0.3766	1.18	9.88
CARBON TETRACHLORIDE	9.68	10.63	10.42	9.91	9.72	10.65	9.61	0.4622	1.45	10.09
VINYL ACETATE	9.70	10.23	11.14	9.75	10.50	11.97	10.87	0.8083	2.54	10.59
BROMODICHLOROMETHANE	9.79	10.26	10.12	10.15	9.90	10.90	9.81	0.3832	1.20	10.13
1,2-DICHLOROPROPANE	9.14	9.95	10.25	9.74	9.78	10.44	9.50	0.4394	1.38	9.83
CIS-1,3-DICHLOROPROPENE (9.6 pp	8.70	9.51	9.83	9.48	9.45	10.17	9.47	0.4472	1.40	9.52
TRICHLOROETHENE	10.35	10.33	10.52	10.18	9.17	10.75	9.90	0.5148	1.62	10.17
DIBROMOCHLOROMETHANE	9.43	10.25	10.37	9.89	10.05	10.93	10.37	0.4660	1.46	10.18
1,1,2-TRICHLOROETHANE	9.29	10.03	10.86	10.00	9.37	10.23	9.63	0.5449	1.71	9.92
BENZENE	10.11	10.10	10.57	10.19	10.02	10.73	10.00	0.2869	0.90	10.25
TRANS-1,3-DICHLOROPROPENE (1	9.82	10.42	10.67	10.36	9.84	10.82	10.30	0.3797	1.19	10.32
2-CHLOROETHYLVINYLETHER	8.02	8.97	10.07	9.50	8.40	10.25	8.98	0.8243	2.59	9.17
BROMOFORM	9.73	10.39	10.50	9.17	10.10	10.75	9.76	0.5433	1.71	10.06
4-METHYL-2-PENTANONE	10.46	9.98	10.61	9.98	11.42	11.00	9.81	0.5942	1.87	10.47
2-HEXANONE	10.15	8.55	8.19	9.65	8.47	8.75	8.56	0.7158	2.25	8.90
TETRACHLOROETHENE	9.43	9.37	10.46	9.92	9.16	10.42	9.76	0.5110	1.60	9.79
1,1,2,2-TETRACHLOROETHANE	10.03	10.27	10.96	9.95	10.31	10.72	10.29	0.3610	1.13	10.36
TOLUENE	9.53	9.73	10.27	9.98	9.78	10.54	9.94	0.3423	1.07	9.97
CHLOROBENZENE	9.26	10.01	10.33	9.95	9.48	10.27	9.60	0.4061	1.28	9.84
ETHYLBENZENE	9.30	9.91	10.48	9.89	9.71	10.34	9.64	0.4070	1.28	9.90
STYRENE	8.95	9.51	10.38	9.59	9.64	9.80	9.79	0.4256	1.34	9.67
XYLENE	9.26	10.22	10.14	10.13	9.64	10.13	10.15	0.3619	1.14	9.95
XYLENE (total)	18.53	19.32	21.23	19.64	19.94	21.47	19.55	1.0503	3.30	19.95

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 624 EMS WATERS
9/93

COMPOUND (10 ppb, exceptions noted)	>E4570 CONC. ug/L	>E4572 CONC. ug/L	>E4578 CONC. ug/L	>E4575 CONC. ug/L	>E4576 CONC. ug/L	>E4577 CONC. ug/L	>E4579 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
CHLOROMETHANE	10.29	10.65	11.31	9.36	9.66	10.46	9.68	0.6804	2.14	10.20
BROMOMETHANE	10.82	11.36	11.32	9.58	10.23	10.30	10.81	0.6389	2.01	10.63
VINYL CHLORIDE	10.16	10.05	10.18	9.60	9.53	10.57	10.50	0.4014	1.26	10.08
CHLOROETHANE	9.02	9.09	8.66	8.29	8.49	9.43	8.80	0.3874	1.22	8.83
METHYLENE CHLORIDE	9.46	9.48	11.53	10.15	10.75	10.71	11.85	0.9317	2.93	10.56
ACETONE	7.16	3.44	6.93	6.79	6.70	8.92	6.12	1.6363	5.14	6.58
CARBON DISULFIDE	10.28	10.72	10.98	10.06	9.94	10.15	10.35	0.3721	1.17	10.35
TRICHLOROFLUOROMETHANE	8.72	9.07	9.15	8.80	8.65	9.04	8.93	0.1899	0.60	8.91
1,1-DICHLOROETHENE	8.70	9.54	8.81	7.28	8.38	8.21	7.90	0.7186	2.26	8.40
ETHER	10.52	9.89	10.23	9.17	9.34	10.65	10.25	0.5693	1.79	10.01
1,1-DICHLOROETHANE	9.18	9.59	10.39	9.16	9.62	10.05	9.55	0.4441	1.39	9.65
1,2-DICHLOROETHENE(cis)	8.52	8.47	9.5	8.15	8.90	9.10	8.52	0.4565	1.43	8.74
1,2-DICHLOROETHENE(trans)	9.06	9.16	9.55	8.55	9.48	9.30	8.90	0.3468	1.09	9.14
CHLOROFORM	9.17	9.34	10.17	8.79	8.84	9.85	9.26	0.5061	1.59	9.35
2-BUTANONE	9.69	8.75	10.82	5.75	7.71	7.22	10.20	1.8036	5.66	8.59
1,2-DICHLOROETHANE	9.47	9.40	10.18	9.31	9.54	10.69	10.19	0.5261	1.65	9.83
1,1,1-TRICHLOROETHANE	9.91	9.20	9.77	9.13	9.46	10.02	10.01	0.3780	1.19	9.64
CARBON TETRACHLORIDE	9.03	9.70	10.48	9.64	9.31	10.37	9.93	0.5276	1.66	9.78
VINYL ACETATE	10.19	6.71	5.05	6.53	6.14	5.68	7.93	1.7101	5.37	6.89
BROMODICHLOROMETHANE	8.75	9.48	9.84	9.10	9.36	10.02	9.76	0.4455	1.40	9.47
1,2-DICHLOROPROPANE	9.34	9.70	9.43	8.41	9.69	9.06	10.12	0.5466	1.72	9.39
CIS-1,3-DICHLOROPROPENE	9.75	9.99	10.18	9.78	10.09	10.85	9.72	0.3945	1.24	10.05
TRICHLOROETHENE	9.41	9.78	10.25	8.82	9.11	9.99	9.31	0.5059	1.59	9.52
DIBROMOCHLOROMETHANE	9.62	9.17	9.17	8.91	8.90	9.67	9.64	0.3417	1.07	9.30
1,1,2-TRICHLOROETHANE	9.39	10.66	9.76	10.25	8.63	10.84	10.41	0.7829	2.46	9.99
BENZENE	10.00	9.51	10.58	9.47	9.99	9.69	10.33	0.4155	1.30	9.94
TRANS-1,3-DICHLOROPROPENE	9.75	9.99	10.18	9.78	10.09	10.85	9.72	0.3945	1.24	10.05
2-CHLOROETHYLVINYLETHER	10.60	8.84	9.9	8.83	9.46	9.18	9.39	0.6269	1.97	9.46
BROMOFORM	10.30	9.58	9.08	8.11	8.49	9.52	9.44	0.7325	2.30	9.22
4-METHYL-2-PENTANONE	10.45	10.84	11.26	9.36	10.55	11.97	11.07	0.8075	2.54	10.79
2-HEXANONE	10.65	8.06	12.77	11.94	5.06	11.09	8.99	2.6438	8.30	9.79
TETRACHLOROETHENE	8.33	9.82	9.18	8.62	9.73	8.88	8.35	0.6146	1.93	8.99
1,1,2,2-TETRACHLOROETHANE	9.75	11.54	11.71	8.47	9.07	9.86	13.18	1.6766	5.26	10.51
TOLUENE	8.60	9.31	10.08	8.84	9.60	9.72	9.75	0.5303	1.67	9.41
CHLOROBENZENE	9.44	9.80	10.34	8.83	9.49	9.05	9.40	0.4929	1.55	9.48
ETHYLBENZENE	9.19	9.67	9.51	9.33	8.96	8.58	9.64	0.3951	1.24	9.27
STYRENE	9.87	10.88	10.53	10.22	10.66	10.47	10.94	0.3742	1.17	10.51
XYLENE (o)	8.90	10.07	10.53	9.30	9.11	9.29	10.49	0.6782	2.13	9.67
XYLENE (m,p) (20 PPB)	18.16	21.37	21.5	18.66	18.41	20.84	20.57	1.4624	4.59	19.93

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 624 EMS WATERS
4/93

COMPOUND (5 ppb, exceptions noted)	>E3859 CONC. ug/L	>E3860 CONC. ug/L	>E3861 CONC. ug/L	>E3867 CONC. ug/L	>E3863 CONC. ug/L	>E3868 CONC. ug/L	>E3865 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
CHLOROMETHANE	4.85	4.51	4.72	3.95	3.59	4.60	4.73	0.4693	1.47	4.42
BROMOMETHANE	4.79	4.85	4.83	4.81	4.98	4.69	4.54	0.1378	0.43	4.78
VINYL CHLORIDE	4.50	4.37	4.74	4.68	4.90	4.10	4.36	0.2718	0.85	4.52
CHLOROETHANE	3.27	5.43	5.25	4.25	5.28	4.38	4.98	0.7745	2.43	4.69
METHYLENE CHLORIDE	4.58	4.61	4.62	5.96	5.36	5.85	5.69	0.6224	1.95	5.24
ACETONE	3.58	3.04	4.52	3.26	4.20	3.74	4.83	0.6601	2.07	3.88
CARBON DISULFIDE	3.93	4.73	4.31	4.89	4.27	3.81	4.04	0.4034	1.27	4.28
TRICHLOROFLUOROMETHANE	4.86	4.88	4.65	4.88	4.83	4.80	4.65	0.1016	0.32	4.79
1,1-DICHLOROETHENE	4.37	4.35	4.40	4.17	4.68	4.42	3.76	0.2841	0.89	4.31
1,1-DICHLOROETHANE	4.40	4.46	4.40	4.43	4.32	4.34	4.14	0.1067	0.34	4.36
1,2-DICHLOROETHENE(cis)	4.75	4.81	4.68	4.55	4.53	4.12	4.11	0.2859	0.90	4.51
1,2-DICHLOROETHENE(trans)	4.85	4.47	4.47	4.37	4.51	4.32	4.46	0.1708	0.54	4.49
CHLOROFORM	5.04	4.67	4.56	4.67	4.82	4.74	4.31	0.2251	0.71	4.69
2-BUTANONE	8.72	7.09	7.27	4.29	7.87	4.32	3.48	2.0672	6.49	6.15
1,2-DICHLOROETHANE	5.11	5.22	5.65	5.35	5.74	5.28	5.43	0.2282	0.72	5.40
1,1,1-TRICHLOROETHANE	4.70	5.07	4.91	5.02	5.41	5.44	5.38	0.2846	0.89	5.13
CARBON TETRACHLORIDE	4.67	4.70	5.02	5.01	4.99	5.59	5.27	0.3193	1.00	5.04
VINYL ACETATE	4.54	5.31	5.97	4.71	6.83	5.98	6.64	0.8934	2.81	5.71
BROMODICHLOROMETHANE	5.21	5.10	5.23	5.13	5.51	5.34	5.59	0.1878	0.59	5.30
1,2-DICHLOROPROPANE	4.60	4.84	4.74	4.74	5.02	5.24	5.06	0.2236	0.70	4.89
CIS-1,3-DICHLOROPROPENE (4.48 ppb)	4.65	4.47	4.65	4.81	5.32	4.81	4.82	0.2659	0.83	4.79
TRICHLOROETHENE	4.74	4.72	4.93	5.19	4.98	5.19	4.85	0.1928	0.61	4.94
DIBROMOCHLOROMETHANE	5.18	5.19	5.81	5.48	6.43	5.59	6.15	0.4722	1.48	5.69
1,1,2-TRICHLOROETHANE	4.68	5.00	5.33	5.02	5.96	5.76	6.09	0.5396	1.69	5.41
BENZENE	4.96	5.11	5.01	4.82	5.17	4.97	4.74	0.1509	0.47	4.97
TRANS-1,3-DICHLOROPROPENE (5.52 ppb)	5.74	5.50	5.73	5.93	6.55	5.93	5.94	0.3267	1.03	5.90
BROMOFORM	5.48	5.54	6.30	5.57	7.42	6.68	7.00	0.7821	2.46	6.28
4-METHYL-2-PENTANONE	5.57	6.48	9.82	5.88	10.85	6.31	9.65	2.2146	6.95	7.79
2-HEXANONE	7.87	8.37	10.87	6.74	7.08	10.87	12.72	2.2719	7.13	9.22
TETRACHLOROETHENE	4.87	5.19	4.82	4.97	5.12	5.04	4.70	0.1733	0.54	4.96
1,1,2,2-TETRACHLOROETHANE	5.72	5.82	6.31	5.40	7.05	5.91	7.52	0.7703	2.42	6.25
TOLUENE	4.84	5.05	5.22	5.07	5.24	4.74	5.09	0.1852	0.58	5.04
CHLOROBENZENE	4.93	4.80	5.09	4.92	5.19	4.75	4.91	0.1539	0.48	4.94
ETHYLBENZENE	5.00	5.33	5.25	5.26	4.94	5.02	5.13	0.1507	0.47	5.13
STYRENE	4.96	5.47	5.23	5.24	5.57	5.28	4.96	0.2310	0.73	5.24
XYLENE (o)	4.83	5.28	5.10	4.81	4.91	4.86	4.77	0.1854	0.58	4.94
XYLENE (m,p) (10.0 ppb)	9.84	9.28	10.00	9.45	10.25	9.19	9.62	0.3888	1.22	9.66

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 624 GMS WATERS
1/93

COMPOUND (5 ppb, exceptions noted)	>G370 CONC ug/L	>G370 CONC ug/L	>G370 CONC ug/L	>G370 CONC ug/L	>G370 CONC ug/L	>G370 CONC ug/L	>G3709 CONC ug/L	STD DEV ====	X 3.14 MDL ug/L ===	MEAN =====
CHLOROMETHANE	3.58	3.73	3.66	3.41	3.39	3.93	3.59	0.1866	0.59	3.61
BROMOMETHANE	3.36	3.14	3.15	3.17	3.40	3.30	3.39	0.1166	0.37	3.27
VINYL CHLORIDE	3.40	4.15	3.80	3.45	3.16	3.84	3.52	0.3318	1.04	3.62
CHLOROETHANE	3.04	3.42	2.91	3.23	3.21	3.43	3.10	0.1921	0.60	3.19
METHYLENE CHLORIDE	3.50	3.22	3.08	3.81	3.90	3.46	3.78	0.3114	0.98	3.54
ACETONE	3.91	2.57	3.72	4.85	3.75	3.86	3.87	0.6639	2.08	3.79
CARBON DISULFIDE	3.82	3.56	3.47	3.78	3.43	3.64	3.53	0.1498	0.47	3.60
TRICHLOROFLUOROMETHANE	3.49	3.33	3.32	3.32	3.34	3.53	3.37	0.0873	0.27	3.39
1,1-DICHLOROETHENE	3.51	3.55	3.37	3.52	3.59	3.35	3.56	0.0946	0.30	3.49
TETRAHYDROFURAN	3.79	3.39	3.62	4.59	3.77	3.51	3.57	0.3967	1.25	3.75
1,1-DICHLOROETHANE	3.44	3.48	3.31	3.47	3.51	3.68	3.48	0.1092	0.34	3.48
1,2-DICHLOROETHENE(cis)	3.38	3.29	3.22	3.19	3.39	3.33	3.24	0.0786	0.25	3.29
1,2-DICHLOROETHENE(trans)	3.39	3.27	3.28	3.54	3.42	3.26	3.35	0.1012	0.32	3.36
CHLOROFORM	3.58	3.58	3.50	3.64	3.44	3.49	3.72	0.0962	0.30	3.56
2-BUTANONE	3.77	3.63	3.89	4.54	4.35	4.22	4.22	0.3311	1.04	4.09
MTBE	3.72	3.67	3.56	3.87	3.79	3.56	3.60	0.1191	0.37	3.68
1,2-DICHLOROETHANE	3.65	3.41	3.42	3.37	3.37	3.43	3.34	0.1034	0.32	3.43
1,1,1-TRICHLOROETHANE	3.06	3.46	3.29	3.25	3.36	3.27	3.25	0.1219	0.38	3.28
CARBON TETRACHLORIDE	3.44	3.74	3.45	3.51	3.53	3.72	3.38	0.1397	0.44	3.54
VINYL ACETATE	3.43	3.58	3.66	3.37	3.50	3.27	3.33	0.1397	0.44	3.45
BROMODICHLOROMETHANE	3.44	3.43	3.50	3.53	3.61	3.44	3.46	0.0652	0.20	3.49
1,2-DICHLOROPROPANE	3.59	3.49	3.71	3.48	3.46	3.32	3.58	0.1229	0.39	3.52
CIS-1,3-DICHLOROPROPENE (4.7 PP	3.19	3.53	3.60	3.15	3.33	3.16	3.10	0.1991	0.63	3.29
TRICHLOROETHENE	3.28	3.56	3.67	3.55	3.45	3.60	3.46	0.1270	0.40	3.51
DIBROMOCHLOROMETHANE	3.44	3.57	3.52	3.57	3.77	3.54	3.61	0.1015	0.32	3.57
1,1,2-TRICHLOROETHANE	3.44	3.57	3.33	3.71	3.68	3.48	3.67	0.1429	0.45	3.55
BENZENE	3.15	3.43	3.34	3.32	3.42	3.41	3.40	0.0986	0.31	3.35
TRANS-1,3-DICHLOROPROPENE (5.	3.43	3.54	3.47	3.45	3.53	3.40	3.28	0.0879	0.28	3.44
2-CHLOROETHYLVINYLETHER	2.86	1.45	2.95	3.89	1.46	2.71	3.85	0.9930	3.12	2.74
BROMOFORM	3.32	3.60	3.53	3.51	3.68	3.47	3.61	0.1168	0.37	3.53
4-METHYL-2-PENTANONE	3.50	2.96	3.40	3.76	3.06	3.12	3.65	0.3088	0.97	3.35
2-HEXANONE	3.52	3.74	3.76	4.25	3.65	3.63	4.01	0.2521	0.79	3.79
TETRACHLOROETHENE	3.38	3.54	3.53	3.67	3.55	3.63	3.47	0.0963	0.30	3.54
1,1,2,2-TETRACHLOROETHANE	3.27	3.72	3.45	3.43	3.42	3.20	3.33	0.1673	0.53	3.40
TOLUENE	3.39	3.23	3.18	3.69	3.58	3.44	3.47	0.1806	0.57	3.43
CHLOROBENZENE	3.48	3.43	3.73	3.42	3.58	3.73	3.73	0.1446	0.45	3.59
ETHYLBENZENE	3.57	3.62	3.58	3.53	3.76	3.67	3.49	0.0905	0.28	3.60
STYRENE	3.20	3.31	3.48	3.47	3.33	3.44	3.31	0.1036	0.33	3.36
XYLENE (O)	3.56	3.61	3.51	3.69	3.40	3.86	3.36	0.1717	0.54	3.57
XYLENE (total) (10 PPB)	6.67	7.08	6.57	7.43	7.20	7.09	6.85	0.3039	0.95	6.98

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 8240 CMS LOW SOIL
1/93

COMPOUND (5 ppb, exceptions noted)	>C548 CONC ug/Kg	>C548 CONC ug/Kg	>C548 CONC ug/Kg	>C548 CONC ug/Kg	>C548 CONC ug/Kg	>C548 CONC ug/Kg	>C5490 CONC ug/Kg	STD DEV	X 3.14 MDL ug/L	MEAN
								====	===	=====
CHLOROMETHANE	4.20	4.74	4.15	4.45	4.38	4.93	5.21	0.3940	1.24	4.58
BROMOMETHANE	3.93	4.96	4.97	4.85	5.06	5.26	5.27	0.4553	1.43	4.90
VINYL CHLORIDE	4.05	4.99	4.64	4.54	5.12	4.96	5.05	0.3815	1.20	4.76
CHLOROETHANE	4.28	5.24	5.18	4.57	5.49	5.48	5.53	0.4933	1.55	5.11
METHYLENE CHLORIDE	4.21	5.15	5.14	5.26	5.09	5.73	5.21	0.4527	1.42	5.11
ACETONE	3.18	4.36	2.87	3.20	5.20	4.15	5.27	0.9821	3.08	4.03
CARBON DISULFIDE	4.57	3.43	4.74	3.72	3.46	3.73	4.05	0.5212	1.64	3.96
TRICHLOROFLUOROMETHANE	5.17	4.54	5.43	3.75	6.51	4.83	6.76	1.0668	3.35	5.28
1,1-DICHLOROETHENE	4.94	5.31	5.55	5.13	5.87	5.70	5.67	0.3365	1.06	5.45
TETRAHYDROFURAN	3.55	3.91	5.17	4.97	4.68	4.37	3.79	0.6209	1.95	4.35
1,1-DICHLOROETHANE	4.00	5.26	5.23	5.14	5.62	5.66	5.85	0.6110	1.92	5.25
1,2-DICHLOROETHENE(total) (10 PP	8.36	10.25	10.40	10.02	10.29	10.72	11.13	0.8752	2.75	10.17
CHLOROFORM	3.69	5.09	5.01	5.00	5.11	5.53	5.34	0.5952	1.87	4.97
2-BUTANONE	3.53	3.89	5.36	5.03	4.52	4.19	3.90	0.6612	2.08	4.35
1,2-DICHLOROETHANE	3.49	5.28	5.04	4.93	5.07	6.04	5.35	0.7712	2.42	5.03
MTBE	3.83	5.08	4.93	5.07	4.64	5.72	5.19	0.5813	1.83	4.92
1,1,1-TRICHLOROETHANE	4.00	5.03	4.34	4.73	5.24	5.32	5.35	0.5247	1.65	4.86
CARBON TETRACHLORIDE	4.03	4.95	4.39	4.29	4.72	5.02	4.94	0.3854	1.21	4.62
VINYL ACETATE	5.04	5.15	5.55	5.33	5.12	3.73	5.13	0.5887	1.85	5.01
BROMODICHLOROMETHANE	3.92	5.31	5.27	4.89	5.01	5.64	5.23	0.5477	1.72	5.04
1,2-DICHLOROPROPANE	3.77	5.20	5.35	5.01	4.99	5.68	5.15	0.5996	1.88	5.02
CIS-1,3-DICHLOROPROPENE (4.7 PP	4.10	5.11	5.26	4.96	5.08	5.59	5.20	0.4606	1.45	5.04
TRICHLOROETHENE	4.27	4.98	4.75	4.38	4.70	5.49	4.87	0.4041	1.27	4.78
DIBROMOCHLOROMETHANE	4.40	5.24	5.17	4.85	4.72	5.47	5.05	0.3581	1.12	4.99
1,1,2-TRICHLOROETHANE	4.51	5.71	5.52	5.48	5.51	6.09	5.62	0.4808	1.51	5.49
BENZENE	4.03	5.09	4.97	4.90	5.02	5.46	5.28	0.4549	1.43	4.96
TRANS-1,3-DICHLOROPROPENE (5.	4.01	5.61	5.73	5.32	5.40	6.03	5.47	0.6437	2.02	5.37
2-CHLOROETHYLVINYLETHER	3.91	5.21	5.27	4.95	4.65	5.73	4.90	0.5704	1.79	4.95
BROMOFORM	5.47	5.29	5.13	4.96	4.70	5.25	4.77	0.2836	0.89	5.08
4-METHYL-2-PENTANONE	4.23	4.99	5.44	5.21	4.95	5.59	4.26	0.5344	1.68	4.95
2-HEXANONE	4.87	4.16	5.29	5.05	4.91	5.50	3.80	0.6082	1.91	4.80
TETRACHLOROETHENE	4.02	4.79	4.34	4.31	4.51	4.63	4.64	0.2592	0.81	4.46
1,1,2,2-TETRACHLOROETHANE	6.11	4.93	5.24	4.92	4.77	4.92	4.69	0.4845	1.52	5.08
TOLUENE	4.09	5.22	4.99	4.86	4.83	5.20	5.16	0.3938	1.24	4.91
CHLOROBENZENE	3.99	5.22	5.04	4.80	4.76	5.24	5.02	0.4286	1.35	4.87
ETHYLBENZENE	3.84	5.21	4.88	4.91	5.06	5.37	5.19	0.5078	1.59	4.92
STYRENE	3.99	5.14	5.16	4.65	5.03	5.50	5.27	0.5003	1.57	4.96
XYLENE	3.91	5.31	5.04	5.22	5.20	5.55	5.42	0.5466	1.72	5.09
XYLENE (total) (10 PPB)	7.94	10.83	10.31	10.23	10.36	11.01	11.12	1.0819	3.40	10.26

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 8240 DMS LOW SOIL - packed column
1/93

OMPOUND (10 ppb, exceptions noted	>D387 CONC ug/Kg	>D387 CONC ug/Kg	>D387 CONC ug/Kg	>D387 CONC ug/Kg	>D387 CONC ug/Kg	>D387 CONC ug/Kg	>D3876 CONC ug/Kg	STD DEV ====	X 3.14 MDL ug/L ===	MEAN =====
HLOROMETHANE	8.62	9.19	8.27	8.50	8.48	8.53	8.26	0.3122	0.98	8.55
ROMOMETHANE	9.08	8.65	8.39	8.55	8.34	8.12	8.56	0.3005	0.94	8.53
VINYL CHLORIDE	9.09	9.04	8.89	8.18	8.30	8.43	8.13	0.4146	1.30	8.58
HLOROETHANE	8.14	7.84	7.89	8.12	7.07	7.87	7.81	0.3566	1.12	7.82
ETHYLENE CHLORIDE	8.66	8.54	8.27	8.42	8.23	7.86	8.39	0.2578	0.81	8.34
ACETONE	6.63	5.05	6.18	6.29	5.73	6.59	5.41	0.6032	1.89	5.98
ARBON DISULFIDE	8.45	8.99	7.67	8.17	8.55	8.16	8.50	0.4108	1.29	8.36
RICHLOROFLUOROMETHANE	9.25	9.53	7.97	8.36	8.68	8.93	8.94	0.5273	1.66	8.81
1,1-DICHLOROETHENE	9.97	10.58	9.49	9.72	9.06	9.47	9.46	0.4845	1.52	9.68
ETRAHYDROFURAN	9.57	9.19	9.02	5.21	4.60	8.60	8.49	2.0255	6.36	7.81
-DICHLOROETHANE	9.09	9.09	8.36	8.47	8.22	8.43	8.56	0.3487	1.09	8.60
1,2-DICHLOROETHENE(total) (20 PP	17.71	17.62	15.69	16.33	15.63	15.85	16.38	0.8742	2.74	16.46
HLOROFORM	9.25	9.40	9.17	9.07	8.93	8.83	8.80	0.2240	0.70	9.06
BUTANONE	9.84	8.33	6.97	7.67	6.61	8.30	6.07	1.2724	4.00	7.68
1,2-DICHLOROETHANE	9.71	9.76	9.34	9.30	9.54	9.10	9.00	0.2911	0.91	9.39
MTBE	9.30	9.95	9.56	9.42	9.41	9.20	9.35	0.2447	0.77	9.46
,1-TRICHLOROETHANE	9.70	10.25	9.62	10.11	9.09	8.97	9.23	0.4965	1.56	9.57
ARBON TETRACHLORIDE	9.82	9.95	9.41	10.17	9.27	8.88	9.53	0.4397	1.38	9.58
VINYL ACETATE	10.22	11.25	9.73	9.65	9.32	9.75	9.26	0.6810	2.14	9.88
ROMODICHLOROMETHANE	10.21	10.39	10.02	10.29	9.56	9.51	9.55	0.3841	1.21	9.93
1,2-DICHLOROPROPANE	10.29	10.56	10.34	10.85	9.64	9.63	10.17	0.4506	1.41	10.21
CIS-1,3-DICHLOROPROPENE (9.6 PP	9.49	9.65	8.97	9.78	8.84	8.80	8.56	0.4763	1.50	9.16
RICHLOROETHENE	9.43	9.39	9.13	10.06	8.91	8.52	9.10	0.4808	1.51	9.22
IBROMOCHLOROMETHANE	10.22	10.90	10.71	10.67	10.31	9.42	9.76	0.5379	1.69	10.28
1,1,2-TRICHLOROETHANE	10.16	11.14	10.39	10.88	9.90	9.81	10.03	0.5060	1.59	10.33
ENZENE	9.97	10.38	9.86	10.15	9.38	9.23	9.86	0.4059	1.27	9.83
RANS-1,3-DICHLOROPROPENE (1	10.80	10.86	10.36	10.98	10.42	10.00	10.00	0.4031	1.27	10.49
2-CHLOROETHYLVINYLETHER	10.57	11.35	7.44	10.78	10.59	10.62	10.81	1.2930	4.06	10.31
ROMOFORM	10.80	11.61	10.60	10.55	10.09	9.73	10.70	0.5899	1.85	10.58
METHYL-2-PENTANONE	12.84	11.61	10.56	10.15	9.75	11.29	9.46	1.1857	3.72	10.81
2-HEXANONE	11.69	10.40	8.42	9.29	7.77	10.47	7.86	1.4938	4.69	9.41
ETRACHLOROETHENE	10.15	10.24	9.90	10.11	9.42	9.71	9.77	0.2903	0.91	9.90
1,2,2-TETRACHLOROETHANE	12.30	11.87	11.42	10.81	10.30	10.96	9.97	0.8322	2.61	11.09
TOLUENE	10.06	10.21	10.04	10.08	9.93	9.63	10.07	0.1836	0.58	10.00
HLOROBENZENE	10.86	10.68	10.35	10.36	9.98	10.15	9.99	0.3353	1.05	10.34
THYLBENZENE	10.73	10.47	10.67	10.56	9.91	9.44	10.12	0.4720	1.48	10.27
STYRENE	10.58	11.14	10.51	10.50	10.17	9.92	10.23	0.3885	1.22	10.44
YLENE	10.18	10.20	10.37	9.92	9.81	9.32	9.40	0.4047	1.27	9.89
YLENE (total) (20 PPB)	20.40	21.28	19.81	20.93	20.03	19.23	19.62	0.7299	2.29	20.19

PACE NEW ENGLAND, INC
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 8240 DMS MEGABORE LOW SOIL
3/93

COMPOUND (5 ppb, exceptions noted)	>D4708 CONC. ug/Kg	>D4707 CONC. ug/Kg	>D4702 CONC. ug/Kg	>D4705 CONC. ug/Kg	>D4703 CONC. ug/Kg	>D4713 CONC. ug/Kg	>D4714 CONC. ug/Kg	STD DEV	X 3.14 MDL ug/L	MEAN
CHLOROMETHANE	3.95	3.7	5.31	3.95	4.73	3.47	3.58	0.6749	2.12	4.10
BROMOMETHANE	2.14	3.62	5.29	5.45	4.65	3.15	4.55	1.2052	3.78	4.12
VINYL CHLORIDE	3.67	2.57	4.45	2.15	3.9	3.54	4.07	0.8269	2.60	3.48
CHLOROETHANE	5.61	5.33	6.58	4.64	3.23	4.32	5.12	1.0577	3.32	4.98
METHYLENE CHLORIDE	7.06	6.98	5.52	5.52	5.33	7.06	7.49	0.9207	2.89	6.42
ACETONE	7.16	6.19	5.88	5.11	5.31	6.85	6.44	0.7587	2.38	6.13
CARBON DISULFIDE	8.88	6.69	5.35	5.25	3.87	6.04	7.09	1.5962	5.01	6.17
TRICHLOROFLUOROMETHANE	3.75	3.87	5.23	4.08	5.02	4.28	3.9	0.5887	1.85	4.30
1,1-DICHLOROETHENE	4.84	4.56	5.58	5.34	4.82	4.53	5.32	0.4137	1.30	5.00
TETRAHYDROFURAN	14.35	11.07	17.11	11.23	10.22	12.15	6.11	3.4286	10.77	11.75
1,1-DICHLOROETHANE	4.72	4.66	5.14	4.89	4.94	4.6	4.49	0.2243	0.70	4.78
1,2-DICHLOROETHENE(cis)	4.94	4.61	5.16	5.01	4.93	4.8	5	0.1747	0.55	4.92
1,2-DICHLOROETHENE(trans)	4.72	4.52	4.32	5.6	5.24	5.49	5.62	0.5441	1.71	5.07
CHLOROFORM	4.85	4.88	5.08	5.2	5.09	4.72	4.65	0.2050	0.64	4.92
2-BUTANONE	6.74	5.87	4.81	4.14	4.19	5.82	5.15	0.9564	3.00	5.25
1,2-DICHLOROETHANE	4.95	5.13	5.02	4.93	4.86	4.58	4.78	0.1774	0.56	4.89
MTBE	5.82	5.43	4.97	5.26	5.06	5.4	5.47	0.2830	0.89	5.34
1,1,1-TRICHLOROETHANE	4.67	4.73	4.86	4.73	4.87	4.9	4.94	0.1028	0.32	4.81
CARBON TETRACHLORIDE	4.89	4.92	4.84	4.76	4.96	4.82	5.17	0.1330	0.42	4.91
VINYL ACETATE	5.17	4.96	4.45	4.38	4.25	4.79	3.39	0.5851	1.84	4.48
BROMODICHLOROMETHANE	4.96	4.91	4.91	5.08	4.92	5	4.89	0.0673	0.21	4.95
1,2-DICHLOROPROPANE	4.88	5.16	4.96	4.87	4.94	5.27	4.58	0.2217	0.70	4.95
CIS-1,3-DICHLOROPROPENE (4.7 ppb)	4.75	5.03	4.81	5.21	5.07	4.66	4.38	0.2825	0.89	4.84
TRICHLOROETHENE	4.61	4.79	4.62	4.62	4.67	4.83	4.59	0.0955	0.30	4.68
DIBROMOCHLOROMETHANE	5.06	5.35	4.86	5.2	5	5.16	4.89	0.1755	0.55	5.07
1,1,2-TRICHLOROETHANE	5.08	5.44	5.09	4.83	5.23	4.99	5.08	0.1907	0.60	5.11
BENZENE	4.96	4.94	4.75	4.92	4.85	4.7	5	0.1125	0.35	4.87
TRANS-1,3-DICHLOROPROPENE (5.3 ppb)	4.75	4.84	5.03	4.85	4.85	4.64	4.66	0.1336	0.42	4.80
2-CHLOROETHYLVINYLETHER	5.96	5.19	4.81	4.89	4.92	4.31	4.92	0.4991	1.57	5.00
BROMOFORM	5.59	5.82	4.54	5	4.93	5.51	4.87	0.4632	1.45	5.18
4-METHYL-2-PENTANONE	6.4	5.97	4.59	4.27	4.44	5.69	5.36	0.8265	2.60	5.25
2-HEXANONE	6.9	5.8	3.95	3.34	4.1	4.99	5.08	1.2127	3.81	4.88
TETRACHLOROETHENE	4.63	5.05	4.84	4.82	4.89	4.72	5.7	0.3560	1.12	4.95
1,1,2,2-TETRACHLOROETHANE	5.86	5.38	4.44	4.41	4.56	4.98	5.18	0.5427	1.70	4.97
TOLUENE	4.96	4.84	4.85	5.01	5.26	4.76	5.2	0.1884	0.59	4.98
CHLOROBENZENE	4.97	5.09	4.98	5.1	5.03	4.7	5.31	0.1834	0.58	5.03
ETHYLBENZENE	5.15	4.65	5.54	5.1	4.99	4.52	4.99	0.3358	1.05	4.99
STYRENE	4.7	4.57	4.8	4.72	4.79	4.27	4.73	0.1855	0.58	4.65
XYLENE(O)	5.09	4.86	5.05	4.88	4.6	4.8	4.93	0.1635	0.51	4.89
XYLENE (total) (10 ppb)	10.2	9.73	10.2	9.99	10.44	9.27	10.33	0.4051	1.27	10.02

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 8240 GMS LOW SOIL
1/93

COMPOUND (5 ppb, exceptions noted)	>G372 CONC ug/Kg	>G372 CONC ug/Kg	>G373 CONC ug/Kg	>G373 CONC ug/Kg	>G373 CONC ug/Kg	>G373 CONC ug/Kg	>G3735 CONC ug/Kg	STD DEV
								====
HLOROMETHANE	4.80	4.14	3.87	4.28	4.40	5.04	5.07	
ROMOMETHANE	4.15	4.52	4.14	4.21	4.07	4.23	4.58	
VINYL CHLORIDE	4.32	3.50	3.92	3.98	3.76	4.51	4.97	
HLOROETHANE	5.00	4.52	4.31	4.07	3.62	4.28	4.15	
ETHYLENE CHLORIDE	5.06	5.51	5.72	5.21	5.55	5.42	5.37	
ACETONE	6.56	5.42	9.01	6.71	8.23	4.99	4.19	
ARBON DISULFIDE	4.25	3.83	4.25	4.52	4.40	4.44	4.67	
RICHLOROFLUOROMETHANE	4.59	4.17	4.39	4.19	4.05	4.45	4.41	
1,1-DICHLOROETHENE	4.21	3.99	4.26	3.76	3.91	4.13	4.21	
ETRAHYDROFURAN	5.66	6.24	5.88	4.29	5.53	5.73	4.89	
-DICHLOROETHANE	4.74	4.43	4.35	4.39	4.54	4.58	4.75	
1,2-DICHLOROETHENE(cis)	4.56	4.44	4.40	4.42	4.24	4.44	4.47	
2-DICHLOROETHENE(trans)	4.64	4.55	4.83	4.27	4.76	4.90	4.45	
HLOROFORM	4.33	4.31	4.63	4.28	4.35	4.17	4.27	
2-BUTANONE	4.56	5.94	5.41	5.29	5.38	4.82	4.62	
TBE	4.53	4.95	4.80	4.77	4.66	4.40	4.37	
-DICHLOROETHANE	4.33	4.46	4.54	4.55	4.43	4.20	4.38	
1,1,1-TRICHLOROETHANE	4.60	4.23	4.26	4.43	4.24	4.07	4.04	
ARBON TETRACHLORIDE	4.45	4.19	4.27	4.10	4.33	4.26	4.39	
NYL ACETATE	4.06	4.66	5.11	4.77	4.35	4.52	4.49	
BROMODICHLOROMETHANE	4.98	4.64	4.65	4.50	4.24	4.36	4.40	
2-DICHLOROPROPANE	5.11	5.83	4.84	4.65	4.72	4.52	4.82	
S-1,3-DICHLOROPROPENE (4.3 ppb	4.08	4.25	3.98	3.79	4.04	3.81	3.81	
TRICHLOROETHENE	4.34	4.12	4.33	4.26	3.83	3.98	4.45	
IBROMOCHLOROMETHANE	4.54	4.45	4.53	4.37	4.30	4.35	4.25	
,2-TRICHLOROETHANE	4.65	4.85	5.28	4.84	4.48	4.19	4.44	
BENZENE	4.60	4.55	4.53	4.26	4.35	4.13	4.47	
TRANS-1,3-DICHLOROPROPENE (5.	4.91	4.67	4.97	4.65	4.77	4.44	4.37	
CHLOROETHYLVINYLETHER	5.07	4.81	4.71	4.26	5.72	3.05	3.33	
BROMOFORM	4.33	4.77	4.57	4.33	4.44	3.89	3.99	
TOLUENE-d8	5.05	4.82	4.93	4.75	4.93	4.96	4.89	
METHYL-2-PENTANONE	4.52	5.01	5.27	4.62	4.89	4.03	3.98	
2-HEXANONE	4.79	5.79	5.52	4.53	5.16	4.11	4.22	
TETRACHLOROETHENE	4.52	4.02	4.51	4.09	4.25	4.23	4.07	
,2,2-TETRACHLOROETHANE	4.87	5.00	5.34	4.51	4.86	4.42	4.41	
OLUENE	4.72	4.50	4.83	4.43	4.71	4.63	4.71	
CHLOROBENZENE	4.75	4.30	4.24	4.12	4.26	4.25	4.07	
THYLBENZENE	4.69	4.41	4.47	4.27	4.05	4.22	4.03	
YRENE	4.51	4.26	4.15	4.02	4.07	4.16	4.29	
XYLENE (O)	4.75	4.17	4.51	4.04	4.31	4.25	4.17	
YLENE (total) (10 ppb)	8.80	8.31	8.52	7.30	8.24	8.24	8.14	

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 8260 DMS LOW WATERS
1/93

COMPOUND (5 ppb, exceptions noted)	>D6909 CONC. ug/L	>D6910 CONC. ug/L	>D6911 CONC. ug/L	>D6912 CONC. ug/L	>D6913 CONC. ug/L	>D6914 CONC. ug/L	>D6916 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
CHLOROMETHANE	5.30	4.69	5.05	4.66	5.29	5.50	5.41	0.3393	1.07	5.13
BROMOMETHANE	5.13	5.06	4.90	4.60	5.14	5.29	5.09	0.2221	0.70	5.03
VINYL CHLORIDE	5.05	4.91	4.74	4.54	5.09	5.34	5.13	0.2660	0.84	4.97
CHLOROETHANE	5.15	4.82	5.19	4.72	5.35	5.26	5.32	0.2477	0.78	5.12
METHYLENE CHLORIDE	5.22	5.23	5.28	4.96	5.47	5.63	5.61	0.2410	0.76	5.34
ACETONE	4.68	6.25	5.05	5.81	4.40	4.76	4.90	0.6643	2.09	5.12
CARBON DISULFIDE	5.08	4.99	5.07	4.70	5.44	5.39	5.42	0.2750	0.86	5.16
TRICHLOROFLUOROMETHANE	5.21	4.84	5.22	4.48	4.94	5.51	5.10	0.3290	1.03	5.04
1,1-DICHLOROETHENE	5.04	5.05	4.97	4.81	5.19	5.23	5.17	0.1465	0.46	5.07
TETRAHYDROFURAN	6.02	6.54	6.51	6.36	6.61	5.73	5.03	0.5739	1.80	6.11
1,1-DICHLOROETHANE	5.11	5.01	5.02	4.84	5.34	5.34	5.31	0.1963	0.62	5.14
1,2-DICHLOROETHENE(cis)	5.12	5.01	5.02	4.81	5.22	5.24	5.09	0.1460	0.46	5.07
1,2-DICHLOROETHENE(trans)	5.07	4.88	4.94	4.74	5.30	5.38	5.21	0.2347	0.74	5.07
CHLOROFORM	5.20	5.18	5.02	4.85	5.40	5.45	5.31	0.2121	0.67	5.20
2-BUTANONE	5.13	5.68	4.99	5.46	5.21	5.00	4.41	0.4026	1.26	5.13
1,2-DICHLOROETHANE	5.22	5.51	5.08	5.27	5.43	5.42	5.19	0.1545	0.48	5.30
MTBE	5.11	5.46	5.01	5.12	5.20	5.11	4.84	0.1883	0.59	5.12
1,1,1-TRICHLOROETHANE	4.98	5.04	5.14	4.99	5.08	5.20	5.18	0.0888	0.28	5.09
CARBON TETRACHLORIDE	4.96	5.01	5.06	4.83	5.08	5.15	5.10	0.1064	0.33	5.03
VINYL ACETATE	4.98	5.75	5.45	5.93	5.58	5.61	4.90	0.3843	1.21	5.46
BROMODICHLOROMETHANE	5.10	5.34	5.27	5.51	5.27	5.39	5.10	0.1492	0.47	5.28
1,2-DICHLOROPROPANE	5.04	5.33	5.22	5.37	5.24	5.45	5.19	0.1344	0.42	5.26
CIS-1,3-DICHLOROPROPENE	5.05	5.23	5.10	5.29	5.16	5.16	4.92	0.1217	0.38	5.13
TRICHLOROETHENE	4.83	4.91	4.92	4.77	5.00	4.89	4.89	0.0723	0.23	4.89
DIBROMOCHLOROMETHANE	5.02	5.48	5.11	5.69	5.13	5.29	4.81	0.2949	0.93	5.22
1,1,2-TRICHLOROETHANE	4.98	5.5	5.10	5.60	5.18	5.14	4.86	0.2670	0.84	5.19
BENZENE	4.97	5.08	5.07	5.05	5.21	5.29	5.09	0.1068	0.34	5.11
TRANS-1,3-DICHLOROPROPENE	5.10	5.44	5.26	5.61	5.18	5.19	4.80	0.2566	0.81	5.23
2-CHLOROETHYLVINYLETHER	4.88	5.37	4.85	5.59	4.97	4.66	4.39	0.4079	1.28	4.96
BROMOFORM	4.85	5.57	5.16	5.83	4.93	5.04	4.73	0.4011	1.26	5.16
4-METHYL-2-PENTANONE	4.78	5.52	4.91	5.75	4.96	4.82	4.48	0.4448	1.40	5.03
2-HEXANONE	4.50	5.43	5.04	5.58	4.94	4.57	4.30	0.4818	1.51	4.91
TETRACHLOROETHENE	4.85	4.74	4.88	4.69	4.91	4.83	4.93	0.0885	0.28	4.83
1,1,2,2-TETRACHLOROETHANE	4.78	5.46	5.00	5.53	4.94	4.96	4.58	0.3449	1.08	5.04
TOLUENE	4.74	4.77	4.88	4.77	4.98	5.02	5.05	0.1303	0.41	4.89
CHLOROBENZENE	4.59	4.82	4.68	4.82	4.89	4.91	4.83	0.1154	0.36	4.79
ETHYLBENZENE	4.84	4.86	4.88	4.83	5.03	5.08	5.03	0.1063	0.33	4.94
STYRENE	4.75	5.02	4.89	5.00	5.00	4.85	4.82	0.1047	0.33	4.90
XYLENE(O)	4.74	4.75	4.74	4.77	4.91	5.00	4.85	0.1013	0.32	4.82
XYLENE (total)	9.68	9.73	9.75	9.66	10.07	10.16	10.05	0.2124	0.67	9.87

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 8260 GMS LOW WATERS
1/93

COMPOUND (5 ppb, exceptions noted)	>G388 CONC ug/L	>G388 CONC ug/L	>G388 CONC ug/L	>G388 CONC ug/L	>G388 CONC ug/L	>G388 CONC ug/L	>G3886 CONC ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
								====	===	=====
CHLOROMETHANE	4.82	4.53	4.57	4.49	4.74	4.50	4.75	0.1370	0.43	4.63
BROMOMETHANE	5.05	4.95	4.58	4.84	4.73	4.72	4.92	0.1610	0.51	4.83
VINYL CHLORIDE	5.09	5.02	4.79	5.00	5.08	4.92	5.08	0.1093	0.34	5.00
CHLOROETHANE	4.99	4.60	4.71	4.90	4.89	4.63	4.99	0.1661	0.52	4.82
METHYLENE CHLORIDE	4.96	5.05	4.59	4.98	4.97	4.91	4.49	0.2176	0.68	4.85
ACETONE	5.95	5.13	5.20	7.41	6.07	6.05	5.31	0.7917	2.49	5.87
CARBON DISULFIDE	4.82	4.47	4.49	4.61	4.72	4.45	4.67	0.1409	0.44	4.60
TRICHLOROFLUOROMETHANE	5.03	4.81	4.56	4.77	4.83	4.66	4.81	0.1470	0.46	4.78
1,1-DICHLOROETHENE	5.25	4.94	4.88	5.06	5.27	5.15	5.05	0.1475	0.46	5.09
TETRAHYDROFURAN	5.13	5.05	3.96	6.34	4.91	4.53	5.06	0.7222	2.27	5.00
1,1-DICHLOROETHANE	5.17	4.88	4.86	4.94	4.93	4.81	5.03	0.1209	0.38	4.95
1,2-DICHLOROETHENE(cis)	4.85	4.76	4.65	4.91	4.85	4.89	4.95	0.1018	0.32	4.84
1,2-DICHLOROETHENE(trans)	5.08	4.70	4.88	4.73	4.98	4.87	5.01	0.1419	0.45	4.89
CHLOROFORM	5.17	4.87	4.77	5.03	5.16	4.96	4.90	0.1494	0.47	4.98
2-BUTANONE	5.81	6.59	5.61	7.19	6.79	6.67	5.81	0.6041	1.90	6.35
MTBE	4.90	4.75	4.78	4.92	5.36	4.94	4.78	0.2092	0.66	4.92
1,2-DICHLOROETHANE	5.08	4.85	4.79	5.06	5.05	4.85	4.77	0.1362	0.43	4.92
1,1,1-TRICHLOROETHANE	5.01	4.93	4.68	4.81	4.94	4.95	4.86	0.1104	0.35	4.88
CARBON TETRACHLORIDE	5.01	4.84	4.55	4.83	4.94	4.75	4.82	0.1465	0.46	4.82
VINYL ACETATE	4.85	4.81	4.46	5.03	4.90	4.52	4.84	0.2065	0.65	4.77
BROMODICHLOROMETHANE	5.15	4.81	4.74	4.84	5.04	4.82	4.89	0.1448	0.45	4.90
1,2-DICHLOROPROPANE	4.87	4.96	4.79	4.92	4.98	5.20	5.12	0.1415	0.44	4.98
CIS-1,3-DICHLOROPROPENE (4.5 PP	4.39	4.25	4.13	4.24	4.35	4.37	4.34	0.0931	0.29	4.30
TRICHLOROETHENE	4.98	4.78	4.83	4.92	5.09	4.93	5.07	0.1148	0.36	4.94
DIBROMOCHLOROMETHANE	5.13	4.94	4.77	5.18	5.18	5.27	5.14	0.1720	0.54	5.09
1,1,2-TRICHLOROETHANE	4.98	4.79	4.79	5.43	5.22	5.44	5.38	0.2911	0.91	5.15
BENZENE	4.84	4.86	4.79	4.97	5.05	4.99	4.88	0.0934	0.29	4.91
TRANS-1,3-DICHLOROPROPENE (5.	5.44	5.30	4.99	5.26	5.52	5.26	5.20	0.1707	0.54	5.28
2-CHLOROETHYLVINYLETHER	4.25	4.07	3.94	3.40	3.51	4.20	4.05	0.3331	1.05	3.92
BROMOFORM	5.21	4.85	4.90	5.22	5.73	5.31	5.09	0.2935	0.92	5.19
CHLOROBENZENE-d5	10.00	10.00	10.00	10.00	10.00	10.00	10.00	0.0000	0.00	10.00
TOLUENE-d8	24.91	24.50	25.24	23.92	24.97	24.41	23.80	0.5419	1.70	24.54
4-METHYL-2-PENTANONE	4.89	4.67	4.30	4.40	4.56	4.72	4.27	0.2317	0.73	4.54
2-HEXANONE	4.38	4.42	4.45	4.27	4.83	4.47	4.55	0.1761	0.55	4.48
TETRACHLOROETHENE	5.11	4.94	5.24	4.98	5.30	5.26	5.25	0.1456	0.46	5.15
1,1,2,2-TETRACHLOROETHANE	4.71	4.79	4.77	5.00	4.42	4.99	4.92	0.2017	0.63	4.80
TOLUENE	4.94	4.67	4.96	4.80	4.75	4.90	4.87	0.1061	0.33	4.84
CHLOROBENZENE	4.89	4.57	4.76	4.66	4.88	4.93	4.75	0.1319	0.41	4.78
ETHYLBENZENE	5.16	4.80	5.00	4.92	5.27	5.16	4.92	0.1680	0.53	5.03
STYRENE	4.95	4.79	4.97	4.78	4.93	4.85	4.88	0.0758	0.24	4.88
XYLENE (O)	4.99	4.76	5.05	4.92	5.08	5.06	4.95	0.1110	0.35	4.97
XYLENE (total) (10 PPB)	9.31	9.16	9.08	9.04	9.44	9.35	9.60	0.2024	0.64	9.28

PACE, INC.

METHOD 601
DETECTION LIMIT STUDY
ON THE WATERS GC
DEC 17 1992 LMH

COMPOUND	AVG	SD	DET LIM	CONCENTRATION (PPB)						
DICHLORODIFLUOROMETHANE	6.17	0.78	2.45	5.65	7.57	7.09	5.26	6.04	5.86	5.69
CHLOROMETHANE	5.98	0.52	1.65	6.19	6.27	6.96	5.42	5.86	5.92	5.27
VINYL CHLORIDE	5.70	0.32	1.02	5.87	5.80	6.16	5.04	5.86	5.65	5.55
BROMOMETHANE	5.42	0.48	1.50	5.24	5.68	5.75	4.33	5.63	5.79	5.55
CHLOROETHANE	5.75	0.52	1.64	6.75	5.31	6.24	5.19	5.79	5.56	5.39
TRICHLOROFLUOROMETHANE	5.53	0.34	1.08	5.63	5.31	5.90	4.82	5.86	5.52	5.65
1,1-DICHLOROETHENE	5.31	0.31	0.98	5.24	4.95	5.46	4.87	5.73	5.24	5.70
METHYLENE CHLORIDE	8.38	0.80	2.50	8.85	7.17	9.36	8.72	8.98	9.15	9.96
TRANS-1,2-DICHLOROETHENE	5.57	0.30	0.95	5.31	5.03	5.49	5.66	5.82	5.69	6.01
1,1-DICHLOROETHANE	5.43	0.24	0.76	5.51	5.15	5.18	5.54	5.81	5.78	5.41
CHLOROFORM	5.56	0.21	0.67	5.85	5.44	5.28	5.78	5.29	5.69	5.59
1,1,1-TRICHLOROETHANE	8.44	0.25	0.79	8.52	8.12	8.52	8.88	8.18	8.63	8.26
CARBON TETRACHLORIDE	6.12	0.39	1.23	6.63	5.72	6.07	6.68	6.29	5.76	5.70
1,2-DICHLOROETHANE	6.22	0.18	0.58	6.19	6.09	6.31	6.35	6.47	5.86	6.25
TRICHLOROETHENE	5.53	0.31	0.98	5.38	5.42	5.60	5.88	5.95	4.94	5.52
1,2-DICHLOROPROPANE	5.65	0.24	0.75	5.78	5.50	5.77	5.60	5.99	5.18	5.72
BROMODICHLOROMETHANE	5.67	0.37	1.16	5.64	5.61	5.91	5.73	5.98	4.83	5.97
2-CHLOROETHYLVINYLETHER	9.49	0.87	2.72	9.01	8.67	9.94	9.55	11.00	8.24	10.04
CIS-1,3-DICHLOROPROPENE	5.99	0.44	1.37	6.42	5.37	6.33	5.84	6.35	5.35	6.27
TRANS-1,3-DICHLOROPROPENE	5.79	0.34	1.08	6.13	5.71	6.13	5.55	6.14	5.15	5.75
1,1,2-TRICHLOROETHANE	5.42	0.37	1.15	5.51	5.14	5.53	5.21	5.89	4.81	5.87
TETRACHLOROETHANE	4.97	0.45	1.41	5.29	4.26	5.22	4.76	5.67	4.52	5.08
DIBROMOCHLOROMETHANE	4.89	0.32	1.01	5.03	4.71	5.04	4.33	5.00	4.68	5.42
CHLOROBENZENE	4.90	0.47	1.48	4.59	4.72	4.60	4.68	5.87	4.52	5.34
BROMOFORM	4.40	0.31	0.97	4.20	4.39	4.44	4.32	5.12	4.17	4.19
1,1,2,2-TETRACHLOROETHANE	5.77	0.24	0.77	6.10	5.53	5.83	5.69	5.46	5.67	6.14
1,3-DICHLOROBENZENE	4.92	0.32	0.99	5.44	4.42	5.12	5.02	5.00	4.57	4.87
1,4-DICHLOROBENZENE	4.69	0.23	0.72	5.05	4.40	4.99	4.63	4.59	4.47	4.67
1,2-DICHLOROBENZENE	4.94	0.17	0.53	5.00	4.79	4.99	4.89	5.00	4.67	5.24

PACE, INC.

METHOD 602
DETECTION LIMIT STUDY ON THE TRACOR GC

STABILWAX COLUMN
FEBRUARY 10 1993 LMH 5PPB STANDARD

COMPOUND	Concentration (ppb)							AVG	SD	DET LIM
MTBE	2.25	2.22	2.34	2.04	2.39	2.45	2.40	2.30	0.13	0.41
BENZENE	2.38	2.42	2.45	2.35	2.46	2.51	2.39	2.42	0.05	0.16
TOLUENE	2.12	2.06	2.17	2.10	2.11	2.21	2.28	2.15	0.07	0.22
ET-BENZENE	2.12	2.16	2.11	2.07	2.20	1.98	2.10	2.11	0.06	0.20
P-XYLENE	2.43	2.47	2.38	2.37	2.52	2.22	2.36	2.39	0.09	0.23
M-XYLENE	2.36	2.49	2.34	2.30	2.49	2.28	2.37	2.38	0.08	0.24
O-XYLENE	2.16	2.17	2.13	2.06	2.28	2.02	2.26	2.15	0.09	0.28

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
SEMIVOLATILE ORGANIC COMPOUNDS
HMS 3/93 method 625 LMR 3/31/93

OMPOUND (20 PPB)	>H9650 (UG/L)	>H9651 (UG/L)	>H9652 (UG/L)	>H9653 (UG/L)	>H9654 (UG/L)	>H9655 (UG/L)	>H9656 (UG/L)	STD DEV	X 3.14 MDL UG/L	MEAN
,4-DICHLOROBENZENE-d4	40.00	40.00	40.00	40.00	40.00	40.00	40.00	0.0000	0.00	40.00
-NITROSODIMETHYLAMINE	20.00	21.20	20.92	20.05	20.73	20.73	20.06	0.4853	1.52	20.53
-FLUOROPHENOL	16.65	17.53	17.81	17.42	17.35	18.12	17.52	0.4531	1.42	17.49
HENOL-d5	17.40	17.95	18.58	17.39	17.94	18.29	17.86	0.4337	1.36	17.92
-CHLOROPHENOL-d4	17.48	18.16	18.50	17.99	18.04	18.81	18.44	0.4300	1.35	18.20
,2-DICHLOROBENZENE-d4	17.40	18.13	18.09	17.40	17.53	18.77	18.10	0.5034	1.58	17.92
HENOL	17.07	17.32	18.11	17.45	17.79	18.11	17.96	0.4112	1.29	17.69
NILINE	17.50	17.86	19.02	18.27	18.12	18.13	18.32	0.4662	1.46	18.17
IS(2-CHLOROETHYL)ETHER	16.55	17.31	17.37	17.09	17.31	17.61	17.58	0.3594	1.13	17.26
-CHLOROPHENOL	17.42	18.04	18.32	17.91	17.98	18.22	18.20	0.2989	0.94	18.01
,3-DICHLOROBENZENE	16.62	17.52	17.47	17.08	17.32	18.16	17.40	0.4666	1.47	17.37
,4-DICHLOROBENZENE	16.49	17.76	17.61	17.35	17.42	18.40	18.05	0.6046	1.90	17.58
ENZYL ALCOHOL	22.97	22.72	23.74	23.51	22.69	21.61	21.53	0.8530	2.68	22.68
,2-DICHLOROBENZENE	16.71	17.54	17.44	17.08	17.35	17.77	17.69	0.3688	1.16	17.37
-METHYLPHENOL	17.72	18.62	19.19	17.96	18.07	18.12	18.53	0.4972	1.56	18.32
IS(2-CHLOROISOPROPYL)ETH	18.34	19.37	19.70	19.09	19.04	19.22	19.30	0.4183	1.31	19.15
-METHYLPHENOL	17.35	17.85	18.22	17.82	18.01	18.22	17.77	0.3013	0.95	17.89
-NITROSO-DI-N-PROPYLAMIN	16.04	16.67	16.99	16.30	16.12	15.95	16.58	0.3809	1.20	16.38
EXACHLOROETHANE	13.12	14.21	14.00	14.12	14.51	15.33	15.11	0.7384	2.32	14.34
APHTHALENE-d8	40.00	40.00	40.00	40.00	40.00	40.00	40.00	0.0000	0.00	40.00
ITROBENZENE	17.45	17.78	18.72	17.74	18.51	18.15	18.24	0.4523	1.42	18.08
SOPHORONE	18.32	18.58	19.53	18.69	18.72	18.51	18.50	0.3924	1.23	18.69
ITROBENZENE-d5	17.43	17.79	18.47	17.87	18.13	18.13	17.57	0.3588	1.13	17.91
-NITROPHENOL	19.06	19.34	20.20	19.34	19.80	19.81	18.92	0.4577	1.44	19.50
,4-DIMETHYLPHENOL	14.99	16.14	17.09	15.92	16.09	16.83	15.08	0.7932	2.49	16.02
ENZOIC ACID	2.27	1.53	2.56	2.22	2.24	3.25	2.01	0.5257	1.65	2.30
IS(2-CHLOROETHOXY)METHAN	17.51	17.71	18.56	18.20	18.52	18.14	18.03	0.3883	1.22	18.10
,4-DICHLOROPHENOL	19.06	19.76	20.61	19.57	19.85	20.20	19.20	0.5421	1.70	19.75
,2,4-TRICHLOROBENZENE	17.98	18.67	19.04	19.08	19.06	19.39	18.68	0.4551	1.43	18.84
APHTHALENE	18.28	18.58	19.24	19.02	19.14	19.14	18.95	0.3498	1.10	18.91
-CHLOROANILINE	18.84	19.05	19.94	19.36	20.08	18.84	19.37	0.4986	1.57	19.35
HEXACHLOROBUTADIENE	17.84	18.61	19.02	18.82	19.03	19.13	18.55	0.4434	1.39	18.71
-CHLORO-3-METHYLPHENOL	19.72	19.89	20.63	20.60	20.77	20.43	19.81	0.4420	1.39	20.26
2-METHYLNAPHTHALENE	18.90	19.03	20.61	19.42	20.34	20.10	19.66	0.6536	2.05	19.72
ACENAPHTHENE-d10	40.00	40.00	40.00	40.00	40.00	40.00	40.00	0.0000	0.00	40.00
,4,6-TRIBROMOPHENOL	23.41	24.01	24.16	24.45	24.54	24.61	23.46	0.4955	1.56	24.09
2-FLUOROBIPHENYL	19.85	20.54	20.95	20.79	21.30	20.67	20.59	0.4445	1.40	20.67
HEXACHLOROCYCLOPENTADIENE	4.54	5.89	6.55	6.87	6.14	7.69	7.59	1.0862	3.41	6.47
,4,6-TRICHLOROPHENOL	20.83	21.61	21.29	20.98	22.17	21.08	20.30	0.5950	1.87	21.18
,4,5-TRICHLOROPHENOL	20.21	20.69	19.74	20.19	21.39	20.65	20.22	0.5264	1.65	20.44
2-CHLORONAPHTHALENE	19.87	20.49	20.84	20.04	20.91	21.37	20.44	0.5200	1.63	20.57
2-NITROANILINE	19.45	19.53	20.38	19.95	20.51	19.96	20.20	0.4025	1.26	20.00
DIMETHYLPHTHALATE	19.78	20.32	20.60	20.16	20.91	21.00	20.76	0.4401	1.38	20.50
ACENAPHTHYLENE	20.01	20.64	21.38	20.57	21.49	21.05	20.20	0.5669	1.78	20.76
3-NITROANILINE	19.54	19.91	20.63	19.80	20.96	20.65	19.75	0.5543	1.74	20.18
ACENAPHTHENE	19.19	19.54	20.51	19.78	20.55	20.20	19.67	0.5136	1.61	19.92
,4-DINITROPHENOL	8.00	8.34	8.95	10.14	10.53	8.97	9.50	0.9163	2.88	9.20
4-NITROPHENOL	17.56	17.90	17.98	17.88	16.97	17.75	17.49	0.3489	1.10	17.65
DIBENZOFURAN	18.76	19.33	19.81	18.84	19.58	19.70	19.19	0.4109	1.29	19.32
,6-DINITROTOLUENE	20.79	22.17	21.87	22.05	21.44	21.15	20.96	0.5492	1.72	21.49
,4-DINITROTOLUENE	19.62	19.56	19.89	20.02	20.31	19.97	19.90	0.2521	0.79	19.90

SEMI-VOLATILE ORGANIC COMPOUNDS - HMS 3-93
METHOD 625 - continued

ETHYLPHTHALATE	18.98	19.20	19.68	18.98	19.93	19.65	19.30	0.3705	1.16	19.39
-CHLOROPHENYL-PHENYLETHE	19.22	19.73	20.34	20.18	20.56	20.10	20.11	0.4391	1.38	20.03
LUORENE	19.36	19.88	20.14	19.75	20.95	20.21	19.31	0.5636	1.77	19.94
-NITROANILINE	20.42	20.48	21.03	19.63	20.68	20.37	20.61	0.4272	1.34	20.46
HENANTHRENE-d10	40.00	40.00	40.00	40.00	40.00	40.00	40.00	0.0000	0.00	40.00
,6-DINITRO-2-METHYLPHENO	12.42	13.37	14.08	15.17	14.93	13.89	14.98	1.0004	3.14	14.12
-NITROSODIPHENYLAMINE	20.63	21.21	22.06	21.27	21.95	22.04	21.50	0.5320	1.67	21.52
ZOBENZENE	22.56	22.99	22.85	22.69	23.64	23.12	22.84	0.3531	1.11	22.96
-BROMOPHENYL-PHENYLETHER	22.48	22.50	22.81	23.12	23.32	24.19	22.74	0.5991	1.88	23.02
EXACHLOROBENZENE	21.95	21.59	23.20	22.60	22.94	23.01	22.40	0.5901	1.85	22.53
ENTACHLOROPHENOL	22.33	22.38	22.58	23.31	22.09	21.51	21.83	0.5765	1.81	22.29
HENANTHRENE	19.87	20.58	20.87	20.56	21.15	21.03	20.58	0.4219	1.32	20.66
NTHRACENE	19.47	20.10	20.62	20.73	20.88	20.65	20.48	0.4846	1.52	20.42
I-N-BUTYLPHTHALATE	20.45	20.55	21.40	20.65	21.49	21.42	21.00	0.4479	1.41	20.99
LUORANTHENE	20.58	20.33	21.00	21.14	21.15	21.12	20.91	0.3176	1.00	20.89
ENZIDINE	27.22	13.21	38.79	23.90	25.33	20.32	25.90	7.7256	24.26	24.95
HRYSENE-d12	40.00	40.00	40.00	40.00	40.00	40.00	40.00	0.0000	0.00	40.00
ERPHENYL-d14	21.87	23.00	22.75	23.26	22.95	23.39	23.50	0.5478	1.72	22.96
YRENE	20.39	21.12	21.48	21.67	21.39	21.29	21.99	0.5011	1.57	21.33
UTYLBENZYLPHTHALATE	20.85	22.24	22.33	22.49	22.19	22.41	22.34	0.5695	1.79	22.12
,3'-DICHLOROBENZIDINE	25.53	26.45	27.46	27.46	26.78	27.88	27.37	0.8006	2.51	26.99
ENZO(A)ANTHRACENE	20.32	21.67	21.61	22.03	21.91	21.66	22.00	0.5899	1.85	21.60
IS(2-ETHYLHEXYL)PHTHALAT	20.07	20.93	20.84	21.06	20.93	21.04	20.97	0.3450	1.08	20.83
HRYSENE	19.58	20.54	20.84	20.59	20.86	21.21	21.32	0.5747	1.80	20.71
ERYLENE-d12	40.00	40.00	40.00	40.00	40.00	40.00	40.00	0.0000	0.00	40.00
DI-N-OCTYLPHTHALATE	21.58	21.57	21.78	22.08	22.22	22.16	21.98	0.2689	0.84	21.91
BENZO(B)FLUORANTHENE	21.24	19.27	18.31	19.57	22.04	21.35	19.06	1.4070	4.42	20.12
BENZO(K)FLUORANTHENE	19.00	21.57	24.56	22.93	20.85	21.27	23.09	1.8060	5.67	21.90
BENZO(A)PYRENE	19.92	19.44	20.19	20.31	20.33	20.36	20.38	0.3444	1.08	20.13
INDENO(1,2,3-CD)PYRENE	19.49	19.40	19.61	19.50	19.71	19.15	19.13	0.2193	0.69	19.43
DIBENZ(A,H)ANTHRACENE	20.30	19.94	20.10	20.12	20.33	20.10	19.73	0.2061	0.65	20.09
BENZO(G,H,I)PERYLENE	18.40	17.93	18.49	18.23	18.36	17.86	17.75	0.2947	0.93	18.15

PACE, INC.

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
EDB/DBCP METHOD 504
1/93

DATA FILES:
(1) G1L09065
(2) G1L09066
(3) G1L09067
(4) G1L09068
(5) G1L09069
(6) G1L09070
(7) G1L09071

COMPOUND	(1) CONC. ug/L	(2) CONC. ug/L	(3) CONC. ug/L	(4) CONC. ug/L	(5) CONC. ug/L	(6) CONC. ug/L	(7) CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
EDB	0.0456	0.0497	0.0402	0.0504	0.0474	0.0414	0.0470	0.0039	0.0122	0.0460
DBCP	0.0455	0.0539	0.0411	0.0502	0.0460	0.0391	0.0453	0.0050	0.0158	0.0459

PPEDB.

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
HERBICIDES DRINKING WATER METHOD 515
4/93

DATA FILES:
(1) G19G03728
(2) G19G03729
(3) G19G03730
(4) G19G03731
(5) G19G03732
(6) G19G03733
(7) G19G03734

COMPOUND	(1) CONC. ug/L	(2) CONC. ug/L	(3) CONC. ug/L	(4) CONC. ug/L	(5) CONC. ug/L	(6) CONC. ug/L	(7) CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
DALAPON	17.5508	17.9803	18.2884	16.7459	17.7101	16.5626	18.7284	0.7845	2.4634	17.652
DICAMBA	1.7808	1.8749	1.7673	1.6548	1.8381	1.6053	1.9399	0.1185	0.3722	1.780
DICHLOROPROP	6.0012	5.7705	5.5396	5.2617	5.2633	4.8595	6.0395	0.4344	1.3640	5.534
2,4-D	3.7465	3.5679	3.4506	3.3916	3.4014	3.1470	3.7603	0.2166	0.6801	3.495
PENTACHLOROPHENOL	1.9613	1.9323	1.8461	1.7117	1.6745	1.5690	2.8515	0.4282	1.3446	1.935
SILVEX	1.8515	1.8300	1.7402	1.6985	1.7467	1.5767	1.8882	0.1062	0.3334	1.762
2,4,5-T	2.1140	1.9021	2.0930	1.8860	1.9280	1.9112	2.1726	0.1205	0.3783	2.001
DINOSEB	2.1146	2.2287	2.3386	1.9298	2.1952	1.9165	2.3982	0.1866	0.5860	2.160
2,4'-DB	14.5637	13.3385	13.0567	11.0684	9.1685	9.1924	14.5307	2.3285	7.3116	12.131
BENTOZON	3.8099	3.8792	3.3789	3.1300	3.1672	3.2863	3.5825	0.3013	0.9459	3.462
PICLORAM	1.8877	2.0006	1.9292	1.7277	1.9509	1.7889	2.1868	0.1493	0.4689	1.925

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
PESTICIDES/PCBS METHOD 608
1/93

DATA FILES:
* GC11
(1) G1L09755
(2) G1L09756
(3) G1L09757
(4) G1L09759
(5) G1L09760
(6) G1L09761
(7) G1L09762

COMPOUND	(1) CONC. ug/L	(2) CONC. ug/L	(3) CONC. ug/L	(4) CONC. ug/L	(5) CONC. ug/L	(6) CONC. ug/L	(7) CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
ALPHA-BHC	0.0442	0.0461	0.0467	0.0453	0.0431	0.0486	0.0436	0.0019	0.0061	0.0454
GAMMA-BHC	0.0467	0.0482	0.0507	0.0485	0.0461	0.0513	0.0467	0.0020	0.0064	0.0483
BETA-BHC	0.0494	0.0529	0.0525	0.0512	0.0501	0.0541	0.0499	0.0018	0.0055	0.0514
HEPTACHLOR	0.0501	0.0526	0.0527	0.0528	0.0507	0.0555	0.0497	0.0020	0.0063	0.0520
DELTA-BHC	0.0400	0.0417	0.0600	0.0419	0.0391	0.0433	0.0403	0.0073	0.0229	0.0438
ALDRIN	0.0489	0.0515	0.0508	0.0511	0.0496	0.0543	0.0496	0.0018	0.0056	0.0508
HEPTACHLOR EPOXIDE	0.0521	0.0560	0.0554	0.0559	0.0535	0.0580	0.0530	0.0021	0.0065	0.0548
GAMMA-CHLORDANE	0.0508	0.0522	0.0563	0.0551	0.0519	0.0573	0.0509	0.0027	0.0084	0.0535
4,4'-DDE	0.1111	0.1182	0.1119	0.1187	0.1112	0.1205	0.1123	0.0041	0.0129	0.1148
DIELDRIN	0.1027	0.1102	0.1061	0.1110	0.1037	0.1131	0.1054	0.0040	0.0125	0.1075
ENDRIN	0.0998	0.1050	0.0937	0.0986	0.0882	0.0981	0.1010	0.0054	0.0170	0.0978
4,4'-DDD	0.0865	0.0917	0.1032	0.0901	0.0847	0.0890	0.0840	0.0065	0.0204	0.0899
ENDOSULFAN II	0.1031	0.1110	0.1124	0.1113	0.1043	0.1123	0.1058	0.0040	0.0127	0.1086
4,4'-DDT	0.0872	0.0919	0.1162	0.0921	0.0825	0.0913	0.0861	0.0111	0.0347	0.0925
ENDRIN ALDEHYDE	0.0997	0.1122	0.1177	0.1102	0.1058	0.1174	0.1086	0.0064	0.0200	0.1102
ENDOSULFAN SULFATE	0.0914	0.0967	0.1382	0.0961	0.0895	0.0971	0.0898	0.0172	0.0541	0.0998
METHOXYCHLOR	0.5046	0.5444	0.6096	0.5422	0.4932	0.5314	0.5101	0.0387	0.1216	0.5336
ENDRIN KETONE	0.0960	0.1063	0.1256	0.1102	0.1066	0.1110	0.0996	0.0095	0.0299	0.1079
ENDOSULFAN I *	0.0473	0.0494	0.0497	0.0491	0.0464	0.0510	0.0468	0.0017	0.0054	0.0485
ALPHA-CHLORDANE *	0.0481	0.0513	0.0526	0.0512	0.0482	0.0527	0.0489	0.0020	0.0063	0.0504

PPGC01A

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
PESTICIDES/PCBS METHOD 608
1/93

DATA FILES:
(1) G1608011
(2) G1608012
(3) G1608013
(4) G1608014
(5) G1608016
(6) G1608017
(7) G1608018

COMPOUND	(1) CONC. ug/L	(2) CONC. ug/L	(3) CONC. ug/L	(4) CONC. ug/L	(5) CONC. ug/L	(6) CONC. ug/L	(7) CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
CHLORDANE	1.130	1.140	1.020	1.090	1.020	1.090	0.986	0.0596	0.1872	1.0680
TOXAPHENE	1.080	1.100	0.942	0.825	0.965	0.985	0.918	0.0946	0.2970	0.9736

PPGC16A.WQ1

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
PCB'S - METHOD 608
1/93

DATA FILES:

A	B	C	D	E
(1) G19M03378	(1) G19M03353	(1) G19M03367	(1) G19M03344	(1) G19M03333
(2) G19M03379	(2) G19M03354	(2) G19M03368	(2) G19M03345	(2) G19M03334
(3) G19M03380	(3) G19M03355	(3) G19M03369	(3) G19M03346	(3) G19M03335
(4) G19M03381	(4) G19M03356	(4) G19M03370	(4) G19M03347	(4) G19M03336
(5) G19M03383	(5) G19M03357	(5) G19M03372	(5) G19M03348	(5) G19M03337
(6) G19M03384	(6) G19M03358	(6) G19M03373	(6) G19M03349	(6) G19M03339
(7) G19M03385	(7) G19M03359	(7) G19M03374	(7) G19M03350	(7) G19M03340

COMPOUND	CONC. ug/L	CONC. ug/L	CONC. ug/L	CONC. ug/L	CONC. ug/L	CONC. ug/L	CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
A =	(1)	(2)	(3)	(4)	(5)	(6)	(7)			
AROCLOR 1016	1.160	1.140	1.210	1.250	1.180	1.240	1.140	0.0456	0.1432	1.1886
AROCLOR 1260	1.090	1.050	1.090	1.130	1.090	1.090	1.050	0.0276	0.0867	1.0843
B =	(1)	(2)	(3)	(4)	(5)	(6)	(7)			
AROCLOR 1232	1.220	0.980	1.240	0.820	1.010	0.780	1.200	0.1908	0.5990	1.0357
C =	(1)	(2)	(3)	(4)	(5)	(6)	(7)			
AROCLOR 1242	1.058	1.047	1.068	1.014	1.056	1.047	0.952	0.0400	0.1255	1.0344
D =	(1)	(2)	(3)	(4)	(5)	(6)	(7)			
AROCLOR 1248	1.100	1.100	1.160	1.090	1.110	1.160	1.210	0.0446	0.1401	1.1329
E =	(1)	(2)	(3)	(4)	(5)	(6)	(7)			
AROCLOR 1221	1.290	1.120	1.070	1.240	1.340	1.320	1.560	0.1607	0.5046	1.2771
AROCLOR 1254	0.890	0.890	0.830	0.970	1.080	1.140	1.290	0.1648	0.5175	1.0129

PCBGC19A.WQ1

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
AROCLOR 1232
6/93
METHOD 608

COMPOUND	SP2765 CONC. ug/L	SP2766 CONC. ug/L	SP2767 CONC. ug/L	SP2768 CONC. ug/L	SP2769 CONC. ug/L	SP2770 CONC. ug/L	SP2771 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
AROCLOR 1232	1.28	1.18	1.53	1.42	1.28	1.16	1.28	0.13	0.41	1.30

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
AROCLOR 1254 IN SOIL
MEDIUM SOLID EXTRACTION
4/93

DATA FILES:
(1) G10M09278
(2) G10M09279
(3) G10M09280
(4) G10M09281
(5) G10M09282
(6) G10M09283
(7) G10M09284

COMPOUND	(1) CONC. ug/g	(2) CONC. ug/g	(3) CONC. ug/g	(4) CONC. ug/g	(5) CONC. ug/g	(6) CONC. ug/g	(7) CONC. ug/g	STD DEV	X 3.14 MDL ug/g	MEAN
ARCLOR 1254	1.97	1.99	1.95	1.99	2.02	1.99	1.92	0.0326	0.1023	1.9757

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
AROCLOR 1254 IN OIL
4/93

DATA FILES:
(1) G6M13337
(2) G6M13338
(3) G6M13339
(4) G6M13340
(5) G6M13341
(6) G6M13342
(7) G6M13344

COMPOUND	(1) CONC. ug/g	(2) CONC. ug/g	(3) CONC. ug/g	(4) CONC. ug/g	(5) CONC. ug/g	(6) CONC. ug/g	(7) CONC. ug/g	STD DEV	X 3.14 MDL ug/g	MEAN
AROCLOR 1254	8.43	8.24	9.24	8.21	8.78	9.26	8.99	0.4493	1.4109	8.7357

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
PESTICIDES/PCBS METHOD 8140
1/93

DATA FILES:
(1) G9G13004
(2) G9G13005
(3) G9G13006
(4) G9G13007
(5) G9G13008
(6) G9G13009
(7) G9G13010

COMPOUND	(1) CONC. ug/L	(2) CONC. ug/L	(3) CONC. ug/L	(4) CONC. ug/L	(5) CONC. ug/L	(6) CONC. ug/L	(7) CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
DICHLORVOS	6.0347	4.7354	5.1758	4.7671	4.9145	4.2948	4.8825	0.5383	1.6903	4.9721
MEVINPHOS	2.6326	2.0288	2.3125	2.1218	2.3538	1.9704	2.1659	0.2265	0.7112	2.2265
ETHOPROP	3.1840	2.5656	2.7250	2.5710	2.7339	2.4029	2.5847	0.2483	0.7795	2.6810
NALED/PHORATE	1.3494	0.8469	1.7460	1.8062	1.4885	0.3882	1.0601	0.5104	1.6025	1.2408
DIAZINON/DEMETON	2.9056	2.3340	2.4283	2.1035	2.4510	2.0723	2.1813	0.2862	0.8987	2.3537
DISULFOTON	0.0818	0.0424	0.7947	1.0371	0.2464	0.0397	0.0554	0.4137	1.2990	0.3282
RONNEL	2.8964	2.4158	2.4236	2.3013	2.4035	2.1624	2.2469	0.2368	0.7436	2.4071
CHLORPYRIFOS/MERPHOS	5.8751	4.7718	4.9066	4.5194	4.6372	4.2605	4.5424	0.5211	1.6364	4.7876
METHYL PARATHION	2.8997	2.3657	2.3988	2.2600	2.3037	2.1135	2.2136	0.2543	0.7985	2.3650
TRICHLORONATE	2.9725	2.4194	2.4812	2.2494	2.3366	2.1568	2.3134	0.2664	0.8364	2.4185
FENTHION	1.3654	0.7726	1.9272	1.9540	1.5344	0.0645	1.1046	0.6712	2.1075	1.2461
TOKUTHION	2.7336	2.1692	2.2445	2.2262	2.2025	1.9579	2.0855	0.2426	0.7618	2.2313
STIROPHOS	2.9153	2.3701	2.4395	2.2319	2.3832	2.1048	2.2728	0.2578	0.8096	2.3882
BOLSTAR	1.2552	0.7169	1.8870	1.9283	1.5098	0.1015	0.9913	0.6564	2.0610	1.1986
FENSULFOTHION	2.9933	2.4949	2.3760	2.1600	2.4053	2.1341	2.2741	0.2903	0.9115	2.4054
AZINPHOSMETHYL	2.7963	2.2596	2.3083	2.1705	2.3095	2.0364	2.1009	0.2490	0.7818	2.2831
COUMAPHOS	2.9304	2.4110	2.4313	2.2163	0.0726	2.0463	2.1998	0.9139	2.8695	2.0440

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
HERBICIDES METHOD 8150
3/93

DATA FILES:
(1) G19G03707
(2) G19G03708
(3) G19G03709
(4) G19G03710
(5) G19G03711
(6) G19G03712
(7) G19G03713

COMPOUND	(1) CONC. ug/L	(2) CONC. ug/L	(3) CONC. ug/L	(4) CONC. ug/L	(5) CONC. ug/L	(6) CONC. ug/L	(7) CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
DIAPON	1.847	1.635	1.596	1.740	1.492	1.910	2.362	0.2879	0.9041	1.797
DICAMBA	2.174	2.032	2.196	2.282	2.285	2.132	2.107	0.0921	0.2892	2.172
MCPA	72.900	89.100	93.800	92.100	93.700	89.900	80.100	7.9101	24.8376	87.371
DICHLOROPROP/MCPP	195.132	186.224	191.310	192.531	200.517	173.562	177.919	9.5924	30.1203	188.171
2,4-D	1.973	1.838	1.964	2.053	2.057	1.900	1.840	0.0911	0.2862	1.947
SILVEX	1.936	1.757	1.894	1.975	1.965	1.856	1.813	0.0811	0.2546	1.885
2,4,5-T	2.274	2.087	2.481	2.480	2.640	2.239	2.345	0.1845	0.5792	2.363
DINOSEB	1.422	0.909	0.846	1.057	1.327	1.017	0.820	0.2348	0.7372	1.057
2,4'-DB	2.021	1.932	1.969	2.063	2.025	1.824	2.035	0.0819	0.2570	1.981

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOL ORGANICS WET LAB PARAMETERS
MARCH 1993

TEST	METHOD	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	STD DEV	MDL ug/L	MEAN	SPIKE LEVEL
									=====	====	====	====
OIL AND GREASE WATER	GRAV	7.3	7.900	7.4	7.300	8.9	8.4	8.9	0.7221	2.267	8.014	
OIL AND GREASE WATER	IR	2.36	2.46	2.55	2.34	2.11	2.50	2.50	0.1502	0.47	2.40	
PHC WATER	IR	2.34	2.16	2.36	2.19	2.28	2.29	2.40	0.0880	0.28	2.29	
PHENOL WATERS	SPEC	10.40	7.53	7.18	6.82	7.18	7.53	5.39	1.5000	4.71	7.43	

JDC 5/24/93

PACE, INC.

METHOD 531.1
CARBAMATE PESTICIDES
DETECTION LIMIT STUDY

INSTRUMENT: LC5
COLUMN: NOVAPAK C18

(ALL CONCENTRATIONS ARE IN UG/L)

COMPOUND	REP1	REP2	REP3	REP4	REP5	REP6	REP7	s	D.L.	AVG	TRUE CONC	RPD
LDICARBSULFOX	3.02	2.76	3.26	2.84	3.17	3.42	3.66	0.32	1.00	3.16	3.0	5.33
LDICARBSULFAN	2.94	2.78	2.96	2.68	2.90	3.24	3.54	0.29	0.92	3.01	3.0	0.19
OXAMYL	2.75	2.64	3.25	2.81	3.13	3.12	3.20	0.24	0.77	2.98	3.0	-0.48
METHOMYL	2.88	2.61	3.08	2.74	3.02	3.16	3.31	0.24	0.77	2.97	3.0	-0.93
3-HYDROXYC	3.04	2.53	3.14	2.63	3.19	3.09	3.63	0.37	1.15	3.04	3.0	1.19
MEXACARB	2.86	2.45	3.00	2.42	2.97	3.07	4.27	0.62	1.93	3.00	3.0	-0.19
AZINYGON	3.01	2.55	3.22	2.68	2.98	2.98	3.65	0.36	1.13	3.01	3.0	0.33
CARBOFURAN	2.55	1.99	2.69	2.51	2.62	3.02	3.32	0.42	1.32	2.71	3.0	-9.52
CARBARYL	4.13	3.45	3.06	2.84	3.17	3.15	3.55	0.42	1.33	3.34	3.0	11.19
DIMETHOCARB	2.84	2.62	2.83	2.39	3.14	2.90	3.78	0.44	1.39	2.93	3.0	-2.38
DEMETON-O	2.62	3.98	2.91	2.19	3.31	3.12	3.87	0.64	2.02	3.14	3.0	4.76

SAMPLE	DATE	FILE
DEM 2306	5/21/93	L5C01652
DEM 2307	5/21/93	L5C10653
DEM 2308	5/21/93	L5C10654
DEM 2309	5/21/93	L5C01655
DEM 2310	5/21/93	L5C01656
DEM 2311	5/21/93	L5C01657
DEM 2313	5/21/93	L5C01660

9.0 DATA REDUCTION, VALIDATION AND REPORTING

All analytical data generated within the PACE NE Laboratories undergo a well-defined, well-documented multi-tier review process before being reported to the client.

9.1 Data Reduction

When primary analytical data, otherwise known as "raw data", are manually generated, the data are recorded either in bound Logbooks with prenumbered pages or on preprinted forms. Entries are made in black ink and are initialled and dated by the individual who makes the entry. It is acceptable to initial and date once for an entire page. Errors are corrected by drawing a single line through the entry; this change is initialled and dated by the individual who makes the change. The reason for the change is indicated either by description or by error code (see Figure 9-1). Raw data may not be obscured in any way. The use of white-out is prohibited on all raw data, including instrumental hardcopy.

The analyst who completes the analysis assembles all relevant raw data and results together with chromatograms, strip chart recordings, instrument settings and other information essential to data interpretation. For data which are reduced by manual calculations, the calculations are documented in a laboratory notebook or on an analyst's worksheet. The results are transferred to a standard laboratory reporting form which has been approved by the Group Supervisor and Lab Manager. Reporting forms include at a minimum the sample identification number, the date analyzed, the result expressed per unit volume, the method reference and the analyst's initials.

9.2 Data Validation

The analyst initiates the data validation process by reviewing and accepting the data. The completed data package is then sent to the Group Supervisor. The Group Supervisor provides a technical assessment of the data package and technical review for accuracy according to methods employed and laboratory protocols. Group Supervisors also review analyst generated calculations.

For data which are reduced via computer, calculations are checked by the analyst (or designee) assigned to this task at a frequency designed to assure that the data manipulations are valid. This data validation step is documented by the analysts' initials on the hardcopy of the raw data. The results are either manually transferred to a standard reporting form or reported via computer generation of forms.

The Group Supervisor submits the validated data package, including the reporting forms and the appropriate laboratory control sheets, to the Laboratory Manager who reviews the package for QC requirements and completeness. If any errors are discovered, the entire package shall be returned to the Group Supervisor for full reworking.

When accepted, the Laboratory Manager assembles the data with other data from the sample set, drafts any narrative comments if required by the Quality Assurance Project Plan, and forwards the report and the data package to the Reporting Department.

The Reporting Department assembles and types the final report, checks for transcription errors, and provides the final report to the Laboratory Manager/Technical Director for final signature.

The Laboratory Manger/Technical Director examines the report for method appropriateness, detection limits and whether or not QC criteria were satisfied. Any deviations from the referenced methods are checked for documentation and validity, and QC corrective actions are reviewed for successful resolution. The Laboratory Manager/Technical Director signs the completed reports prior to their release.

The Laboratory Manager/Technical Director may delegate the final review and signing of reports to the Regional Director, as necessary.

9.3 Data Report

All data segments pertaining to a particular PACE NE Laboratory Number are channeled to the Reporting Department for assembly into the final report format and generation of the analytical narrative. All points mentioned during technical and QC review are included in the narrative if it is deemed to impact the quality of the data.

The final report is given to the Laboratory Manager/Technical Director for final review and release. After verifying the report's completeness and accuracy, the Technical Director signs the cover letter indicating acceptance of the report.

The standard commercial report to the client consists of the following sections:

1) the narrative
2) sample results
3) Chain-of-Custody forms

The narrative briefly describes the condition of the samples upon receipt, sample holding time performance, instrument calibration information, and the quality control results. Any discrepancies discovered and matrix problems are also addressed in this section.

The sample results are tabulated. PACE NE number, client identification, and data analyzed are presented along with the observed concentrations for each parameter analyzed and detection limits.

9.4 Data Archive

Each data report which supports the analytical process for all samples received by the laboratory is thoroughly reviewed for completeness and accuracy. After the technical review it is routed to the Reporting Department for assembling the final report for submission to the client. The report is approved, signed, and submitted.

One copy of the report remains with all the raw data which is stored in the data archives under the control of the QA Department.

The Data Archivist has oversight responsibility for the data archive ensuring the continued integrity of all documentation generated in support of laboratory analyses.

The archive room is a secure storage area with limited access to non-authorized personnel. Sign-out procedures are in place where every document removed from the archive room must be electronically signed out by a member of the QA Department.

A copy of the report is forwarded to the Hazardous Waste Manager for use in characterizing the samples for ultimate disposal.

TABLE 9-1.

Error Codes

1 (or E1)	Misspelled
2 (or E2)	Mathematical Error
3 (or E3)	Wrong Entry
4 (or E4)	Transposition or Sequencing Error
5 (or E5)	Transcription Change (copy error)
6 (or E6)	Procedural Change
7 (or E7)	Wrong Conclusion
8 (or E8)	Illegible Entry
9 (or E9)	Unnecessary Entry
10 (or E10)	Footnoted Explanation
11 (or E11)	Additional Comment
12 (or E12)	Instrumentation Error/Failure

10.0 RECORDS MANAGEMENT

Records are the means by which an organization documents its operations and activities. They are an integral part of the Quality Assurance program since they provide documented evidence for program functionality and necessary information for performance evaluation and quality assurance audits.

10.1 Standard Operating Procedures

Standard Operating Procedures (SOPs) are written for specific procedures or operations. Complex tasks of inspection, testing, calibration, monitoring, maintenance, data handling, and quality control as well as methods utilized in the laboratory are specified and documented by SOPs.

As a minimum requirement, each SOP must include a title, the purpose or applicability, list of materials or references, and detailed procedures. SOPs are updated when necessary. Each has an PACE NE reference number and revision data at the upper right corner of each page. More detailed information regarding SOPs can be found in Section 12.

All personnel are required to follow these documents when a specific operation or method is being utilized. It is the responsibility of the supervisor to make sure that employees are aware of and follow the SOPs. Any suggestions for additional SOPs or changes to existing SOPs can be directed to the QA Department.

10.2 Sample Tracking

Samples are tracked from the time they are received, through storage, preparation, analysis, and final disposition.

Proper sample identification must be established during sample collection. This information must be clearly and permanently written on a label and attached to the sample. In addition, a Chain-of-Custody must be initiated with the appropriate information recorded. Samples should also be properly preserved and stored.

Sample Management Personnel verifies the samples' integrity as they are unpacked. The PACE NE Project Manager and/or the Client are notified of samples that are broken or have not been properly stored or preserved. The sample identification label must also be checked against Chain-of-Custody identification. Any discrepancies must be verified

by the Client or sampler. All these checks and any discrepancies or changes must be documented on the Sample Receiving documentation.

The Sample Management Personnel assign each sample a sequential laboratory identification number, which is written on the sample container and recorded onto the Chain-of-Custody. Samples are properly stored in their respective storage refrigerators.

Upon receipt the Sample Management Personnel also initiates an Internal Custody Record for the sample set. This sheet is used to document sample removal from and return to sample storage. The final disposition of a sample is documented on the hazardous waste disposal spreadsheet and on the internal sample custody record.

10.2.1 Chain-of-Custody

The Chain-of-Custody Form traces the possession of a sample from the time the sample is obtained in the field through analysis in the laboratory. To initiate a Chain-of-Custody, the field sampler must fill in the appropriate information: Client or Project Name, Signature of Sampler, Sample Identification, Date and Time Sampled, Type of Sample, and Analysis Requested. After the sample is brought into the laboratory, sample breakage, preservation, and identification are checked. Any inconsistencies are noted in the sample management documentation. For samples accepted into the laboratory, the Sample Management Personnel record the assigned lab sample number for each sample onto the Chain-of-Custody form, signs in the space marked "Received for Laboratory" and records the date and time received.

10.2.2 Internal Sample Custody Record

The Internal Custody Record is created at the time of sample receipt and is a mechanism for tracking samples from sample management to sample preparation and back. When laboratory personnel remove samples from sample storage, it is recorded on the Internal Custody Record. Upon returning any remaining sample, the individual records the date in the "Returned By" box for the appropriate sample. The original Internal Custody Record is archived by the QA department.

10.3 Standards

Standards preparation is documented at PACE NE in a Standards Logbook maintained by each laboratory. These logbooks are where the preparer records all information

needed to maintain proper traceability. More complete information regarding standards is provided in Section 7.1.

10.4 Maintenance Logbooks

Maintenance Logbooks are kept for each instrument. Each logbook is unique to its instrument. In the logbook, an analyst records initial instrument setup, routine preventive maintenance, and instrumental malfunctions, dates taken in and out of service, and resolutions. Instrument logs not only describe the instrument's history, but can be helpful when troubleshooting.

10.5 Data Report/Raw Data Package

A Data Report contains the results of analyses as presented to the Client. There is a narrative describing the general condition of the samples and an overview of the analyses. For more information see Section 9.3.

The Raw Data Package contains information needed to reconstruct how the analysis of a batch of samples including QA/QC results data were derived. Information such as inorganic or organic preparation, chromatograms or strip chart recording, and regression analysis data are usually included.

11.0 QUALITY CONTROL

A quality control program is a systematic process that controls the validity of analytical results by measuring the accuracy and precision of each method and matrix, developing expected control limits, using these limits to detect errors or out-of-control events, and requiring corrective action techniques to prevent or minimize the recurrence of these events. When laboratory established control limits are less stringent than method control limits, the method control limits are used to detect errors or out-of-control events.

11.1 Accuracy and Precision Measurements

The results of quality control samples created in the laboratory represent estimates of accuracy and precision for the preparation and analysis steps of sample handling. This section describes the quality control information provided by each of these analytical measurements. Information on the procedures to follow in preparation of the samples or spiking solutions is described for each method and matrix in the respective method Standard Operating Procedure.

Method Blank

A method blank is a volume of deionized, distilled laboratory water for water samples, or a purified solid matrix for soil/sediment samples, carried through the entire analytical procedure. The volume or weight of the blank must be approximately equal to the sample volume or weight processed. A method blank is performed with each batch of samples or one with every 20 field samples whichever is more frequent. Analysis of the blank verifies that method interferences caused by contaminants in solvents, reagents, glassware, and other sample processing hardware are known and minimized. Optimally, a method blank should contain no greater than five times (5X) the method detection limit for common laboratory solvents and phthalate esters; less than the detection limit for all other parameters unless otherwise specified in the method or project QA plan. Results of method blank analyses are maintained with other QC data in the respective laboratories. If requested by the client, this data will be included in the report.

Accuracy Measurements

Laboratory Control Samples (LCS), consist of aliquots of ideal matrices (water, sand, etc.) spiked with analytes of interest. LCS's for methods with extensive lists of analytes that may interfere with one another may include a limited number of

analytes, but the analytes included must be representative of as many analytes as is practical. In the case of metals analysis, all analytes of interest must be included. Laboratory pure water is used to prepare most LCS's for methods for analysis of water. Highly characterized solids, where available, are used for LCS's for methods for analysis of solids. Where no such solid LCS is available, spiked laboratory pure water or spiked reagent blanks may be substituted. LCS's provide an estimate of bias based on recovery of the compounds from a clean, control matrix. They provide evidence that the laboratory is performing the method within accepted guidelines without potential non-matrix interferences. They are prepared in duplicate at a rate of one set per twenty samples or one set per 14 days whichever is more frequent.

For tests that are performed infrequently, an LCS and its duplicate shall be analyzed at least monthly if the number of samples is less than 20. This monthly requirement shall NOT apply to low-volume tests for which state certification is not sought, or for tests expected to be performed solely as part of a special project, or for tests involving study specific matrices other than water, soil, sludges and oils.

Matrix Spikes/Matrix Spike Duplicates are similar to the Laboratory Control Sample except the analytes used for spiking are added to a second and third separate aliquot from the same container of a selected few client samples in a batch of analyses. When prepared and analyzed, MS/MSD's can also provide a measure of overall precision. They incorporate sample matrix effects and field conditions. MS/MSD's are routinely prepared at a frequency of 10% when adequate sample volume is provided.

Surrogates provide an estimate of bias based on recovery of similar compounds, but not the compounds analyzed, for each sample, incorporating sample matrix effects and field conditions. Surrogates are added to all samples analyzed by GC/MS and certain GC analyses prior to sample preparation.

An **Internal standard** is an analyte that has the same characteristics as the surrogate, but is added to each sample in a batch, just prior to analysis and is used for quantitation. It corrects for bias or change in instrument performance from sample to sample, incorporating matrix effects associated with the analysis process only.

Precision Measurements

A **Laboratory duplicate** is a laboratory control sample that has been homogenized and split into two equal portions before the method sample preparation process. It measures method precision associated with the preparation through analysis and is

prepared and analyzed at a rate of one per batch or one per twenty samples whichever is greater.

A **Sample duplicate** is a sample that has been homogenized and split into two equal portions before the method sample preparation process. It measures sample precision associated with the preparation through analysis and is prepared and analyzed at a rate of one per batch or one per twenty samples whichever is greater in the inorganic laboratories. For organic analyses the MS/MSD fills this function.

11.2 Control Charts

Control charts are quality control tools which graphically display the QC parameters over time. Accuracy (Figure 11-1) control charts are maintained for each method and matrix. Each chart can be broken into three parts: sample identification, sample response/calculation, and graphic representation (the plot).

11.2.1 Accuracy

For certain analytical programs (NEESA, AFCEE), accuracy charts are maintained for Surrogate and Laboratory Control Sample recovery. Each sample is identified by its PACE NE sample number. The true value (three-significant-figure expected value based on the amount spiked) is denoted as SR. This amount is fixed for each method and matrix to be approximately five to ten times the MDL. The experimental value (three-significant-figure observed value) is denoted by SA and varies for each sample based on the recovery of the amount spiked. From these two values the percent recovery (%R) is calculated as:

$$\%R = (SR / SA) * 100$$

except for the matrix spike sample where the concentration present in the original sample aliquot must also be factored in. For matrix spike samples, the percent recovery is calculated as:

$$(SSR-SR)/SA \times 100$$

where: **SSR** is the spiked sample recovery
SR is the original sample recovery
SA is the amount of spike added

The percent recovery is plotted onto the graph where:

- the x-axis is the number of data points per page; and
- the y-axis is the range of percent recoveries.

11.2.2 Limits

Both upper and lower warning limits and upper and lower control limits are established to aid in interpreting a suspicious or an out-of-control event. Warning limits express a narrower confidence interval and are used to warn the analyst or supervisor of possible system inconsistencies or failures, before an out-of-control event occurs. Control limits express the outer limits of accepted method variability. Control limits and warning limits are updated at least yearly.

Warning Limits

When not mandated by the method, PACE NE adopts warning limits to be the mean ± 2 standard deviations or a 95% confidence interval.

Control Limits

Unless otherwise specified by the analytical method in use or by the project QA plan, PACE NE uses the 99% confidence interval as the control limits, which is defined as the mean ± 3 standard deviations. Where interlaboratory expected ranges have been determined, PACE NE's goal is for their control limits to fall within these multi-laboratory expected ranges for that method. When this does not happen, the method multi-laboratory expected ranges are used.

Both warning and control limits are determined and published at the end of each year for each method and matrix based on the cumulative historic performance. However, a running mean and standard deviation may be calculated with each addition of 20 new data points to demonstrate short term variability and is available to those interested.

Suspicious/Out-of-Control Events

Plotting and connecting successive data points on control charts enables the laboratory to detect many types of suspicious and out-of-control situations. An event is considered suspicious if it falls within the control limits but is statistically out-of-control. Suspicious and out-of-control events can be caught by monitoring the following: outliers (suspicious and out-of-control), runs (suspicious), trends (suspicious), and periodicity (suspicious). Both suspicious and out-of-control events require investigation and corrective action by the laboratory.

Outliers

There are two types of outliers: any particular point that falls outside the control limits or three consecutive points that fall outside the warning limits. A point that falls outside the control limits is classified as an out-of-control event; three points that falls outside the warning limits is classified as a suspicious event.

Runs

A run is defined as a series of points that line up on one side of the central line (the mean). Any run that has a length of eight points is indicative of a potential abnormality in the process, a suspicious event. A run can suggest several potential problems such as a leak in the system, elevated contamination, or incorrect dilutions of standards. When a run is detected investigation and corrective action will be initiated.

Trends

A trend is defined as a series of points that are marked by an unbroken rise or fall. Any trend with a length of five points is classified as a suspicious event. A trend may indicate a change in instrument sensitivity due to a dirty source or injection port or standard degradation, to name a few.

Periodicity

Periodicity is a term used to describe a recurring pattern of change over equal intervals. This occurrence may be of any length or amplitude; thus, careful observation of the control chart is necessary.

11.3 Corrective Action

Procedural changes, insufficient analyst training, an improperly prepared stock solution, or a new standard supplier are some of the things that may lead to a trend being observed. Investigation will be initiated immediately when a trend is observed. A record of the investigation and return to control will be documented on a corrective action report. The reason behind a trend may not be readily discernable and investigation may continue over a period of time. If the quality control data falls with in the 99% confidence limits, data may be reported while investigation continues. If data falls outside the 99% confidence interval, analysis must stop until the system is brought back into control.

11.4 Utilization of Quality Control Data

The purpose for preparing and analyzing quality control samples is to demonstrate, through the known entities, how accurate and precise the investigative sample data are. Tables 11-1 and 11-2 summarize the quality control assessment criteria by matrix for the most commonly used methods by this laboratory. Different criteria may be dictated by different methods or by project QA plans.

TABLE 11-1
TYPICAL QUALITY CONTROL CRITERIA FOR ORGANIC ANALYSES

Parameter	Type	Frequency	Compounds	Performance Criteria	
WATER					
Volatiles (OLMO1.8)	Method blank	1/20 or 1/batch	—	± D.L.	
	System Monitoring Compounds	every sample	$D_4$1,2-dichloroethane	76 to 114%	
			BFB	86 to 115%	
			D_8-toluene	88 to 110%	
				Recovery	RPD
	Matrix Spike/ Matrix Spike Duplicate Sample	1/20 or 1/batch	Benzene	76 to 127%	11
			1,1-dichloroethene	61 to 145%	14
			Trichloroethene	71 to 120%	14
			Chlorobenzene	75 to 130%	13
			Toluene	76 to 125%	13
	Calibration check	every 12 hours		≤ 25% difference from min. RRFs for the majority of target analytes	
Base/neutral Acid compounds (OLMO1.8)	Method blank	1/20 or 1/batch	—	± D.L.	
	Surrogate spike	every sample	D_5 -phenol	10 to 110%	
			2-fluorophenol	21 to 110%	
			2,4,6-tribromophenol	10 to 123%	
			D_5-nitrobenzene	35 to 114%	
			2-fluorobiphenyl	43 to 116%	
			D_{14}-terphenyl	33 to 141%	
			2-chlorophenol-d4 (advisory)	33 to 110%	
			1,2-dichlorobenzene-d4 (")	16 to 110%	
				Recovery	RPD
	Matrix Spike Matrix Spike Duplicate	1/20 or 1/batch	Phenol	12 to 110%	42
			2-chlorophenol	27 to 123%	40
			1,4-dichlorobenzene	36 to 97%	28
			N-nitrosodipropylamine	41 to 116%	38
			1,2,4-trichlorobenzene	39 to 98%	28
			4-chloro-3-methylphenol	23 to 97%	42
			Acenaphthene	46 to 118%	31
			2,4-dinitrotoluene	24 to 96%	38
			4-nitrophenol	10 to 80%	50
			Pentachlorophenol	9 to 103%	50
			Pyrene	26 to 127%	31
	Calibration check	every 12 hours		≤25% difference from min. RRFs for majority of target analytes	

TABLE 11-1 (Continued)

Parameter	Type	Frequency	Compounds	Performance Criteria	
Pesticides & Aroclors (OLMO1.8)	Method blank	1/20 or 1/batch	—	± D.L.	
	Instrument Blank	every 12 hours			
	Surrogate spike	every sample	TCX (advisory)	60 to 150%	
			DCB (advisory)	60 to 150%	
				Recovery	RPD
	Matrix Spike	1/20 or 1/batch	Lindane	56 to 123%	15
	Matrix Spike Duplicate		Heptachlor	40 to 131%	20
	LCS		Aldrin	40 to 120%	22
			Dieldrin	52 to 126%	18
			Endrin	56 to 121%	21
			4,4-DDT	38 to 127%	27
			Arochlor 1254	27 to 122%	
	Calibration check	every 12 hours		PEMs - ≤25 %D ≤20% breakdown	
Pesticides & Aroclors (method 8080)	Method blank	1/20 or 1/batch	—	± D.L.	
	Surrogate spike	every sample	Dibutyl chlorendate	24 to 154%	
				Recovery	RPD
	Laboratory Control Sample, MS/MSD	1/20 or 1/batch	Lindane	56 to 123%	15
			Heptachlor	40 to 131%	20
			Aldrin	40 to 120%	22
			Dieldrin	52 to 126%	18
			Endrin	56 to 121%	21
			4,4-DDT	38 to 127%	27
	Calibration check	every 10 samples		≤ 15% difference	
SOIL					
Volatiles (OLMO1.8)	Method blank	1/20 or 1/batch	—	± D.L.	
	System monitoring compound spike recovery	every sample	$D_4$1,2-dichloroethane	70 to 121%	
			BFB	59 to 113%	
			D_8-toluene	84 to 138%	
				Recovery	RPD
	Matrix Spike Matrix spike duplicate Sample	1/20 or 1/batch	Benzene	66 to 142%	21
			1,1-dichloroethene	59 to 172%	22
			Trichloroethene	62 to 137%	24
			Chlorobenzene	60 to 133%	21
			Toluene	59 to 139%	21
	Calibration check	every 12 hours		≤ 25% difference from min. RRFs for the majority of target analytes	

TABLE 11-1 (Continued)

Parameter	Type	Frequency	Compounds	Performance Criteria	
Base/Neutral Acid compounds (OLMO1.8)	Method blank	1/20 or 1/batch	—	± D.L.	
	Surrogate spike	every sample	D_5 -phenol	24 to 113%	
			2-fluorophenol	25 to 121%	
			2,4,6-tribromophenol	19 to 122%	
			D_5-nitrobenzene	23 to 120%	
			2-fluorobiphenyl	30 to 115%	
			D_{14}-terphenyl	18 to 137%	
			2-chlorophenol-d4 (advisory)	20 to 130%	
			1,2-dichlorobenzene (*)	20 to 130%	
				Recovery	RPD
	Matrix Spike Matrix Spike Duplicate Sample	1/20 or 1/batch	Phenol	26 to 90%	35
			2-chlorophenol	25 to 102%	50
			1,4-dichlorobenzene	28 to 104%	27
			N-nitrosodipropylamine	41 to 126%	38
			1,2,4-trichlorobenzene	38 to 107%	23
			4-chloro-3-methylphenol	26 to 103%	33
			Acenaphthene	31 to 137%	19
			2,4-dinitrotoluene	28 to 89%	47
			4-nitrophenol	11 to 114%	50
			Pentachlorophenol	17 to 109%	47
			Pyrene	35 to 142%	36
	Calibration check	every 12 hours		≤25% difference from min. RRFs for the majority of target analytes	
Pesticides & Aroclors (OLMO1.8)	Method blank	1/20 or 1/batch	—	± D.L.	
	Instrument Blank	every 12 hours			
	Surrogate spike	every sample	TCX (advisory)	60 to 150%	18 to 150%
			DCB (advisory)	60 to 150 %	
				Recovery	RPD
	Matrix Spike Matrix Spike Duplicate LCS	1/20 or 1/batch	Lindane	46 to 127%	50
			Heptachlor	35 to 130%	31
			Aldrin	34 to 132%	43
			Dieldrin	31 to 134%	38
			Endrin	42 to 139%	45
			4,4-DDT	23 to 134%	50
			Arochlor 1254	21 to 128%	
	Calibration check	every 12 hours	INDs - ≤25 %D	PEMs - ≤25 %D; ≤20% breakdown	
Pesticides & PCBs (method 8080)	Method blank	1/20 or 1/batch	—	± D.L.	
	Surrogate spike	every sample	Dibutyl chlorendate	18 to 150%	
				Recovery	RPD
	Laboratory Control Sample, MS/MSD	1/20 or 1/batch	Lindane	46 to 127%	50
			Heptachlor	35 to 130%	31
			Aldrin	34 to 132%	43
			Dieldrin	31 to 134%	38
			Endrin	42 to 139%	45
			4,4-DDT	23 to 134%	50
	Calibration check	every 10 samples		≤ 15% difference	

TABLE 11-2
TYPICAL QUALITY CONTROL CRITERIA FOR INORGANICS ANALYSES

Soil and Water

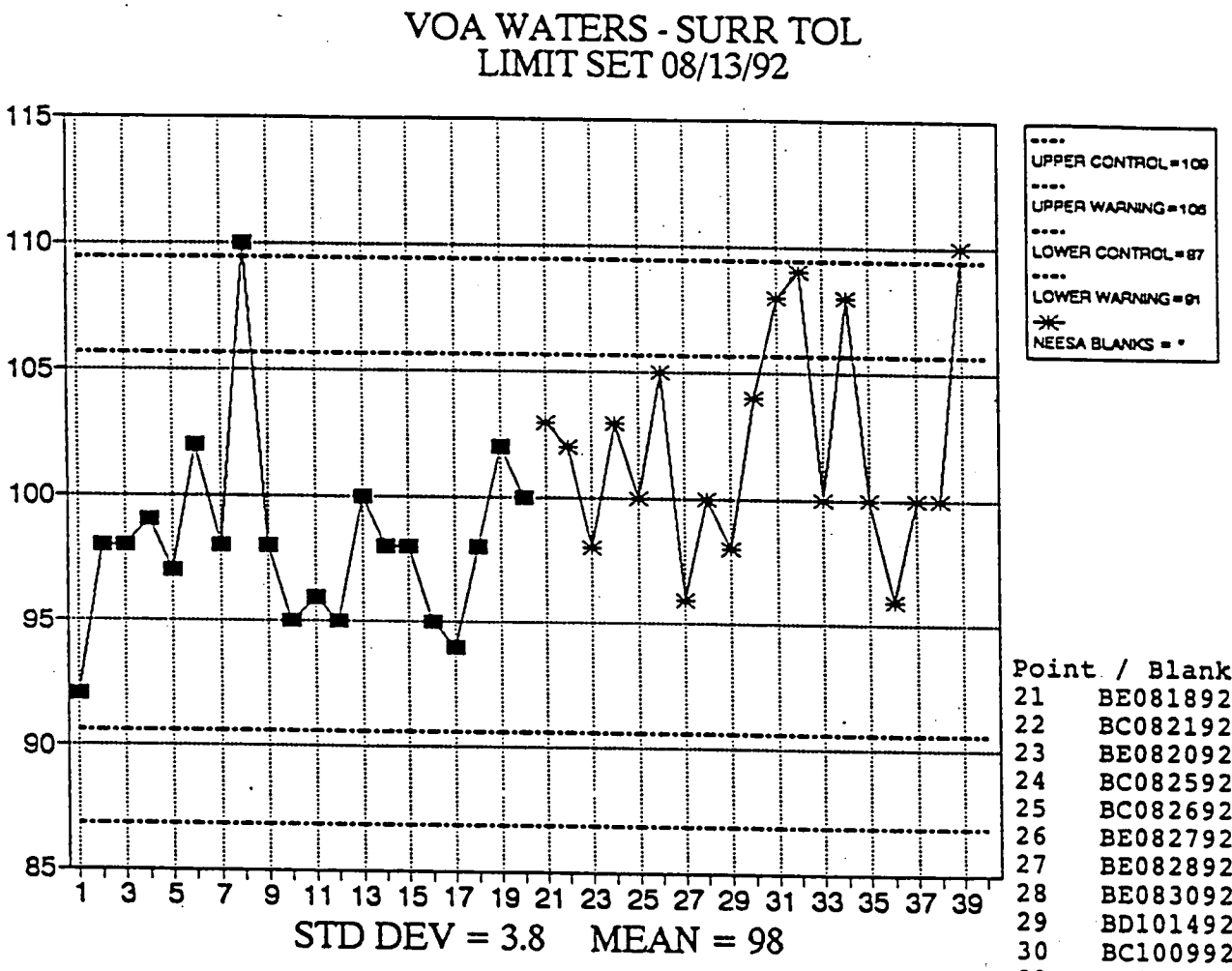
Parameter	Type	Frequency	Performance Criteria
Metals by ICP (Method 6010)	Calibration Blank	every calibration	± D.L.
	Calibration verification	every calibration	90 to 110%
	Continuing calibration	1/10 samples	90 to 110%
	Method blank	1/20 or 1/batch	± D.L.
	Laboratory Control Sample/LSC dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± D.L. or 20% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%
Metals by Furnace AA (7000 series methods)	Calibration blank	every calibration	± D.L.
	Calibration verification	every calibration	90 to 110%
	Continuing calibration	1/10 samples	90 to 110%
	Method blank	1/20 or 1/batch	± D.L.
	Laboratory Control Sample/LCS dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± D.L. or 20% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%
	Duplicate injections	every sample and standard	± 20% RPD
Cold Vapor AA (Mercury)	Calibration blank	every calibration	± D.L.
	Calibration verification	every calibration	80 to 120%
	Continuing calibration	1/10 samples	80 to 120%
	Method blank	1/20 or 1/batch	± D.L.
	Lab control sample/LCS Dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± D.L. or 20% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%
Total Petroleum Hydrocarbons	Calibration blank	every calibration	± D.L.
	Calibration verification	every calibration	85 to 115%
	Continuing calibration	1/10 samples	85 to 115%
	Method blank	1/20 or 1/batch	± D.L.
	Lab control sample	1/20 or 1/batch	75 to 125%
	Sample duplicate	1/20 or 1/batch	± 30% RPD
Total Cyanide	Calibration blank	every calibration	± D.L.
	Calibration verification	every calibration	85 to 115%
	Continuing calibration	1/10 samples	85 to 115%
	Method blank	1/20 or 1/batch	± D.L.
	Laboratory Control Sample/LCS dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± 30% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%
General Wet Chemistries	Calibration blank	every calibration	± D.L.
	Calibration verification	every calibration	85 to 115%
	Continuing calibration	1/10 samples	85 to 115%
	Method blank	1/20 or 1/batch	± D.L.
	Laboratory Control Sample/LCS dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± 30% RPD
	Matrix Spike	1/20 ro 1/batch	75 to 125%

TABLE 11-2 (cont.)
TYPICAL QUALITY CONTROL CRITERIA FOR INORGANICS ANALYSES

Soil and Water

Parameter	Type	Frequency	Performance Criteria
Metals by ICP (ILMO3.0)	Calibration Blank	1/10 samples	< CRDL
	Calibration verification	every calibration	90 to 110%
	Continuing calibration	1/10 samples	90 to 110%
	Method blank	1/20 or 1/batch	< CRDL
	Laboratory Control Sample/LSC dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± D.L. or 20% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%
Metals by Furnace AA (ILMO3.0)	Calibration blank	1/10 samples	< CRDL
	Calibration verification	every calibration	90 to 110%
	Continuing calibration	1/10 samples	90 to 110%
	Method blank	1/20 or 1/batch	< CRDL
	Laboratory Control Sample/LCS dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± D.L. or 20% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%
	Duplicate injections	every sample and standard	± 20% RPD
Cold Vapor AA (Mercury ILMO3.0)	Calibration blank	1/10 samples	< CRDL
	Calibration verification	every calibration	80 to 120%
	Continuing calibration	1/10 samples	80 to 120%
	Method blank	1/20 or 1/batch	< CRDL
	Lab control sample/LCS Dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± D.L. or 20% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%
Total Cyanide (ILMO3.0)	Calibration blank	every calibration	± D.L.
	Calibration verification	every calibration	85 to 115%
	Continuing calibration	1/10 samples	85 to 115%
	Method blank	1/20 or 1/batch	± D.L.
	Laboratory Control Sample/LCS dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± 20% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%

Figure 11-1
Examples of Accuracy Control Chart



Point	/ Blank
21	BE081892A
22	BC082192A
23	BE082092A
24	BC082592A
25	BC082692A
26	BE082792A
27	BE082892B
28	BE083092A
29	BD101492A
30	BC100992A
31	BC110692A
32	BC111992A
33	BE112092A
34	BC112392A
35	BG113092B
36	BG120192A
37	BC122292A
38	BG013093B
39	BC012193A

12.0 STANDARD OPERATING PROCEDURES

12.1 Purpose and General Provisions

Standard Operating Procedures (SOPs) are formal, revision-controlled documents that:

1) define, to PACE NE's clients and to regulatory agencies, the methods used by PACE NE in the performance of tasks having an effect on the quality of data, findings or conclusions;

2) establish the basis for similar training of personnel and set a standard for assessment;

3) provide standard methods for execution and documentation of work, to maximize consistency, uniformity and reliability of products; and

4) facilitate coordination among individuals performing separate, but interdependent tasks.

SOPs describe standard methodologies that may at times be inappropriate for a specific project. In such cases, exceptions to the SOPs are stated in an SOP Deviation Form, with rationale. The SOP Deviation form is kept as part of the data package archived at PACE NE.

12.2 Responsibilities

The Laboratory Section Managers are responsible for determining, through consultation with the Quality Assurance Officer and PACE NE Management, the activities that require SOPs, and for working with the appropriate technical personnel to develop the SOPs.

The Quality Assurance Department is responsible for obtaining technical review and approval of SOPs, for maintaining control of new SOPs and revisions, and for maintaining an up-to-date distribution list for SOPs.

PACE NE personnel are responsible for performing tasks in accordance with applicable SOPs, except as explicitly directed by the relevant Quality Assurance Project Plan, contract, or Health and Safety policy. PACE NE personnel are also responsible for assisting in designing accurate and practical SOPs and in keeping the SOPs up-to-date.

Technical reviewers of SOPs are responsible for providing review of drafts sent to them within the schedule indicated in the request.

12.3 Minimum Contents of SOPs

Each Standard Operating Procedure shall contain at a minimum, the following information:

Title - The name of the concerned task

SOP Number - The internal document control number assigned and tracked by the QA Department

Acceptance - The signature of the originator(s), Quality Assurance Officer and appropriate operations management authority to officially adopt the procedure

Date - date of issue of most recent revision

Section 1.0 - Purpose and Applicability - An explanation of the objectives of the procedure, typical applications and limitations

Section 2.0 - Definitions - A listing of any terms, expressions, or acronyms found in the procedure

Section 3.0 - Applicable Documents/References - A listing of pertinent, supporting procedure or reference documents such as methods, manuals and/or SOPs

Section 4.0 - Apparatus and Materials - A complete list of the equipment, apparatus, reagents, etc. needed for the procedure

Section 5.0 - Method/Procedure - A clear description of the task on a step-by-step basis. The method description should be written clearly enough, and in sufficient detail, to ensure that any two persons performing the procedure will achieve equivalent results, and to provide clients and reviewing agencies with a thorough understanding of the procedure. Acceptable and equivalent alternatives should be addressed whenever possible, and described in the same detail

Section 6.0 - Quality Control Requirements and Acceptance Criteria - An outline of quality control requirements, including procedures frequency requirements and acceptance criteria. Acceptance criteria may take the form of an illustration such as a

chart of acceptable results with tolerances, or other appropriate forms

Section 7.0 - Calculations, Data Management and Reporting of Results - A summary of the automated and manual calculations performed as well as reporting requirements, including data flow charts as appropriate

Section 8.0 Corrective Actions - A description of what must be done, when and by whom in instances when the QC requirements are not met

Section 9.0 Responsibilities - Identification of the individuals (by title or organizational position) who are responsible for performing and facilitating the tasks governed by the SOP

Section 10.0 Health and Safety Considerations - A discussion of specific Health and Safety issues that must be considered prior to and during the performance of the procedure described.

12.4 SOP Development and Approval

Laboratory SOPs are developed by the laboratory's technical staff, working with the QA Department (PACE NE SOP QA-553 Preparation of SOP's). The QA Department will also assist by assigning SOP numbers and by coordinating word processing, review and approval. Laboratory SOPs must be reviewed and approved by the management of the laboratory operations to which the SOPs apply. Thus, the following people must review and approve each laboratory SOP:

- the Supervisor of the specific operation to which the SOP pertains if applicable) or the Laboratory Manager - This signature indicates that the written SOP reflects the current practice in the laboratory.
- the Laboratory Technical Director - This signature indicates that the SOP is technically adequate to handle the analysis of environmental samples expected to be received at PACE NE and technically compliant within the framework given in Section 8.0 and with any known exceptions noted.
- the Quality Assurance Officer - This signature indicates that the SOP has been reviewed for compliance with the referenced methods and that desrepencies between the method and practice have been resolved.
- the PACE NE Regional Director - This signature signifies a management review and approval of the practices detailed in the SOP.

12.5 Numbering

Each SOP is assigned a unique PACE NE number from the Inventory of PACE NE SOPs, maintained by the QA Department. Each laboratory section has been assigned a block of numbers.

12.6 Revisions

SOP revisions may be necessitated by regulatory requirements, technological advancements or other causes, but not by the requirements of a single project alone. Contradictions between standard procedures and the requirements of a specific project are resolved in the quality assurance plan for that project and are controlled internally through the generation of an SOP Deviation Form (Figure 12-1).

Revisions may be proposed initially by the Quality Assurance Department or they may be recommended by users. Recommendations for revisions must be sent to the Quality Assurance Department.

Technical changes to an SOP need to be made immediately, but revisions must not be made by an individual to only his/her personal copy. If there are changes to an SOP, they need the approval of the Group Supervisor, Lab Manager and QA and must be made manually to ALL copies of that SOP in use in the lab. A formal revision should be initiated ASAP. Recommendations for minor revisions will be accumulated by QA until sufficient to warrant a document revision.

Revisions are accomplished by the preparation of a new typed draft with the changes incorporated and listed on the cover page. (The cover page is a permanent document and stays with the SOP despite revisions.) Approval of the revisions is signified by dated acceptance signatures adjacent to the listed revisions in the lower section of the cover page. The QA Officer is authorized to approve minor revisions. Revisions which effect the technical approach or content will also require review and approval of a technical or section manager. Once formally accepted, the revised document replaces the previous version and is distributed to controlled copy holders with instructions as to what document(s) it replaces.

Occasionally, revisions are significant enough to warrant a complete rewrite. In such cases, the changes are not listed on the cover page. Instead the words "complete rewrite" are entered and the new document must undergo review and approval as for a new SOP. The judgement as to whether a complete rewrite is required shall be made by the Quality Assurance Officer.

Technical revisions and complete rewrites will necessitate training recertification for all personnel involved. The laboratory or section manager is responsible for ensuring that training is accomplished and documented. Required training documentation and instructions will be distributed with the SOPs by the QA Department.

12.7 Distribution

The QA Department distributes SOPs to technical staff and maintains distribution lists to ensure that revisions and new SOPs are distributed to all responsible individuals. The QA Department maintains a complete set of up-to-date SOPs and distributes them as required. An SOP archive is maintained by QA Department and SOPs are distributed from that archive.

12.8 SOP Archive

An archive of all PACE NE SOPs, in the form of both hard-copy and electronic masters of current revisions, are maintained by the Quality Assurance Department. The hard-copy archive also contains a hard-copy master of all obsolete versions of each revised SOP.

Access to originals is obtained through QA personnel.

Figure 12-1
SOP Deviation Form
(Revision 1, 1/93)

SOP Number and Title:_____

Date and Signature_____

Lab Number/Job/or Client deviation applies to:

_____
_____
_____

Describe deviation in detail, including normal procedure and reason for deviation:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Approval/Date

_____Date_____
Technical Director

_____Date_____
Quality Assurance Officer

_____Date_____
Regional Director

13.0 PERFORMANCE AND SYSTEM AUDITS

PACE NE's Analytical Chemistry Laboratory participates in a variety of interlaboratory tests and intralaboratory and performance checks to provide periodic assessment of the effectiveness of the overall quality control program.

13.1 Interlaboratory Performance Surveys

Performance surveys conducted by the EPA and the New Hampshire Department of Environmental Services constitute the bulk of interlaboratory comparisons.

- EPA Performance Evaluations - Water Supply - Semiannual (April and September)
  - Trace Metals
  - Nitrate/Nitrite/Fluoride
  - Insecticides
  - Herbicides
  - PAH's
  - Adipate/Phthalates
  - Trihalomethanes (THMs)
  - Volatile Organic Compounds
  - Residual Free Chlorine
  - Turbidity
  - Total Filterable Residue
  - Calcium (as $CaCO_3$)
  - pH
  - Alkalinity
  - Corrosivity
  - Sodium
  - Sulfate
  - Total Cyanide
- EPA Performance Evaluations - Water Pollution - Semiannual (February and August)
  - Trace Metals
  - Minerals
  - Nutrients

- Demand
- PCB's
- PCB's in Oil
- Pesticides
- Volatile Halocarbons
- Volatile Aromatics
- Total Cyanide
- Non-Filterable Residue
- Oil and Grease
- Total Phenolics

PACE NE's performance is evaluated by the respective agency after each round of testing, and reported to the Laboratory Technical Director. The Laboratory Technical Director forwards the results to the QA Auditor in charge of certifications. The QA Auditor distributes copies of the results to section managers and the QA Officer.

In addition to the EPA WP/WS performance evaluation studies, PACE NE participates in a number of different state, federal and commercial studies such as the State of New York, US Navy NEESA, US Army COE, USEPA CLP Quarterly Blind samples, US EPA DMR PE studies, and Chemical Waste Management round robin studies.

13.2 Periodic Internal Audits

Internal auditing is conducted by the QA Auditors. These audits occur at least every month, and typically focus on either performance relative to an SOP or a specific project. Internal audits take two forms - performance audits and systems audits. Performance audits involve submittal of blind spikes to the laboratory by the Quality Assurance Department for assessment of analytical accuracy. Systems audits consist of a thorough review of procedures and documentation to confirm that work was performed in accordance with this Manual, SOPs, and/or project QA Plan and that adequate documentation exists to satisfy the project requirements.

13.2.1 Performance Audits

<u>Audit Standards</u>

As required on specific projects, the Quality Assurance Department provides spikes for analysis as independent check samples (audit standards). The QA Department prepares any audit standards that can be prepared readily from relatively non-hazardous, pure materials or certified concentrated standards. In

some cases, preparation of reliable audit standards requires special facilities and equipment due to the hazardous nature of the materials and/or the requirement for precise measurement of minute quantities. In such cases, audit standards are obtained from the USEPA, Environmental Monitoring and Support Laboratory (EMSL), Cincinnati, Ohio, or from an equivalent source. The nature of the audit standards and the frequency of performance audits are specified in the Quality Assurance Plan of each project for which performance auditing is required. When practical, audit standards are provided in matrices resembling real project sample matrices, and undergo the full sample preparation and analysis procedure. However in many cases this is impractical, and it is necessary to submit audit samples as extracts, for analysis only. All measurable constituents in the audit standards should be within the expected range of concentrations to be encountered in the real samples (or in the extracts).

13.2.2 Systems Audits

There are two different types of laboratory systems audits. Systems audits of laboratory operations are performed at a minimum frequency of once every month. Systems audits address general laboratory operations and conformance to the Laboratory Quality Assurance Manual. Some project quality assurance plans require project-specific laboratory systems audits (Project Audits).

Systems Audit Procedures

The systems audits are performed by the Quality Assurance Auditors. Audit checklists are used to ensure that all salient points are addressed and documented. The checklists are filled out legibly and reproduceably, in ink, by the auditor, and are signed and dated by the auditor when completed. The audit checklist is based on EPA laboratory evaluation criteria, the provisions of the Laboratory Quality Assurance Manual and PACE NE SOPs. Project audit checklists are drawn from the applicable QAPPs, as well as relevant provisions of the QA Manual.

Audit checklists will cover at least the following areas:

- Systems Audit
  - Personnel qualifications and training records
  - Adequacy of laboratory facilities, including work space, lighting, ventilation, and supplies
  - Maintenance and calibration recordkeeping for analytical

equipment
- Safety (facility configuration and practices)
- General operations, including glassware cleaning, inventory and checking of reagents and standards, and storage procedures
- Recordkeeping, including sample log-in and tracking, traceability of standards, control charts, and raw data recording and tracking.

- Project Audit

  - Sample log-in and chain-of-custody records
  - Sample storage procedures and records
  - Sample preparation and analysis procedures
  - Method validation (where applicable)
  - Conformance to QAPP
  - Control charts
  - Precision and accuracy assessment
  - Method blanks, reagent blanks, duplicates, check samples, fortifications, surrogates, etc.
  - Calibration
  - Data packages
  - Analyst qualifications
  - Data validation and reporting

13.3 QA Reporting and Corrective Action

Each systems audit is immediately followed by a debriefing, in which the auditor discusses his/her findings with the laboratory representatives. The debriefing serves a two-fold purpose. First, laboratory management is afforded an early summary of findings, which allows them to begin formulating corrective strategies, and second, the auditor has a chance to test preliminary conclusions and to correct any misconceptions before drafting his report.

The systems audit report (which may or may not contain performance audit findings) is issued to the Laboratory Manager and appropriate supervisors and personnel for corrective action. These responses are forwarded, in writing, to the auditor. The auditor then circulates the report to the QA Officer, laboratory management and to company management.

Results of interlaboratory performance surveys and in-house audits, along with unresolved corrective action items are summarized in a monthly report from the Quality Assurance Officer to the PACE NE Regional Director.

14.0 PREVENTIVE MAINTENANCE

To minimize downtime and interruption of analytical work, preventive maintenance is routinely performed on each analytical instrument. Designated laboratory personnel are trained in routine maintenance procedures for all major instrumentation. When repairs are necessary, they are performed by either trained staff or instrument manufacturer service personnel.

SOPs are written for each instrument that cover basic operation and maintenance procedures (QA-800, Use, Calibration, and Maintenance of Equipment - Inorganics Lab, QA-801, Use, Calibration, and Maintenance of Equipment - Organics Lab). Detailed logbooks documenting preventive maintenance, non-routine maintenance and repairs are also maintained for each instrument. The following are brief summaries of maintenance for each major instrument.

14.1 Preventive Maintenance - GC/MS

Regularly performed maintenance includes, but is not limited to the following for GC/MS instrumentation:

- hard tune with calibration gas (PFTBA)
- removal of 2-3 inches from the injection end of the capillary columns
- replacement of 2-3 inches of column packing from the injection end of packed columns
- injection port liner replacement
- replace injection port septum
- clean ion source as needed
- check vacuum pump oil level
- check carrier gas tanks
- replace or recondition vent traps

14.2 Preventive Maintenance - GC

Regularly performed maintenance includes, but is not limited to the following for GC instrumentation:

- replacement of 2-3 inches from the injection end of the capillary columns
- removal of 2-3 inches of column packing from the injection end of packed columns
- injection port liner replacement
- replace septum
- check carrier and support gases
- NRC wipe test ECD

14.3 Preventive Maintenance - ICP

- check liquid argon tank level
- change pump tubing
- clean nebulizer and spray chamber as needed
- replace and realign plasma torch when required
- check cooling system water level
- empty waste reservoir when full

14.4 Preventive Maintenance - AA Graphite Furnace

- check and align source lamps
- clean and inspect graphite tube, replacing when surface appears excessively burnt or cracked

  clean and inspect contact ring, replacing when excessively worn

- clean mirrors for optical sensor and sample compartment windows
- check autosampler injector alignment and deposition

14.5 Preventive Maintenance - Mercury Analyzer

- Check and align source lamp
- remove and clean sample cell and connecting tubes
- check sparger for proper operation
- clean sample compartment windows

14.6 Preventive Maintenance - General Laboratory Areas

- clean and calibrate balances biannually
- check balance calibration each day of use
- clean balance pan prior to each use
- calibrate class "S" weights every two years
- calibrate automatic pipets and burets monthly
- calibrate thermometers yearly against an NBS traceable thermometer
- record refrigerator, freezer, and oven temperatures each weekday
- clean, check, calibrate to manufacturers specifications all pH, DO, conductivity and, turbidity meters, and spectrophotometers biannually
- general housekeeping: keep counter tops, hoods, and floors clean
- check airflow in hoods once a week

15.0 CORRECTIVE ACTION

When errors, deficiencies, unusual occurrences, or out-of control situations exist, the QA program provides systematic procedures, called "corrective actions", to resolve problems and restore proper functioning to the analytical system. Within PACE NE, a distinction is made between "out-of-control events" and "unusual occurrences" for the purposes of requiring corrective actions.

An out-of-control event is any event which is beyond the acceptance limits established for laboratory operation by PACE NE SOP's, EPA methods, or client specific contracts or protocols. This can be due to data which are outside of the accepted bounds for accuracy and/or precision, method contamination, improper instrument calibration or maintenance, or deviations from the contract or SOP detected by a QA audit.

An unusual occurrence is a situation in which the analytical system is, strictly speaking, compliant with the protocol or SOP and therefore in control but an atypical or undesirable incident has occurred which warrants further investigation. Such an occurrence could be a holding blank which is contaminated or differences in the pattern of non-spiked target compounds between a spiked and unspiked aliquot of a sample used as the matrix spike.

Both out-of-control events and unusual occurrences are noted on a PACE NE Corrective Action Report (Figure 15-1). A corrective action report must be generated whenever either type of event is noted.

15.1 Out-of Control Events

Out-of-control events associated with the statistical analysis and review of data are straight forward to identify. The analyst generating the data is responsible for checking the results against the established limits. Any deviations are immediately addressed. If data are outside accepted limits, the analyst immediately notifies the responsible section supervisor. If the situation is not corrected so that an out-of-control condition occurs, or is expected to, the section supervisor shall notify the Laboratory Manager and the Quality Assurance Officer. The Laboratory Manager and Section Supervisors are responsible for identifying the source of the problem and initiating corrective action. Completion of corrective action should be evidenced by the return of data to prescribed acceptable limits.

Events which do not readily cause an immediate obvious effect on data quality are more difficult to identify. Such events could be samples stored at an incorrect temperature or held beyond prescribed holding times, or improper maintenance of records. Everyone in the laboratory is

responsible for reporting "system" problems. Analysts should report out-of-control events to their supervisor, the Section Supervisors, who should in turn **report** to the Laboratory Manager. Corrective action is again the responsibility of the Laboratory Manager and the Section Supervisors. They shall review and approve the action taken.

If an out-of-control event does occur during analysis, for instance an LCS recovery falls outside the expected range, the analyst must describe on the corrective action report the event, the investigative and corrective actions taken, the cause of the event, and notify the QA Officer. In some cases, investigation of an out-of-control event will reveal no problems. In such cases, only the event and the investigative action is recorded.

The investigative action taken is somewhat dependent on the analysis and the event. However, listed below is a progression of steps which may be taken to find the cause of an out-of-control event:

- Check calculations to ensure there are no errors
- Check standard and spiking solutions for degradation or contamination
- Check instrument performance

If the problem is with the standards or instrument performance, the analyst must recalibrate or retune the instrument before reanalyzing the sample extracts affected. If the out-of-control condition is still not remediated, the samples may require reextraction and reanalysis or data qualification.

It is occasionally necessary to qualify data when the accompanying quality control data are not within established performance criteria. The qualifying of data alert the data end user to the fact that the analysis was, to some degree, flawed and that the precision and accuracy of the data produced may not fulfill the data quality objectives (DQOs) for that particular project. Based on the project DQOs, analytical data with qualifiers may not be appropriate for the intended use.

15.1.1 Volatile Organic Analyses

<u>Method Blanks</u>

If target compounds are detected in the method blank above the detection limit (above 5 times the detection limit for methylene chloride, acetone, toluene, and 2-butanone) the corrective action consists of checking the calculations, reanalyzing the blank, qualifying the associated sample data, and investigating the source of the problem to implement corrective action for the future. When target list compounds are detected in a method blank, the following condition applies:

- When any target compound is detected in a method blank above the action levels listed earlier, but not in associated samples, then no qualifier is applied.

Surrogates

The % recovery of the surrogates is calculated for each sample, blank, and LCS. Corrective action is taken whenever one (or more) surrogate recovery is outside the acceptance criteria. The following corrective actions are taken when required as stated above:

- Check calculations to assure there are no errors;
- Check internal standard and surrogate solutions for degradation, contamination, etc., and check instrument performance;
- If instrument failure is indicated, reanalyze the sample;
- If a method blank surrogate is outside of acceptance criteria, then the problem must be corrected before proceeding with sample analysis. This may include reanalysis, reextraction or recalibration;
- If the surrogate could not be measured because the sample required a dilution, no corrective action is required. The recovery of the surrogate is recorded with the note "surrogate diluted out".
- If all QC associated with the sample is within acceptance limits (the method blank surrogate recovery and LCS spike recovery), the problem may be attributed to a matrix effect. Samples exhibiting a matrix effect will be qualified and discussed in the report narrative.

Laboratory Control Sample/Laboratory Control Sample Duplicates

The % recovery of the Laboratory Control Samples (LCS) and the relative percent difference (RPD) for LCS Duplicates are calculated. Corrective action is taken whenever one (or more) recovery or RPD is outside the established acceptance criteria. The following corrective actions are taken when required as stated above:

Check calculations to assure there are no errors;

- Check internal standard and spiking standard solutions for degradation, contamination, etc., and check instrument performance;
- Reanalyze samples associated with a failed LCS, if available;
- If that does not correct the problem, then the data is reported and a qualifying statement included in the report narrative.

For Matrix Spike and Matrix Spike Duplicates, if all QC associated with a sample is within acceptance limits (the method blank and LCS/LCS dup spike recovery), the problem may be attributed to a matrix effect. Samples exhibiting a matrix effect will be qualified and discussed in the report narrative.

Calibration

For an initial 5 point calibration curve to be valid, the % relative standard deviation of the individual relative response factors (RRF) for the Calibration Check Compounds (CCC) shall be less than or equal to 25%. If this criteria is not met, then the calibration curve shall be reanalyzed.

For continuing calibration checks to be valid, the relative response factor for each of the System Performance Check Compounds (SPCC) should be at least 0.300 (0.250 for Bromoform) and the RRF for each of the CCC should be $\leq$25% different from the average RRF from the initial calibration. If these criteria are not met, then the following corrective actions should be taken:

- Check internal standard and standard solutions for degradation, contamination, etc.,
- Check instrument for contamination at the injection port inlet and front end of the column;
- If no source of the problem is identified, then a complete 5 point initial calibration must be performed.

The SPCC and CCC for Volatiles are:

SPCC	CCC
Chloromethane	Vinyl Chloride
1,1-Dichloroethane	1,1-Dichloroethene
Bromoform	Chloroform

1,1,2,2-Tetrachloroethane	1,2-Dichloropropane
Chlorobenzene	Toluene
	Ethylbenzene

15.1.2 Semivolatile Organic Compounds

Method Blanks

If target compounds are detected in the method blank above the detection limit (above 5 times the detection limit for phthalate esters) the corrective action consists of the following:

- checking the calculations;
- reanalyzing the blank;
- flagging the associated sample data;
- investigating the source of the problem to implement corrective action for the future.

When target list compounds are detected in a method blank, the following data condition applies:

- when any target compound is detected in a method blank above the action levels listed earlier but not in associated samples, then no flag is applied.

Surrogates

The % recovery of the surrogates is calculated for each sample, blank, and standard. Corrective action is taken whenever one (or more) surrogate recovery from either the base/neutral or acid fraction is outside the acceptance criteria. The following corrective actions are taken when required as stated above:

- Check calculations to assure there are no errors;
- Check internal standard and surrogate solutions for degradation, contamination, etc., and check instrument performance;

  If instrument failure is indicated, reanalyze the sample;

- If more than one method blank surrogate is outside of acceptance criteria or if one surrogate yields less than 10% recovery, then the problem must be corrected before proceeding with sample analysis. This may include reanalysis, reextraction or recalibration;

- If the surrogate could not be measured because the sample required a dilution, no corrective action is required. The recovery of the surrogate is recorded with the note "surrogate diluted out";

- If all QC associated with the sample is within acceptance limits (the method blank surrogate recovery and LCS spike recovery), the problem may be attributed to a matrix effect. Samples exhibiting a matrix effect will be qualified and discussed in the report narrative.

Laboratory Control Sample/Laboratory Control Sample Duplicates

The % recovery of the Laboratory Control Samples and the relative percent difference (RPD) for LCS Duplicates are calculated. Corrective action is taken whenever one (or more) recovery or RPD is outside the acceptance criteria. The following corrective action is taken when required as stated above:

- Check calculations to assure there are no errors;

- Check internal standard and spiking standards solutions for degradation, contamination, etc., and check instrument performance;

- Reanalyze all associated samples, if available;

- If that does not correct the problem, then the data is reported and a qualifying statement regarding the laboratory control sample is included in the report narrative.

For Matrix Spike and Matrix Spike Duplicates, if all QC associated with a sample is within acceptance limits (the method blank and LCS/LCS dup spike recovery), the problem may be attributed to a matrix effect. Samples exhibiting a matrix effect will be qualified and discussed in the report narrative.

Calibration

For an initial 5 point calibration curve to be valid, the % relative standard

deviation of the individual relative response factors (RRF) for the Calibration Check Compounds (CCC) should be less than or equal to 40%. If this criteria is not met, then the calibration curve should be reanalyzed.

For continuing calibration checks to be valid, the relative response factor for each of the System Performance Check Compounds (SPCC) should be at least 0.050 and the RRF for each of the CCC should be $\leq$ 40% different from the average RRF from the initial calibration. If these criteria are not met, then the following corrective actions should be taken:

- Check internal standard and standard solutions for degradation, contamination, etc.,
- Check instrument for contamination at the injection port inlet and front end of the column;
- If no source of the problem is identified, then a complete 5 point initial calibration must be performed.

The SPCC and CCC for Semivolatiles are:

<u>SPCC</u>

N-Nitroso-di-n-propylamine
Hexachlorocyclopentadiene
2,4-Dinitrophenol
4-Nitrophenol

<u>CCC</u>

Acenaphthene	4-Chloro-3-Methylphenol
1,4-Dichlorobenzene	2,4-Dichlorophenol
Hexachlorobutadiene	2-Nitrophenol
N-Nitroso-di-phenylamine	Phenol
Di-n-octylphthalate	Pentachlorophenol
Fluoranthene	2,4,6-Trichlorophenol
Benzo(a)pyrene	

15.1.3 Gas Chromatography

Method Blanks

If target compounds are detected in the method blank above the detection limit the corrective action consists of the following:

- checking the calculations;
- reanalyzing the blank;
- flagging the associated sample data;
- Investigating the source of the problem to implement corrective action for the future.

When target compounds are detected in a method blank, the following conditions apply:

- when any target compound is detected in a method blank above the action levels listed earlier, but not in associated samples, then no flag is applied.

Surrogates

The % recovery of the surrogates is calculated for each sample, blank, and standard. Corrective action is taken whenever one (or more) surrogate recovery is outside the acceptance criteria. The following corrective action is taken when required as stated above:

- Check calculations to assure there are no errors;
- Check standard and surrogate solutions for degradation, contamination, etc., and check instrument performance;
- If instrument failure is indicated, reanalyze the sample;
- If the surrogate could not be measured because the sample required a dilution, no corrective action is required. The recovery of the surrogate is recorded with the note "surrogate diluted out";
- If all QC associated with the sample is within acceptance limits (the method blank surrogate recovery and LCS spike recovery), the problem

may be attributed to a matrix effect. Samples exhibiting a matrix effect will be qualified and discussed in the report narrative.

Laboratory Control Sample/Laboratory Control Sample Duplicates

The % recovery of the Laboratory Control Samples and the relative percent difference (RPD) for LCS Duplicates are calculated for each set of spiked samples. Corrective action is taken whenever one (or more) recovery or RPD is outside the acceptance criteria. The following corrective action is taken when required as stated above:

- Check calculations to assure there are no errors;
- Check standard and spiking standard solutions for degradation, contamination, etc., and check instrument performance;
- If that does not correct the problem, then the data is reported and a qualifying statement regarding the laboratory control sample is included in the report narrative.

Calibration

For an initial 5 point calibration curve to be valid, the responses for each compound should be linear over the calibration range. If this criteria is not met, then the calibration curve should be reanalyzed.

For continuing calibration checks to be valid, the % difference in the calibration factor for each compound in calibration should not exceed 15% from the initial calibration. If these criteria are not met, then the following corrective actions should be taken:

- Check standard solutions for degradation, contamination, etc.,
- Check instrument for contamination at the injection port inlet and front end of the column;
- If no source of the problem is identified, then a complete 5 point initial calibration must be performed.

15.1.4 Metals Analyses

Method Blanks

If target analytes are detected in the method blank above the reporting limit the corrective action consists of the following:

- checking the calculations;
- reanalyzing the blank;
- investigating the source if the problem to implement corrective action for the future;
- redigesting and reanalyzing the associated samples if the analyte concentration in the samples is less than 5 times the blank concentration and greater than the reporting limit.
- Data that cannot be regenerated acceptably is flagged as non-compliant.

When target analytes are detected in a method blank, the following data condition applies:

- when any target analyte is detected in a method blank above the action levels listed earlier but not in associated samples, then no flag is applied.

Laboratory Control Sample/Laboratory Control Sample Duplicates

The % recovery of the Laboratory Control Samples and the relative percent difference (RPD) for LCS Duplicates are calculated for each set of spiked samples. Corrective action is taken whenever one (or more) recovery or RPD is outside the acceptance criteria. The following corrective action is taken when required as stated above:

- Check calculations to assure there are no errors;
- Check standard and spiking standard solutions for degradation, contamination, etc., check instrument performance;
- Redigest and reanalyze samples if there is no indication of failure in any of the above;

- If that does not correct the problem, then the data is reported and a qualifying statement regarding the laboratory control sample is included in the report narrative.

An exception to this criteria is allowed for matrix spike samples when the sample concentration exceeds the spike concentration by a factor or 4 or more. In that instance, the data is reported unqualified.

For Matrix Spike, Matrix Spike Duplicates and Sample Duplicates, if all QC associated with a sample is within acceptance limits (the method blank and LCS/LCS dup spike recovery), the problem may be attributed to a matrix effect. Samples exhibiting a matrix effect will be qualified and discussed in the report narrative.

Calibration

For an initial and continuing instrument calibration to be valid, the responses for each analyte must be linear over the calibration range and the accuracy of calibration, as determined by analysis of an independent check standard, must be within $\pm 10\%$ of the true value for ICP/AA analyses and within $\pm 20\%$ for cold vapor AA analyses. If these criteria are not met, then the following corrective actions taken:

- Check standard solutions for degradation, contamination, etc.,
- Check instrument for contamination, incorrect operating conditions, etc.;
- If no source of the problem is identified, then a complete instrument calibration must be performed.

15.1.5 Classical Wet Chemistry Techniques

Method Blanks

If target analytes are detected in the method blank above the detected limit the corrective action consists of the following:

- checking the calculations;

  reanalyzing the blank;

- investigating the source if the problem to implement corrective action for the future;

- redigesting and reanalyzing the associated samples if the analyte concentration in the samples is less than 5 times the blank concentration.

When target analytes are detected in a method blank, the following data condition applies:

- when any target analyte is detected in a method blank above the action levels listed earlier but not in associated samples, then no flag is applied.

Laboratory Control Sample/Laboratory Control Sample Duplicates

The % recovery of the Laboratory Control Samples and the relative percent difference (RPD) for LCS Duplicates are calculated for each set of spiked samples. Corrective action is taken whenever one (or more) recovery or RPD is outside the acceptance criteria. The following corrective action is taken when required as stated above:

- Check calculations to assure there are no errors;

- Check standard and spiking standard solutions for degradation, contamination, etc., and check instrument performance;

- Reanalyze the sample if no problems are indicated by checking the items above;

- If that does not correct the problem, then the data is reported and a qualifying statement regarding the laboratory control sample is included in the report narrative.

An exception to this criteria is allowed for matrix spike samples when the sample concentration exceeds the spike concentration by a factor or 4 or more. In that instance, the data is reported unqualified.

For Matrix Spike, Matrix Spike Duplicates and Sample Duplicates, if all QC associated with a sample is within acceptance limits (the method blank and

LCS/LCS dup spike recovery), the problem may be attributed to a matrix effect. Samples exhibiting a matrix effect will be qualified and discussed in the report narrative.

Calibration

For an initial and continuing instrument calibration to be valid, the responses for each analyte must be linear over the calibration range and the accuracy of calibration, as determined by analysis of an independent check standard, must be within $\pm 10\%$ of the true value. If these criteria are not met, then the following corrective actions taken:

- Check standard solutions for degradation, contamination, etc.,
- Check instrument for contamination, incorrect operating conditions, etc.;
- If no source of the problem is identified, then a complete instrument calibration must be performed.

15.2 Unusual Occurrences

Whereas out-of-control events involve occurrences outside of pre-established acceptance windows, unusual occurrences are more subjective and involve incidents which may be compliant with the assessment criteria but still warrant investigation. Many of these investigations will be the result of the professional judgement of the analyst, auditor or data reviewer that the analysis was not typical or reasonable. Another example of this type of investigation is an inquiry or questioning of data received from a client or from the results of performance evaluation samples.

FIGURE 15-1

PACE NE CORRECTIVE ACTION REPORT

Revision 1 - 12/92

Protocol_____

Date:_____ Reported By:_____

Sample ID Number(s) Involved and QC batch #:_____

Type of Event: ☐ Out-of Control Event ☐ Unusual Occurrence

Description of Event:_____

Discussion of Known or Suspected Cause:_____

Corrective Action(s) Taken (include date, person and action):_____

Signed_____

Signed_____
Group Supervisor

Signed_____
Technical Director

Follow Up:_____

Quality Assurance Review

_____ Date _____

Management Review

_____ Date _____

16.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

The Quality Assurance Officer and Quality Assurance Auditors are responsible for preparing reports to management indicating effectiveness of the laboratory Quality Assurance Program.

16.1 Quality Assurance Auditors

Results of audits performed by the QA staff are detailed in formal, written audit reports. These reports are distributed to the audited personnel, section supervisor, Laboratory director, QA officer, and Regional Director for review and appropriate action. These and other QA-related reports are distributed as produced, with no set schedule.

Auditor reports will include, but not be limited to:

- Results of internal laboratory review activities
- Results of internal data review activities
- Results of Proficiency Evaluation studies
- Results of state certification applications
- Summary of holding time exceedence and data qualification
- Method detection limit study status

To demonstrate management review, the audit report will contain a page which will be signed and dated by the QA Officer and Regional Director acknowledging that they have received the report and have reviewed its contents, and taken the necessary action dictated by their position.

16.2 Quality Assurance Officer

The Quality Assurance Officer will issue a report of QA activities and findings on a monthly basis to the Regional Director. The monthly status report will include:

- Results of internal systems or performance audits
- Corrective Action recommendations
- Discussion of QA issues raised by laboratory users
- Results of third party or external audits
- Status of laboratory certifications
- Other significant events
- Performance Evaluation Sample Results

16.3 Management Review of the Quality Assurance Program

Review of the appropriateness and adequacy of the Quality Assurance Program is ongoing. At anytime, any laboratory employee, through the Laboratory Manager may present recommended changes to the Quality Assurance Officer.

During system audits, the Quality Assurance Program should be discussed. The audit report will document recommendations made by either the Laboratory Manager or the auditor for revision.