

APPENDIX Q

**FINAL EXCAVATION PLAN
FOR THE BASE INDUSTRIAL AREA**



**FINAL
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FOR THE BASE INDUSTRIAL AREA (BIA)**

Environmental Management Directorate
Robins Air Force Base, Georgia

April 2001

**FINAL
EXCAVATION PLAN
FOR THE BASE INDUSTRIAL AREA (BIA)**

FOR

**WARNER ROBINS AIR LOGISTICS CENTER
ROBINS AFB, GEORGIA
CONTRACT NO. F09650-00-D-0012, DELIVERY ORDER NO. 5001
EARTH TECH PROJECT NO. 42846**

Prepared for:

Environmental Management Directorate
Robins Air Force Base, Georgia

Prepared by:
Earth Tech, Inc.

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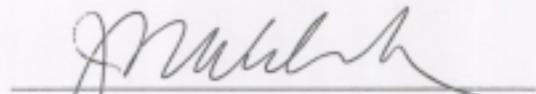

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LIST OF ACRONYMS

AFB	Air Force Base
APR	air purifying respirator
BIA	Base Industrial Area
CE	Civil Engineering
CFR	Code of Federal Regulations
EM	Environmental Management Directorate
EMQ	Environmental Management Compliance and Restoration Division
eV	electron Volts
FID	flame ionization detector
GA EPD	Georgia Environmental Protection Division
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSO	Health and Safety Officer
lpm	liters per minute
OSHA	Occupational Safety and Health Act
OVA	organic vapor analyzer
OVM	organic vapor monitor
PID	photoionization detector
PPE	personal protective equipment
ppm	parts per million
PSI	pounds per square inch
SCBA	self-contained breathing apparatus
SGPB	Bioenvironmental Engineering
SHSO	Site Health and Safety Officer
TCLP	Toxic Characteristics Leaching Procedure
TI	Technology and Industrial Support
US EPA	United States Environmental Protection Agency
VOC	volatile organic compound

1.0 INTRODUCTION

The Occupational Safety and Health Act (OSHA), under Title 29 of the Code of Federal Regulations (CFR), specifies the requirements for activities conducted in areas where workers may encounter either petroleum products or substances defined as hazardous under OSHA. Previous environmental investigations in the Base Industrial Area (BIA) have shown that some of the subsurface soils are contaminated with these hazardous substances; OSHA requirements apply for any activity in the BIA that could expose workers to these contaminants. The individual designated as the Health and Safety Officer (HSO) for organizations that may perform tasks in the subsurface soil within the BIA (e.g., excavation to repair utilities), as well as the Site Health and Safety Officer (SHSO) managing individual tasks must be familiar with requirements of this guidance plan and all other pertinent regulations, plans, and requirements.

This document provides specific guidance when performing work that could expose workers to contamination anywhere within the BIA as designated in Figure 1. The locations within the BIA where samples have been collected and analyzed are shown in Figure 2. These analytical results indicate that a number of volatile organic compounds (VOCs) may be present in the subsurface soils. Analytical results are presented in Appendix A. These chemicals, listed with their exposure limits in Table 1, are considered hazardous substances under OSHA guidelines. As a result, any work in the BIA that could lead to worker exposure to these chemicals is subject to the requirements of 29 CFR 1910.120.

This guidance is primarily intended for government civilian and military personnel who must initiate emergency repair activities within the BIA. As such, it is not intended to encompass all required actions. Instead, it should be viewed as a supplement that outlines requirements imposed by the fact that an excavation is being done in an area where there is the potential of encountering hazardous material and should be used in conjunction with existing health and safety plans, safety requirements, and other relevant work procedures. Any work performed by government workers and/or military members must be in accordance with all applicable health and safety standards and existing plans. The SHSO for work being performed by government and/or military personnel will be provided by Bioenvironmental Engineering (SGPB).

While work being performed by government and military workers, Bioenvironmental will be the SHSO for the site in all cases. Work performed by contractors/subcontractors is subject to their own health and

safety requirements as well as those for Robins Air Force Base (AFB). The SHSO duties and responsibilities are identical for all sites whether government or contractor personnel are performing the work. As such, the SHSO must be present during excavation activities that may lead to worker exposure. The SHSO for work being performed by contractors and/or subcontractors to the government will be set by the prime contractor and will abide by all OSHA and base requirements.

While contract personnel must follow their own health and safety plan, the contractor SHSO is responsible for assuring that contractors follow all requirements of the health and safety plan governing work at that particular site. In cases where there may be discrepancies between the two plans, the more conservative requirement should be followed. During project activities, a field logbook should be kept documenting that the responsibilities detailed above, as well as all other safety and health requirements from other plans, were met.

The requirements outlined in this guidance are designed to safeguard workers and should be used whenever performing work that entails penetrating the soil, floor, or pavement. The contaminants detected in this area are typically volatile; workers' exposure could result from contact with either the soil or the vapors from the contaminants within the soil. Hence, any trenching or excavation activities that penetrate the subsurface soil such as utility repairs, geotechnical borings, trenching, and coring activities could expose workers to contaminants. Conversely, activities that are confined to the top six inches of soil in defined landscaped areas such as planting, landscape maintenance, or grass mowing are exempt from these requirements.

2.0 ROLES AND RESPONSIBILITIES

The following organizations have a role and responsibility in the implementation of this plan. This plan does not supercede existing guidance and is intended to supplement existing roles and responsibilities already required of organizations on Robins AFB.

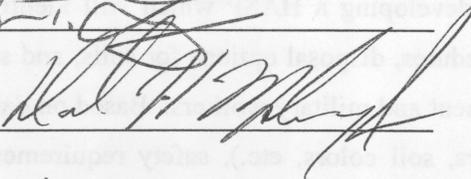
- Bioenvironmental Engineering (SGPB): ensure that all governmental and military workers operate safely when performing any excavation in this area. They are responsible for being the SHSO on any working being performed by government or military personnel in the BIA. The SHSO will be responsible for developing a HASP which will identify air monitoring requirements, decontamination procedures, disposal options for soils, and set back exclusion zones to ensure safety of all government and military workers. Based on data collected at the site (e.g., air monitoring data, odors, soil colors, etc.), safety requirements can be either increased or decreased at the discretion of the SHSO.
- Environmental Management Compliance and Restoration Division (EMQ): Is a support function to Civil Engineering (CE) and SGPB. The use of the 332 and 813 process will provide notification will be given to EM and all necessary parties. This prior planning is critical to ensure proper design and specification can be used and thus reduce cost and risk of exposure to governmental, military and contractor personnel. EM will maintain, modify and update this plan as necessary. EM will provide technical guidance for sample analysis requirements, and maintaining the database of information in the BIA. EM will update the Figure 3 as certified laboratory data is collected.
- CE and Technology and Industrial Support (TI): Adhere to the requirements of the plan when working in the BIA, coordinate all subsurface activities with EM and SGPB, provide EMQ with suggestions to improve the plan, and provide EMQ feedback whenever new certified analytical data is generated indicating the presence or absence of chemicals in the subsurface soil.
- Safety (SE): The safety office is tasked with providing support for all repair activities and will periodically inspect activities covered by this plan. Their presence will serve to ensure

that activities follow safety requirements and plans on Robins AFB in addition to those covered by this plan.

To facilitate proper coordination of future projects, samples should be taken during the design phase of the project. This advance sampling can reduce the cost of construction and limit any potential exposure to harmful chemicals, and assure proper disposal of any contaminated soils.

Signature Required:

Date:

EMO:		<u>14 Jun 01</u>
78 th CES:		<u>14 Jun 01</u>
SGPB:	<u>Derek C. W. ...</u>	<u>14 Jun 01</u>
TIP:	<u>Alan S. Kelley</u>	<u>6/15/01</u>
SEG:	<u>David E. Decker</u>	<u>6/18/01</u>
DPCEL:	<u>Chris B. Miller</u>	<u>6/18/01</u>
EM:	<u>Steve W. Boyle</u>	<u>6/20/01</u>
78 th CEG:	<u>Richard P. Bantoe</u>	<u>7/3/01</u> <u>7/2/01</u>
SE:	<u>Steve M. Sully</u>	<u>6/18/01</u>
SG:	<u>John L. ...</u>	<u>6/27/01</u>
TI:	<u>John A. Walker</u>	<u>7/16/01</u>

3.0 HAZARD ASSESSMENT

The analytical results from sample sites shown in Figure 2 and in Appendix A were used to develop zones to indicate the presence or absence of contamination within the BIA. The criteria used to designate these zones, shown in Figure 3, were as follows:

- Red Zone – indicates an area where hazardous chemicals have been detected,
- Yellow Zone – indicates an area where there are no data to confirm the presence or absence of contamination or contaminants, and
- Green Zone – indicates an area where analytical results indicate no hazardous chemicals were present.

Developing these zones required that the data be extrapolated between points known to be contaminated and points known to be contaminant-free. However, these zones can only be taken as guidelines and must not be considered true boundaries. With the limited amount of data available and numerous different types of operations at the site, it is probable that there are areas of contamination within the Green and Yellow Zone areas. It is doubtful that all areas within the Red Zones are contaminated. These uncertainties and the fact that each site and job performed entails their own risk for exposure, this guidance is conservative in its approach. For example, air monitoring and the presence of an SHSO are required for all sites, regardless of zone designation. If any organic chemical is detected above its background level, this guidance dictates that worst case scenario procedures be followed until analytical results indicate that less conservative procedures are appropriate.

Workers in the Red Zones are expected to be exposed to hazardous chemicals; safety requirements for these areas are the most stringent. Workers in the Green Zones should not be exposed to chemicals; there are no additional safety requirements levied under this plan once the area is cleared by the SHSO. There is no data from the Yellow Zones. These areas may be treated as uncontaminated as long as the SHSO is on-site and is providing continuous air monitoring. Specific requirements for each zone are covered in later sections within this document.

To properly assess the site, the SHSO for excavation projects in the BIA must be certified under the Hazardous Waste Operations and Emergency Response (HAZWOPER) program as defined by OSHA under 29 CFR 1910.120. The duties of the SHSO at all BIA sites include the following:

- Controls access to the excavation area,
- Ensures that this and all other safety plan(s) are followed at all times,
- Halts work and evacuates the site as applicable when an unsafe condition occurs,
- Documents work stoppage incidents and notify EMQ as soon as possible, and
- Provides for medical evacuation of any personnel on-site who exhibits symptoms of exposure.

When working within the Green and Yellow Zones, the SHSO is the only person that is required to have HAZWOPER certification at the onset of work. Conversely, for work within Red Zones, all site personnel and all workers must have HAZWOPER Certification. If site conditions indicate a change, these zone designations can be upgraded or downgraded as needed. If an excavation is completed in a Red Zone and no contamination has been discovered, the area may be upgraded to a Green Zone and monitoring can be halted.

There are areas within the BIA that may be contaminated with electroplating solutions such as chromium, cadmium, or cyanide. Unfortunately, standard monitoring techniques do not detect the presence of these chemicals; therefore, great care must be exercised prior to performing work in an area where such contamination could be present. Because these contaminants are rarely a danger to inhalation exposure and workers are generally sufficiently protected using standard field equipment such as gloves. In dusty environments, breathing protection is recommended.

4.0 WORK WITHIN THE GREEN ZONES

Although previous analytical results indicated that Green Zones were areas with no contamination, the SHSO is required to be on-site until it can be shown that no unknown contamination is detected. Once the area has been analyzed and proven to be contaminant free, the SHSO may leave the site while the construction is completed.

4.1 SHSO MONITORING RESPONSIBILITIES

There are a number of indicators that contamination may be present and the SHSO must be sensitive to all. Odors and color changes in the soil are examples of things that can indicate contamination. However, the most reliable and important method of detecting contamination is air monitoring using an organic vapor analyzer (OVA). The SHSO must have some type of analyzer such as a photoionization detector (PID) or flame ionization detector (FID) on-site during all excavation activities. Air monitoring measurements made during air monitoring must be documented on an Atmospheric Log form; an example is included in Appendix B. SGPB should identify the appropriate AF DOD Forms.

Organic vapor monitors (OVMs) detect nearly all organic vapors. Because maintenance activities such as painting and solvent cleaning that routinely occur in the BIA often produce such vapors, it is important for the SHSO to obtain background measurements using the detector in areas away from the work zone. In this manner, the SHSO will be able to detect increases in vapor concentrations above background levels and he or she can determine whether the monitor is recording natural ambient vapors or potential contamination from the excavation.

At a minimum, air monitoring must be performed at the following times in a Green Zone:

- Upon initiating the investigation when ground is first broken. This is particularly important when excavating through a relatively impervious cap such as pavement or concrete. Organic vapors may have collected just beneath the surface and may escape upon breaking the cover.
- Periodically throughout the investigation to ensure a previously unknown area of contamination has not been uncovered. This can be accomplished by analyzing either the excavated area or the soil removed from the excavation.
- Periodically throughout the excavation in the breathing zone.

The advantages, disadvantages, monitoring specifications, and calibration specifications for the various monitoring devices are detailed later in this guidance.

If a contaminant is detected (e.g., the OVM shows a reading above background levels or someone in the area detects the odor of solvent), all work should be halted, the excavation area secured, and personnel not certified under HAZWOPER evacuated pending analyses and investigation. A procedure such as, placing heavy gauge plastic in the excavation and covering it with clean fill material serves to contain the potentially harmful vapors and can be used to secure the site. The plastic prevents the fill material from contacting the potentially contaminated soil in the excavation and will seal off any vapors.

In the event of vapor detection, any material already excavated from the site will have to be treated as potentially hazardous waste. As such, it must be secured in the same manner as the excavation itself. With the limited data available and the potential to encounter unrecorded areas of contamination, it is recommended that all excavated material in the BIA be segregated by placing it on heavy plastic, in metal drums, or in a roll-off container. In this manner, if contamination is encountered, securing the excavated material will be greatly simplified.

As discussed earlier, if an indicator such as odors or elevated readings with the OVA suggests the possible presence of a hazardous substance, the site will be immediately upgraded to a Red Zone site. Once the upgrade is done, only HAZWOPER certified personnel, as defined by 29 CFR 1910.120, with the proper personal protective equipment (PPE) will be allowed on-site. Furthermore, for governmental and military personnel, the SHSO must contact both EMQ and SGPB; these offices will help arrange for additional monitoring and chemical analyses to determine whether or not the area should continue to be designated as a Red Zone area. For contractors they shall follow all OSHA and Robins AFB requirements outlined under their approved HASP, and coordinate their activities through the contracting officer, or contracting officer representative.

With the potential to encounter contamination, work within the BIA even in Green Zones, should be planned in advance whenever possible. This allows for test borings to be made, samples collected, and analyses completed during the planning phase. Knowing whether or not contamination is present not only helps safeguard the workforce, but it also helps avoid potential construction delays once the site work has begun. If advanced sample collection and analyses are desired, the Environmental Management Directorate (EM) can assist by providing procedures for obtaining contractor support.

4.2 HEALTH SCREENING AND SURVEILLANCE FOR PERSONNEL WORKING ON-SITE

For work in Green Zone areas, only the SHSO is required to be under a medical monitoring program as required under 29 CFR 1910.120. If a hazardous substance is detected during excavation activities, an exposure report must be prepared and forwarded to EMQ and SGPB. This report will be used as the basis for determining whether additional exposed personnel should be incorporated into a medical monitoring program and whether additional monitoring is required for the SHSO. Additional medical testing shall be required if recommended after consultation with a physician or if signs and symptoms of exposure occur.

4.3 SOIL SAMPLING/ANALYSIS

It is possible that organic vapors detected by the OVA are not hazardous; however, because of the potential for contact with hazardous materials, all detections are considered to indicate the presence of hazardous material. As a result, if vapor monitoring indicated an increase in organic vapors during an excavation, additional analytical data may be required to identify whether or not hazardous substances are present in the proposed excavation area.

Due to the fact that each excavation area and contaminant is somewhat unique, the purpose of sampling is to collect a sufficient number of samples to characterize the entire excavation area. As a result, the number of samples required will vary with each site, but it is important to remember that the purpose of collecting samples is to determine if there are areas of contamination anywhere within the excavation and not at any specific point. If the excavation were halted because an area of discolored soil increased the reading on the OVA, the tendency would be to sample only that specific point. However, if the analytical results from that single sample indicated the presence of a contaminant, it would be impossible to determine the extent of contamination. As a result, samples should be collected throughout the excavation area at depths ranging over the entire interval to be excavated.

While discrete sampling (i.e., collecting separate samples from a number of points) would provide the most information regarding the extent of contamination, it also increases the number of samples and the analytical costs. In a relatively small excavation, 3 feet by 3 feet by 3 feet deep, if the sides and bottom were sampled every foot, there would be a very large number of samples. The data resulting would allow the SHSO to pinpoint the areas of contamination, but the cost would be very high. As a result, composite samples from well defined areas are often used. Soil may be collected at one-foot intervals from one side

of an excavation and mixed, and a representative composite sample may be taken from that mixture. That sample would then be representative of the entire area.

The potential presence of contamination automatically upgrades the area to a Red Zone, samples must be collected by trained personnel with HAZWOPER certification to ensure correct procedures are followed and cross contamination does not occur. All sampling must be accomplished in accordance with the United States Environmental Protection Agency's (US EPA's) Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Once collected, the samples must be properly preserved and delivered to a certified analytical laboratory for the following analyses: volatile organic compounds using US EPA Method SW 8260, semi-volatile organic compounds using US EPA Method SW 8270, and metals using US EPA Method SW 6010.

Soil excavated from such a site must likewise be assumed to be hazardous; it should be kept segregated until laboratory analyses confirms otherwise. If the excavation is determined to contain hazardous waste, the excavated soil cannot be returned to the excavation and must be treated as potentially hazardous waste. As such, composite samples of the excavated material must also be taken and analyzed as discussed above. Alternatively, if no hazardous substances are detected in the excavated material and it is suitable, it can be used as backfill for the excavation. Additional guidance, for governmental and military personnel, on sampling procedures, protocols, and requirements can be obtained from either EM or SGPB. See Appendix C for Sample Control, Field Records, and Document Control; Sampling Design and Quality Assurance Procedures; and Soil Sampling Procedures outlined by USEPA Region IV.

4.4 PERSONAL PROTECTIVE EQUIPMENT

There are no specific PPE requirements for working in Green Zone areas unless contamination is detected. However, requirements for other standard safety gear such as hardhats, gloves, and safety glasses are outlined in the Health and Safety Plan and in work procedures and must be observed. Should the SHSO determine the presence of a potentially hazardous substance, all non-HAZWOPER trained personnel must evacuate the area, and the PPE requirements outlined under the section entitled "Work Within the Red Zones" must be followed.

5.0 WORK WITHIN THE YELLOW ZONES

There is no data available for media in the Yellow Zone; Green Zone procedures are followed in Yellow Zones. However, because of the potential for exposure, it is recommended that HAZWOPER certified personnel be used in the area until the SHSO can determine the zone to be contaminant free. All requirements applicable to the Green Zone areas must be followed in Yellow Zone areas as well. As with the Green Zone areas, if samples collected and analyzed prior to excavating the soil show the area to be uncontaminated, there are no additional safety measures imposed on the workers; therefore, the area could be upgraded to a Green Zone.

6.0 WORK WITHIN THE RED ZONE AREAS

With proper planning in these areas the 332 and 813 process can notify EM and SGPB, therefore allowing enough time to gather additional data. With the additional data a proper HASP plan can be developed by SGPB as well as plans and specifications by TI and CE for these construction projects. This forward planning will save money and the risk of any potential exposure. These areas are considered hazardous waste sites. All personnel working in the Red Zones must be certified as having completed the 40-hour HAZWOPER training course as defined in 29 CFR 1910.120. As with all sites, there must be a designated SHSO monitoring and controlling the excavation area. If the area is within a building or confined area, great care must be taken not to expose persons in surrounding areas to contaminants.

Red Zone areas are known to be contaminated. The duties of the SHSO not only include those listed in the section on working in Green Zones, but also entail a number of other requirements that are listed in this section. Daily safety briefings must be held in which the SHSO informs excavation personnel of the concerns regarding hazardous substances such as physical characteristics of the excavation area (odor, color, texture, etc.) that would indicate potential contamination.

6.1 REQUIREMENTS FOR HANDLING EXCAVATED SOIL

Soil excavated from Red Zone areas are assumed to be contaminated. The excavation material must be containerized (i.e. placed on plastic or contained in roll-off boxes/drums) and treated as potentially hazardous material. Excavating soil from Red Zone areas implies that the material cannot be used to backfill the excavation; consequently, suitable clean fill material must be transported to the site. Upon completion of the excavation, a composite soil sample of the excavation material must be collected and submitted for full Toxic Characteristics Leaching Procedure (TCLP) analyses, pH, flash point, and paint filter testing. The disposal requirements will be determined by the results of these analyses. Laboratory results should be submitted to EMQ. Based on those results EMQ will provide guidance for disposal of the excavated soils.

6.2 RUN-OFF CONTROL REQUIREMENTS

The HASP provided by the SGPB or the contractor should identify run-off controls required to minimize any additional contamination migrating from the area. Any materials removed from the excavation is

considered to be potentially hazardous waste. Care must be taken either to prevent rainwater from contacting the soil or to contain run-off that could contain contaminated soil. Run-off barriers, excavation covers, and other protective devices must be maintained and must provide for the run-off water to drain into the excavation area. Because of the potential for contamination, if run-off water is drained or pumped from the excavation, it must be regarded as liquid hazardous waste and treated accordingly. It is often possible to dispose of liquid waste in the wastewater treatment system; however, all discharges to the industrial sewer system or the Groundwater Treatment Plant must be pre-approved by EMQ.

6.3 SITE SAFETY MEETINGS

The SHSO from Bioenvironmental for governmental and military personnel will conduct daily site safety briefings prior to starting field activities or as tasks and site conditions change. These briefings should be documented on the form included as Appendix B. Contractors will identify the need and content of their Site Safety briefings. Site safety briefing topics include: a general discussion of the health and safety plan governing the work, the requirements of this guidance, site specific hazards, location of work zones, PPE requirements, equipment, any special requirements, and emergency procedures. In addition, the following issues should be addressed in the initial site safety meeting.

- The proper procedures for handling and storing hazardous material generated on-site including waste removed from the excavation and contaminated PPE
- The location of any applicable Material Safety Data Sheets on the contaminant
- On-site communications that will be used during site work such as line of sight/hand signals, air horn warnings, two-way radio, or cellular phones
- The location of equipment for off-site communications
- A review of the "buddy" system
- The restrictions on eating, drinking, and smoking in contaminated areas, exclusion zones, or decontamination zones and areas where such activities are allowed
- The restrictions on the use of contact lenses in exclusion or decontamination zones
- The appropriate PPE required and the requirements for its use

6.4 ACCIDENT AND INCIDENT REPORTING

In addition to the SHSO entries in the daily log and any work stoppage reports, any accident and/or chemical exposure incident shall be investigated, analyzed, and documented in an accident investigation report and reported to EMQ and SGPB. Notification of exposure incidents should occur within 24 hours if any civilian/military personnel, subcontractor, or visitor is involved in a reportable accident or exposure incident or exhibits symptoms that might indicate exposure to contaminants. Accident and incident reports are prepared by the SHSO in consultation with the EMQ and SGPB, and should contain a full description and analysis of the incident including exposure work hours and a log of occupational injuries and illnesses (OSHA Form 200 or equivalent as prescribed by 29 CFR 1904).

The EMQ/SGPB shall prepare formal accident reports for any reportable diagnosed illness or injury that results in a lost workday or fatality. The accident report shall identify contributing causes and recommend future hazard control measures to reduce the risk of recurrence.

6.5 VISITOR CLEARANCES

The SHSO is responsible for clearing all personnel visiting the site. A log must be kept detailing the identity of visitors and the times they were on-site. Red Zone areas are treated as hazardous waste sites, visitors must not be allowed to enter the exclusion zone unless they present the SHSO with documentation verifying that they are HAZWOPER certified. Prior to entry into an exclusion zone, the SHSO shall brief the visitor on specific site procedures (i.e., type of hazards existing in the exclusion zone, decontamination protocols, safety procedures, emergency contacts, etc.) in the same manner as any other site personnel.

Because of the congestion and number of workers within the BIA, the SHSO, in consultation with the HSO, EMQ, and SGPB as needed, shall determine the size of the exclusion zone around the excavation site. Depending upon site conditions (e.g., organic vapor detections) this exclusion zone can be expanded or contracted as needed. The visitor clearance policy applies to anyone entering this exclusion zone.

6.6 TRAINING REQUIREMENTS

All personnel working in Red Zone areas shall have received training required by 29 CFR 1910.1200, Hazard Communication; 29 CFR 1910.134, Respiratory Protection; and 29 CFR 1910.120, Hazardous Waste

Operations and Emergency Response (40-hour initial training, 8-hour update, and 8-hour supervisor training, when applicable). In addition to this training, the OSHA regulations require that all personnel receive 3 days of supervised on-site training prior to working on a HAZWOPER site. This training must be documented on a form similar to that included in Appendix B and should be part of the employee's records. Additionally, the SHSO provides site-specific training in the form of the daily health and safety briefings; these briefings should be documented as previously discussed.

6.7 MEDICAL SURVEILLANCE

All personnel working in a Red Zone area or in an area that has been upgraded to a Red Zone must have passed a pre-assignment and/or periodic medical examination as required in 29 CFR 1910.120 (f). SGPB will coordinate all medical monitoring. Additional medical testing shall be required if after consultation with a physician, signs and symptoms of exposure or over exposure occur. Contract personnel may maintain their own medical surveillance records; however, they must provide the SHSO with written documentation certifying that each of their employees at the site has met the requirements of the Medical Surveillance Program. This documentation will be provided before the first day of work for each employee assigned to the site.

6.8 JOB EXPOSURE REPORT

Both at the end of each person's time on the site and at times when a new SHSO is assigned to the site prior to the end of excavation activities, the outgoing SHSO must complete a Job Exposure Report form (Appendix B). The report documents actual and/or suspected exposures that were experienced by the worker(s) and may be needed by medical personnel when determining appropriate periodic examination procedures. These reports must be available for review by either EMQ or SGPB.

6.9 AIR MONITORING

Air monitoring will be conducted in accordance with the guidelines set by the SHSO and shall be continual. Typically, such monitoring will be conducted using either an FID or PID. There are advantages and disadvantages associated with these units, and these issues should be considered when selecting the most suitable type of equipment for monitoring.

The PID is moisture sensitive, and even morning dew or fog may elevate readings; however, the unit is relatively easy to maintain. Alternatively, the FID is not sensitive to water vapor, but it does require a hydrogen source. Therefore, maintenance requirements are more complex, and arrangements must be made for storing hydrogen cylinders. In addition, if the action level is upgraded to Level C, colorimetric tubes are required when chlorinated solvents are the hazardous substances of concern. The following table summarizes site-monitoring requirements.

Monitoring Specifications

Site ID	Instrument	Tasks	Action Levels	Colorimetric Tubes	Frequency
All sites contaminated or potentially contaminated with a hazardous substance	PID or FID (both types of OVAs)	Excavations, preliminary sampling activities	If action levels are met or exceeded in the workers' breathing zone over a 10 minute period <1-25 parts per million (ppm) Level D 25-100 ppm Level C >100 ppm Stop work; re-evaluate	PCE, DCE, TCE, and CT if at Level C	Initially and periodically throughout task. Air monitoring will be performed in the employees' breathing zone. If action levels are met or exceeded over a 10-minute period, the appropriate PPE level and procedures are required.

Monitoring equipment should be calibrated daily prior to excavation and monitoring activities and periodically throughout the day (e.g., after halting work for lunch) during activity. Calibration procedures should be documented in a logbook or on a form such as that found in Appendix B with the serial number of the monitoring equipment and the lot number of the calibration gas included in the notes. Equipment calibration specifications are presented below.

Calibration Specifications

Instrument	Gas	Span	Reading	Method
PID: HNu or equivalent, 10.2 electron Volts (eV) probe	100 ppm isobutylene	9.8 ± 2.0	55 ppm	1.5 liters per minute (lpm) regulator (reg) T-tubing
PID: OVM, 10.0 or 10.6 eV bulb; OVA	100 ppm isobutylene	RF = 0.55	55 ppm	1.5 lpm reg T-tubing
FID: OVA-128	100 ppm methane	3.0 ± 1.5	100 ppm	1.5 lpm reg T-tubing
Note: HNu is a brand name of a particular PID				

6.10 PERSONAL PROTECTIVE EQUIPMENT

The table below details the PPE required to initiate excavation activities in either Green or Yellow Zones.

Personal Protective Equipment Specifications for Green/Yellow Zones

Task	Level	Body	Foot	Head	Eye	Hand	Respirator
Excavation Activities in Green or Yellow Zones	D or modified D	Work clothes/ waders Tyvek suits provided upon request for spill protection	Steel-toed, steel-shank, neoprene boots or steel-toed work boots	Requirements for specific headgear such as hardhats shall be as specified by the Health and Safety Plan and normal work procedures.	Safety glasses or safety sunglasses	Latex gloves, nitrile gloves	None required

If the area is determined to be contaminated or if no contamination is found, the level of PPE may be increased or decreased according to the action levels as follows.

Reasons To Upgrade or Downgrade Level of Protection

Upgrade	Downgrade
<ul style="list-style-type: none"> - Request of individual performing task - Change in work task that will increase contact or potential contact with hazardous materials - Occurrence or likely occurrence of gas or vapor emission - Known or suspected presence of dermal hazards - Instrument action levels exceeded - Introduction of a new chemical, soil, or groundwater constituent into the work area 	<ul style="list-style-type: none"> - New information indicating that situation is less hazardous than originally thought - Change in site conditions that decreases the hazard - Change in work task that will reduce contact with hazardous materials

The table below details the PPE required to initiate excavation activities in the Red Zones.

Personal Protective Equipment Specifications for Red Zones

Task	Level	Body	Foot	Head	Eye	Hand	Respirator
Red Zones or upgraded Zones	C	Tyvek or polyethylene coated Tyvek	Steel-toe, steel-shank neoprene boots or steel-toed work boots with boot covers-taped	Requirements for specific headgear such as hardhats shall be as specified by the Health and Safety Plan and normal work procedures.	Safety glasses or safety sunglasses	Nitrile outer gloves - taped, over latex gloves	air purifying respirator (APR), full face, MSA Ultratwin with GMC-H cartridges, or equivalent
Red Zones or upgraded Zones	B	Polyethylene coated Tyvek or Saranex	Steel-toe, steel-shank neoprene boots or steel-toed work boots with boot covers-taped	Requirements for specific headgear such as hardhats shall be as specified by the Health and Safety Plan and normal work procedures.	Safety glasses or safety sunglasses	Latex inner gloves with nitrile outer gloves-taped	MSA, full face positive pressure self-contained breathing apparatus (SCBA), or equivalent

6.11 DECONTAMINATION PROCEDURES

Personnel decontamination should follow the HAZWOPER guidelines. After decontamination, all PPE must be treated the same way as the excavation material or liquid. Additionally, any equipment used in excavating Red Zone areas must also be decontaminated. This includes any portion of the backhoe such as backhoe buckets, chains, and hoists that was used in the excavation area. A steam cleaner and/or high pressure washer capable of generating pressure of at least 2500 pounds per square inch (PSI), producing hot water and/or steam (200°F plus) and equipped with a soap compartment should be used for all equipment decontamination. This decontamination activity should be conducted in an area designated by EMQ.

The potential for cross contamination from one location to the next is possible. Sampling equipment such as stainless steel bowls, spoons, and hand auger buckets should be decontaminated using the following steps:

- Wash with soap and water
- Rinse with tap water
- Rinse with laboratory grade isopropanol
- Rinse with organic free water or analyte free water
- Wrap in aluminum foil

Rinsing with isopropanol can be omitted if the HSO determines that the soils contained only trace amounts of organic substances, and any residual contamination will not influence analytical results. The use of organic or analyte free water is dependent upon the analyses to be accomplished. If the sample equipment will be used to collect samples for organic analyses (e.g., US EPA Method 8260), organic free water should be used. Conversely, if the sample equipment will be used to collect samples for metals analyses, analyte free water should be used.

Cleaning materials for decontamination activities must meet the following standards:

- Soap shall be a standard brand of phosphate-free laboratory detergent such as Liquinox[®]. Use of other detergents must be justified and documented in the field logbooks and inspection or investigative reports.
- Tap water may be used from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.
- Isopropanol shall be pesticide-grade. Any other lesser grade must be justified in the work plan for the site and approved by the HSO. If lesser grades are used, it must be documented in SHSO's logbook.
- Analyte free water is tap water that has been treated by passing through a standard deionizing resin column. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds (i.e., at or above analytical detection limits) as defined by a standard inductively coupled Argon Plasma Spectrophotometer (or equivalent) scan. Analyte free water obtained by other methods is acceptable as long as it meets the above analytical criteria.

- Organic/analyte free water is defined as tap water that has been treated with activated carbon and deionizing units. A portable system to produce organic/analyte free water under field conditions is available. At a minimum, the finished water cannot contain detectable levels of pesticides, herbicides, extractable organic compounds, or VOCs above minimum detectable levels set by the US EPA and the Georgia Environmental Protection Division (GA EPD). Organic/analyte free water obtained by other methods is acceptable, as long as the above analytical criteria are met.

In some cases, other specific solvents may be substituted for a rinsing agent, if required. For example, removal of concentrated waste materials may require the use of either pesticide-grade hexane or petroleum ether. If this is the case, after the waste material is removed with the additional solvent, the equipment must be subjected to the standard cleaning procedure. Because these solvents are not miscible with water, the equipment must be completely dry prior to use. Usage of this solvent must be approved by EMQ.

Solvents, laboratory detergent, and rinse waters used to clean equipment shall not be reused during field decontamination.

6.11.1 Handling and Containers for Cleaning Solutions

If improperly handled, cleaning solutions may easily become contaminated. To avoid that possibility, storage and application containers must be constructed of the proper materials to ensure their integrity. The following materials are acceptable for use for containing the specified cleaning solutions:

- Soap must be kept in clean plastic, metal, or glass containers until used. It should be poured directly from the container during use.
- Solvent must be stored in the unopened original containers until used. They may be applied using the low-pressure nitrogen system fitted with a Teflon[®] nozzle or using Teflon[®] squeeze bottles.
- Tap water may be kept in clean tanks, hand pressure sprayers, or squeeze bottles or may be applied directly from a hose.
- Analyte free water must be stored in clean glass, stainless steel, or plastic containers that can be closed prior to use. It can be applied from plastic squeeze bottles.

- Organic/analyte free water must be stored in clean glass, Teflon[®], or stainless steel containers prior to use. It may be applied using either Teflon[®] squeeze bottles or the portable system.

Hand pump sprayers, including stainless steel sprayers, are generally not acceptable for storing or applying the above materials except for tap water because all hand sprayers have internal oil coated gaskets and black rubber seals that may contaminate the rinses and, in turn, the sampling equipment.

6.11.2 Safety Procedures for Field Cleaning Operations

Some of the materials used and procedures outlined in this section can be harmful if used improperly. All personnel should exercise caution and follow all applicable safety procedures. At a minimum, the following precautions should be taken in the field during these cleaning operations:

- Latex gloves and safety goggles or glasses with splash shields will be worn during all cleaning operations.
- Solvent rinsing operations will be conducted in the open (never in a closed room).
- No eating, smoking, drinking, chewing, or hand-to-mouth contact should be permitted during cleaning operations.

7.0 SUMMARY

This document provides specific guidance when performing work that could expose workers to contamination anywhere within the BIA. The responsible Robins AFB organizations for this area and this plan include EMQ, 78th CEG, SGPB, and TIP. Any work performed by government workers and/or military members must be in accordance with all applicable health and safety standards and existing plans. Work performed by contractors and their subcontractors are subject to their own health and safety requirements as well as Robins AFB requirements.

The guidance outlined in this plan is primarily intended for personnel that must initiate repair activities on an emergency basis and is not intended to be all encompassing. Zones were defined based on the chemicals detected in the BIA. These zones are defined as Red, Yellow, or Green, with the Red Zone being the zone with the highest probability to find contamination while excavating. With these defined zones come different levels of health and safety requirements. These requirements become more stringent as the zone becomes more contaminated.

This plan should be viewed as a supplement that provides additional guidance specific to the potential of encountering hazardous material and should be used in conjunction with existing health and safety plans and work procedures. Specific requirements are outlined in the OSHA, under Title 29 of the CFR.

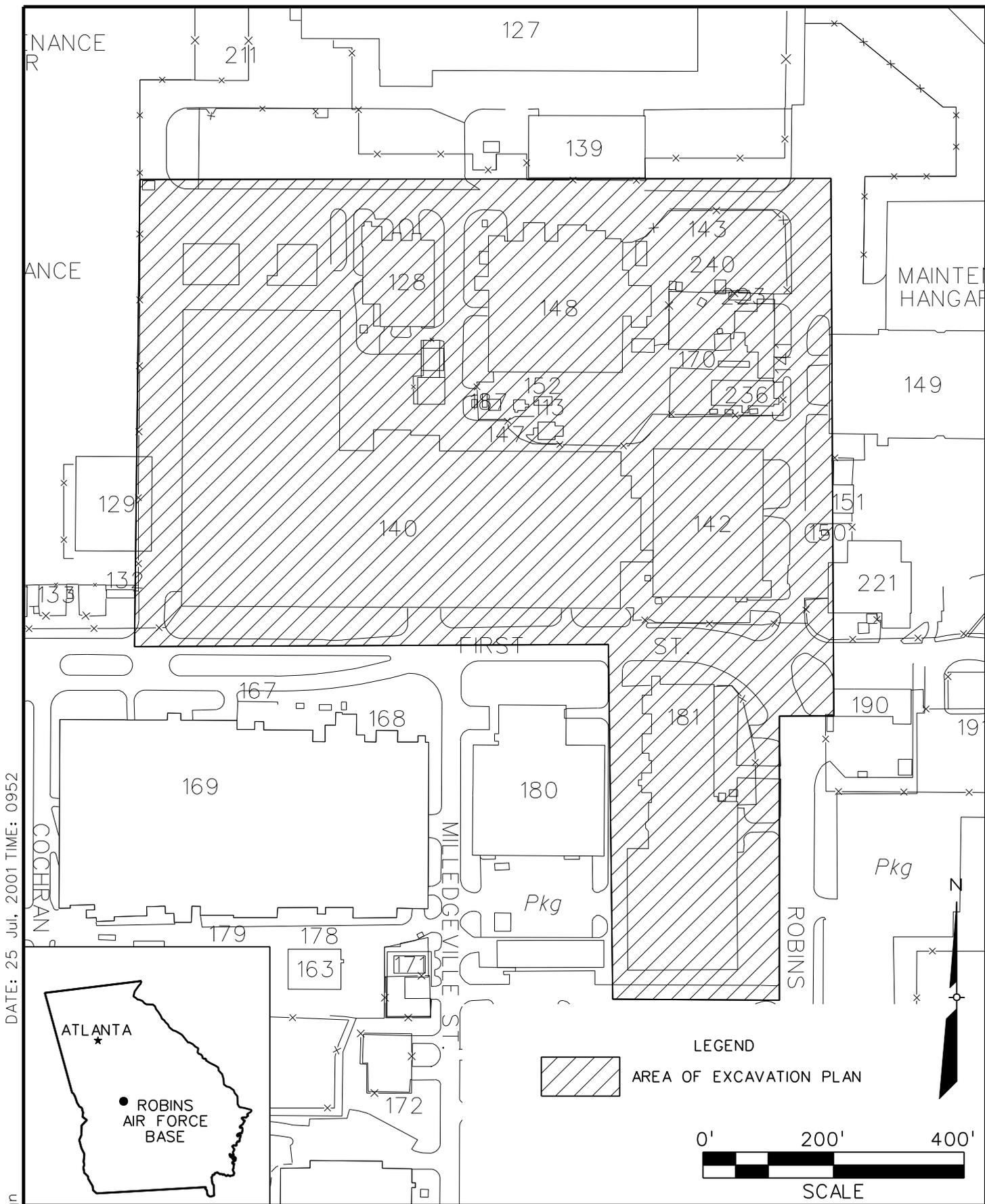
Table 1

**Chemicals Detected in the GBIA
(Exposure Limits Based On Human Health Criteria For Chemical Detected)**

<u>Chemical</u>	<u>TLV-TWA</u>	<u>TLV-STEL</u>	<u>PEL-TWA</u>	<u>PEL-STEL</u>	<u>IDLH</u>
Acetone	250 ppm	750 ppm	1000 ppm	---	2500 ppm
Trichloroethane	10 ppm	---	10 ppm	---	100 ppm, Ca
Arsenic, metal	0.002 mg/m ³ , A1	---	0.01 mg/m ³ , I	---	5 mg/m ³ , Ca
1,1,2,2 Tetrachloroethane	500 ppm	---	500 ppm	---	2000 ppm
Benzene	0.1ppm,Ca, skin A1	1 ppm	1 ppm	5 ppm	500 ppm, Ca
Chlorobenzene	10 ppm, A3	---	75 ppm	---	1000 ppm
Methylene chloride	50 ppm, Ca, A3	---	25 ppm	125 ppm	2300 ppm, Ca
Methyl ethyl ketone,	200 ppm	300 ppm	200 ppm	---	3000 ppm
Naphthalene	10 ppm	15 ppm	10 ppm	---	250 ppm
Tetrachloroethylene	25 ppm, Ca, A3	100 ppm	100 pm	200 ppm, Ceiling	150 ppm, Ca
1,1-Dichloroethylene	5 ppm	20 ppm	---	---	N.D., Ca
1,2-Dichloroethylene	200 ppm	---	200 ppm	---	1000 ppm
Ethylbenzene	100 ppm	125 ppm	100 ppm	---	800 ppm
Fuel Oil (stoddard solvent)	350 ppm	1,800 mg/m ³	500 ppm	---	20,000 mg/m ³
Gasoline	300 ppm, A3	500 ppm	---	---	N.D., Ca
1,1-Dichloroethane	100 ppm	---	100 ppm	---	3000 ppm
1,2-Dichloroethane	10 ppm	---	50 ppm	100 ppm, ceiling	50 ppm, Ca
Trichloroethylene	50 ppm	100 ppm	100 ppm	200 ppm	1000 ppm, Ca
Toluene	100 ppm, Skin	150 ppm	200 ppm	300 ppm, Ceiling	500 ppm
Vinyl Chloride	5 ppm,Ca A1	---	1 ppm	5 ppm Ceiling	N.D., Ca
Xylene, Para	100 ppm	150 ppm	100 ppm	---	900 ppm
Xylene	100 ppm	150 ppm	100 ppm	---	900 ppm

A1 = Confirmed Human Carcinogen
A2 = Suspect Human Carcinogen
A3 = Animal Carcinogen
Ca = Carcinogen
ND = Not Determined
Skin = Skin Contact Hazard
RF = Respirable Fraction
TD = Total Dust
RD = Respirable Dust

O = Organic
I = Inorganic
NA = Not Available
TLV-TWA = Threshold Limit Value – Time Weighted Average
TLV-STEL = Threshold Limit Value – Short Term Exposure Limit
PEL-TWA = Permissible Exposure Limit – Time Weighted Average
PEL-STEL = Permissible Exposure Limit – Short Term Exposure Limit
IDLH = Immediately Dangerous to Life or Health



DATE: 25 Jul, 2001 TIME: 0952

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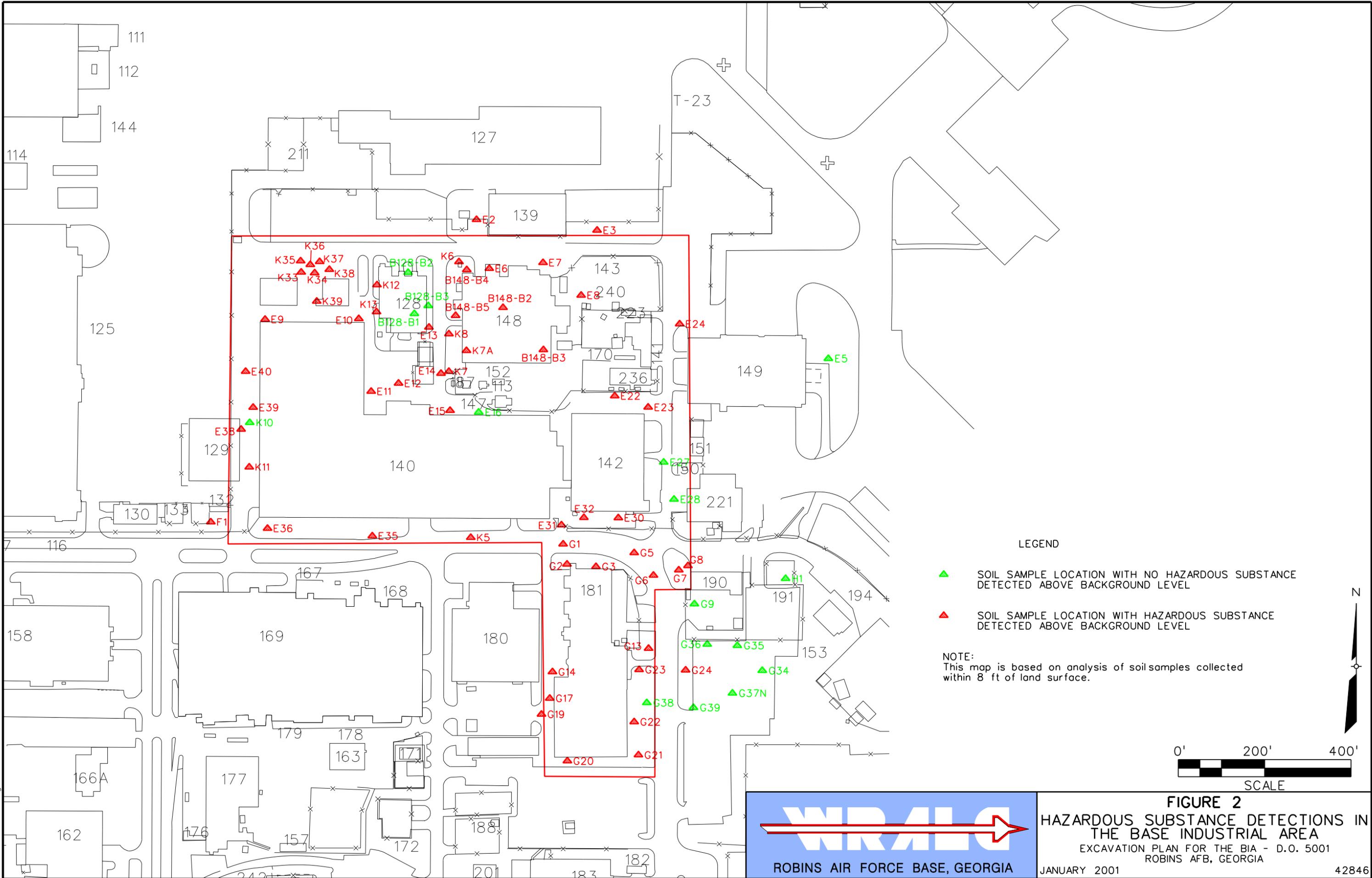



ROBINS AIR FORCE BASE, GEORGIA

FIGURE 1
AREA FOR EXCAVATION PLAN
FOR THE BASE INDUSTRIAL AREA
 EXCAVATION PLAN FOR THE BIA - D.O. 5001
 ROBINS AFB, GEORGIA
 JANUARY 2001 42846

DATE: 25 Jul, 2001 TIME: 0953

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LEGEND

- ▲ SOIL SAMPLE LOCATION WITH NO HAZARDOUS SUBSTANCE DETECTED ABOVE BACKGROUND LEVEL
- ▲ SOIL SAMPLE LOCATION WITH HAZARDOUS SUBSTANCE DETECTED ABOVE BACKGROUND LEVEL

NOTE:
 This map is based on analysis of soil samples collected within 8' ft of land surface.

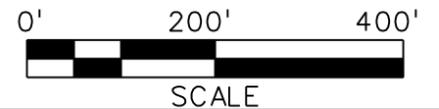
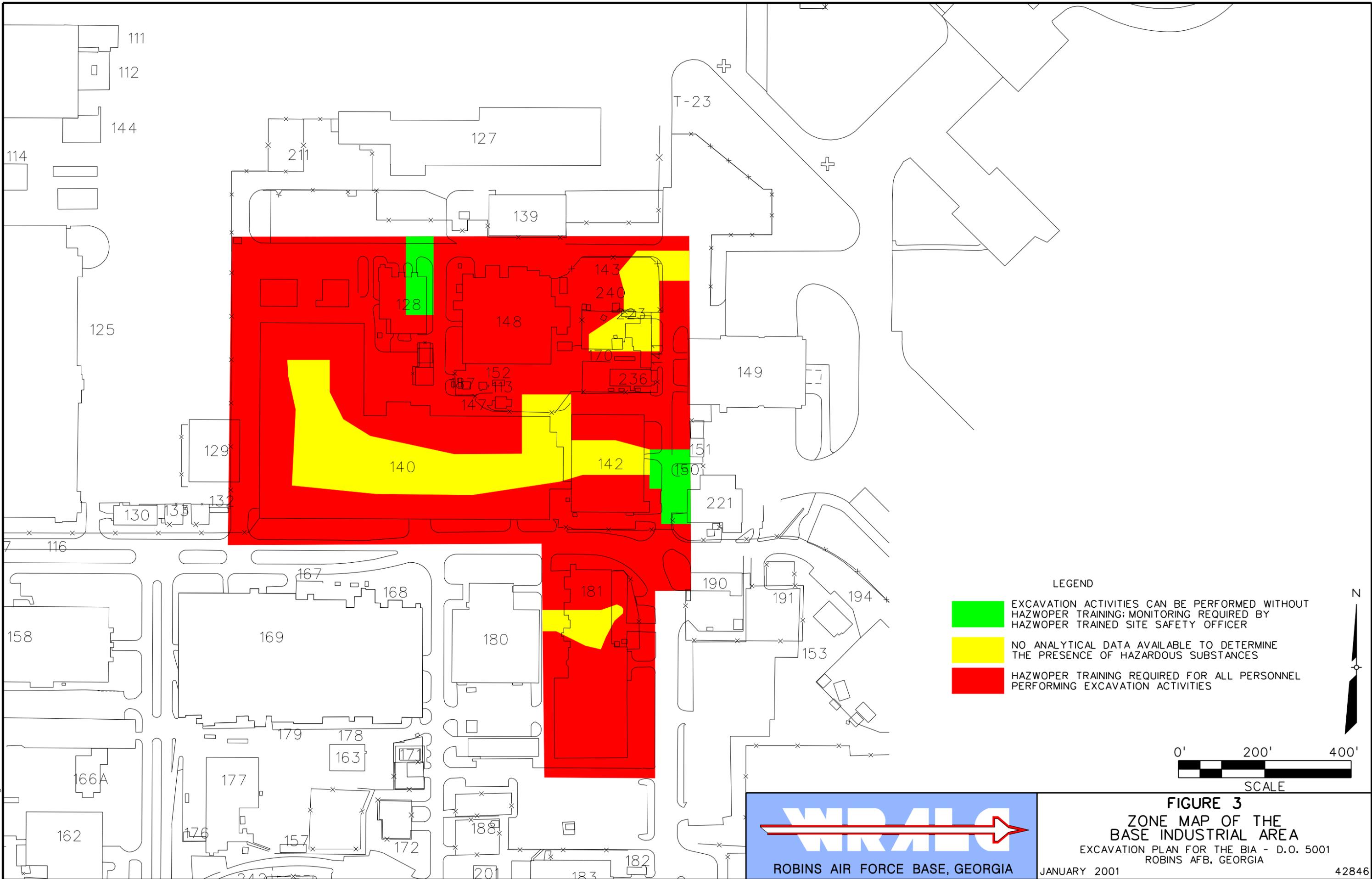


FIGURE 2
HAZARDOUS SUBSTANCE DETECTIONS IN THE BASE INDUSTRIAL AREA
 EXCAVATION PLAN FOR THE BIA - D.O. 5001
 ROBINS AFB, GEORGIA
 JANUARY 2001
 42846

DATE: 25 Jul, 2001 TIME: 0953

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LEGEND

- EXCAVATION ACTIVITIES CAN BE PERFORMED WITHOUT HAZWOPER TRAINING; MONITORING REQUIRED BY HAZWOPER TRAINED SITE SAFETY OFFICER
- NO ANALYTICAL DATA AVAILABLE TO DETERMINE THE PRESENCE OF HAZARDOUS SUBSTANCES
- HAZWOPER TRAINING REQUIRED FOR ALL PERSONNEL PERFORMING EXCAVATION ACTIVITIES



FIGURE 3
ZONE MAP OF THE
BASE INDUSTRIAL AREA
 EXCAVATION PLAN FOR THE BIA - D.O. 5001
 ROBINS AFB, GEORGIA
 JANUARY 2001 42846

Appendix A
Analytical Results

Appendix A
Analytical Data for GBIA Institutional Controls
Earth Tech Project No. 42846

Sample Location	Sample Name	Analytical Method	CAS Number	Chemical Name	Result
E10					
	E10-3S	SW6010	7429-90-5	aluminum	5040
	E10-3S	SW6010	7440-38-2	arsenic	1.6
	E10-3S	SW6010	7440-39-3	barium	18 J
	E10-3S	SW6010	7440-41-7	beryllium	0.093 J
	E10-3S	SW6010	7440-43-9	cadmium	1.1 J
	E10-3S	SW6010	7440-70-2	calcium	800 B
	E10-3S	SW6010	7440-47-3	chromium	13.8
	E10-3S	SW6010	7440-48-4	cobalt	1.3 J
	E10-3S	SW6010	7440-50-8	copper	3.1 B
	E10-3S	SW6010	7439-89-6	iron	7480 B
	E10-3S	SW6010	7439-92-1	lead	17.1 J
	E10-3S	SW6010	7439-95-4	magnesium	137 B
	E10-3S	SW6010	7439-96-5	manganese	56.4
	E10-3S	SW6010	7440-02-0	nickel	1.4 J
	E10-3S	SW6010	7440-09-7	potassium	116 J
	E10-3S	SW6010	7782-49-2	selenium	0.25 J
	E10-3S	SW6010	7440-22-4	silver	0.71 J
	E10-3S	SW6010	7440-23-5	sodium	93.2 B
	E10-3S	SW6010	7440-62-2	vanadium	22.3
	E10-3S	SW6010	7440-66-6	zinc	7.7
	E10-3S	SW7471	7439-97-6	mercury	0.19
	E10-3S	SW8260B	78-93-3	2-butanone (MEK)	2.1 J
	E10-3S	SW8260B	67-64-1	acetone	20 JB
	E10-3S	SW8260B	108-90-7	chlorobenzene	2.1 J
	E10-3S	SW8260B	75-09-2	methylene chloride	0.62 JB
	E10-3S	SW8260B	127-18-4	tetrachloroethene (PCE)	2.9 J
	E10-3S	SW8260B	79-01-6	trichloroethene	2.7 JB
	E10-7S	SW6010	7429-90-5	aluminum	5110
	E10-7S	SW6010	7440-38-2	arsenic	1.5
	E10-7S	SW6010	7440-39-3	barium	6.6 J J
	E10-7S	SW6010	7440-41-7	beryllium	0.054 J
	E10-7S	SW6010	7440-70-2	calcium	352 J
	E10-7S	SW6010	7440-47-3	chromium	12.6
	E10-7S	SW6010	7440-48-4	cobalt	0.21 J
	E10-7S	SW6010	7440-50-8	copper	2.7 B
	E10-7S	SW6010	7439-89-6	iron	8480
	E10-7S	SW6010	7439-92-1	lead	4.5
	E10-7S	SW6010	7439-95-4	magnesium	74.6 B
	E10-7S	SW6010	7439-96-5	manganese	18.3
	E10-7S	SW6010	7440-02-0	nickel	1.2 J
	E10-7S	SW6010	7440-09-7	potassium	71 J
	E10-7S	SW6010	7782-49-2	selenium	0.57
	E10-7S	SW6010	7440-22-4	silver	0.63 J
	E10-7S	SW6010	7440-23-5	sodium	44.8 J
	E10-7S	SW6010	7440-62-2	vanadium	29.4
	E10-7S	SW6010	7440-66-6	zinc	4.0

Appendix A
Analytical Data for GBIA Institutional Controls
Earth Tech Project No. 42846

Sample Location	Sample Name	Analytical Method	CAS Number	Chemical Name	Result
	E10-7S	SW7471	7439-97-6	mercury	0.17
	E10-7S	SW8260B	67-64-1	acetone	6.6 JB
	E10-7S	SW8260B	108-90-7	chlorobenzene	0.56 J
	E10-7S	SW8260B	75-09-2	methylene chloride	0.75 JB
	E10-7S	SW8260B	79-01-6	trichloroethene	0.75 JB
E11					
	E11-3S	SW6010	7429-90-5	aluminum	7840
	E11-3S	SW6010	7440-38-2	arsenic	1.6
	E11-3S	SW6010	7440-39-3	barium	16.1 J
	E11-3S	SW6010	7440-41-7	beryllium	0.1 J
	E11-3S	SW6010	7440-70-2	calcium	127 J
	E11-3S	SW6010	7440-47-3	chromium	11.0
	E11-3S	SW6010	7440-48-4	cobalt	0.56 J
	E11-3S	SW6010	7440-50-8	copper	3.5 B
	E11-3S	SW6010	7439-89-6	iron	10700
	E11-3S	SW6010	7439-92-1	lead	4.7
	E11-3S	SW6010	7439-95-4	magnesium	110 B
	E11-3S	SW6010	7439-96-5	manganese	36.0
	E11-3S	SW6010	7440-02-0	nickel	2.2 J
	E11-3S	SW6010	7440-09-7	potassium	86.4 J
	E11-3S	SW6010	7782-49-2	selenium	0.75
	E11-3S	SW6010	7440-22-4	silver	0.63 J
	E11-3S	SW6010	7440-23-5	sodium	24.1 J
	E11-3S	SW6010	7440-62-2	vanadium	29.8
	E11-3S	SW6010	7440-66-6	zinc	4.0
	E11-3S	SW7471	7439-97-6	mercury	0.024 J
	E11-3S	SW8260B	75-34-3	1,1-dichloroethane	0.9 J
	E11-3S	SW8260B	95-63-6	1,2,4-trimethylbenzene	1.8 J
	E11-3S	SW8260B	108-67-8	1,3,5-trimethylbenzene	0.99 J
	E11-3S	SW8260B	67-64-1	acetone	9.1 JB
	E11-3S	SW8260B	108-90-7	chlorobenzene	0.98 J
	E11-3S	SW8260B	156-59-2	cis-1,2-dichloroethene	98 J
	E11-3S	SW8260B	127-18-4	tetrachloroethene (PCE)	0.78 J
	E11-3S	SW8260B	156-60-5	trans-1,2-dichloroethene	2.3 J
	E11-3S	SW8260B	79-01-6	trichloroethene	820 B
	E11-7S	SW6010	7429-90-5	aluminum	3310
	E11-7S	SW6010	7440-38-2	arsenic	0.86 J
	E11-7S	SW6010	7440-39-3	barium	8.1 J
	E11-7S	SW6010	7440-41-7	beryllium	0.064 J
	E11-7S	SW6010	7440-70-2	calcium	46.5 J
	E11-7S	SW6010	7440-47-3	chromium	8.1
	E11-7S	SW6010	7440-48-4	cobalt	0.3 J
	E11-7S	SW6010	7440-50-8	copper	1.4 B
	E11-7S	SW6010	7439-89-6	iron	4930
	E11-7S	SW6010	7439-92-1	lead	2.2
	E11-7S	SW6010	7439-95-4	magnesium	42.7 B
	E11-7S	SW6010	7439-96-5	manganese	42.7

Appendix A
Analytical Data for GBIA Institutional Controls
Earth Tech Project No. 42846

Sample Location	Sample Name	Analytical Method	CAS Number	Chemical Name	Result
	E11-7S	SW6010	7440-02-0	nickel	0.83 J
	E11-7S	SW6010	7782-49-2	selenium	0.31 J
	E11-7S	SW6010	7440-22-4	silver	0.35 J
	E11-7S	SW6010	7440-23-5	sodium	16.2 J
	E11-7S	SW6010	7440-62-2	vanadium	16.6
	E11-7S	SW6010	7440-66-6	zinc	2.1 J
E12					
	E12-3S	SW6010	7429-90-5	aluminum	6470
	E12-3S	SW6010	7440-38-2	arsenic	1.9
	E12-3S	SW6010	7440-39-3	barium	16.2 J
	E12-3S	SW6010	7440-41-7	beryllium	0.14 J
	E12-3S	SW6010	7440-70-2	calcium	121 J
	E12-3S	SW6010	7440-47-3	chromium	8.8
	E12-3S	SW6010	7440-48-4	cobalt	0.7 J
	E12-3S	SW6010	7440-50-8	copper	2.6 J
	E12-3S	SW6010	7439-89-6	iron	9390
	E12-3S	SW6010	7439-92-1	lead	3.7
	E12-3S	SW6010	7439-95-4	magnesium	107 J
	E12-3S	SW6010	7439-96-5	manganese	44.3
	E12-3S	SW6010	7440-02-0	nickel	1.8 J
	E12-3S	SW6010	7440-09-7	potassium	99 J
	E12-3S	SW6010	7782-49-2	selenium	0.39 J
	E12-3S	SW6010	7440-22-4	silver	0.44 J
	E12-3S	SW6010	7440-23-5	sodium	14.3 J
	E12-3S	SW6010	7440-62-2	vanadium	20.9
	E12-3S	SW6010	7440-66-6	zinc	4.0
	E12-3S	SW7471	7439-97-6	mercury	0.03 J
	E12-7S	SW8260B	78-93-3	2-butanone (MEK)	2.5 J
	E12-7S	SW8260B	67-64-1	acetone	9.9 JB
	E12-7S	SW8260B	108-90-7	chlorobenzene	2.5 J
	E12-7S	SW8260B	156-59-2	cis-1,2-dichloroethene	50
	E12-7S	SW8260B	75-09-2	methylene chloride	1.5 JB
	E12-7S	SW8260B	127-18-4	tetrachloroethene (PCE)	23
	E12-7S	SW8260B	79-01-6	trichloroethene	11
E13					
	E13-3S	SW6010	7429-90-5	aluminum	8870
	E13-3S	SW6010	7440-38-2	arsenic	1.5
	E13-3S	SW6010	7440-39-3	barium	20.3 J
	E13-3S	SW6010	7440-41-7	beryllium	0.13 J
	E13-3S	SW6010	7440-70-2	calcium	235 B
	E13-3S	SW6010	7440-47-3	chromium	10.1
	E13-3S	SW6010	7440-48-4	cobalt	0.74 J
	E13-3S	SW6010	7440-50-8	copper	3.7 B
	E13-3S	SW6010	7439-89-6	iron	8140 B
	E13-3S	SW6010	7439-92-1	lead	4.6
	E13-3S	SW6010	7439-95-4	magnesium	160 B
	E13-3S	SW6010	7439-96-5	manganese	27.9

Appendix A
Analytical Data for GBIA Institutional Controls
Earth Tech Project No. 42846

Sample Location	Sample Name	Analytical Method	CAS Number	Chemical Name	Result
	E13-3S	SW6010	7440-02-0	nickel	2.7 J
	E13-3S	SW6010	7440-09-7	potassium	147 J
	E13-3S	SW6010	7782-49-2	selenium	0.29 J
	E13-3S	SW6010	7440-22-4	silver	0.47 J
	E13-3S	SW6010	7440-23-5	sodium	14.5 B
	E13-3S	SW6010	7440-62-2	vanadium	24.3
	E13-3S	SW6010	7440-66-6	zinc	6.4
	E13-3S	SW7471	7439-97-6	mercury	0.016 J
	E13-7S	SW8260B	95-63-6	1,2,4-trimethylbenzene	16
	E13-7S	SW8260B	108-67-8	1,3,5-trimethylbenzene	4.2 J
	E13-7S	SW8260B	78-93-3	2-butanone (MEK)	3.1 J
	E13-7S	SW8260B	67-64-1	acetone	35 B
	E13-7S	SW8260B	71-43-2	benzene	1.3 J
	E13-7S	SW8260B	108-90-7	chlorobenzene	9.0
	E13-7S	SW8260B	156-59-2	cis-1,2-dichloroethene	0.94 J
	E13-7S	SW8260B	100-41-4	ethylbenzene	2.2 J
	E13-7S	SW8260B	98-82-8	isopropylbenzene	4.5 J
	E13-7S	SW8260B	75-09-2	methylene chloride	0.88 JB
	E13-7S	SW8260B	104-51-8	n-butylbenzene	2.8 J
	E13-7S	SW8260B	103-65-1	n-propylbenzene	11
	E13-7S	SW8260B	1330-20-7	xylene	1.7 J
E14					
	E14-3S	SW6010	7429-90-5	aluminum	9720
	E14-3S	SW6010	7440-38-2	arsenic	1.3
	E14-3S	SW6010	7440-39-3	barium	24.1
	E14-3S	SW6010	7440-41-7	beryllium	0.12 J
	E14-3S	SW6010	7440-43-9	cadmium	0.24 J
	E14-3S	SW6010	7440-70-2	calcium	211 B
	E14-3S	SW6010	7440-47-3	chromium	10.5
	E14-3S	SW6010	7440-48-4	cobalt	0.75 J
	E14-3S	SW6010	7440-50-8	copper	5.2 B
	E14-3S	SW6010	7439-89-6	iron	9190 B
	E14-3S	SW6010	7439-92-1	lead	7.6
	E14-3S	SW6010	7439-95-4	magnesium	134 B
	E14-3S	SW6010	7439-96-5	manganese	64.4
	E14-3S	SW6010	7440-02-0	nickel	2.6 J
	E14-3S	SW6010	7440-09-7	potassium	109 J
	E14-3S	SW6010	7782-49-2	selenium	0.62
	E14-3S	SW6010	7440-22-4	silver	0.49 J
	E14-3S	SW6010	7440-23-5	sodium	26.1 B
	E14-3S	SW6010	7440-62-2	vanadium	23.7
	E14-3S	SW6010	7440-66-6	zinc	6.7
	E14-3S	SW7471	7439-97-6	mercury	0.033 J
	E14-7S	SW6010	7429-90-5	aluminum	3060
	E14-7S	SW6010	7440-38-2	arsenic	0.44 J
	E14-7S	SW6010	7440-39-3	barium	5.5 J
	E14-7S	SW6010	7440-70-2	calcium	41.1 B

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Sample Location	Sample Name	Analytical Method	CAS Number	Chemical Name	Result
	E14-7S	SW6010	7440-47-3	chromium	3.8
	E14-7S	SW6010	7440-50-8	copper	1.8 B
	E14-7S	SW6010	7439-89-6	iron	2350 B
	E14-7S	SW6010	7439-92-1	lead	4.0
	E14-7S	SW6010	7439-95-4	magnesium	55.3 B
	E14-7S	SW6010	7439-96-5	manganese	3.4
	E14-7S	SW6010	7440-02-0	nickel	0.57 J
	E14-7S	SW6010	7440-09-7	potassium	37.9 J
	E14-7S	SW6010	7440-22-4	silver	0.13 J
	E14-7S	SW6010	7440-23-5	sodium	12.3 B
	E14-7S	SW6010	7440-62-2	vanadium	8.3
	E14-7S	SW6010	7440-66-6	zinc	2.4
	E14-7S	SW8260B	95-63-6	1,2,4-trimethylbenzene	0.75 J
	E14-7S	SW8260B	78-93-3	2-butanone (MEK)	3.2 J
	E14-7S	SW8260B	67-64-1	acetone	45 B
	E14-7S	SW8260B	71-43-2	benzene	0.46 J
	E14-7S	SW8260B	75-15-0	carbon disulfide	0.65 J
	E14-7S	SW8260B	108-90-7	chlorobenzene	1.7 J
	E14-7S	SW8260B	156-59-2	cis-1,2-dichloroethene	0.68 J
	E14-7S	SW8260B	75-09-2	methylene chloride	0.75 JB
E2					
	E2-3S	SW6010	7429-90-5	aluminum	9560 J
	E2-3S	SW6010	7440-38-2	arsenic	1.7
	E2-3S	SW6010	7440-39-3	barium	21.7 J
	E2-3S	SW6010	7440-41-7	beryllium	0.15 J
	E2-3S	SW6010	7440-70-2	calcium	183 J
	E2-3S	SW6010	7440-47-3	chromium	19.4 J
	E2-3S	SW6010	7440-48-4	cobalt	0.73 J
	E2-3S	SW6010	7440-50-8	copper	3.3 B
	E2-3S	SW6010	7439-89-6	iron	9120
	E2-3S	SW6010	7439-92-1	lead	5.2
	E2-3S	SW6010	7439-95-4	magnesium	157 B
	E2-3S	SW6010	7439-96-5	manganese	45.3
	E2-3S	SW6010	7440-02-0	nickel	2.6 J
	E2-3S	SW6010	7440-09-7	potassium	136 J
	E2-3S	SW6010	7782-49-2	selenium	0.5 J
	E2-3S	SW6010	7440-22-4	silver	0.57 J
	E2-3S	SW6010	7440-23-5	sodium	22.5 J
	E2-3S	SW6010	7440-28-0	thallium	0.28 J
	E2-3S	SW6010	7440-62-2	vanadium	27.3
	E2-3S	SW6010	7440-66-6	zinc	5 J
	E2-3S	SW7471	7439-97-6	mercury	0.024 J
	E2-3S	SW8260B	67-64-1	acetone	20 JB
	E2-3S	SW8260B	108-90-7	chlorobenzene	2.3 J
	E2-3S	SW8260B	156-59-2	cis-1,2-dichloroethene	4.6 J
	E2-3S	SW8260B	75-09-2	methylene chloride	0.44 JB
	E2-3S	SW8260B	156-60-5	trans-1,2-dichloroethene	0.6 J

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	E2-3S	SW8260B	79-01-6	trichloroethene	4.9 JB
E22					
	E22-3S	SW6010	7429-90-5	aluminum	2730
	E22-3S	SW6010	7440-38-2	arsenic	1.2 J
	E22-3S	SW6010	7440-39-3	barium	18.8 J
	E22-3S	SW6010	7440-41-7	beryllium	0.14 J
	E22-3S	SW6010	7440-70-2	calcium	103 J
	E22-3S	SW6010	7440-47-3	chromium	3.7
	E22-3S	SW6010	7440-48-4	cobalt	0.83 J
	E22-3S	SW6010	7440-50-8	copper	1 J
	E22-3S	SW6010	7439-89-6	iron	3380
	E22-3S	SW6010	7439-92-1	lead	3.9
	E22-3S	SW6010	7439-95-4	magnesium	54.6 J
	E22-3S	SW6010	7439-96-5	manganese	95.7
	E22-3S	SW6010	7440-02-0	nickel	0.84 J
	E22-3S	SW6010	7440-09-7	potassium	65.5 J
	E22-3S	SW6010	7782-49-2	selenium	0.24 J
	E22-3S	SW6010	7440-22-4	silver	0.085 J
	E22-3S	SW6010	7440-23-5	sodium	7.6 J
	E22-3S	SW6010	7440-62-2	vanadium	8 J
	E22-3S	SW6010	7440-66-6	zinc	2.3 J
	E22-3S	SW7471	7439-97-6	mercury	0.023 J
	E22-3S	SW8260B	71-55-6	1,1,1-trichloroethane	13 J
	E22-3S	SW8260B	75-34-3	1,1-dichloroethane	0.42 J
	E22-3S	SW8260B	67-64-1	acetone	77 JB
	E22-3S	SW8260B	75-09-2	methylene chloride	1.2 JB
	E22-3S	SW8260B	127-18-4	tetrachloroethene (PCE)	1.9 J
	E22-3S	SW8260B	79-01-6	trichloroethene	19 J
	E22-7S	SW6010	7429-90-5	aluminum	1110
	E22-7S	SW6010	7440-38-2	arsenic	0.29 J
	E22-7S	SW6010	7440-39-3	barium	8.8 J
	E22-7S	SW6010	7440-41-7	beryllium	0.05 J
	E22-7S	SW6010	7440-70-2	calcium	33.1 J
	E22-7S	SW6010	7440-47-3	chromium	1.2
	E22-7S	SW6010	7440-48-4	cobalt	0.48 J
	E22-7S	SW6010	7440-50-8	copper	0.6 J
	E22-7S	SW6010	7439-89-6	iron	1100
	E22-7S	SW6010	7439-92-1	lead	1.5
	E22-7S	SW6010	7439-95-4	magnesium	61.5 J
	E22-7S	SW6010	7439-96-5	manganese	27.6
	E22-7S	SW6010	7440-02-0	nickel	0.63 J
	E22-7S	SW6010	7440-09-7	potassium	43.1 J
	E22-7S	SW6010	7782-49-2	selenium	0.16 J
	E22-7S	SW6010	7440-23-5	sodium	4.9 J
	E22-7S	SW6010	7440-62-2	vanadium	2.5 J
	E22-7S	SW6010	7440-66-6	zinc	1.8 J
	E22-7S	SW7471	7439-97-6	mercury	0.012 J

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	E22-7S	SW8260B	78-93-3	2-butanone (MEK)	1.5 J
	E22-7S	SW8260B	67-64-1	acetone	11 JB
	E22-7S	SW8260B	75-09-2	methylene chloride	1.4 JB
	E22-7S	SW8260B	79-01-6	trichloroethene	0.53 J
E23					
	E23-3S	SW6010	7429-90-5	aluminum	7110
	E23-3S	SW6010	7440-38-2	arsenic	1.6
	E23-3S	SW6010	7440-39-3	barium	27.5
	E23-3S	SW6010	7440-41-7	beryllium	0.17 J
	E23-3S	SW6010	7440-70-2	calcium	186 J
	E23-3S	SW6010	7440-47-3	chromium	8.3
	E23-3S	SW6010	7440-48-4	cobalt	1.3 J
	E23-3S	SW6010	7440-50-8	copper	2.5 B
	E23-3S	SW6010	7439-89-6	iron	7530
	E23-3S	SW6010	7439-92-1	lead	4.3
	E23-3S	SW6010	7439-95-4	magnesium	140 B
	E23-3S	SW6010	7439-96-5	manganese	64.6
	E23-3S	SW6010	7440-02-0	nickel	2.3 J
	E23-3S	SW6010	7440-09-7	potassium	140 J
	E23-3S	SW6010	7782-49-2	selenium	0.51 J
	E23-3S	SW6010	7440-22-4	silver	0.33 J
	E23-3S	SW6010	7440-23-5	sodium	19.5 J
	E23-3S	SW6010	7440-62-2	vanadium	17.5
	E23-3S	SW6010	7440-66-6	zinc	5.0
	E23-3S	SW7471	7439-97-6	mercury	0.025 J
	E23-8S	SW8260B	67-64-1	acetone	6.0 JB
	E23-8S	SW8260B	108-90-7	chlorobenzene	0.53 J
	E23-8S	SW8260B	75-09-2	methylene chloride	1.4 JB
	E23-8S	SW8260B	79-01-6	trichloroethene	1.6 J
E24					
	E24-3S	SW6010	7429-90-5	aluminum	5700
	E24-3S	SW6010	7440-38-2	arsenic	1.8
	E24-3S	SW6010	7440-39-3	barium	19.2 J
	E24-3S	SW6010	7440-41-7	beryllium	0.13 J
	E24-3S	SW6010	7440-70-2	calcium	143 J
	E24-3S	SW6010	7440-47-3	chromium	8.0
	E24-3S	SW6010	7440-48-4	cobalt	0.63 J
	E24-3S	SW6010	7440-50-8	copper	2.1 J
	E24-3S	SW6010	7439-89-6	iron	7320
	E24-3S	SW6010	7439-92-1	lead	3.6
	E24-3S	SW6010	7439-95-4	magnesium	100 J
	E24-3S	SW6010	7439-96-5	manganese	51.4 J
	E24-3S	SW6010	7440-02-0	nickel	1.6 J
	E24-3S	SW6010	7440-09-7	potassium	101 J
	E24-3S	SW6010	7782-49-2	selenium	0.3 J
	E24-3S	SW6010	7440-22-4	silver	0.41 J
	E24-3S	SW6010	7440-23-5	sodium	6.8 J

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	E24-3S	SW6010	7440-62-2	vanadium	20 J
	E24-3S	SW6010	7440-66-6	zinc	3.8
	E24-3S	SW7471	7439-97-6	mercury	0.026 J
	E24-3S	SW8260B	67-64-1	acetone	22 JB
	E24-3S	SW8260B	108-90-7	chlorobenzene	0.52 J
	E24-3S	SW8260B	75-09-2	methylene chloride	1.4 JB
E28					
	E28-7S	SW8260B	67-64-1	acetone	4.5 JB
	E28-7S	SW8260B	75-09-2	methylene chloride	1.3 JB
E3					
	E3-3S	SW6010	7429-90-5	aluminum	3740
	E3-3S	SW6010	7440-38-2	arsenic	1.5
	E3-3S	SW6010	7440-39-3	barium	19.2 J
	E3-3S	SW6010	7440-41-7	beryllium	0.13 J
	E3-3S	SW6010	7440-70-2	calcium	269 J
	E3-3S	SW6010	7440-47-3	chromium	9.9
	E3-3S	SW6010	7440-48-4	cobalt	0.71 J
	E3-3S	SW6010	7440-50-8	copper	3.1
	E3-3S	SW6010	7439-89-6	iron	6930
	E3-3S	SW6010	7439-92-1	lead	5.2
	E3-3S	SW6010	7439-95-4	magnesium	155 J
	E3-3S	SW6010	7439-96-5	manganese	69.5
	E3-3S	SW6010	7440-02-0	nickel	1.7 J
	E3-3S	SW6010	7440-09-7	potassium	153 J
	E3-3S	SW6010	7782-49-2	selenium	0.14 J
	E3-3S	SW6010	7440-22-4	silver	0.42 J
	E3-3S	SW6010	7440-23-5	sodium	12.8 J
	E3-3S	SW6010	7440-62-2	vanadium	21.5
	E3-3S	SW6010	7440-66-6	zinc	4.1
	E3-3S	SW7471	7439-97-6	mercury	0.021 J
	E3-3S	SW8260B	78-93-3	2-butanone (MEK)	2.9 J
	E3-3S	SW8260B	67-64-1	acetone	36 B
	E3-3S	SW8260B	75-09-2	methylene chloride	2.2 JB
	E3-7S	SW8260B	67-64-1	acetone	9.8 JB
	E3-7S	SW8260B	108-90-7	chlorobenzene	0.68 J
	E3-7S	SW8260B	75-09-2	methylene chloride	2.4 JB
	E3-7S	SW8260B	79-01-6	trichloroethene	4.7 J
E30					
	E30-7S	SW6010	7429-90-5	aluminum	7200
	E30-7S	SW6010	7440-38-2	arsenic	0.66 J
	E30-7S	SW6010	7440-39-3	barium	12.8 J
	E30-7S	SW6010	7440-41-7	beryllium	0.05 J
	E30-7S	SW6010	7440-70-2	calcium	137 J
	E30-7S	SW6010	7440-47-3	chromium	4.7
	E30-7S	SW6010	7440-48-4	cobalt	0.2 J
	E30-7S	SW6010	7440-50-8	copper	3.2 J
	E30-7S	SW6010	7439-89-6	iron	862

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	E30-7S	SW6010	7439-92-1	lead	5.8
	E30-7S	SW6010	7439-95-4	magnesium	51.2 J
	E30-7S	SW6010	7439-96-5	manganese	2.2 J
	E30-7S	SW6010	7440-02-0	nickel	1.1 J
	E30-7S	SW6010	7440-09-7	potassium	117 J
	E30-7S	SW6010	7782-49-2	selenium	0.12 J
	E30-7S	SW6010	7440-22-4	silver	0.39 J
	E30-7S	SW6010	7440-23-5	sodium	16.1 J
	E30-7S	SW6010	7440-62-2	vanadium	20.4
	E30-7S	SW6010	7440-66-6	zinc	5.4
	E30-7S	SW7471	7439-97-6	mercury	0.041 J
	E30-7S	SW8260B	95-63-6	1,2,4-trimethylbenzene	24
	E30-7S	SW8260B	108-67-8	1,3,5-trimethylbenzene	7.1
	E30-7S	SW8260B	67-64-1	acetone	6.1 JB
	E30-7S	SW8260B	71-43-2	benzene	1.2 J
	E30-7S	SW8260B	100-41-4	ethylbenzene	2.5 J
	E30-7S	SW8260B	98-82-8	isopropylbenzene	2.2 J
	E30-7S	SW8260B	75-09-2	methylene chloride	1.6 JB
	E30-7S	SW8260B	104-51-8	n-butylbenzene	0.75 J
	E30-7S	SW8260B	103-65-1	n-propylbenzene	2.7 J
	E30-7S	SW8260B	108-88-3	toluene	2 J
	E30-7S	SW8260B	1330-20-7	xylene	18
E31					
	E31-3S	SW6010	7429-90-5	aluminum	8990
	E31-3S	SW6010	7440-38-2	arsenic	0.69 J
	E31-3S	SW6010	7440-39-3	barium	13.1 J
	E31-3S	SW6010	7440-41-7	beryllium	0.052 J
	E31-3S	SW6010	7440-70-2	calcium	61.8 J
	E31-3S	SW6010	7440-47-3	chromium	9.9
	E31-3S	SW6010	7440-48-4	cobalt	0.34 J
	E31-3S	SW6010	7440-50-8	copper	4 B
	E31-3S	SW6010	7439-89-6	iron	2290
	E31-3S	SW6010	7439-92-1	lead	3.5
	E31-3S	SW6010	7439-95-4	magnesium	150 B
	E31-3S	SW6010	7439-96-5	manganese	3.8
	E31-3S	SW6010	7440-02-0	nickel	2.5 J
	E31-3S	SW6010	7440-09-7	potassium	133 J
	E31-3S	SW6010	7782-49-2	selenium	0.19 J
	E31-3S	SW6010	7440-22-4	silver	0.39 J
	E31-3S	SW6010	7440-23-5	sodium	52.1 J
	E31-3S	SW6010	7440-62-2	vanadium	19.5
	E31-3S	SW6010	7440-66-6	zinc	4.6
	E31-3S	SW7471	7439-97-6	mercury	0.068 J
	E31-3S	SW8260B	67-64-1	acetone	5.1 JB
	E31-3S	SW8260B	156-59-2	cis-1,2-dichloroethene	0.55 J
	E31-3S	SW8260B	75-09-2	methylene chloride	1.4 JB
	E31-3S	SW8260B	79-01-6	trichloroethene	1.3 J

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	E31-7S	SW6010	7429-90-5	aluminum	6070
	E31-7S	SW6010	7440-38-2	arsenic	0.42 J
	E31-7S	SW6010	7440-39-3	barium	5.9 J
	E31-7S	SW6010	7440-70-2	calcium	22.3 J
	E31-7S	SW6010	7440-47-3	chromium	3.7
	E31-7S	SW6010	7440-50-8	copper	3.3 B
	E31-7S	SW6010	7439-89-6	iron	1870
	E31-7S	SW6010	7439-92-1	lead	3.6
	E31-7S	SW6010	7439-95-4	magnesium	56.9 B
	E31-7S	SW6010	7439-96-5	manganese	2.5
	E31-7S	SW6010	7440-02-0	nickel	0.95 J
	E31-7S	SW6010	7440-09-7	potassium	73.3 J
	E31-7S	SW6010	7782-49-2	selenium	0.16 J
	E31-7S	SW6010	7440-22-4	silver	0.36 J
	E31-7S	SW6010	7440-23-5	sodium	73.5 J
	E31-7S	SW6010	7440-62-2	vanadium	19.1
	E31-7S	SW6010	7440-66-6	zinc	2.4
	E31-7S	SW8260B	67-64-1	acetone	3.9 JB
	E31-7S	SW8260B	71-43-2	benzene	0.37 J
	E31-7S	SW8260B	75-09-2	methylene chloride	1.3 JB
	E31-7S	SW8260B	79-01-6	trichloroethene	3.4 J
E32					
	E32-3S	SW6010	7429-90-5	aluminum	6650
	E32-3S	SW6010	7440-38-2	arsenic	0.76 J
	E32-3S	SW6010	7440-39-3	barium	11.7 J
	E32-3S	SW6010	7440-41-7	beryllium	0.047 J
	E32-3S	SW6010	7440-70-2	calcium	189 J
	E32-3S	SW6010	7440-47-3	chromium	8.4
	E32-3S	SW6010	7440-48-4	cobalt	0.25 J
	E32-3S	SW6010	7440-50-8	copper	3.4 B
	E32-3S	SW6010	7439-89-6	iron	4010
	E32-3S	SW6010	7439-92-1	lead	5.4
	E32-3S	SW6010	7439-95-4	magnesium	87.5 B
	E32-3S	SW6010	7439-96-5	manganese	4.8
	E32-3S	SW6010	7440-02-0	nickel	2 J
	E32-3S	SW6010	7440-09-7	potassium	72 J
	E32-3S	SW6010	7782-49-2	selenium	0.23 J
	E32-3S	SW6010	7440-22-4	silver	0.43 J
	E32-3S	SW6010	7440-23-5	sodium	14.2 J
	E32-3S	SW6010	7440-62-2	vanadium	18.6
	E32-3S	SW6010	7440-66-6	zinc	11.2
	E32-3S	SW7471	7439-97-6	mercury	0.029 J
	E32-3S	SW8260B	67-64-1	acetone	11 JB
	E32-3S	SW8260B	75-09-2	methylene chloride	2.7 JB
	E32-3S	SW8260B	79-01-6	trichloroethene	0.55 J
E35					
	E35-3S	SW8260B	67-64-1	acetone	20 J

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Sample Location	Sample Name	Analytical Method	CAS Number	Chemical Name	Result
	E35-3S	SW8260B	71-43-2	benzene	0.69 J
	E35-3S	SW8260B	108-90-7	chlorobenzene	1.1 J
	E35-3S	SW8260B	75-09-2	methylene chloride	1.4 JB
E36					
	E36-3S	SW6010	7429-90-5	aluminum	3020 B
	E36-3S	SW6010	7440-38-2	arsenic	1.1 J
	E36-3S	SW6010	7440-39-3	barium	65.0
	E36-3S	SW6010	7440-41-7	beryllium	0.18 J
	E36-3S	SW6010	7440-70-2	calcium	309 B
	E36-3S	SW6010	7440-47-3	chromium	2.9 B
	E36-3S	SW6010	7440-48-4	cobalt	1.3 J
	E36-3S	SW6010	7440-50-8	copper	2.1 J
	E36-3S	SW6010	7439-89-6	iron	2830 B
	E36-3S	SW6010	7439-92-1	lead	5.7
	E36-3S	SW6010	7439-95-4	magnesium	98.9 B
	E36-3S	SW6010	7439-96-5	manganese	191
	E36-3S	SW6010	7440-02-0	nickel	0.92 B
	E36-3S	SW6010	7782-49-2	selenium	0.64 J
	E36-3S	SW6010	7440-22-4	silver	0.12 J
	E36-3S	SW6010	7440-23-5	sodium	47.6 B
	E36-3S	SW6010	7440-62-2	vanadium	6.5 J
	E36-3S	SW6010	7440-66-6	zinc	1.7 J
	E36-3S	SW7471	7439-97-6	mercury	0.032 B
	E36-3S	SW8260B	71-55-6	1,1,1-trichloroethane	1.7 J
	E36-3S	SW8260B	79-34-5	1,1,2,2-tetrachloroethane	1.3 J
	E36-3S	SW8260B	79-00-5	1,1,2-trichloroethane	2.5 J
	E36-3S	SW8260B	78-93-3	2-butanone (MEK)	1.5 J
	E36-3S	SW8260B	67-64-1	acetone	880 J
	E36-3S	SW8260B	108-90-7	chlorobenzene	0.35 J
	E36-3S	SW8260B	156-59-2	cis-1,2-dichloroethene	0.25 J
	E36-3S	SW8260B	75-09-2	methylene chloride	0.6 JB
	E36-3S	SW8260B	127-18-4	tetrachloroethene (PCE)	45 J
	E36-3S	SW8260B	79-01-6	trichloroethene	46 J
E38					
	E38-3S	SW6010	7429-90-5	aluminum	2670 B
	E38-3S	SW6010	7440-38-2	arsenic	0.7 J
	E38-3S	SW6010	7440-39-3	barium	20.8 J
	E38-3S	SW6010	7440-41-7	beryllium	0.087 J
	E38-3S	SW6010	7440-70-2	calcium	103 B
	E38-3S	SW6010	7440-47-3	chromium	4.4 B
	E38-3S	SW6010	7440-48-4	cobalt	0.42 J
	E38-3S	SW6010	7440-50-8	copper	1.8 J
	E38-3S	SW6010	7439-89-6	iron	4800 B
	E38-3S	SW6010	7439-92-1	lead	2.7
	E38-3S	SW6010	7439-95-4	magnesium	35.4 B
	E38-3S	SW6010	7439-96-5	manganese	111
	E38-3S	SW6010	7440-02-0	nickel	0.56 B

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Sample Location	Sample Name	Analytical Method	CAS Number	Chemical Name	Result
	E38-3S	SW6010	7440-09-7	potassium	27 J
	E38-3S	SW6010	7782-49-2	selenium	0.87
	E38-3S	SW6010	7440-22-4	silver	0.22 J
	E38-3S	SW6010	7440-23-5	sodium	4.5 B
	E38-3S	SW6010	7440-62-2	vanadium	10.3
	E38-3S	SW7471	7439-97-6	mercury	0.027 B
	E38-3S	SW8260B	75-34-3	1,1-dichloroethane	2.1 J
	E38-3S	SW8260B	78-93-3	2-butanone (MEK)	6 J
	E38-3S	SW8260B	67-64-1	acetone	130 JB
	E38-3S	SW8260B	156-59-2	cis-1,2-dichloroethene	63 J
	E38-3S	SW8260B	75-09-2	methylene chloride	1.5 JB
	E38-3S	SW8260B	156-60-5	trans-1,2-dichloroethene	4.1 J
	E38-3S	SW8260B	79-01-6	trichloroethene	70 J
	E38-7S	SW6010	7429-90-5	aluminum	1680 B
	E38-7S	SW6010	7440-38-2	arsenic	0.63 J
	E38-7S	SW6010	7440-39-3	barium	3.7 J
	E38-7S	SW6010	7440-41-7	beryllium	0.042 J
	E38-7S	SW6010	7440-70-2	calcium	35.7 B
	E38-7S	SW6010	7440-47-3	chromium	2.8 B
	E38-7S	SW6010	7440-50-8	copper	0.85 J
	E38-7S	SW6010	7439-89-6	iron	2840 B
	E38-7S	SW6010	7439-92-1	lead	2.0
	E38-7S	SW6010	7439-95-4	magnesium	30.4 B
	E38-7S	SW6010	7439-96-5	manganese	6.4
	E38-7S	SW6010	7440-02-0	nickel	0.43 B
	E38-7S	SW6010	7782-49-2	selenium	0.43 J
	E38-7S	SW6010	7440-22-4	silver	0.17 J
	E38-7S	SW6010	7440-23-5	sodium	5.7 B
	E38-7S	SW6010	7440-62-2	vanadium	8.0
	E38-7S	SW7471	7439-97-6	mercury	0.012 B
E39					
	E39-3S	SW6010	7429-90-5	aluminum	12500 B
	E39-3S	SW6010	7440-38-2	arsenic	1.4
	E39-3S	SW6010	7440-39-3	barium	21.3 J
	E39-3S	SW6010	7440-41-7	beryllium	0.16 J
	E39-3S	SW6010	7440-43-9	cadmium	0.22 J
	E39-3S	SW6010	7440-70-2	calcium	149 B
	E39-3S	SW6010	7440-47-3	chromium	12.0
	E39-3S	SW6010	7440-48-4	cobalt	1.1 J
	E39-3S	SW6010	7440-50-8	copper	5.0
	E39-3S	SW6010	7439-89-6	iron	9170
	E39-3S	SW6010	7439-92-1	lead	5.4 B
	E39-3S	SW6010	7439-95-4	magnesium	195 J
	E39-3S	SW6010	7439-96-5	manganese	80.0
	E39-3S	SW6010	7440-02-0	nickel	4 J
	E39-3S	SW6010	7440-09-7	potassium	204 J
	E39-3S	SW6010	7782-49-2	selenium	1.1

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Sample Location	Sample Name	Analytical Method	CAS Number	Chemical Name	Result	
	E39-3S	SW6010	7440-22-4	silver	0.53	J
	E39-3S	SW6010	7440-23-5	sodium	20.9	B
	E39-3S	SW6010	7440-62-2	vanadium	23.7	
	E39-3S	SW6010	7440-66-6	zinc	7.1	
	E39-3S	SW7471	7439-97-6	mercury	0.03	J
	E39-3S	SW8260B	67-64-1	acetone	14	JB
	E39-3S	SW8260B	108-90-7	chlorobenzene	0.28	J
	E39-3S	SW8260B	67-66-3	chloroform	0.13	J
	E39-3S	SW8260B	75-09-2	methylene chloride	3	JB
	E39-3S	SW8260B	127-18-4	tetrachloroethene (PCE)	0.46	J
	E39-3S	SW8260B	79-01-6	trichloroethene	1.1	J
	E39-7S	SW6010	7429-90-5	aluminum	4570	B
	E39-7S	SW6010	7440-38-2	arsenic	1	J
	E39-7S	SW6010	7440-39-3	barium	4.9	J
	E39-7S	SW6010	7440-41-7	beryllium	0.055	J
	E39-7S	SW6010	7440-70-2	calcium	34.8	B
	E39-7S	SW6010	7440-47-3	chromium	6.0	
	E39-7S	SW6010	7440-48-4	cobalt	0.29	J
	E39-7S	SW6010	7440-50-8	copper	1.6	J
	E39-7S	SW6010	7439-89-6	iron	4980	
	E39-7S	SW6010	7439-92-1	lead	3.9	B
	E39-7S	SW6010	7439-95-4	magnesium	86.3	J
	E39-7S	SW6010	7439-96-5	manganese	10.0	
	E39-7S	SW6010	7440-02-0	nickel	1.4	J
	E39-7S	SW6010	7440-09-7	potassium	104	J
	E39-7S	SW6010	7782-49-2	selenium	0.39	J
	E39-7S	SW6010	7440-22-4	silver	0.24	J
	E39-7S	SW6010	7440-23-5	sodium	14.7	B
	E39-7S	SW6010	7440-62-2	vanadium	11.4	
	E39-7S	SW6010	7440-66-6	zinc	3.0	
	E39-7S	SW7471	7439-97-6	mercury	0.0056	J
E40						
	E40-3S	SW8260B	71-55-6	1,1,1-trichloroethane	1.4	J
	E40-3S	SW8260B	67-64-1	acetone	130	JB
	E40-3S	SW8260B	75-09-2	methylene chloride	3	JB
	E40-3S	SW8260B	127-18-4	tetrachloroethene (PCE)	2.6	J
	E40-3S	SW8260B	79-01-6	trichloroethene	7.7	J
	E40-7S	SW6010	7429-90-5	aluminum	3020	B
	E40-7S	SW6010	7440-38-2	arsenic	1.1	J
	E40-7S	SW6010	7440-39-3	barium	4.1	J
	E40-7S	SW6010	7440-41-7	beryllium	0.041	J
	E40-7S	SW6010	7440-70-2	calcium	347	B
	E40-7S	SW6010	7440-47-3	chromium	10.3	B
	E40-7S	SW6010	7440-50-8	copper	1.6	J
	E40-7S	SW6010	7439-89-6	iron	7040	B
	E40-7S	SW6010	7439-92-1	lead	3.3	
	E40-7S	SW6010	7439-95-4	magnesium	28	B

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Sample Location	Sample Name	Analytical Method	CAS Number	Chemical Name	Result
	E40-7S	SW6010	7439-96-5	manganese	5.2
	E40-7S	SW6010	7440-02-0	nickel	0.4 B
	E40-7S	SW6010	7440-09-7	potassium	36.3 J
	E40-7S	SW6010	7782-49-2	selenium	1.0
	E40-7S	SW6010	7440-22-4	silver	0.61 J
	E40-7S	SW6010	7440-23-5	sodium	4.8 B
	E40-7S	SW6010	7440-62-2	vanadium	28.0
	E40-7S	SW7471	7439-97-6	mercury	0.019 B
E5					
	E5-3S	SW6010	7429-90-5	aluminum	1760
	E5-3S	SW6010	7440-38-2	arsenic	0.62 J
	E5-3S	SW6010	7440-39-3	barium	15.5 J
	E5-3S	SW6010	7440-41-7	beryllium	0.078 J
	E5-3S	SW6010	7440-70-2	calcium	470 J
	E5-3S	SW6010	7440-47-3	chromium	5.0
	E5-3S	SW6010	7440-48-4	cobalt	0.32 J
	E5-3S	SW6010	7440-50-8	copper	1.4 J
	E5-3S	SW6010	7439-89-6	iron	1850
	E5-3S	SW6010	7439-92-1	lead	14.9
	E5-3S	SW6010	7439-95-4	magnesium	53 J
	E5-3S	SW6010	7439-96-5	manganese	36.7
	E5-3S	SW6010	7440-02-0	nickel	0.46 J
	E5-3S	SW6010	7440-09-7	potassium	45.8 J
	E5-3S	SW6010	7782-49-2	selenium	0.11 J
	E5-3S	SW6010	7440-22-4	silver	0.17 J
	E5-3S	SW6010	7440-23-5	sodium	18.5 J
	E5-3S	SW6010	7440-62-2	vanadium	9.9
	E5-3S	SW6010	7440-66-6	zinc	3.8
	E5-3S	SW7471	7439-97-6	mercury	0.022 J
	E5-3S	SW8260B	67-64-1	acetone	28 B
	E5-3S	SW8260B	75-09-2	methylene chloride	1.1 JB
E6					
	E6-3S	SW6010	7429-90-5	aluminum	10900
	E6-3S	SW6010	7440-38-2	arsenic	2.3
	E6-3S	SW6010	7440-39-3	barium	25.7
	E6-3S	SW6010	7440-41-7	beryllium	0.2 J
	E6-3S	SW6010	7440-70-2	calcium	132 B
	E6-3S	SW6010	7440-47-3	chromium	12.8
	E6-3S	SW6010	7440-48-4	cobalt	0.99 J
	E6-3S	SW6010	7440-50-8	copper	5.6
	E6-3S	SW6010	7439-89-6	iron	12500 B
	E6-3S	SW6010	7439-92-1	lead	6.2
	E6-3S	SW6010	7439-95-4	magnesium	191 B
	E6-3S	SW6010	7439-96-5	manganese	63.9
	E6-3S	SW6010	7440-02-0	nickel	3.5 J
	E6-3S	SW6010	7440-09-7	potassium	187 J
	E6-3S	SW6010	7782-49-2	selenium	1.6

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Sample Location	Sample Name	Analytical Method	CAS Number	Chemical Name	Result
	E6-3S	SW6010	7440-22-4	silver	0.68 B
	E6-3S	SW6010	7440-23-5	sodium	30.6 B
	E6-3S	SW6010	7440-28-0	thallium	0.22 J
	E6-3S	SW6010	7440-62-2	vanadium	33.0
	E6-3S	SW6010	7440-66-6	zinc	7.7
	E6-3S	SW7471	7439-97-6	mercury	0.023 J
	E6-7S	SW6010	7429-90-5	aluminum	9210
	E6-7S	SW6010	7440-38-2	arsenic	2.0
	E6-7S	SW6010	7440-39-3	barium	12.9 J
	E6-7S	SW6010	7440-41-7	beryllium	0.11 J
	E6-7S	SW6010	7440-70-2	calcium	89.7 B
	E6-7S	SW6010	7440-47-3	chromium	18.4
	E6-7S	SW6010	7440-48-4	cobalt	0.52 J
	E6-7S	SW6010	7440-50-8	copper	4.0
	E6-7S	SW6010	7439-89-6	iron	9910 B
	E6-7S	SW6010	7439-92-1	lead	4.7
	E6-7S	SW6010	7439-95-4	magnesium	159 B
	E6-7S	SW6010	7439-96-5	manganese	60.0
	E6-7S	SW6010	7440-02-0	nickel	2.4 J
	E6-7S	SW6010	7440-09-7	potassium	124 J
	E6-7S	SW6010	7782-49-2	selenium	1.5
	E6-7S	SW6010	7440-22-4	silver	0.78 B
	E6-7S	SW6010	7440-23-5	sodium	19.1 B
	E6-7S	SW6010	7440-62-2	vanadium	36.7
	E6-7S	SW6010	7440-66-6	zinc	6.0
	E6-7S	SW7471	7439-97-6	mercury	0.0092 J
	E6-7S	SW8260B	75-34-3	1,1-dichloroethane	1.5 J
	E6-7S	SW8260B	108-67-8	1,3,5-trimethylbenzene	0.35 J
	E6-7S	SW8260B	78-93-3	2-butanone (MEK)	3.8 J
	E6-7S	SW8260B	67-64-1	acetone	110 JB
	E6-7S	SW8260B	71-43-2	benzene	1 J
	E6-7S	SW8260B	108-90-7	chlorobenzene	0.35 J
	E6-7S	SW8260B	156-59-2	cis-1,2-dichloroethene	5.8 J
	E6-7S	SW8260B	75-09-2	methylene chloride	1.4 JB
	E6-7S	SW8260B	108-88-3	toluene	0.57 J
E7					
	E7-3S	SW6010	7429-90-5	aluminum	10200
	E7-3S	SW6010	7440-38-2	arsenic	2.3
	E7-3S	SW6010	7440-39-3	barium	20.2 J
	E7-3S	SW6010	7440-41-7	beryllium	0.13 J
	E7-3S	SW6010	7440-43-9	cadmium	0.44 J
	E7-3S	SW6010	7440-70-2	calcium	330 B
	E7-3S	SW6010	7440-47-3	chromium	28.8
	E7-3S	SW6010	7440-48-4	cobalt	0.55 J
	E7-3S	SW6010	7440-50-8	copper	3.3 B
	E7-3S	SW6010	7439-89-6	iron	14600 B
	E7-3S	SW6010	7439-92-1	lead	5.0

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Sample Location	Sample Name	Analytical Method	CAS Number	Chemical Name	Result
	E7-3S	SW6010	7439-95-4	magnesium	164 B
	E7-3S	SW6010	7439-96-5	manganese	78.1
	E7-3S	SW6010	7440-02-0	nickel	2.3 J
	E7-3S	SW6010	7440-09-7	potassium	108 J
	E7-3S	SW6010	7782-49-2	selenium	0.80
	E7-3S	SW6010	7440-22-4	silver	0.73 J J
	E7-3S	SW6010	7440-23-5	sodium	88.5 B B
	E7-3S	SW6010	7440-62-2	vanadium	34.3
	E7-3S	SW6010	7440-66-6	zinc	5.0
	E7-3S	SW7471	7439-97-6	mercury	0.028 J J
	E7-3S	SW8260B	75-34-3	1,1-dichloroethane	1.9 J J
	E7-3S	SW8260B	78-93-3	2-butanone (MEK)	3.0 J J
	E7-3S	SW8260B	67-64-1	acetone	69 B B
	E7-3S	SW8260B	71-43-2	benzene	3.1 J J
	E7-3S	SW8260B	108-90-7	chlorobenzene	0.67 J J
	E7-3S	SW8260B	156-59-2	cis-1,2-dichloroethene	23
	E7-3S	SW8260B	75-09-2	methylene chloride	0.58 JB JB
	E7-3S	SW8260B	108-88-3	toluene	1.8 J J
	E7-3S	SW8260B	156-60-5	trans-1,2-dichloroethene	0.39 J J
	E7-3S	SW8260B	79-01-6	trichloroethene	17
	E7-3S	SW8260B	75-01-4	vinyl chloride	1.9 J
E8					
	E8-3S	SW6010	7429-90-5	aluminum	7010 B
	E8-3S	SW6010	7440-38-2	arsenic	1.8
	E8-3S	SW6010	7440-39-3	barium	14.3 J
	E8-3S	SW6010	7440-41-7	beryllium	0.14 J
	E8-3S	SW6010	7440-70-2	calcium	350 B
	E8-3S	SW6010	7440-47-3	chromium	12.1 B
	E8-3S	SW6010	7440-48-4	cobalt	0.39 J
	E8-3S	SW6010	7440-50-8	copper	3.0
	E8-3S	SW6010	7439-89-6	iron	10900 B
	E8-3S	SW6010	7439-92-1	lead	3.9
	E8-3S	SW6010	7439-95-4	magnesium	110 B
	E8-3S	SW6010	7439-96-5	manganese	21.5
	E8-3S	SW6010	7440-02-0	nickel	1.6 B
	E8-3S	SW6010	7440-09-7	potassium	106 J
	E8-3S	SW6010	7782-49-2	selenium	1.3
	E8-3S	SW6010	7440-22-4	silver	0.61 J
	E8-3S	SW6010	7440-23-5	sodium	9.5 B
	E8-3S	SW6010	7440-62-2	vanadium	28.5
	E8-3S	SW6010	7440-66-6	zinc	3.2
	E8-3S	SW7471	7439-97-6	mercury	0.038 B
	E8-7S	SW6010	7429-90-5	aluminum	4410 B
	E8-7S	SW6010	7440-38-2	arsenic	1.3
	E8-7S	SW6010	7440-39-3	barium	18 J
	E8-7S	SW6010	7440-41-7	beryllium	0.13 J
	E8-7S	SW6010	7440-70-2	calcium	190 B

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Sample Location	Sample Name	Analytical Method	CAS Number	Chemical Name	Result
	E8-7S	SW6010	7440-47-3	chromium	7.4 B
	E8-7S	SW6010	7440-48-4	cobalt	0.65 J
	E8-7S	SW6010	7440-50-8	copper	1.9 J
	E8-7S	SW6010	7439-89-6	iron	5230 B
	E8-7S	SW6010	7439-92-1	lead	3.5
	E8-7S	SW6010	7439-95-4	magnesium	114 B
	E8-7S	SW6010	7439-96-5	manganese	49.9
	E8-7S	SW6010	7440-02-0	nickel	1.2 B
	E8-7S	SW6010	7440-09-7	potassium	64.5 J
	E8-7S	SW6010	7782-49-2	selenium	0.75
	E8-7S	SW6010	7440-22-4	silver	0.3 J
	E8-7S	SW6010	7440-23-5	sodium	11.3 B
	E8-7S	SW6010	7440-62-2	vanadium	13.9
	E8-7S	SW6010	7440-66-6	zinc	2.7
	E8-7S	SW7471	7439-97-6	mercury	0.022 B
	E8-7S	SW8260B	67-64-1	acetone	20 J
	E8-7S	SW8260B	71-43-2	benzene	0.37 J
	E8-7S	SW8260B	156-59-2	cis-1,2-dichloroethene	310 E
	E8-7S	SW8260B	75-09-2	methylene chloride	1 JB
	E8-7S	SW8260B	156-60-5	trans-1,2-dichloroethene	16 J
	E8-7S	SW8260B	79-01-6	trichloroethene	16 J
	E8-7S	SW8260B	75-01-4	vinyl chloride	22 J
E9					
	E9-3S	SW6010	7429-90-5	aluminum	1550 B
	E9-3S	SW6010	7440-38-2	arsenic	0.37 J
	E9-3S	SW6010	7440-39-3	barium	9.3 J
	E9-3S	SW6010	7440-70-2	calcium	152 B
	E9-3S	SW6010	7440-47-3	chromium	3.1 B
	E9-3S	SW6010	7440-50-8	copper	0.82 J
	E9-3S	SW6010	7439-89-6	iron	1790 B
	E9-3S	SW6010	7439-92-1	lead	1.8
	E9-3S	SW6010	7439-95-4	magnesium	23.6 B
	E9-3S	SW6010	7439-96-5	manganese	5.5
	E9-3S	SW6010	7440-02-0	nickel	0.36 B
	E9-3S	SW6010	7440-09-7	potassium	40.7 J
	E9-3S	SW6010	7782-49-2	selenium	0.29 J
	E9-3S	SW6010	7440-22-4	silver	0.14 J
	E9-3S	SW6010	7440-23-5	sodium	7.8 B
	E9-3S	SW6010	7440-62-2	vanadium	6.5
	E9-3S	SW7471	7439-97-6	mercury	0.016 B
	E9-3S	SW8260B	67-64-1	acetone	12 JB
	E9-3S	SW8260B	75-09-2	methylene chloride	1.8 JB
	E9-3S	SW8260B	127-18-4	tetrachloroethene (PCE)	0.8 J
	E9-7S	SW6010	7429-90-5	aluminum	7280 B
	E9-7S	SW6010	7440-38-2	arsenic	2.3
	E9-7S	SW6010	7440-39-3	barium	8.9 J
	E9-7S	SW6010	7440-41-7	beryllium	0.082 J

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	E9-7S	SW6010	7440-70-2	calcium	85.3 B
	E9-7S	SW6010	7440-47-3	chromium	22.5 B
	E9-7S	SW6010	7440-50-8	copper	3.4
	E9-7S	SW6010	7439-89-6	iron	15400 B
	E9-7S	SW6010	7439-92-1	lead	4.9
	E9-7S	SW6010	7439-95-4	magnesium	67.5 B
	E9-7S	SW6010	7439-96-5	manganese	23.8
	E9-7S	SW6010	7440-02-0	nickel	1.3 B
	E9-7S	SW6010	7440-09-7	potassium	61.3 J
	E9-7S	SW6010	7782-49-2	selenium	2.5
	E9-7S	SW6010	7440-22-4	silver	1.2
	E9-7S	SW6010	7440-23-5	sodium	8.9 B
	E9-7S	SW6010	7440-62-2	vanadium	56.0
	E9-7S	SW6010	7440-66-6	zinc	3.6
	E9-7S	SW7471	7439-97-6	mercury	0.013 B
F1					
	F1-3S	SW6010	7429-90-5	aluminum	18100
	F1-3S	SW6010	7440-38-2	arsenic	2.6
	F1-3S	SW6010	7440-39-3	barium	23.5
	F1-3S	SW6010	7440-41-7	beryllium	0.18 J
	F1-3S	SW6010	7440-43-9	cadmium	0.33 J
	F1-3S	SW6010	7440-70-2	calcium	249 B
	F1-3S	SW6010	7440-47-3	chromium	18.6
	F1-3S	SW6010	7440-48-4	cobalt	0.97 J
	F1-3S	SW6010	7440-50-8	copper	6.2
	F1-3S	SW6010	7439-89-6	iron	15600 B
	F1-3S	SW6010	7439-92-1	lead	7.0
	F1-3S	SW6010	7439-95-4	magnesium	293 B
	F1-3S	SW6010	7439-96-5	manganese	21.3
	F1-3S	SW6010	7440-02-0	nickel	5.6
	F1-3S	SW6010	7440-09-7	potassium	265 J
	F1-3S	SW6010	7782-49-2	selenium	2.3
	F1-3S	SW6010	7440-22-4	silver	0.86 B
	F1-3S	SW6010	7440-23-5	sodium	27.3 B
	F1-3S	SW6010	7440-62-2	vanadium	40.5
	F1-3S	SW6010	7440-66-6	zinc	10.4
	F1-3S	SW7471	7439-97-6	mercury	0.03 J
	F1-3S	SW8260B	67-64-1	acetone	39 J
	F1-3S	SW8260B	75-09-2	methylene chloride	0.8 JB
	F1-3S	SW8260B	108-88-3	toluene	0.54 J
	F1-7S	SW6010	7429-90-5	aluminum	2270
	F1-7S	SW6010	7440-38-2	arsenic	0.42 J
	F1-7S	SW6010	7440-39-3	barium	10.8 J
	F1-7S	SW6010	7440-41-7	beryllium	0.075 J
	F1-7S	SW6010	7440-70-2	calcium	61.7 B
	F1-7S	SW6010	7440-47-3	chromium	2.4
	F1-7S	SW6010	7440-48-4	cobalt	0.34 J

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	F1-7S	SW6010	7440-50-8	copper	1.5 J
	F1-7S	SW6010	7439-89-6	iron	725 B
	F1-7S	SW6010	7439-92-1	lead	2.9
	F1-7S	SW6010	7439-95-4	magnesium	88.7 B
	F1-7S	SW6010	7439-96-5	manganese	13.0
	F1-7S	SW6010	7440-02-0	nickel	0.92 J
	F1-7S	SW6010	7440-09-7	potassium	57.2 J
	F1-7S	SW6010	7440-22-4	silver	0.043 B
	F1-7S	SW6010	7440-23-5	sodium	13.8 B
	F1-7S	SW6010	7440-62-2	vanadium	3.2 J
	F1-7S	SW6010	7440-66-6	zinc	2.9
	F1-7S	SW8260B	67-64-1	acetone	87 J
	F1-7S	SW8260B	71-43-2	benzene	0.32 J
	F1-7S	SW8260B	156-59-2	cis-1,2-dichloroethene	0.28 J
	F1-7S	SW8260B	75-09-2	methylene chloride	1 JB
	F1-7S	SW8260B	127-18-4	tetrachloroethene (PCE)	1.5 J
	F1-7S	SW8260B	79-01-6	trichloroethene	0.64 J
G1					
	G1-3S	SW8260B	67-64-1	acetone	7.2 JB
	G1-3S	SW8260B	156-59-2	cis-1,2-dichloroethene	0.4 J
	G1-3S	SW8260B	75-09-2	methylene chloride	2.2 JB
	G1-3S	SW8260B	79-01-6	trichloroethene	2.8 J
	G1-7S	SW6010	7429-90-5	aluminum	5140
	G1-7S	SW6010	7440-38-2	arsenic	0.97 J
	G1-7S	SW6010	7440-39-3	barium	11.9 J
	G1-7S	SW6010	7440-41-7	beryllium	0.071 J
	G1-7S	SW6010	7440-70-2	calcium	31 J
	G1-7S	SW6010	7440-47-3	chromium	4.8
	G1-7S	SW6010	7440-50-8	copper	2.2 J
	G1-7S	SW6010	7439-89-6	iron	3770
	G1-7S	SW6010	7439-92-1	lead	3.8
	G1-7S	SW6010	7439-95-4	magnesium	50.2 J
	G1-7S	SW6010	7439-96-5	manganese	1.7
	G1-7S	SW6010	7440-02-0	nickel	0.84 J
	G1-7S	SW6010	7440-09-7	potassium	70.5 J
	G1-7S	SW6010	7782-49-2	selenium	0.1 J
	G1-7S	SW6010	7440-22-4	silver	0.84 J
	G1-7S	SW6010	7440-23-5	sodium	6.5 J
	G1-7S	SW6010	7440-62-2	vanadium	39.4
	G1-7S	SW6010	7440-66-6	zinc	2 J
	G1-7S	SW7471	7439-97-6	mercury	0.024 J
G13					
	G13-3S	SW6010	7429-90-5	aluminum	258
	G13-3S	SW6010	7440-39-3	barium	0.33 J
	G13-3S	SW6010	7440-70-2	calcium	107 B
	G13-3S	SW6010	7440-47-3	chromium	0.58 J
	G13-3S	SW6010	7440-50-8	copper	0.54 J

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	G13-3S	SW6010	7439-89-6	iron	644 B
	G13-3S	SW6010	7439-92-1	lead	0.47
	G13-3S	SW6010	7439-95-4	magnesium	7.9 B
	G13-3S	SW6010	7439-96-5	manganese	0.23 J
	G13-3S	SW6010	7440-02-0	nickel	0.083 J
	G13-3S	SW6010	7440-22-4	silver	0.086 B
	G13-3S	SW6010	7440-23-5	sodium	9.3 B
	G13-3S	SW6010	7440-62-2	vanadium	2.4 J
	G13-3S	SW6010	7440-66-6	zinc	2.3
	G13-3S	SW8260B	67-64-1	acetone	8 JB
	G13-3S	SW8260B	75-09-2	methylene chloride	0.6 JB
	G13-7S	SW6010	7429-90-5	aluminum	614
	G13-7S	SW6010	7440-39-3	barium	0.65 J
	G13-7S	SW6010	7440-70-2	calcium	271 B
	G13-7S	SW6010	7440-47-3	chromium	2.6
	G13-7S	SW6010	7440-50-8	copper	0.42 J
	G13-7S	SW6010	7439-89-6	iron	388 B
	G13-7S	SW6010	7439-92-1	lead	1.1
	G13-7S	SW6010	7439-95-4	magnesium	14.7 B
	G13-7S	SW6010	7439-96-5	manganese	0.6 J
	G13-7S	SW6010	7440-02-0	nickel	0.63 J
	G13-7S	SW6010	7440-22-4	silver	0.18 B
	G13-7S	SW6010	7440-23-5	sodium	12.5 B
	G13-7S	SW6010	7440-62-2	vanadium	8.4
	G13-7S	SW6010	7440-66-6	zinc	1.7 J
G14					
	G14-3S	SW6010	7429-90-5	aluminum	1270
	G14-3S	SW6010	7440-38-2	arsenic	0.27 J
	G14-3S	SW6010	7440-39-3	barium	1.8 J
	G14-3S	SW6010	7440-70-2	calcium	28.3 B
	G14-3S	SW6010	7440-47-3	chromium	4.8
	G14-3S	SW6010	7440-50-8	copper	0.57 J
	G14-3S	SW6010	7439-89-6	iron	1030 B
	G14-3S	SW6010	7439-92-1	lead	2.0
	G14-3S	SW6010	7439-95-4	magnesium	13.5 B
	G14-3S	SW6010	7439-96-5	manganese	1.4 J
	G14-3S	SW6010	7440-02-0	nickel	0.1 J
	G14-3S	SW6010	7440-09-7	potassium	47.1 J
	G14-3S	SW6010	7782-49-2	selenium	0.15 J
	G14-3S	SW6010	7440-22-4	silver	0.42 B
	G14-3S	SW6010	7440-23-5	sodium	18.5 B
	G14-3S	SW6010	7440-62-2	vanadium	19.7
	G14-3S	SW6010	7440-66-6	zinc	1.5 J
	G14-3S	SW7471	7439-97-6	mercury	0.01 J
	G14-3S	SW8260B	71-55-6	1,1,1-trichloroethane	880
	G14-3S	SW8260B	75-34-3	1,1-dichloroethane	1.0 J J
	G14-3S	SW8260B	75-35-4	1,1-dichloroethene	880

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	G14-3S	SW8260B	107-06-2	1,2-dichloroethane	14
	G14-3S	SW8260B	67-64-1	acetone	8.2 JB
	G14-3S	SW8260B	71-43-2	benzene	0.35 J
	G14-3S	SW8260B	108-90-7	chlorobenzene	0.39 J
	G14-3S	SW8260B	67-66-3	chloroform	7.8
	G14-3S	SW8260B	75-09-2	methylene chloride	1.9 JB
	G14-3S	SW8260B	127-18-4	tetrachloroethene (PCE)	6.4
	G14-3S	SW8260B	108-88-3	toluene	1.5
	G14-3S	SW8260B	79-01-6	trichloroethene	440 J
G17					
	G17-7S	SW8260B	71-55-6	1,1,1-trichloroethane	1.2 J
	G17-7S	SW8260B	75-35-4	1,1-dichloroethene	0.92 J
	G17-7S	SW8260B	67-64-1	acetone	4.8 J
	G17-7S	SW8260B	71-43-2	benzene	0.68 J
	G17-7S	SW8260B	108-90-7	chlorobenzene	0.59 J
	G17-7S	SW8260B	75-09-2	methylene chloride	1 JB
	G17-7S	SW8260B	108-88-3	toluene	1 J
G19					
	G19-3S	SW8260B	71-55-6	1,1,1-trichloroethane	8.2
	G19-3S	SW8260B	75-34-3	1,1-dichloroethane	0.85 J
	G19-3S	SW8260B	75-35-4	1,1-dichloroethene	0.67 J
	G19-3S	SW8260B	78-93-3	2-butanone (MEK)	3 J
	G19-3S	SW8260B	67-64-1	acetone	31 B
	G19-3S	SW8260B	71-43-2	benzene	0.64 J
	G19-3S	SW8260B	108-90-7	chlorobenzene	0.92 J
	G19-3S	SW8260B	156-59-2	cis-1,2-dichloroethene	23
	G19-3S	SW8260B	75-09-2	methylene chloride	2.1 JB
	G19-3S	SW8260B	127-18-4	tetrachloroethene (PCE)	78
	G19-3S	SW8260B	108-88-3	toluene	0.94 J
	G19-3S	SW8260B	79-01-6	trichloroethene	59
G2					
	G2-3S	SW6010	7429-90-5	aluminum	8070
	G2-3S	SW6010	7440-38-2	arsenic	1.1 J
	G2-3S	SW6010	7440-39-3	barium	15.2 J
	G2-3S	SW6010	7440-41-7	beryllium	0.092 J
	G2-3S	SW6010	7440-43-9	cadmium	0.34 J
	G2-3S	SW6010	7440-70-2	calcium	647
	G2-3S	SW6010	7440-47-3	chromium	10.3
	G2-3S	SW6010	7440-48-4	cobalt	0.41 J
	G2-3S	SW6010	7440-50-8	copper	5.4 B
	G2-3S	SW6010	7439-89-6	iron	8650
	G2-3S	SW6010	7439-92-1	lead	16.1
	G2-3S	SW6010	7439-95-4	magnesium	115 B
	G2-3S	SW6010	7439-96-5	manganese	27.2
	G2-3S	SW6010	7440-02-0	nickel	1.9 J
	G2-3S	SW6010	7440-09-7	potassium	90.5 J
	G2-3S	SW6010	7782-49-2	selenium	0.37 J

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	G2-3S	SW6010	7440-22-4	silver	0.6 J
	G2-3S	SW6010	7440-23-5	sodium	37 J
	G2-3S	SW6010	7440-62-2	vanadium	27.2
	G2-3S	SW6010	7440-66-6	zinc	10.8
	G2-3S	SW7471	7439-97-6	mercury	0.042 J
	G2-7S	SW6010	7429-90-5	aluminum	10200
	G2-7S	SW6010	7440-38-2	arsenic	0.8 J
	G2-7S	SW6010	7440-39-3	barium	25.6
	G2-7S	SW6010	7440-41-7	beryllium	0.086 J
	G2-7S	SW6010	7440-43-9	cadmium	0.34 J
	G2-7S	SW6010	7440-70-2	calcium	797
	G2-7S	SW6010	7440-47-3	chromium	10.6
	G2-7S	SW6010	7440-48-4	cobalt	0.53 J
	G2-7S	SW6010	7440-50-8	copper	7.8 B
	G2-7S	SW6010	7439-89-6	iron	13400
	G2-7S	SW6010	7439-92-1	lead	11.8
	G2-7S	SW6010	7439-95-4	magnesium	145 B
	G2-7S	SW6010	7439-96-5	manganese	35.1
	G2-7S	SW6010	7440-02-0	nickel	2.8 J
	G2-7S	SW6010	7440-09-7	potassium	129 J
	G2-7S	SW6010	7782-49-2	selenium	0.75
	G2-7S	SW6010	7440-22-4	silver	0.55 J
	G2-7S	SW6010	7440-23-5	sodium	38.7 J
	G2-7S	SW6010	7440-62-2	vanadium	26.6
	G2-7S	SW6010	7440-66-6	zinc	11.5
	G2-7S	SW7471	7439-97-6	mercury	0.042 J
	G2-7S	SW8260B	67-64-1	acetone	13 B
	G2-7S	SW8260B	108-90-7	chlorobenzene	0.81 J
	G2-7S	SW8260B	75-09-2	methylene chloride	0.65 JB
G20					
	G20-3S	SW8260B	120-82-1	1,2,4-trichlorobenzene	0.35 J
	G20-3S	SW8260B	67-64-1	acetone	2800 B
	G20-3S	SW8260B	71-43-2	benzene	1.2 J
	G20-3S	SW8260B	108-90-7	chlorobenzene	0.79 J
	G20-3S	SW8260B	75-09-2	methylene chloride	1.9 JB
	G20-3S	SW8260B	108-88-3	toluene	0.76 J
	G20-7S	SW8260B	78-93-3	2-butanone (MEK)	7.2 J
	G20-7S	SW8260B	67-64-1	acetone	1200 B
	G20-7S	SW8260B	108-90-7	chlorobenzene	0.61 J
	G20-7S	SW8260B	75-09-2	methylene chloride	1.7 JB
	G20-7S	SW8260B	79-01-6	trichloroethene	0.85 J
G21					
	G21-3S	SW8260B	67-64-1	acetone	7.3 JB
	G21-3S	SW8260B	108-90-7	chlorobenzene	0.47 J
	G21-3S	SW8260B	75-09-2	methylene chloride	0.88 JB
G22					
	G22-3S	SW8260B	67-64-1	acetone	12 JB

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	G22-3S	SW8260B	75-09-2	methylene chloride	0.71	JB
	G22-3S	SW8260B	127-18-4	tetrachloroethene (PCE)	1.2	J
	G22-3S	SW8260B	108-88-3	toluene	0.25	J
G23						
	G23-3S	SW8260B	75-09-2	methylene chloride	0.56	JB
	G23-3S	SW8260B	108-88-3	toluene	0.28	J
G24						
	G24-3S	SW8260B	67-64-1	acetone	5.9	JB
	G24-3S	SW8260B	156-59-2	cis-1,2-dichloroethene	0.37	J
	G24-3S	SW8260B	75-09-2	methylene chloride	0.9	JB
	G24-3S	SW8260B	108-88-3	toluene	0.76	J
	G24-3S	SW8260B	79-01-6	trichloroethene	0.54	J
G3						
	G3-7S	SW6010	7429-90-5	aluminum	4370	B
	G3-7S	SW6010	7440-38-2	arsenic	1.3	
	G3-7S	SW6010	7440-39-3	barium	4.5	J
	G3-7S	SW6010	7440-41-7	beryllium	0.058	J
	G3-7S	SW6010	7440-70-2	calcium	132	B
	G3-7S	SW6010	7440-47-3	chromium	9.2	
	G3-7S	SW6010	7440-50-8	copper	3.1	
	G3-7S	SW6010	7439-89-6	iron	11200	
	G3-7S	SW6010	7439-92-1	lead	3.0	
	G3-7S	SW6010	7439-95-4	magnesium	58.4	B
	G3-7S	SW6010	7439-96-5	manganese	0.94	J
	G3-7S	SW6010	7440-02-0	nickel	0.53	J
	G3-7S	SW6010	7440-09-7	potassium	58.3	J
	G3-7S	SW6010	7782-49-2	selenium	1.4	
	G3-7S	SW6010	7440-22-4	silver	1.2	
	G3-7S	SW6010	7440-23-5	sodium	11.6	J
	G3-7S	SW6010	7440-62-2	vanadium	53.5	
	G3-7S	SW6010	7440-66-6	zinc	4.2	
	G3-7S	SW7471	7439-97-6	mercury	0.0096	J
	G3-7S	SW8260B	67-64-1	acetone	6.3	J
	G3-7S	SW8260B	71-43-2	benzene	0.72	J
	G3-7S	SW8260B	108-90-7	chlorobenzene	0.77	J
	G3-7S	SW8260B	75-09-2	methylene chloride	1.1	JB
	G3-7S	SW8260B	108-88-3	toluene	0.53	J
G5						
	G5-3S	SW6010	7429-90-5	aluminum	4220	
	G5-3S	SW6010	7440-38-2	arsenic	0.42	J
	G5-3S	SW6010	7440-39-3	barium	7.3	J
	G5-3S	SW6010	7440-70-2	calcium	119	B
	G5-3S	SW6010	7440-47-3	chromium	3.0	
	G5-3S	SW6010	7440-48-4	cobalt	0.17	J
	G5-3S	SW6010	7440-50-8	copper	2.5	B
	G5-3S	SW6010	7439-89-6	iron	2970	B
	G5-3S	SW6010	7439-92-1	lead	3.2	

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	G5-3S	SW6010	7439-95-4	magnesium	68.7 B
	G5-3S	SW6010	7439-96-5	manganese	3.4
	G5-3S	SW6010	7440-02-0	nickel	0.86 J
	G5-3S	SW6010	7440-09-7	potassium	98.3 J
	G5-3S	SW6010	7440-22-4	silver	0.36 J
	G5-3S	SW6010	7440-23-5	sodium	19.6 B
	G5-3S	SW6010	7440-62-2	vanadium	17.8
	G5-3S	SW6010	7440-66-6	zinc	3.6
	G5-7S	SW6010	7429-90-5	aluminum	7060
	G5-7S	SW6010	7440-38-2	arsenic	0.57 J
	G5-7S	SW6010	7440-39-3	barium	6.3 J
	G5-7S	SW6010	7440-41-7	beryllium	0.07 J
	G5-7S	SW6010	7440-70-2	calcium	19 B
	G5-7S	SW6010	7440-47-3	chromium	8.9 J
	G5-7S	SW6010	7440-48-4	cobalt	0.24 J
	G5-7S	SW6010	7440-50-8	copper	4.8 B
	G5-7S	SW6010	7439-89-6	iron	9270 JB
	G5-7S	SW6010	7439-92-1	lead	6.0
	G5-7S	SW6010	7439-95-4	magnesium	61.1 B
	G5-7S	SW6010	7439-96-5	manganese	5.0
	G5-7S	SW6010	7440-02-0	nickel	1.3 J
	G5-7S	SW6010	7440-09-7	potassium	87.2 J
	G5-7S	SW6010	7782-49-2	selenium	0.2 J
	G5-7S	SW6010	7440-22-4	silver	0.81 J
	G5-7S	SW6010	7440-23-5	sodium	18.1 B
	G5-7S	SW6010	7440-62-2	vanadium	39.0
	G5-7S	SW6010	7440-66-6	zinc	4.7
	G5-7S	SW8260B	67-64-1	acetone	6.4 J
	G5-7S	SW8260B	108-90-7	chlorobenzene	0.22 J
	G5-7S	SW8260B	156-59-2	cis-1,2-dichloroethene	1.6 J
	G5-7S	SW8260B	75-09-2	methylene chloride	0.93 JB
	G5-7S	SW8260B	127-18-4	tetrachloroethene (PCE)	1.7 J
	G5-7S	SW8260B	108-88-3	toluene	0.41 J
	G5-7S	SW8260B	79-01-6	trichloroethene	20
G6					
	G6-3S	SW6010	7429-90-5	aluminum	800
	G6-3S	SW6010	7440-38-2	arsenic	0.27 J
	G6-3S	SW6010	7440-39-3	barium	3.2 J
	G6-3S	SW6010	7440-70-2	calcium	328 B
	G6-3S	SW6010	7440-47-3	chromium	2.3
	G6-3S	SW6010	7440-50-8	copper	0.88 J
	G6-3S	SW6010	7439-89-6	iron	1500 B
	G6-3S	SW6010	7439-92-1	lead	7.5
	G6-3S	SW6010	7439-95-4	magnesium	39.5 B
	G6-3S	SW6010	7439-96-5	manganese	7.7
	G6-3S	SW6010	7440-02-0	nickel	0.29 J
	G6-3S	SW6010	7440-09-7	potassium	53.2 J

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	G6-3S	SW6010	7782-49-2	selenium	0.26 J
	G6-3S	SW6010	7440-22-4	silver	0.77 B
	G6-3S	SW6010	7440-23-5	sodium	19.5 B
	G6-3S	SW6010	7440-62-2	vanadium	12.3
	G6-3S	SW6010	7440-66-6	zinc	2.9
	G6-3S	SW7471	7439-97-6	mercury	0.028 J
	G6-7S	SW6010	7429-90-5	aluminum	459
	G6-7S	SW6010	7440-39-3	barium	0.57 J
	G6-7S	SW6010	7440-70-2	calcium	227 B
	G6-7S	SW6010	7440-47-3	chromium	1.7
	G6-7S	SW6010	7440-50-8	copper	0.32 J
	G6-7S	SW6010	7439-89-6	iron	634 B
	G6-7S	SW6010	7439-92-1	lead	0.65
	G6-7S	SW6010	7439-95-4	magnesium	8.7 B
	G6-7S	SW6010	7439-96-5	manganese	0.41 J
	G6-7S	SW6010	7440-02-0	nickel	0.076 J
	G6-7S	SW6010	7440-22-4	silver	0.37 B
	G6-7S	SW6010	7440-23-5	sodium	19.2 B
	G6-7S	SW6010	7440-62-2	vanadium	15.0
	G6-7S	SW8260B	67-64-1	acetone	5.1 J
	G6-7S	SW8260B	108-90-7	chlorobenzene	0.72 J
	G6-7S	SW8260B	75-09-2	methylene chloride	0.94 JB
	G6-7S	SW8270C	117-81-7	bis(2-ethylhexyl)phthalate	70 J
G8					
	G8-0S	SW6010	7429-90-5	aluminum	10000
	G8-0S	SW6010	7440-39-3	barium	28
	G8-0S	SW6010	7440-41-7	beryllium	0.18
	G8-0S	SW6010	7440-70-2	calcium	1500
	G8-0S	SW6010	7440-47-3	chromium	45
	G8-0S	SW6010	7440-48-4	cobalt	2.5
	G8-0S	SW6010	7440-50-8	copper	4.6
	G8-0S	SW6010	7439-89-6	iron	8400
	G8-0S	SW6010	7439-92-1	lead	6.6
	G8-0S	SW6010	7439-95-4	magnesium	220
	G8-0S	SW6010	7439-96-5	manganese	190
	G8-0S	SW6010	7440-02-0	nickel	2.9
	G8-0S	SW6010	7440-09-7	potassium	190
	G8-0S	SW6010	7440-62-2	vanadium	23
	G8-0S	SW6010	7440-66-6	zinc	18
	G8-0S	SW7060	7440-38-2	arsenic	0.99
	G8-0S	SW8260B	78-93-3	2-butanone (MEK)	5.3 J
	G8-0S	SW8260B	67-64-1	acetone	31 B
	G8-0S	SW8260B	75-09-2	methylene chloride	2.4 JB
	G8-0S	SW8260B	108-88-3	toluene	0.32 J
	G8-0S	SW8270C	117-81-7	bis(2-ethylhexyl)phthalate	170 J
	G8-0S	SW8270C	84-74-2	di-n-butyl phthalate	140 J
	G8-0S	SW8270C	85-01-8	phenanthrene	38 J

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	G8-6S	SW6010	7429-90-5	aluminum	540
	G8-6S	SW6010	7440-70-2	calcium	43
	G8-6S	SW6010	7440-47-3	chromium	2.0
	G8-6S	SW6010	7439-89-6	iron	1400
	G8-6S	SW6010	7439-92-1	lead	1.4
	G8-6S	SW6010	7439-96-5	manganese	1.2
	G8-6S	SW6010	7440-62-2	vanadium	4.0
	G8-6S	SW8260B	108-67-8	1,3,5-trimethylbenzene	3000 J
	G8-6S	SW8260B	100-41-4	ethylbenzene	19000
	G8-6S	SW8260B	98-82-8	isopropylbenzene	11000
	G8-6S	SW8260B	75-09-2	methylene chloride	1300 JB
	G8-6S	SW8260B	104-51-8	n-butylbenzene	16000
	G8-6S	SW8260B	103-65-1	n-propylbenzene	24000
	G8-6S	SW8260B	108-88-3	toluene	4300 J
	G8-6S	SW8270C	105-67-9	2,4-dimethylphenol	380
	G8-6S	SW8270C	91-57-6	2-methyl naphthalene	13000
	G8-6S	SW8270C	56-55-3	benzo(a)anthracene	43 J
	G8-6S	SW8270C	117-81-7	bis(2-ethylhexyl)phthalate	260
	G8-6S	SW8270C	218-01-9	chrysene	44 J
	G8-6S	SW8270C	84-74-2	di-n-butyl phthalate	130 J
	G8-6S	SW8270C	206-44-0	fluoranthene	170 J
	G8-6S	SW8270C	91-20-3	naphthalene	5300
	G8-6S	SW8270C	85-01-8	phenanthrene	1700
	G8-6S	SW8270C	129-00-0	pyrene	270
G9					
	G9-8S	SW6010	7429-90-5	aluminum	2500
	G9-8S	SW6010	7440-39-3	barium	1.6
	G9-8S	SW6010	7440-70-2	calcium	170
	G9-8S	SW6010	7440-47-3	chromium	5.2
	G9-8S	SW6010	7439-89-6	iron	590
	G9-8S	SW6010	7439-92-1	lead	2.1
	G9-8S	SW6010	7439-96-5	manganese	2.3
	G9-8S	SW6010	7440-62-2	vanadium	11
	G9-8S	SW8260B	67-64-1	acetone	5.6 JB
	G9-8S	SW8260B	75-09-2	methylene chloride	1.5 JB
K11					
	K11-7S	SW8260B	95-63-6	1,2,4-trimethylbenzene	1200 JB
	K11-7S	SW8260B	108-67-8	1,3,5-trimethylbenzene	500 J
	K11-7S	SW8260B	67-64-1	acetone	15 JB
	K11-7S	SW8260B	71-43-2	benzene	0.99 J
	K11-7S	SW8260B	75-15-0	carbon disulfide	0.64 JB
	K11-7S	SW8260B	156-59-2	cis-1,2-dichloroethene	8.7 J
	K11-7S	SW8260B	100-41-4	ethylbenzene	230 J
	K11-7S	SW8260B	98-82-8	isopropylbenzene	250 J
	K11-7S	SW8260B	75-09-2	methylene chloride	3.1 JB
	K11-7S	SW8260B	104-51-8	n-butylbenzene	260 J
	K11-7S	SW8260B	103-65-1	n-propylbenzene	140 J

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	K11-7S	SW8260B	127-18-4	tetrachloroethene (PCE)	120 J
	K11-7S	SW8260B	108-88-3	toluene	2 JB
	K11-7S	SW8260B	79-01-6	trichloroethene	4.5 J
	K11-7S	SW8260B	1330-20-7	xylenes	600 J
K12					
	K12-0S	SW8260B	78-93-3	2-butanone (MEK)	5.7 J
	K12-0S	SW8260B	67-64-1	acetone	47 B
	K12-0S	SW8260B	1330-20-7	xylenes	0.73 J
	K12-6S	SW8260B	78-93-3	2-butanone (MEK)	3.1 J
	K12-6S	SW8260B	67-64-1	acetone	34 B
	K12-6S	SW8260B	75-09-2	methylene chloride	2.4 JB
	K12-8S	SW8260B	95-63-6	1,2,4-trimethylbenzene	0.48 JB
	K12-8S	SW8260B	78-93-3	2-butanone (MEK)	14 B
	K12-8S	SW8260B	67-64-1	acetone	56 B
	K12-8S	SW8260B	75-15-0	carbon disulfide	7.1 B
	K12-8S	SW8260B	75-09-2	methylene chloride	6 B
	K12-8S	SW8260B	108-88-3	toluene	1 J
K13					
	K13-0S	SW8260B	78-93-3	2-butanone (MEK)	8.7 J
	K13-0S	SW8260B	67-64-1	acetone	75
	K13-0S	SW8260B	127-18-4	tetrachloroethene (PCE)	0.65 J
	K13-0S	SW8260B	79-01-6	trichloroethene	2.4 J
	K13-6S	SW8260B	78-93-3	2-butanone (MEK)	1.8 J
	K13-6S	SW8260B	67-64-1	acetone	22 B
	K13-6S	SW8260B	127-18-4	tetrachloroethene (PCE)	3.7 J
	K13-6S	SW8260B	79-01-6	trichloroethene	4.1 J
K33					
	K33-6S	SW8260	87-61-6	1,2,3-trichlorobenzene	4200
	K33-6S	SW8260	120-82-1	1,2,4-trichlorobenzene	9200
	K33-6S	SW8260	95-63-6	1,2,4-trimethylbenzene	1300
	K33-6S	SW8260	95-50-1	1,2-dichlorobenzene	560000
	K33-6S	SW8260	108-67-8	1,3,5-trimethylbenzene	430 J
	K33-6S	SW8260	541-73-1	1,3-dichlorobenzene	31000
	K33-6S	SW8260	106-46-7	1,4-dichlorobenzene	110000
	K33-6S	SW8260	67-64-1	acetone	830 J
	K33-6S	SW8260	71-43-2	benzene	390 J
	K33-6S	SW8260	108-90-7	chlorobenzene	91000
	K33-6S	SW8260	156-59-2	cis-1,2-dichloroethene	1800
	K33-6S	SW8260	98-82-8	isopropylbenzene	43 J
	K33-6S	SW8260	104-51-8	n-butylbenzene	190 J
	K33-6S	SW8260	103-65-1	n-propylbenzene	110 J
	K33-6S	SW8260	108-88-3	toluene	110 J
	K33-6S	SW8260	79-01-6	trichloroethene	1500
	K33-6S	SW8260	1330-20-7	xylenes	280 J
K34					
	K34-6S	SW8260	87-61-6	1,2,3-trichlorobenzene	8300
	K34-6S	SW8260	120-82-1	1,2,4-trichlorobenzene	21000

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	K34-6S	SW8260	95-63-6	1,2,4-trimethylbenzene	3900	J
	K34-6S	SW8260	95-50-1	1,2-dichlorobenzene	950000	
	K34-6S	SW8260	108-67-8	1,3,5-trimethylbenzene	1200	J
	K34-6S	SW8260	541-73-1	1,3-dichlorobenzene	72000	
	K34-6S	SW8260	106-46-7	1,4-dichlorobenzene	180000	
	K34-6S	SW8260	71-43-2	benzene	610	J
	K34-6S	SW8260	108-90-7	chlorobenzene	19000	
	K34-6S	SW8260	156-59-2	cis-1,2-dichloroethene	260	J
	K34-6S	SW8260	103-65-1	n-propylbenzene	240	J
	K34-6S	SW8260	79-01-6	trichloroethene	2400	J
K35						
	K35-3S	SW8260B	87-61-6	1,2,3-trichlorobenzene	390	J
	K35-3S	SW8260B	120-82-1	1,2,4-trichlorobenzene	1800	
	K35-3S	SW8260B	95-63-6	1,2,4-trimethylbenzene	8800	
	K35-3S	SW8260B	95-50-1	1,2-dichlorobenzene	10000000	
	K35-3S	SW8260B	78-87-5	1,2-dichloropropane	99	J
	K35-3S	SW8260B	108-67-8	1,3,5-trimethylbenzene	3100	
	K35-3S	SW8260B	541-73-1	1,3-dichlorobenzene	470000	
	K35-3S	SW8260B	106-46-7	1,4-dichlorobenzene	1800000	
	K35-3S	SW8260B	67-64-1	acetone	810	J
	K35-3S	SW8260B	71-43-2	benzene	94	J
	K35-3S	SW8260B	108-90-7	chlorobenzene	42000	
	K35-3S	SW8260B	156-59-2	cis-1,2-dichloroethene	2300	
	K35-3S	SW8260B	98-82-8	isopropylbenzene	200	J
	K35-3S	SW8260B	75-09-2	methylene chloride	670	
	K35-3S	SW8260B	104-51-8	n-butylbenzene	740	
	K35-3S	SW8260B	103-65-1	n-propylbenzene	960	
	K35-3S	SW8260B	127-18-4	tetrachloroethene (PCE)	730	
	K35-3S	SW8260B	108-88-3	toluene	1000	
	K35-3S	SW8260B	156-60-5	trans-1,2-dichloroethene	110	J
	K35-3S	SW8260B	79-01-6	trichloroethene	160000	
	K35-3S	SW8260B	1330-20-7	xylenes	1600	
K36						
	K36-3.5S	SW8260B	87-61-6	1,2,3-trichlorobenzene	200	J
	K36-3.5S	SW8260B	120-82-1	1,2,4-trichlorobenzene	1200	
	K36-3.5S	SW8260B	95-63-6	1,2,4-trimethylbenzene	4300	
	K36-3.5S	SW8260B	95-50-1	1,2-dichlorobenzene	9600000	
	K36-3.5S	SW8260B	108-67-8	1,3,5-trimethylbenzene	1500	
	K36-3.5S	SW8260B	541-73-1	1,3-dichlorobenzene	480000	
	K36-3.5S	SW8260B	106-46-7	1,4-dichlorobenzene	1400000	
	K36-3.5S	SW8260B	67-64-1	acetone	690	J
	K36-3.5S	SW8260B	108-90-7	chlorobenzene	47000	
	K36-3.5S	SW8260B	156-59-2	cis-1,2-dichloroethene	240	J
	K36-3.5S	SW8260B	98-82-8	isopropylbenzene	100	J
	K36-3.5S	SW8260B	75-09-2	methylene chloride	91	J
	K36-3.5S	SW8260B	104-51-8	n-butylbenzene	450	
	K36-3.5S	SW8260B	103-65-1	n-propylbenzene	400	J

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	K36-3.5S	SW8260B	127-18-4	tetrachloroethene (PCE)	890
	K36-3.5S	SW8260B	108-88-3	toluene	420 J
	K36-3.5S	SW8260B	79-01-6	trichloroethene	16000
	K36-3.5S	SW8260B	1330-20-7	xylenes	1300
	K36-8S	SW8260B	87-61-6	1,2,3-trichlorobenzene	8300
	K36-8S	SW8260B	120-82-1	1,2,4-trichlorobenzene	65000
	K36-8S	SW8260B	95-63-6	1,2,4-trimethylbenzene	1300
	K36-8S	SW8260B	95-50-1	1,2-dichlorobenzene	2800000
	K36-8S	SW8260B	108-67-8	1,3,5-trimethylbenzene	470
	K36-8S	SW8260B	541-73-1	1,3-dichlorobenzene	170000
	K36-8S	SW8260B	106-46-7	1,4-dichlorobenzene	430000
	K36-8S	SW8260B	67-64-1	acetone	840 J
	K36-8S	SW8260B	108-90-7	chlorobenzene	5400
	K36-8S	SW8260B	156-59-2	cis-1,2-dichloroethene	240 J
	K36-8S	SW8260B	104-51-8	n-butylbenzene	310 J
	K36-8S	SW8260B	103-65-1	n-propylbenzene	94 J
	K36-8S	SW8260B	127-18-4	tetrachloroethene (PCE)	330 J
	K36-8S	SW8260B	79-01-6	trichloroethene	5900
	K36-8S	SW8260B	1330-20-7	xylenes	230 J
K37					
	K37-2S	SW8260	120-82-1	1,2,4-trichlorobenzene	1400 J
	K37-2S	SW8260	95-50-1	1,2-dichlorobenzene	130000
	K37-2S	SW8260	541-73-1	1,3-dichlorobenzene	6400
	K37-2S	SW8260	106-46-7	1,4-dichlorobenzene	21000
	K37-2S	SW8260	108-90-7	chlorobenzene	250 J
	K37-2S	SW8260	79-01-6	trichloroethene	400 J
K38					
	K38-0S	SW8260	87-61-6	1,2,3-trichlorobenzene	0.9 J
	K38-0S	SW8260	120-82-1	1,2,4-trichlorobenzene	1 J
	K38-0S	SW8260	95-63-6	1,2,4-trimethylbenzene	2.4 J
	K38-0S	SW8260	95-50-1	1,2-dichlorobenzene	51
	K38-0S	SW8260	108-67-8	1,3,5-trimethylbenzene	0.96 J
	K38-0S	SW8260	541-73-1	1,3-dichlorobenzene	5.0
	K38-0S	SW8260	106-46-7	1,4-dichlorobenzene	12
	K38-0S	SW8260	78-93-3	2-butanone (MEK)	3.9 J
	K38-0S	SW8260	67-64-1	acetone	34 B
	K38-0S	SW8260	71-43-2	benzene	0.91 J
	K38-0S	SW8260	108-90-7	chlorobenzene	4 J
	K38-0S	SW8260	104-51-8	n-butylbenzene	0.37 J
	K38-0S	SW8260	127-18-4	tetrachloroethene (PCE)	1.3 J
	K38-4S	SW8260	87-61-6	1,2,3-trichlorobenzene	0.72 J
	K38-4S	SW8260	120-82-1	1,2,4-trichlorobenzene	9.2
	K38-4S	SW8260	95-63-6	1,2,4-trimethylbenzene	1.8 J
	K38-4S	SW8260	95-50-1	1,2-dichlorobenzene	4600
	K38-4S	SW8260	108-67-8	1,3,5-trimethylbenzene	0.49 J
	K38-4S	SW8260	541-73-1	1,3-dichlorobenzene	91
	K38-4S	SW8260	106-46-7	1,4-dichlorobenzene	1700

Appendix A
Analytical Data for GBIA Institutional Controls
Earth Tech Project No. 42846

Sample Location	Sample Name	Analytical Method	CAS Number	Chemical Name	Result
	K38-4S	SW8260	78-93-3	2-butanone (MEK)	4.9 J
	K38-4S	SW8260	67-64-1	acetone	36 B
	K38-4S	SW8260	75-15-0	carbon disulfide	15
	K38-4S	SW8260	108-90-7	chlorobenzene	54
K39					
	K39-6S	SW8260	95-63-6	1,2,4-trimethylbenzene	2.9 J
	K39-6S	SW8260	95-50-1	1,2-dichlorobenzene	59
	K39-6S	SW8260	108-67-8	1,3,5-trimethylbenzene	1.1 J
	K39-6S	SW8260	541-73-1	1,3-dichlorobenzene	8100
	K39-6S	SW8260	106-46-7	1,4-dichlorobenzene	24000
	K39-6S	SW8260	78-93-3	2-butanone (MEK)	18
	K39-6S	SW8260	67-64-1	acetone	100
	K39-6S	SW8260	71-43-2	benzene	55
	K39-6S	SW8260	108-90-7	chlorobenzene	58000
	K39-6S	SW8260	156-59-2	cis-1,2-dichloroethene	1100
	K39-6S	SW8260	103-65-1	n-propylbenzene	0.48 J
	K39-6S	SW8260	108-88-3	toluene	2.5 J
	K39-6S	SW8260	156-60-5	trans-1,2-dichloroethene	6.8
	K39-6S	SW8260	79-01-6	trichloroethene	0.54 J
	K39-6S	SW8260	75-01-4	vinyl chloride	0.72 J
	K39-6S	SW8260	1330-20-7	xylenes	4.6
K5					
	K5-4S	SW8260B	78-93-3	2-butanone (MEK)	3.1 J
	K5-4S	SW8260B	67-64-1	acetone	6 JB
	K5-8S	SW8260B	78-93-3	2-butanone (MEK)	3.4 J
	K5-8S	SW8260B	67-64-1	acetone	11 B
	K5-8S	SW8260B	156-59-2	cis-1,2-dichloroethene	0.47 J
	K5-8S	SW8260B	127-18-4	tetrachloroethene (PCE)	2.5 J
	K5-8S	SW8260B	79-01-6	trichloroethene	5.9
	K5-8S	SW8260B	1330-20-7	xylenes	0.97 J
K6					
	K6-4S	SW8260B	71-55-6	1,1,1-trichloroethane	0.75 J
	K6-4S	SW8260B	78-93-3	2-butanone (MEK)	4 J
	K6-4S	SW8260B	67-64-1	acetone	65 B
	K6-4S	SW8260B	108-88-3	toluene	0.56 J
	K6-4S	SW8260B	79-01-6	trichloroethene	1.1 J
	K6-6S	SW8260B	67-64-1	acetone	36 B
	K6-6S	SW8260B	75-09-2	methylene chloride	2.1 J
	K6-6S	SW8260B	108-88-3	toluene	0.63 J
K7					
	K7-7S	SW8260B	95-63-6	1,2,4-trimethylbenzene	1.8 JB
	K7-7S	SW8260B	108-67-8	1,3,5-trimethylbenzene	0.36 JB
	K7-7S	SW8260B	78-93-3	2-butanone (MEK)	9.5 JB
	K7-7S	SW8260B	67-64-1	acetone	51 B
	K7-7S	SW8260B	71-43-2	benzene	45

Appendix A
Analytical Data for GBIA Institutional Controls
Earth Tech Project No. 42846

Sample Location	Sample Name	Analytical Method	CAS Number	Chemical Name	Result
	K7-7S	SW8260B	75-15-0	carbon disulfide	1.3 JB
	K7-7S	SW8260B	108-90-7	chlorobenzene	1.5 J
	K7-7S	SW8260B	100-41-4	ethylbenzene	2.1 J
	K7-7S	SW8260B	98-82-8	isopropylbenzene	3.7 J
	K7-7S	SW8260B	75-09-2	methylene chloride	3.5 JB
	K7-7S	SW8260B	104-51-8	n-butylbenzene	1.9 J
	K7-7S	SW8260B	103-65-1	n-propylbenzene	4.7 J
	K7-7S	SW8260B	108-88-3	toluene	1.9 JB
	K7-7S	SW8260B	79-01-6	trichloroethene	0.38 J
	K7-7S	SW8260B	1330-20-7	xylene	2.1 J
	K7-7S	SW8270C	95-50-1	1,2-dichlorobenzene	84 J
	K7-7S	SW8270C	91-57-6	2-methyl naphthalene	100 J
	K7-7S	SW8270C	117-81-7	bis(2-ethylhexyl)phthalate	83 J
	K7-7S	SW8270C	91-20-3	naphthalene	110 J
K7A					
	K7A-2S	SW8260B	78-93-3	2-butanone (MEK)	4 J
	K7A-2S	SW8260B	67-64-1	acetone	23 B
	K7A-2S	SW8260B	127-18-4	tetrachloroethene (PCE)	0.5 J
	K7A-6S	SW8260B	71-55-6	1,1,1-trichloroethane	0.9 J
	K7A-6S	SW8260B	78-93-3	2-butanone (MEK)	3 J
	K7A-6S	SW8260B	67-64-1	acetone	18 B
	K7A-6S	SW8260B	127-18-4	tetrachloroethene (PCE)	8.9
	K7A-6S	SW8260B	79-01-6	trichloroethene	15
K8					
	K8-0S	SW8260B	78-93-3	2-butanone (MEK)	4.6 J
	K8-0S	SW8260B	67-64-1	acetone	52 B
	K8-0S	SW8260B	100-41-4	ethylbenzene	0.42 J
	K8-0S	SW8260B	108-88-3	toluene	0.62 JB
	K8-0S	SW8260B	1330-20-7	xylene	1.7 J
	K8-4S	SW8260B	95-63-6	1,2,4-trimethylbenzene	0.66 JB
	K8-4S	SW8260B	78-93-3	2-butanone (MEK)	8.1 J
	K8-4S	SW8260B	108-10-1	4-methyl-2-pentanone	3.3 J
	K8-4S	SW8260B	67-64-1	acetone	50 B
	K8-4S	SW8260B	75-15-0	carbon disulfide	1 JB
	K8-4S	SW8260B	100-41-4	ethylbenzene	9.7
	K8-4S	SW8260B	108-88-3	toluene	1.1 JB
	K8-4S	SW8260B	1330-20-7	xylene	29

Note: Results are in parts per billion (ppb)

Data qualifiers:

B - detection is suspect due to blank contamination

E - estimated value above detection limit

J - estimated concentration

JB - estimated value detected in the associated method blank

Any sample locations as seen on the corresponding figure (fig. 2) that are not listed in the above table, either have detections below the eight foot sample depth or have no detections at all.

Appendix B

Health And Safety Forms



Page ____ Of ____

Project: _____ Date: _____

Project Number: _____ Time: _____

Meeting Conducted by: _____
Name Signature

Summary of Items Discussed: _____

Personnel Present

- 1. _____
- 2. _____
- 3. _____
- 4. _____
- 5. _____
- 6. _____
- 7. _____
- 8. _____
- 9. _____
- 10. _____
- 11. _____
- 12. _____
- 13. _____
- 14. _____
- 15. _____
- 16. _____
- 17. _____
- 18. _____
- 19. _____
- 20. _____

Supervisor's Report of Incident

This is an official document to be initiated by the injured employee's Supervisor. Please answer all questions completely. Fax to your Region EHS Manager within 24 hours of the injury. See reverse side for instructions.

Employee Data		S.S.N.	Sex	Birth Date
Injured's Name		Phone	Marital Status	No. of Dependents
Home Address		City	State	Zip Code
Job Title	Dept No.	Office Location Address		
<input type="checkbox"/> Injury <input type="checkbox"/> Illness <input type="checkbox"/> Vehicle Injury <input type="checkbox"/> Near Miss			Hire Date	Hourly Wage

Supervisor (Must complete each item or processing delays will occur) - Print Clearly

Date of Incident	Time	Date Reported	To Whom
Client Name	Job Assignment at Time of Incident		Time Shift Began
Exact Location & Address of Incident		Did injured leave work? If so, when? (date & time)	
Has injured returned to work? <input type="checkbox"/> Yes <input type="checkbox"/> No		Did employee miss a regularly scheduled shift? <input type="checkbox"/> Yes <input type="checkbox"/> No	
Doctor/Hospital Name		Address	
Witness Name		Statements Attached <input type="checkbox"/> Yes <input type="checkbox"/> No	
Nature of Injury		Body Part(s) Affected:	
Describe Medical Attention Provided:			
Describe Incident			
What caused the incident?			
Supervisor/Foreman (Print Name)		Signature	Date

Manager

Comments on incident and corrective actions taken		
Manager (Print Name)	Signature	Date

Environmental, Health and Safety Department

Concur with action taken? <input type="checkbox"/> Yes <input type="checkbox"/> No Remarks:			
OSHA Classification: <input type="checkbox"/> Pending <input type="checkbox"/> Incident only <input type="checkbox"/> First aid <input type="checkbox"/> No lost work days			
OSHA Recordable: <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Lost work days ____ <input type="checkbox"/> Days of restricted activity ____ <input type="checkbox"/> Fatality			
Crawford Claim No.:		WC Location Code:	
EHS Professional (Print Name)	Signature	Date	Telephone



Instructions: This report is to be completed by the Site Safety Officer at the end of each Rust E&I Employee's participation in site activities. A copy of this report must be submitted to the REHSM for placement in the employee's medical file.

Employee Name: _____

Social Security Number: _____

Project Name: _____

Project Number: _____

Location: _____

Site Function: _____

Level of Protection: _____

Dates of Site Participation: _____

1. Were action levels exceeded in the work area (breathing zone)? Yes _____ No _____

2. If yes, list type of monitoring and readings: _____

3. List known or suspected contaminants on-site (list from HASP):

4. Personal exposure monitoring data attached? Yes _____ No _____ N/A _____

SSO Name (Print): _____

SSO Signature: _____

Date: _____

Appendix C
Standard Operating Procedures

SECTION 3 SAMPLE CONTROL, FIELD RECORDS, AND DOCUMENT CONTROL

SECTION OBJECTIVES:

- Present standard procedures for sample identification.
- Present standard procedures for sample control.
- Present standard procedures for chain-of-custody.
- Present standard procedures for maintenance of field records and document control.

3.1 Introduction

All sample identification, chain-of-custody records, receipt for sample forms, and field records should be recorded with waterproof, non-erasable ink. If errors are made in any of these documents, corrections should be made by crossing a single line through the error and entering the correct information. All corrections should be initialed and dated. If possible, all corrections should be made by the individual making the error.

If information is entered onto sample tags, logbooks, or sample containers using stick-on labels, the labels should not be capable of being removed without leaving obvious indications of the attempt. Labels should never be placed over previously recorded information. Corrections to information recorded on stick-on labels should be made as stated above.

Following are definitions of terms used in this section:

<u>Project Leader:</u>	The individual with overall responsibility for conducting a specific field investigation in accordance with this SOP.
<u>Field Sample Custodian:</u>	Individual responsible for maintaining custody of the samples and completing the sample tags, Chain-of-Custody Record, and Receipt for Sample form.
<u>Sample Team Leader:</u>	An individual designated by the project leader to be present during and responsible for all activities related to the collection of samples by a specific sampling team.
<u>Sampler:</u>	The individual responsible for the actual collection of a sample.
<u>Transferee:</u>	Any individual who receives custody of samples subsequent to release by the field sample custodian.
<u>Laboratory Sample Custodian:</u>	Individual or their designee(s) responsible for accepting custody of samples from the field sample custodian or a transferee.

One individual may fulfill more than one of the roles described above while in the field.

3.2 Sample and Evidence Identification

PERFORMANCE OBJECTIVES:

- To accurately identify samples and evidence collected.
- To adequately insure that chain-of-custody was maintained.

3.2.1 Sample Identification

The method of sample identification used depends on the type of sample collected. Samples collected for specific field analyses or measurement data are recorded directly in bound field logbooks or recorded directly on the Chain-of-Custody Record, with identifying information, while in the custody of the samplers. Examples include pH, temperature, and conductivity. Samples collected for laboratory analyses are identified by using standard sample tags (Figure 3-1) which are attached to the sample containers. In some cases, particularly with biological samples, the sample tags may have to be included with or wrapped around the samples. The sample tags are sequentially numbered and are accountable documents after they are completed and attached to a sample or other physical evidence. The following information shall be included on the sample tag using waterproof, non-erasable ink:

- project number;
- field identification or sample station number;
- date and time of sample collection;
- designation of the sample as a grab or composite;
- type of sample (water, wastewater, leachate, soil, sediment, etc.) and a very brief description of the sampling location;
- the signature of either the sampler(s) or the designated sampling team leader and the field sample custodian (if appropriate);
- whether the sample is preserved or unpreserved;
- the general types of analyses to be performed (checked on front of tag); and
- any relevant comments (such as readily detectable or identifiable odor, color, or known toxic properties).

Samples or other physical evidence collected during criminal investigations are to be identified by using the "criminal sample tag." This tag is similar to the standard sample tag shown in Figure 3-1, except that it has a red border around the front and a red background on the back of the tag. If a criminal sample tag is not available, the white sample tag may be used and should be marked "Criminal" in bold letters on the tag.

If a sample is split with a facility, state regulatory agency, or other party representative, the recipient should be provided (if enough sample is available) with an equal weight or volume of sample (see Section 2.3.6). The split sample should be clearly marked or identified with a stick-on label.

Tags for blank or duplicate samples will be marked "blank" or "duplicate," respectively. This requirement does not apply to blind-spiked or blank samples which are to be submitted for laboratory quality control purposes. Blind-spiked or blank samples shall not be identified as such. This identifying information shall also be recorded in the bound field logbooks and on the Chain-Of-Custody Record as outlined in Sections 3.3 and 3.5.

3.2.2 Photograph Identification

Photographs used in investigative reports or placed in the official files shall be identified on the back of the print with the following information:

- A brief, but accurate description of what the photograph shows, including the name of the facility or site and the location.
- The date and time that the photograph was taken.
- The name of the photographer.

When photographs are taken, a record of each frame exposed shall be kept in the bound field logbook along with the information required for each photograph. The film shall be developed with the negatives supplied uncut. The field investigator shall then enter the required information on the prints, using the photographic record from the bound field logbook, to identify each photograph. For criminal investigations, the negatives must be maintained with the bound field logbook in the project file and stored in a secured file cabinet.

3.2.3 Identification of Physical Evidence

Physical evidence, other than samples, shall be identified by utilizing a sample tag or recording the necessary information on the evidence. When samples are collected from vessels or containers which can be moved (drums for example), mark the vessel or container with the field identification or sample station number for future identification, when necessary. The vessel or container may be labeled with an indelible marker (e.g., paint stick or spray paint). The vessel or container need not be marked if it already has a unique marking or serial number; however, these numbers shall be recorded in the bound field logbooks. In addition, it is suggested that photographs of any physical evidence (markings, etc.) be taken and the necessary information recorded in the field logbook.

Occasionally, it is necessary to obtain recorder and/or instrument charts from facility owned analytical equipment, flow recorders, etc., during field investigations and inspections. Mark the charts and write the following information on these charts while they are still in the instrument or recorder :

- Starting and ending time(s) and date(s) for the chart.
- Take an instantaneous measurement of the media being measured by the recorder. The instantaneous measurement shall be entered at the appropriate location on the chart along with the date and time of the measurement.
- A description of the location being monitored and any other information required to interpret the data such as type of flow device, chart units, factors, etc.

All of the above information should be initialed by the field investigator. After the chart has been removed, the field investigator shall indicate on the chart who the chart (or copy of the chart) was received from and enter the date and time, as well as the investigator's initials.

Documents such as technical reports, laboratory reports, etc., should be marked with the field investigator's signature, the date, the number of pages, and from whom they were received. Confidential documents should not be accepted, except in special circumstances such as process audits, hazardous waste site investigations, etc.

3.3 Chain-of-Custody Procedures

PERFORMANCE OBJECTIVE:

- To maintain and document the possession of samples or other evidence from the time of collection until they or the data derived from the samples are introduced as evidence.

3.3.1 Introduction

Chain-of-custody procedures are comprised of the following elements; 1) maintaining sample custody and 2) documentation of samples for evidence. To document chain-of-custody, an accurate record must be maintained to trace the possession of each sample from the moment of collection to its introduction into evidence.

3.3.2 Sample Custody

A sample or other physical evidence is in custody if:

- it is in the actual possession of an investigator;
- it is in the view of an investigator, after being in their physical possession;
- it was in the physical possession of an investigator and then they secured it to prevent tampering; and/or
- it is placed in a designated secure area.

3.3.3 Documentation of Chain-of-Custody

Sample Tag

A sample tag (Figure 3-1) should be completed for each sample using waterproof, non-erasable ink as specified in Section 3.2.

Sample Seals

Samples should be sealed as soon as possible following collection utilizing the EPA custody seal (EPA Form 7500-2(R7-75)) shown in Figure 3-2. A similar seal is used for samples collected during criminal investigations, however, the seal is red. Though not required, red custody seal is preferred for sealing samples collected during criminal investigations. The sample custodian should write the date and their signature or initials on the seal. The use of custody seals may be waived if field investigators keep the samples in their custody as defined in Section 3.3.2 from the time of collection until the samples are delivered to the laboratory analyzing the samples.

Chain-of-Custody Record

The field Chain-Of-Custody Record (Figure 3-3) is used to record the custody of all samples or other physical evidence collected and maintained by investigators. All physical evidence or sample sets shall be accompanied by a Chain-Of-Custody Record. This Chain-Of-Custody Record documents transfer of custody of samples from the sample custodian to another person, to the laboratory, or other organizational elements. To simplify the Chain-of-Custody Record and eliminate potential litigation problems, as few people as possible should have custody of the samples or physical evidence during the investigation. This form shall not be used to document the collection of split samples where there is a legal requirement to provide a receipt for samples (see Section 3.4). The Chain-Of-Custody Record also serves as a sample logging mechanism for the laboratory sample custodian. A Chain-of-Custody Record will be completed for all samples or physical evidence collected. A separate Chain-of-Custody Record should be used for each final destination or laboratory utilized during the investigation.

The following information must be supplied in the indicated spaces (Figure 3-3) to complete the field Chain-Of-Custody Record.

- The project number.
- The project name.
- All samplers and sampling team leaders (if applicable) must sign in the designated signature block.
- The sampling station number, date, and time of sample collection, grab or composite sample designation, and a brief description of the type of sample and/or the sampling location must be included on each line. One sample should be entered on each line and a sample should not be split among multiple lines.
- If multiple sampling teams are collecting samples, the sampling team leader's name should be indicated in the "Tag No./Remarks" column.
- If the individual serving as the field sample custodian is different from the individual serving as the project leader, the field sample custodian's name and the title of the sample custodian (e.g., Jane Doe, Sample Custodian) should be recorded in the "Remarks" section in the top right corner of the Chain-of-Custody Record. The Remarks section may also be used to record airbill numbers, registered or certified mail serial numbers, or other pertinent information.

- The total number of sample containers must be listed in the "Total Containers" column for each sample. The number of individual containers for each analysis must also be listed. There should not be more than one sample type per sample. Required analyses should be circled or entered in the appropriate location as indicated on the Chain-of-Custody Record.
- The tag numbers for each sample and any needed remarks are to be supplied in the "Tag No./Remarks" column.
- The sample custodian and subsequent transferee(s) should document the transfer of the samples listed on the Chain-of-Custody Record. The person who originally relinquishes custody should be the sample custodian. Both the person relinquishing the samples and the person receiving them must sign the form. The date and time that this occurred should be documented in the proper space on the Chain-of-Custody Record.
- Usually, the last person receiving the samples or evidence should be the laboratory sample custodian or their designee(s).

The Chain-of-Custody Record is a serialized document. Once the Record is completed, it becomes an accountable document and must be maintained in the project file. The suitability of any other form for chain-of-custody should be evaluated based upon its inclusion of all of the above information in a legible format.

If chain-of-custody is required for documents received during investigations, the documents should be placed in large envelopes, and the contents should be noted on the envelope. The envelope shall be sealed and an EPA custody seal placed on the envelope such that it cannot be opened without breaking the seal. A Chain-Of-Custody Record shall be maintained for the envelope. Any time the EPA seal is broken, that fact shall be noted on the Chain-Of-Custody Record and a new seal affixed. The information on the seal should include the sample custodian's signature or initials, as well as the date.

Physical evidence such as video tapes or other small items shall be placed in Zip-Loc® type bags or envelopes and an EPA custody seal should be affixed so that they cannot be opened without breaking the seal. A Chain-Of-Custody Record shall be maintained for these items. Any time the EPA seal is broken, that fact shall be noted on the Chain-of-Custody Record and a new seal affixed. The information on the seal should include the sample field custodian's signature or initials, as well as the date.

EPA custody seals can be used to maintain custody of other items when necessary by using similar procedures as those previously outlined in this section.

Samples should not be accepted from other sources unless the sample collection procedures used are known to be acceptable, can be documented, and the sample chain-of-custody can be established. If such samples are accepted, a standard sample tag containing all relevant information and the Chain-Of-Custody Record shall be completed for each set of samples.

3.3.4 Transfer of Custody with Shipment

- Samples shall be properly packaged for shipment in accordance with the procedures outlined in Appendix D.
- All samples shall be accompanied by the Chain-Of-Custody Record. The original and one copy of the Record will be placed in a plastic bag inside the secured shipping container if samples are shipped. When shipping samples via common carrier, the "Relinquished By" box should be filled in; however, the "Received By" box should be left blank. The laboratory sample custodian is responsible for receiving custody of the samples and will fill in the "Received By" section of the Chain-of-Custody Record. One copy of the Record will be retained by the project leader. The original Chain-of-Custody Record will be transmitted to the project leader after the samples are accepted by the laboratory. This copy will become a part of the project file.
- If sent by mail, the package shall be registered with return receipt requested. If sent by common carrier, a Government Bill of Lading (GBL) or Air Bill should be used. Receipts from post offices, copies of GBL's, and Air Bills shall be retained as part of the documentation of the chain-of-custody. The Air Bill number, GBL number, or registered mail serial number shall be recorded in the remarks section of the Chain-Of-Custody Record or in another designated area if using a form other than that shown in Figure 3-2.

3.4 Receipt for Samples Form (CERCLA/RCRA/TSCA)

3.4.1 Introduction

Section 3007 of the Resource Conservation and Recovery Act (RCRA) of 1976 and Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) of 1980 require that a "receipt" for all facility samples collected during inspections and investigations be given to the owner/operator of each facility before the field investigator departs the premises. The Toxic Substances Control Act (TSCA) contains similar provisions.

3.4.2 Receipt for Samples Form

The Receipt for Samples form (Figure 3-4) is to be used to satisfy the receipt for samples provisions of RCRA, CERCLA, and TSCA. The form also documents that split samples were offered and either "Received" or "Declined" by the owner/operator of the facility or site being investigated. The following information must be supplied and entered on the Receipt for Samples form.

- The project number, project name, name of facility or site, and location of the facility or site must be entered at the top of the form in the indicated locations.
- The sampler(s) must sign the form in the indicated location. If multiple sample teams are collecting samples, the sample team leader's name should be indicated in the "EPA Sample Tag No.'s/Remarks" column.

- Each sample collected from the facility or site must be documented in the sample record portion of the form. The sample station number, date and time of sample collection, composite or grab sample designation, whether or not split samples were collected (yes or no should be entered under the split sample column), the tag numbers of samples collected which will be removed from the site, a brief description of each sampling location, and the total number of sample containers for each sample must be entered.
- The bottom of the form is used to document the site operator's acceptance or rejection of split samples. The project leader must sign and complete the information in the "Split Samples Transferred By" section (date and time must be entered). If split samples were not collected, the project leader should initial and place a single line through "Split Samples Transferred By" in this section. The operator of the site must indicate whether split samples were received or declined and sign the form. The operator must give their title, telephone number, and the date and time they signed the form. If the operator refuses to sign the form, the sampler(s) should note this fact in the operator's signature block and initial this entry.

The Receipt for Samples form is serialized and becomes an accountable document after it is completed. A copy of the form is to be given to the facility or site owner/operator. The original copy of the form must be maintained in the project files.

3.5 Field Records

PERFORMANCE OBJECTIVE:

- To accurately and completely document all field activities.

Each project should have a dedicated logbook. The project leader's name, the sample team leader's name (if appropriate), the project name and location, and the project number should be entered on the inside of the front cover of the logbook. It is recommended that each page in the logbook be numbered and dated. The entries should be legible and contain accurate and inclusive documentation of an individual's project activities. At the end of all entries for each day, or at the end of a particular event if appropriate, the investigator should draw a diagonal line and initial indicating the conclusion of the entry. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and must be maintained as part of the official project files. All aspects of sample collection and handling, as well as visual observations, shall be documented in the field logbooks. The following is a list of information that should be included in the logbook:

- sample collection equipment (where appropriate);
- field analytical equipment, and equipment utilized to make physical measurements shall be identified;
- calculations, results, and calibration data for field sampling, field analytical, and field physical measurement equipment;
- property numbers of any sampling equipment used, if available;

- sampling station identification;
- time of sample collection;
- description of the sample location;
- description of the sample;
- who collected the sample;
- how the sample was collected;
- diagrams of processes;
- maps/sketches of sampling locations; and
- weather conditions that may affect the sample (e.g., rain, extreme heat or cold, wind, etc.)

3.6 Document Control

The term document control refers to the maintenance of inspection and investigation project files. All project files shall be maintained in accordance with Divisional guidelines. All documents as outlined below shall be kept in project files. Investigators may keep copies of reports in their personal files, however, all official and original documents relating to inspections and investigations shall be placed in the official project files. The following documents shall be placed in the project file, if applicable:

- request memo from the program office;
- copy of the study plan;
- original Chain-Of-Custody Records and bound field logbooks;
- copy of the Receipt for Sample forms;
- records obtained during the investigation;
- complete copy of the analytical data and memorandums transmitting analytical data;
- official correspondence received by or issued by the Branch relating to the investigation including records of telephone calls;
- photographs and negatives associated with the project;
- one copy of the final report and transmittal memorandum(s); and
- relevant documents related to the original investigation/inspection or follow-up activities related to the investigation/inspection.

Under no circumstances are any inappropriate personal observations or irrelevant information to be filed in the official project files. The project leader shall review the file at the conclusion of the project to insure that it is complete.

3.7 Disposal of Samples or Other Physical Evidence

Disposal of samples or other physical evidence obtained during investigations is conducted on a case-by-case basis. Before samples which have been analyzed are disposed, laboratory personnel shall contact the project leader or his/her supervisor in writing, requesting permission to dispose of the samples. The samples will not be disposed of until the project leader or his/her supervisor completes the appropriate portions of the memorandum, signs, and returns the memorandum to the laboratory, specifically giving them permission to dispose of the samples. Personnel should check with the EPA Program Office requesting the inspection or investigation before granting permission to dispose of samples or other physical evidence. The following general guidance is offered for the disposal of samples or other physical evidence:

- No samples, physical evidence, or any other document associated with a criminal investigation shall be disposed without written permission from EPA's Criminal Investigations Division.
- Internal quality assurance samples are routinely disposed after the analytical results are reported. The laboratory does not advise the Quality Assurance Officer of the disposal of these samples.
- Samples associated with routine inspections may be disposed following approval from the project leader.

After samples are disposed, the laboratory shall send the sample tags to the Field Equipment Center (FEC) coordinator. These sample tags are accountable and must be placed and maintained in official files at the FEC.

3.8 Field Operations Records Management System (FORMS)

FORMS is a computer program designed to streamline the documentation required by ESD and/or the Contract Laboratory Program (CLP) for sample identification and chain-of-custody. Once the appropriate information is entered into the computer, FORMS will generate stick-on labels for the sample tags, sample containers (CLP), and field logbooks, and will generate the sample receipt and chain-of-custody reports for the appropriate laboratory. The advantages to this system include faster processing of samples and increased accuracy. Accuracy is increased because the information is entered only once, and consequently, consistent from the log book to the tags, bottle labels, and chain-of-custody forms. Operating instructions are available for use with the FORMS program.

FIGURE 3-2
EPA CUSTODY SEAL

 UNITED STATES ENVIRONMENTAL PROTECTION AGENCY OFFICIAL SAMPLE SEAL	SAMPLE No.	DATE	SEAL BROKEN BY	DATE
	SIGNATURE			
	PRINT NAME AND TITLE (<i>INSPECTOR, ANALYST or TECHNICIAN</i>)			

EPA FORM
1500-2(R7-75)

SECTION 5 SAMPLING DESIGN AND QUALITY ASSURANCE PROCEDURES

SECTION OBJECTIVES:

- Define planning and quality assurance elements that must be incorporated in all sampling operations.
- Define sampling site selections and collection procedures for individual media.
- Define sampling quality assurance procedures.

5.1 Introduction

This section discusses the standard practices and procedures used by Branch personnel during field operations to ensure the collection of representative samples. Sampling activities conducted by field investigators are conducted with the expectation that information obtained may be used for enforcement purposes, unless specifically stated to the contrary in advance of the field investigation. Therefore, correct use of proper sampling procedures is essential. Collection of representative samples depends upon:

- Ensuring that the sample is representative of the material being sampled.
- The use of proper sampling, sample handling, preservation, and quality control techniques.

5.2 Definitions

Sample -- part of a larger lot, usually an area, a volume, or a period of time.

Representative Sample -- a sample that reflects one or more characteristics of a population.

Sample Representativeness -- the degree to which a set of samples defines the characteristics of a population, where each sample has an equal probability of yielding the same result.

Variability -- the range or “distribution” of results around the mean value obtained from samples within a population. There are three types of variability which must be measured or otherwise accounted for in field sampling.

1. Temporal Variability

Temporal variability is the range of results due to changes in contaminant concentrations over time. An example would be the range of concentrations obtained for a given parameter in wastewater samples collected at different times from an outfall where contaminant concentrations vary over time.

2. Spacial Variability

Spacial variability is the range of results due to changes in contaminant concentrations as a function of their location. An example would be the range of concentrations obtained for a given parameter in surface soil from a site where discrete "hot spots" are present due to localized releases of contaminants on otherwise uncontaminated soil.

3. Sample Handling Variability

Sample handling variability is the range of results due to the sample collection and handling by the sampler. This variability manifests itself as a positive bias due to errors such as unclean sampling equipment, cross contamination, etc., or a negative bias due to improper containers or sample preservation.

Accuracy -- a measure of agreement between the true value and the measured value of a parameter.

Precision -- measure of the agreement among individual measurements of identical samples.

Bias -- consistent under or over-estimation of the true value due to sampling errors, sample handling errors, or analytical errors.

Grab Sample -- an individual sample collected from a single location at a specific time or period of time. Grab samples are generally authoritative in nature.

Composite Samples -- a sample collected over a temporal or spacial range that typically consists of a series of discrete, equal samples (or "aliquots") which are combined or "composited". Four types of composite samples are listed below:

1. Time Composite (TC) - a sample comprised of a varying number of discrete samples (aliquots) collected at equal time intervals during the compositing period. The TC sample is typically used to sample wastewater or streams.
2. Flow Proportioned Composite (FPC) - a sample collected proportional to the flow during the compositing period by either a time-varying/constant volume (TVCV) or time-constant/varying volume (TCVV) method. The TVCV method is typically used with automatic samplers that are paced by a flow meter. The TCVV method is a manual method that individually proportions a series of discretely collected aliquots. The FPC is typically used when sampling wastewater.
3. Areal Composite - sample composited from individual, equal aliquots collected on an areal or horizontal cross-sectional basis. Each aliquot is collected in an identical manner. Examples include sediment composites from quarter-point sampling of streams and soil samples from within grids.
4. Vertical Composite - a sample composited from individual, equal aliquots collected from a vertical cross section. Each aliquot is collected in an identical manner. Examples include vertical profiles of soil/sediment columns, lakes, and estuaries.

Quality Control Samples

Quality control samples are collected during field studies for various purposes which include the isolation of site effects (control samples), define background conditions (background sample), evaluate field/laboratory variability (spikes and blanks, trip blanks, duplicate, split samples).

The definitions for specific quality control samples are listed below:

Control Sample -- typically a discrete grab sample collected to isolate a source of contamination. Isolation of a source could require the collection of both an upstream sample at a location where the medium being studied is unaffected by the site being studied, as well as a downstream control which could be affected by contaminants contributed from the site under study.

Background Sample -- a sample (usually a grab sample) collected from an area, water body, or site similar to the one being studied, but located in an area known or thought to be free from pollutants of concern.

Split Sample -- a sample which has been portioned into two or more containers from a single sample container or sample mixing container. The primary purpose of a split sample is to measure sample handling variability.

Duplicate Sample -- two or more samples collected from a common source. The purpose of a duplicate sample is to estimate the variability of a given characteristic or contaminant associated with a population.

Trip Blanks -- a sample which is prepared prior to the sampling event in the actual container and is stored with the investigative samples throughout the sampling event. They are then packaged for shipment with the other samples and submitted for analysis. At no time after their preparation are trip blanks to be opened before they reach the laboratory. Trip blanks are used to determine if samples were contaminated during storage and/or transportation back to the laboratory (a measure of sample handling variability resulting in positive bias in contaminant concentration). If samples are to be shipped, trip blanks are to be provided with each shipment but not for each cooler.

Spikes -- a sample with known concentrations of contaminants. Spike samples are often packaged for shipment with other samples and sent for analysis. At no time after their preparation are the sample containers to be opened before they reach the laboratory. Spiked samples are normally sent with each shipment to contract laboratories only. Spiked samples are used to measure negative bias due to sample handling or analytical procedures, or to assess the performance of a laboratory.

Equipment Field Blanks -- a sample collected using organic-free water which has been run over/through sample collection equipment. These samples are used to determine if contaminants have been introduced by contact of the sample medium with sampling equipment. Equipment field blanks are often associated with collecting rinse blanks of equipment that has been field cleaned.

Pre- and Post-Preservative Blanks -- a sample that is prepared **in the field** and used to determine if the preservative used during field operations was contaminated, thereby causing a positive bias in the contaminant concentration. On small studies, usually only a post-preservative blank is prepared at the end of all sampling activities. On studies extending beyond one week, a pre-preservative blank should also be prepared prior to beginning sampling activities. At the discretion of the project leader, additional preservative blanks can be prepared at intervals throughout the field investigation. These blanks are prepared by putting organic/analyte-free water in the container and then preserving the sample with the appropriate preservative.

Field Blanks -- a sample that is prepared in the field to evaluate the potential for contamination of a sample by site contaminants from a source not associated with the sample collected (for example airborne dust or organic vapors which could contaminate a soil sample). Organic-free water is taken to the field in sealed containers or generated on-site. The water is poured into the appropriate sample containers at pre-designated locations at the site. Field blanks should be collected in dusty environments and/or from areas where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled.

Material Blanks -- samples of sampling materials (e.g., material used to collect wipe samples, etc.), construction materials (e.g., well construction materials), or reagents (e.g., organic/analyte free water generated in the field, water from local water supplies used to mix well grout, etc.) collected to measure any positive bias from sample handling variability. Commonly collected material blanks are listed below:

Wipe Sample Blanks -- a sample of the material used for collecting wipe samples. The material is handled, packaged, and transported in the same manner as all other wipe samples with the exception that it is not exposed to actual contact with the sample medium.

Grout Blanks -- a sample of the material used to make seals around the annular space in monitoring wells.

Filter Pack Blanks -- a sample of the material used to create an interface around the screened interval of a monitoring well.

Construction Water Blanks -- a sample of the water used to mix or hydrate construction materials such as monitoring well grout.

Organic/Analyte Free Water Blanks -- a sample collected from a field organic/analyte free water generating system. The sample is normally collected at the end of sampling activities since the organic/analyte free water system is recharged prior to use on a study. On large studies, samples can be collected at intervals at the discretion of the project leader. The purpose of the organic/analyte free water blank is to measure positive bias from sample handling variability due to possible localized contamination of the organic/analyte free water generating system or contamination introduced to the sample containers during storage at the site. Organic/analyte free water blanks differ from field blanks in that the sample should be collected in as clean an area as possible (a usual location for the organic/analyte free water system) so that only the water generating system/containers are measured.

5.3 Sampling Design

5.3.1 Introduction

Development of a sampling design may follow the seven steps outlined in the EPA publication, "Guidance for the Data Quality Objectives Process" (1). The Data Quality Objectives (DQOs) process is a logical step-by-step method of identifying the study objective, defining the appropriate type of data to collect, clarifying the decisions that will be based on the data collected, and considering the potential limitations with alternate sampling designs. Investigations may be executed without completing the DQO process step-by-step; however, the basic elements of the DQO process should be considered by the project leader for each investigation.

Sampling designs are typically either non-probabilistic (directed sampling designs) or probabilistic (random sampling designs) in nature. The sampling design ultimately must meet specific study objectives. The location and frequency of sampling (number of samples) should be clearly outlined in the sampling design, as well as provisions for access to all areas of the site, the use of special sampling equipment, etc. Development of the sampling design in the context of DQOs and sampling optimization are discussed in the ASTM documents "Standard Practice for Generation of Environmental Data Related to Waste Management Activities: Development of Data Quality Objectives" (2), and "Standard Guide for the Generation of Environmental Data Related to Waste Management Activities" (3).

5.3.2 Representative Sampling

A "representative sample" is often defined as a sample that reflects one or more characteristics of the population being sampled. For example, the characteristic which is desired to be reflected by the sample may be the average, minimum, or maximum concentration of a constituent of concern. Ultimately a representative sample is defined by the study objectives. For instance, the objective of the study may be to determine the maximum concentration of lead in the sludge from a surface impoundment. One sample collected near the inlet to the impoundment may provide that information. The collection of a representative sample may be influenced by factors such as equipment design, sampling techniques, and sample handling.

5.3.3 Stratification and Heterogeneous Wastes

Environmental media, as well as waste matrices, may be stratified, i.e., different portions of the population, which may be separated temporally or spatially, may have similar characteristics or properties which are different from adjacent portions of the population. An example would be a landfill that contains a trench which received an industrial waste contaminated with chromium. The trench would be considered a strata within the landfill if chromium was the contaminant of concern. A special case, "stratification by component", is often observed with waste matrices when the constituent of interest is associated with one component of the matrix. An example would be slag contaminated with lead that is mixed with otherwise uncontaminated fire brick. Thus the lead is stratified by component, that being the slag. Stratified sampling designs are discussed later which incorporate independent sampling of each strata, thereby reducing the number of samples required.

Some environmental and waste matrices may be, for purposes of the field investigation, homogeneous (for instance the surface water in a limited segment of a small stream). If the composition of the matrix and the distribution of contaminants are known, or can be estimated, less sampling may be necessary to define the properties of interest. An estimate of the variability in contaminant distribution may be based on knowledge, or determined by preliminary sampling. The more heterogeneous the matrix, the greater the planning and sampling requirements.

A population could also have very localized strata or areas of contamination that are referred to as "hot spots". Specific procedures for hot spot identification and characterization are available in Statistical Methods for Environmental Pollution Monitoring (4).

5.3.4 Specific Sampling Designs

Sampling strategies used by the Branch typically fall into two general groups: **directed** or **probabilistic**. Directed or "authoritative" approaches typically rely on the judgement and experience of the investigators, as well as available information on the matrix of concern. Probabilistic, or "statistical" approaches may be appropriate when estimates on uncertainty and specific confidence levels in the results are required. The probabilistic approaches include: simple random sampling, stratified random sampling, and systematic grid sampling. The main feature of a probabilistic approach is that each location at the site has an equal probability of being sampled, therefore statistical bias is minimized.

5.3.5 Determining the Number of Samples to Collect

The number of samples to collect as part of a sampling design will typically be based on several factors, e.g., the study objectives, properties of the matrix, degree of confidence required, access to sampling points, and resource constraints. Practical guidance for determining the number of samples is included in several documents including the ASTM document Standard Guide for General Planning of Waste Sampling (5), the US-EPA document Characterization of Hazardous Waste Sites - A Methods Manual, Volume 1 - Site Investigations (6), and Statistical Methods for Environmental Pollution Monitoring by Richard O. Gilbert (4).

5.3.6 Authoritative or Directed Sampling

Directed sampling is based on the judgement of the investigator, and does not necessarily result in a sample that reflects the average characteristics of the entire matrix. Directed sampling is also called authoritative or judgmental sampling, and is considered non-probabilistic. The experience of the investigator is often the basis for sample collection, and bias (depending on the study objectives) should be recognized as a potential problem. However, preliminary or screening investigations, and certain regulatory investigations, may correctly employ directed sampling. Directed sampling may focus on "worst case" conditions in a matrix, for example, the most visually contaminated area or the most recently generated waste. In the presence of high temporal or spacial variability, directed samples have a very limited degree of representativeness.

5.3.7 Simple Random Sampling

Simple random sampling insures that each element in the population has an equal chance of being included in the sample. This is often be the method of choice when, for purposes of the investigation, the matrix is considered homogeneous or when the population is randomly heterogeneous. If the population contains trends or patterns of contamination, a stratified random sampling or systematic grid sampling strategy would be more appropriate.

5.3.8 Systematic Sampling over Time or Space

Systematic sampling over time at the point of generation is useful if the material was sampled from a wastewater sewer, a materials conveyor belt, or being delivered via truck or pipeline. The sampling interval would be determined on a time basis, for example every hour from a conveyor belt or pipeline discharge, or from every third truck load. Systematic sampling over space might involve the collection of samples at defined intervals from a ditch, stream, or other matrix that is spatially unique.

5.3.9 Stratified Random Sampling

Stratified random sampling may be useful when distinct strata or "homogeneous sub-groups" are identified within the population. The strata could be located in different areas of the population, or the strata may be comprised of different layers. This approach is useful when the individual strata may be considered internally homogeneous, or at least have less internal variation, in what would otherwise be considered a heterogeneous population. Information on the site is usually required to establish the location of individual strata. A grid may be utilized for sampling several horizontal layers if the strata are horizontally oriented. A simple random sampling approach is typically utilized for sample collection within each strata. The use of a stratified random sampling strategy may result in the collection of fewer samples.

5.3.10 Systematic Grid Sampling

Systematic grid sampling involves the collection of samples at fixed intervals when the contamination is assumed to be randomly distributed. This method is commonly used with populations when estimating trends or patterns of contamination. This approach may not be acceptable if the entire population is not accessible, or if the systematic plan becomes "phased" with variations in the distribution of contaminants within the matrix. This approach may also be useful for identifying the presence of strata within the population. The grid and starting points should be randomly laid out over the site, yet the method allows for rather easy location of exact sample locations within each grid. Also, the grid size would typically be adjusted according to the number of samples that are required.

5.4 General Considerations for Sampling Designs

Prior to commencing work on any project, the objective of the study in terms of the purpose the data generated is to serve should be known. Some examples of uses for which data are generated include:

- RCRA waste identification investigations;
- RCRA or Superfund screening investigations (presence or absence of contaminants);
- Superfund Remedial Investigations, Removal Actions, or Feasibility Studies;
- Surface water and sediment studies;
- Wastewater treatment plant evaluations;
- Monitoring investigations;
- UST/UIC investigations; and
- Special environmental characterization investigations.

The purpose of data collection is to meet the objectives of the investigation. The process of designing an investigation typically follows a logical series of steps. Proper evaluation of these steps will greatly enhance the project leader's ability to choose a design which adequately serves the purpose of the study. The DQO approach may not be strictly followed, but the elements of the approach are always considered during study planning. These elements include:

- Identification of objectives, and investigation boundaries;
- Collection of information concerning historical data, site survey, and site history;
- Sampling design selection and design optimization;
- Sample types and number;
- Analytical requirements and limitations; and
- Data interpretation and assessment.

5.5 Soil Sampling Designs

The objectives of a soil sampling investigation must be clearly defined in terms of the purpose of the data generated. A discussion of study planning elements that include considerations specific to soil investigations follows.

5.5.1 Historical Sampling Data, Site Survey, and Site History

Investigations that are used for initial site screening purposes are one of the few cases where historical sampling data is usually not available. In this case, the purpose of the sampling effort is to determine the presence/absence of contaminants and if present, to determine their nature. Such a purpose can be served with a minimum of samples whose locations can be determined from a site survey and a review of the site history. When designing a soil sampling study for purposes other than site screening, a record of previous sampling efforts is usually available from which a relatively sound foundation of historical sampling data can be derived.

The site survey is invaluable for soil sample design. Information which should be obtained during a site survey includes:

- General site layout;
- Site access;
- Soil types and depths;
- Surface water drainage pathways;
- Existing site conditions;
- Visible staining of surface soil;
- Vegetation stress; and
- Possible offsite or non-site related sources.

The site history should include factors such as previous land use both on and nearby the site, types of industrial operations conducted both on the site and on adjoining property, types of contaminants to which the site has been exposed, and locations of possible dumping/burial areas. The site history can be derived from property plats, tax records, aerial photos, and interviews with people familiar with the site.

5.5.2 Data Quality Objectives (DQOs)

Consideration of the purpose which the data generated from the soil sampling effort is to serve drives the selection of DQOs. DQO selection will then be the main factor which determines the types of samples to be collected, the types of equipment to be used, and the analytical requirements for the samples. See Section 5.12 for a discussion of DQOs.

5.5.3 Authoritative Designs for Soil Investigations

When the purpose of the investigation is to determine the presence of contaminants, a simple strategy can be used. Such a purpose is normally encountered during screening inspections, criminal investigations, and any other project where the scope is limited to gathering evidence of contamination. These cases are normally characterized by a lack of previous sampling data, thereby requiring that sample types and locations be determined by site history and a site survey. In these instances, an authoritative design is normally used.

Authoritative sampling usually involves a limited number of locations (10 to 15) from which grab samples are collected. Locations are selected where there is a good probability of finding high levels of contamination. Examples may include areas where significant releases or spillage occurred according to the site history or areas of visible staining, stressed vegetation, or surface drainage are noted in the site survey. An authoritative design usually involves the selection of two or three control sampling locations to measure possible contaminants migrating onto the site from adjacent sources not involved in the study. The selection of control locations is similar to the selection of other sampling locations, except that upstream or upgradient control samples are expected to be unaffected by site contaminants.

Because of the biased nature of an authoritative design, the degree of representativeness is difficult to estimate. Authoritative samples are not intended to reflect the average characteristics of the site. Since determining representativeness is not an issue with this type of design, duplicate samples designed to estimate variability are not normally collected. However, split samples should be collected to measure sample handling variability.

An interactive approach may be used in an authoritative design to determine the extent of contamination on a site when the source can be identified. Samples are typically collected using a pattern that radiates outward from the source. The direction of contaminant migration may not be known which will result in the collection of more samples, and in this case field screening would be desirable to help in determining appropriate sampling locations.

5.5.4 Systematic Grid Sampling Designs for Soil Investigations

In cases where both the presence of contaminants and the extent of contamination needs to be determined, an authoritative design is inappropriate as site variability cannot be estimated without collecting an inordinate number of samples. A systematic design is normally used during investigations when determining the extent of contamination, such as remedial investigations and removal actions.

Once a site has reached the stage where the extent of contamination becomes an issue, access to data from previous sampling efforts (screening investigations) which used an authoritative design is normally available. The preliminary data can be used to estimate the variability of contaminant concentrations as a function of area and/or depth for purposes of planning the more extensive systematic design. In the absence of previous sampling data a variability study should be conducted. An alternative would be to estimate the variability, with confirmation of the estimate being made during the more extensive systematic study. If a variability study is to be conducted, it will be limited in scope and will use certain default values or assumptions to determine the number of samples to collect for determining site variability. The methods used for variability studies are included in the following discussion of systematic sampling strategies.

Determination of the Number of Samples to Collect

When designing a systematic grid sampling investigation, the number of samples to be collected must be determined first. This can be calculated based on variability information derived from previous sampling data. Upon review of the historical data, a contaminant or contaminants of concern (COCs) can be selected. COCs are parameters which are closest to or in excess of an action level. Their presence is normally the driving force behind the need to determine the extent of contamination.

The following steps are to be followed to determine the number of samples to collect (6):

1. Select a margin of error (p) acceptable for the subsequent use of the data. For soil studies, a margin of error of 0.20 is not unusual. The margin of error may be obtained by dividing the precision wanted (in units of concentration; e.g. ±10 ppm, etc.) by the known or anticipated mean concentration of the COCs. Note that changes in the precision or mean concentration for the COC relative to those anticipated during the planning process may require a re-evaluation of the assumed margin of error.
2. A coefficient of variation (CV), which is defined as the standard deviation of a COC divided by the mean of the COC, is either obtained using previous sampling data, or estimated based on anticipated variability. If a CV above 0.65 is obtained, a large number of samples will usually result.

The number of samples required may be minimized by using a stratified design if areas with known high variability can be identified and addressed separately from areas of lower variability. Areas of high variability will require more samples while areas of low variability will require fewer using the approach outlined in this section. The overall effect will normally be a substantially lower number of samples for the entire site.

3. A confidence level (t_α) needs to be established. For work involving hazardous wastes, a confidence level of 95% should be used. For a 95% confidence level, a factor of 1.96 (from standard statistical tables) is used to calculate the number of samples required.
4. The required number of samples is calculated using the following formula:

$$n = \frac{t_\alpha^2(CV)^2}{p^2}$$

Where:

- n = number of samples to collect
- t_α = statistical factor for a 95% confidence level
- CV = coefficient of variation
- p = margin of error

In a case where no previous sampling data is available, the default values given in the previous discussion can be used.

$$n = \frac{(1.96)^2(0.65)^2}{(0.20)^2}$$

$$n = 40 \text{ samples}$$

Upon completion of the soil sampling effort, the data obtained for the COCs is reviewed. It can then be determined if an adequate number of samples were collected with respect to the margin of error and confidence selected during the planning process. This determination is completed by calculating the CV using the data obtained during the study. The standard deviation of the concentration for a COC is divided by the mean concentration and the CV is calculated. This CV may be higher or lower than the CV selected during the planning process. Using this CV value, the same equation is used to determine the required number of samples based on the actual CV for the study. If this second value for "n" is less than or equal to the number of samples collected during the study, then the site has been characterized for the extent of COCs within the

limits of confidence and error stated. If the second value for "n" is significantly greater, then additional sampling is necessary, or an adjustment to the margin of error or confidence level should be considered. If the collection of additional samples is deemed necessary by the investigation team, the data that has been generated may be used to plan for a more efficient and cost-effective re-sampling of the site. Areas of the site where higher than anticipated variabilities were obtained may be segregated from areas of lower variability (stratified design). A recalculation of the number of samples required to characterize each strata should then be completed and resampling may proceed.

The following table illustrates the number of samples required at a 95% confidence level with varying margins of error (p) and coefficients of variation (CV):

	Coefficient of Variation (CV)				
	0.1	0.5	0.65	1.0	2.0
Margin of Error (p)					
0.1	4	96	162	384	1537
0.2	1	24	40	96	384
0.3	-	10	18	42	170
0.5	-	4	6	15	61
1.0	-	1	2	4	15
2.0	-	-	-	1	4
	Number of Samples (n)				

Note that as the CV increases at a set margin of error, the number of samples required increases. When the variability is low (as measured by the standard deviation or the square root of the variance) relative to the mean of the data, then the CV is low. However, as the variability in the population begins to increase relative to the mean of the data, then the CV increases and the number of samples required increases if characterization of the site at a 95% confidence level and a set margin of error is desired.

A similar relationship is observed for the margin of error. When the precision required (say ± 10 ppm lead) is high relative to the mean of the data (say 100 ppm lead), then the margin of error is low (in this case 0.1). In this case 162 samples would be required with a CV of 0.65. If the investigators could accept a higher margin of error (e.g., $\pm 20\%$), and the mean concentration of the data is still 100 ppm lead, then the resulting margin of error (0.2) would result in a lower number of required samples. Note that 40 samples would be required at the same CV of 0.65.

If the investigators change the confidence level, then the numbers in the table provided would change accordingly. If the confidence level is decreased to 80%, then the required number of samples reflected in this table would be lower for each margin of error and CV combination.

Establishment of the Grid

Having determined the number of samples to collect, the project leader should then determine how to disperse the samples within the site. Commonly, a grid system is used. The number of grids is equal to the number of samples required for a systematic grid design. Grids may also be used to determine sampling locations when using a random design; however, with this type of design every grid is not sampled.

The size of the grids is calculated by dividing the area of the site by the number of samples required. The product of this calculation is the area of each grid. By taking the square root of the grid area, the length of a grid side is determined.

$$G = (a/n)^{1/2}$$

Where:

G = length per side of each individual grid
a = area
n = number of samples required

The length of a grid size should be "rounded" down to some number convenient for the method used in laying out the grid (e.g., plane survey, geographical positioning system (GPS), etc.). Rounding down the grid size will increase the number of samples slightly. It is important to remember that the number of samples calculated is the minimum, and that site conditions may not allow for collection of all samples. Therefore, additional samples would be appropriate.

Grab vs Composite Samples

When designing a systematic grid sampling investigation, a determination of whether to collect grab or composite samples must be made. Grab samples may not adequately describe variability, even within individual grid cells, and therefore, limit the representativeness of the data set. If the study involves a small area with grid cells of 25 feet or less in length, then grab samples could be collected in each grid cell without significantly affecting the representativeness of the data. However, most studies have much larger grids (100 to 500 feet per side). In these cases, composite samples collected within each grid cell result in more representative data. It should be remembered that a composite sample under the best of conditions will yield an average value of contaminants within the grid. Composite samples are most appropriate where a reasonable degree of variability is anticipated, and where soil types are amenable to adequate mixing. This is normally the case when contaminants have been distributed by airborne deposition (relatively homogeneous distribution across the site). Where localized "hot spots" are present due to releases from process units, indiscriminate dumping, or the burying of wastes, a more specialized approach that takes these types of distribution into account is required. Situations where the distribution of contaminants is strongly non-random (heterogeneous distributions) are the most difficult to plan for and characterize.

Composite samples should consist of five to nine aliquots per sample located on compass points within the grid cell. Greater than nine aliquots per sample can result in dilution of fairly high concentrations down to a value below the analytical detection limits. Less than 5 aliquots may limit the representativeness of the sample with no added value over a single grab sample within the grid cell. A certain number of samples are collected (10 percent of the grid cells is often selected) during the investigation for variability determinations based on rotating the aliquot distribution pattern on the points of the compass within the grid cell.

Surface vs Sub-Surface Samples

The two main considerations for sub-surface soil samples are contaminant mobility and type of deposition. A contaminant that is relatively immobile in soil will naturally be found in the same area in which it was deposited. Mobile contaminants require specialized consideration of the likely extent of their migration in order to determine sub-surface soil sampling locations and depths. Airborne deposition of mobile contaminants normally require a considerable amount of sub-surface soil sampling to determine their extent in a systematic design.

5.6 Ground Water Sampling Designs

Sampling design, as it pertains to ground water, often involves the use of some form of temporary well point or direct push technology (DPT) for rapid in-field screening and plume delineation. These techniques are discussed in Section 6. Samples obtained using these techniques are usually analyzed immediately, using an on-site field laboratory, or are sent to an off-site laboratory for quick turnaround analyses. In this manner, delineations of both a horizontal (areal) and vertical nature can be rapidly achieved in the field. These delineations can then be used as the basis for locating and installing permanent ground water monitoring wells.

The degree of complexity for these delineations varies, depending on a number of factors which include:

- The known or anticipated size of the suspected source area.
- Site stratigraphy.
- The amount of information regarding hydrogeological conditions (thickness of aquifers or water-bearing units, depth to confining units, ground water flow direction, etc.).
- The type of contamination (aqueous phase, light non-aqueous phase liquid (LNAPL), or dense non-aqueous phase liquid (DNAPL)).

In addition to the design considerations imposed by the preceding factors, screening program designs may be either simple iterative or grid-based. Grid-based may even transform, at some point, to a more or less iterative program.

5.6.1 Single Source Iterative Programs

The simplest case is one in which there is a small source area of an aqueous phase contaminant or component, such as benzene, toluene, ethyl benzene, and xylene (BTEX) contamination without associated product, and there is a high degree of confidence with respect to ground water flow direction. In this situation, a sample location would be placed in the middle of the source area, for source area characterization, and several locations would be established downgradient. It is not possible to specify the numbers and locations for these sampling points. Three points would typically be the minimum number, one located immediately downgradient of the source area and two located to either side of the center line. If contaminants were detected in any of the downgradient locations, additional locations would need to be established downgradient and/or side-gradient of those locations to complete boundary delineation. This process would continue until both the downgradient and lateral extent of the contamination were established.

As indicated, the numbers and locations of these sampling locations are subject to site scale and other factors and can only be determined in the field using best judgement. At this point, some attention should be given to vertical characterization of the contaminants. Additional samples should be collected at locations below the depths at which the contaminants were identified until the vertical extent is determined. If this is not accomplished during screening activities, it must be done during subsequent investigations with permanent monitoring wells.

Single-source light non-aqueous phase liquids (LNAPL) problems are generally no more complicated than the non-aqueous phase delineation problems. If there are no serious vertical profiling problems, however, the sampling device should be capable of identifying the presence of and determining the thicknesses of the floating LNAPL layers.

A more complex situation would be a single source area in which there is a dense non-aqueous phase liquid (DNAPL) product layer with associated aqueous phase contamination. The initial part of the investigation would be conducted in a manner similar to the simplest case. After delineation of the aqueous phase plume, additional characterization would be required for the DNAPL component. If a confining layer is present and the depth to the surface of this layer is known, samples should be collected from the boundary between the water-bearing formation and the confining unit to determine if DNAPL products are present. Wherever DNAPLs are found, additional samples must be collected. The rationale for sample location selection depends on both sub-surface structure and ground water flow direction. DNAPL constituents may flow down-dip on the surface of confining units, in directions that are totally contrary to ground water flow directions. No attempt at DNAPL characterization should be made until the site geology (stratigraphy, structure and ground water flow patterns) are known.

5.6.2 Multiple-Source Area Grided Programs

Some ground water screening investigations involve identifying multiple source areas and determining the size and shape (delineation) of the associated plumes over relatively large areas. In these cases, it may be appropriate to pre-determine and establish a grid pattern to direct the collection of ground water samples. As the apparent contaminant pattern begins to develop, it may be appropriate to disregard established but unsampled sampling locations and concentrate on other areas within the grid pattern. It may even be appropriate to expand the area of investigation by establishing additional sampling locations. These locations may be determined by using a grid or may be located using best judgement, in an iterative manner.

Considerations regarding non-aqueous phases must be observed here as well. If aqueous phase sample analysis indicates that DNAPL constituents may be present, sampling should be conducted at the surface of the confining unit to determine if product layers are present.

5.6.3 Typical Ground Water Screening Devices

Listed below are numerous tools, devices, and techniques available to field investigators that can be used to effectively collect ground water samples for rapid field screening and plume delineation.

- Temporary wells -- Well casing can be installed temporarily, either inside hollow-stem augers or in an open hole after removal of hollow- or solid-stem augers. Because of the potential for cross-communication between vertical intervals, this technique is appropriate only for screening the upper portion of the saturated zone. Samples are pumped or bailed directly from the well casing. Because turbidity is likely to be a problem using this technique, care should be taken when using the samples for metals screening. Depth of the investigation is limited only by the capability of the drill rig and cross-contamination considerations. See section 6.10 for temporary well installation procedures.
- Geoprobe® -- Slotted steel pipe is hydraulically pushed or hammer driven to the desired sampling depth. Samples are usually acquired with a peristaltic pump. The device is subject to cross-communication at threaded rod joints. It requires some knowledge of the saturated interval. The Geoprobe® is most useful at depths less than 30 to 40 feet below ground surface.

- Hydropunch® -- A larger, more versatile device, similar to the Geoprobe®, which is pushed to sampling depths with a drill rig. It requires some knowledge of saturated intervals to use successfully. Depths of investigation with this technology are roughly correlated to the capability of the drill rig used to push the sampling device.
- Hydrocone® -- This is a pressure-sealed sampling device that is hydraulically pushed to the desired sampling depth. It is capable of collecting a discrete sample from any depth at which it can be pushed. A limited volume of about 700 ml is collected and is generally turbid. This technique is mainly applicable for the screening for volatile organic compounds. A temporary well point can be driven by the same drill rig to collect samples with greater volume requirements. Samples from depths exceeding 100 feet have been obtained with this device. Routine depths obtained without special anchoring are generally within the 50-foot range, but are dependent on the geological materials being encountered.

5.7 Surface Water and Sediment Sampling Designs

5.7.1 Sampling Site Selection

The following factors should be considered in the selection of surface water and sediment sampling locations:

- Study objectives;
- Water use;
- Point source discharges;
- Nonpoint source discharges;
- Tributary locations;
- Changes in stream characteristics;
- Type of stream bed;
- Depth of stream;
- Turbulence;
- Presence of structures (weirs, dams, etc.);
- Accessibility; and
- Tidal effect (estuarine).

If the study objective is to investigate a specific water use such as a source of water supply, recreation, or other discrete use, then considerations such as accessibility, flow, velocity, physical characteristics, etc., are not critical from a water quality investigation standpoint.

If the objective of a water quality study is to determine patterns of pollution, provide data for mathematical modeling purposes, conduct assimilative capacity studies, etc., where more than a small area or short stream reach is to be investigated, then several factors become interrelated and need to be considered in sampling location selection. An excellent guide to conducting surface water stream studies is F. W. Kittrells, "A Practical Guide to Water Quality Studies" (7).

Before any sampling is conducted, an initial reconnaissance should be made to locate suitable sampling locations. Bridges and piers are normally good choices as sites since they provide ready access and permit water sampling at any point across the width of the water body. However, these structures may alter the nature of water flow and thus influence sediment deposition or scouring. Additionally, bridges and piers are not always located in desirable locations with reference to waste sources, tributaries, etc. Wading for water samples in lakes, ponds, and slow-moving rivers and streams must be done with caution since bottom deposits are easily disturbed, thereby resulting in increased sediments in the overlying water column. On the other hand, wadeable areas may be best for sediment sampling. In slow-moving or deep water, a boat is usually required for sampling. Sampling station locations can be chosen without regard to other means of access if the stream is navigable by boat, especially in estuarine systems where boats frequently provide the only access to critical sampling locations.

Fresh water environments are commonly separated into two types:

- Flowing water, including rivers, creeks, and small to intermittent streams; and
- Water that is contained, with restricted flow including lakes, ponds, and manmade impoundments

Since these waterways differ considerably in general characteristics, site selection must be adapted to each. Estuarine environments are a special case and are discussed separately.

5.7.2 Rivers, Streams, and Creeks

In the selection of a surface water sampling site in rivers, streams, or creeks, areas that exhibit the greatest degree of cross-sectional homogeneity should be located. When available, previously collected data may indicate if potential sampling locations are well mixed or vertically or horizontally stratified. Since mixing is principally governed by turbulence and water velocity, the selection of a site immediately downstream of a riffle area will insure good vertical mixing. These locations are also likely areas for deposition of sediments since the greatest deposition occurs where stream velocities decrease provided that the distance is far enough downstream from the riffle area for the water to become quiescent. Horizontal (cross-channel) mixing occurs in constrictions in the channel, but because of velocity increases, the stream bottom may be scoured, and therefore, a constriction is a poor location to collect sediment.

Typical sediment depositional areas are located:

- Inside of river bends;
- Downstream of islands;
- Downstream of obstructions; and
- Areas of flow reversals.

Sites that are located immediately upstream or downstream from the confluence of two streams or rivers should generally be avoided since flows from two tributaries may not immediately mix, and at times due to possible backflow can upset the depositional flow patterns.

When several locations along a stream reach are to be sampled, they should be strategically located:

- At intervals based on time-of-water-travel, not distance, e.g., sampling stations may be located about one-half day time-of-water-travel for the first three days downstream of a waste source (the first six stations) and then approximately one day through the remaining distance.
- At the same locations if possible, when the data collected is to be compared to a previous study.
- Whenever a marked physical change occurs in the stream channel. Example: A stream reach between two adjacent stations should not include both a long rapids section of swift shallow water with a rocky bottom, and a long section of deep, slow-moving water with a muddy bottom. Stations at each end of the combined reach would yield data on certain rates of change, such as reaeration, that would be an unrealistic average of two widely different rates. The actual natural characteristics of the stream would be better defined by inserting a third sampling station within the reach, between the rapids and the quiet water sections.
- To isolate major discharges as well as major tributaries. Dams and weirs cause changes in the physical characteristics of a stream. They usually create quiet, deep pools in river reaches that previously were swift and shallow. Such impoundments should be bracketed with sampling stations. When time-of-water-travel through the pools are long, stations should be established within the impoundments.

Some structures, such as dams, permit overflow and cause swirls in streams that accomplishes significant reaeration of oxygen deficient water. In such cases, stations should be located short distances upstream and downstream from the structures to measure the rapid, artificial increase in dissolved oxygen, which is not representative of natural reaeration.

When major changes occur in a stream reach, an upstream station, a downstream station, and an intermediate station should be selected. Major changes may consist of:

- A wastewater discharge;
- A tributary inflow;
- Non-point source discharge (farms or industrial sites); and
- A significant difference in channel characteristics.

The use of three stations is especially important when rates of change of unstable constituents are being determined. If results from one of only two stations in a subreach are in error for some unforeseen reason, it may not be possible to judge which of the two sets of results indicate the actual rate of change. Results from at least two of three stations, on the other hand, may support each other and indicate the true pattern of water quality in the subreach.

To determine the effects of certain discharges or tributary streams on ambient water quality, stations should be located both upstream and downstream from the discharges. In addition to the upstream and downstream stations bracketing a tributary, a station should be established on the tributary at a location upstream and out of the influence of the receiving stream.

Unless a stream is extremely turbulent, it is nearly impossible to measure the effect of a waste discharge or tributary immediately downstream from the source. Inflow frequently "hugs" the stream bank due to differences in density, temperature, and specific gravity, and consequently lateral (cross-channel) mixing does not occur for some distance.

Tributaries should be sampled as near the mouth as feasible. Frequently, the mouths of tributaries are accessible by boat. Care should be exercised to avoid collecting water samples from stratified locations which are due to differences in density resulting from temperature, dissolved solids, or turbidity.

Actual sampling locations will vary with the size of the water body and the mixing characteristics of the stream or river. Generally, for small streams less than 20 feet wide, a sampling site should be selected where the water is well mixed. In such cases, a single grab sample taken at mid-depth at the center of the channel is adequate to represent the entire cross-section. A sediment sample could also be collected in the same vicinity if available.

For slightly larger streams, at least one vertical composite should be collected from mid-stream. Samples should be collected just below the surface, at mid-depth, and just above the bottom. For larger streams and rivers, at least quarter point (1/4, 1/2, and 3/4 width) composite samples should be collected. Dissolved oxygen, pH, temperature, and conductivity should be measured from each aliquot of the vertical composite.

For large rivers, several locations across the channel width should be sampled. Vertical composites across the channel width should be located in a manner that is roughly proportional to flow, i.e., they should be closer together toward mid-channel, where most of the flow is, than toward the banks, where the proportion of total flow is less. The number of vertical composites required and the number of depths sampled for each are usually determined in the field by the investigators. This determination is based on a reasonable balance between the following two considerations:

- The larger the number of subsamples, the more closely the composite sample will represent the water body; and
- Subsample collection is time-consuming and expensive, and increases the chance of cross-contamination.

In most circumstances, a number of sediment samples should be collected along a cross-section of a river or stream in order to adequately characterize the bed material. A common procedure is to sample at quarter points along the cross-section. When the sampling technique or equipment requires that the samples be extruded or transferred on site, they may be combined into a single composite sample. However, samples of dissimilar composition should not be combined but should be stored for separate analysis in the laboratory. To insure representative samples, the preferred method is diver deployed coring tubes.

5.7.3 Lakes, Ponds, and Impoundments

Lakes, ponds, and impoundments have a much greater tendency to stratify than rivers and streams. The relative lack of mixing generally requires that more samples be obtained. Occasionally, an extreme turbidity difference may occur where a highly turbid river enters a lake. For these situations, each layer of the vertically stratified water column needs to be considered. Since the stratification is caused by water temperature differences, the cooler, more dense river water is beneath the warmer lake water. A temperature profile of the water column as well as visual observation of lake samples can often detect the different layers which can be sampled separately.

The number of water sampling stations on a lake, pond, or impoundment will vary with the objective of the investigation as well as the size and shape of the basin. In ponds and small impoundments, a single vertical composite at the deepest point may be sufficient. Dissolved oxygen, pH, and temperature are generally measured for each vertical composite aliquot. In naturally-formed ponds, the deepest point is usually near the center; in impoundments, the deepest point is usually near the dam.

In lakes and larger impoundments, several vertical subsamples should be composited to form a single sample. These vertical sampling locations are often collected along a transect or grid. The number of vertical subsamples and the depths at which subsamples are taken are usually at the discretion of the field investigators. In some cases, it may be of interest to collect separate composites of epilimnetic and hypolimnetic zones (above and below the thermocline or depth of greatest temperature change).

In lakes with irregular shapes and with several bays and coves that are protected from the wind, additional separate composite samples may be needed to adequately determine water quality. Similarly, additional samples should be collected where discharges, tributaries, land use characteristics, etc., are suspected of influencing water quality.

When collecting sediment samples in lakes, ponds, and reservoirs, the sampling site should be approximately at the center of the water mass. This is particularly true for reservoirs that are formed by the impoundment of rivers or streams. Generally, the coarser grained sediments are deposited near the headwaters of the reservoir, and the bed sediments near the center of the water mass will be composed of fine-grained materials. The shape, inflow pattern, bathymetry, and circulation must be considered when selecting sediment sampling sites in lakes or reservoirs.

5.7.4 Estuarine Waters

Estuarine areas are zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Estuaries are generally categorized into three types, dependent upon freshwater inflow and mixing properties:

- Mixed estuary -- Characterized by an absence of vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically this type of estuary is found in major freshwater sheetflow areas, featuring shallow depths.
- Salt wedge estuary -- Characterized by a sharp vertical increase in salinity and channelized freshwater inflow into a deep estuary. In these estuaries, the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally, back and forth, with the tidal phase.
- Oceanic estuary -- Characterized by salinities approaching full strength oceanic waters. Seasonally, freshwater inflow is small with the preponderance of the fresh and saline water mixing occurring near, or at, the shore line.

A reconnaissance investigation should be conducted for each estuarine study unless prior knowledge of the estuarine type is available. The reconnaissance should focus upon the freshwater and oceanic water dynamics with respect to the study objective. National Oceanic Atmospheric Administration (NOAA) tide tables and United States Geological Survey (USGS) freshwater surface water flow records provide valuable insights into the estuary hydrodynamics. The basic in-situ measurement tools for reconnaissance are:

- Boat;
- Recording fathometer;
- Salinometer;
- Dissolved oxygen meter; and
- Global Positioning System (GPS) equipment and charts.

These instruments coupled with the study objective or pollution source location, whether it is a point or nonpoint source problem, provide the focus for selecting sampling locations. More often than not, preplanned sampling locations in estuarine areas are changed during the actual study period. Because of the dynamics of estuaries, the initial sampling results often reveal that the study objective could be better served by relocating, adding, or deleting sampling locations.

Water sampling in estuarine areas is normally based upon the tidal phases, with samples collected on successive slack tides. All estuarine sampling should include vertical salinity measurements at one to five-foot increments coupled with vertical dissolved oxygen and temperature profiles. A variety of water sampling devices are used, but in general, the Van Dorn (or similar type) horizontal sampler or peristaltic pump are suitable.

Samples are normally collected at mid-depth in areas where the depths are less than 10 feet, unless the salinity profile indicates the presence of a halocline (salinity stratification). In that case, samples are collected from each stratum. Depending upon the study objective, when depths are greater than 10 feet, water samples may be collected at the one-foot depth from the surface, mid-depth, and one-foot from the bottom.

Generally, estuarine investigations are two phased, with study investigations conducted during wet and dry periods. Depending upon the freshwater inflow sources, estuarine water quality dynamics cannot normally be determined by a single season study.

5.7.5 Control Stations

In order to have a basis of comparison of water quality, the collection of samples from control stations is always necessary. A control station upstream from the waste source is as important as are stations downgradient, and should be chosen with equal care to ensure representative results. In some situations it is desirable to have background stations located in similar, nearby estuaries which are not impacted by the phenomena or pollutants being investigated. At times it may be desirable to locate two or three stations downstream from the waste inflow to establish the rate at which the unstable material is changing. The time-of-water-travel between the stations should be sufficient to permit accurate measurement of the change in the constituent under consideration.

5.8 Waste Sampling Designs

5.8.1 Introduction

Waste sampling involves the collection of materials that are typically generated from industrial processes, and therefore may contain elevated concentrations of hazardous constituents. Waste sampling in its broadest term is conventionally considered to be sampling of processed wastes or man-made waste materials. Because of the regulatory, safety, and analytical considerations, wastewater sampling should be separate from waste sampling. Environmental sampling is also different from waste sampling as it involves the collection of samples from natural matrices such as soil, sediment, groundwater, surface water and air.

It is convenient to distinguish waste management units into two types due to Branch safety protocols. The first, "open units", are units where wastes are generated, stored, or disposed, and would be open to the environment and environmental influences. Examples of open waste units are surface impoundments and waste piles. "Closed units" are waste containers/drums, tanks, or sumps where the potential for the accumulation of toxic vapors or explosive/ignitable gases exists. While both open and closed waste units are considered dangerous because of the potential exposure to concentrated wastes, closed units are regarded as high hazards due to their potential to accumulate gases and vapors.

5.8.2 Waste Investigation Objectives

The first step in an investigation is the identification of study objectives. Thorough planning and researching of the waste generation/management practices is then required for the samples and associated data to reflect the waste population characteristic(s) of interest. Prior to sampling wastes, it is extremely important to obtain and assess all of the available information, e.g., waste generation process(es), waste handling and storage practices, previous field screening results, existing sampling and analytical data, any pertinent regulations, and permitting or compliance issues.

Common objectives in waste sampling investigations include:

- Determine if a material is a hazardous waste;
- Characterize a wastestream;
- Determine if a waste material has been released into the environment; or
- Characterize environmental media contaminated with hazardous waste.

The most frequently used objective during RCRA Case Development/Investigation Evaluations and Criminal Investigations involve hazardous waste determinations. For studies that are designed to determine if a release has occurred, it is recommended that samples be collected from the source as well as both the affected and the unaffected media.

Waste matrices are frequently heterogenous in nature due to the physical characteristics of the material (particle size, viscosity, etc.), the distribution of hazardous constituents within the matrix, or the manner in which the material has been managed or disposed. When waste is comprised of strata that can be separated by the sampling equipment (e.g., liquid-liquid or liquid-solid phases), it is not necessary to collect a sample that is representative of the entire unit to make a waste determination. An acceptable objective would be to make a waste determination on a specific strata. For example, in drums containing an oil and water mixture, a glass thief or a composite liquid waste sampler (COLIWASA) could be used to sample only the oil or only the water phase to determine if the phase of interest contains hazardous constituents or characteristics.

5.8.3 Considerations for Waste Sampling Designs

Waste sampling designs should consider the variability of the sample population in terms of the characteristic of concern, the physical size and state of items present in the population, and the ability to access all portions of the population for purposes of sampling. Elements of the sampling design may include the determination of the actual sampling locations and the number of samples to be collected, decisions on the type of samples (grab or composite) to collect, and selection of the appropriate sampling equipment. While sampling locations are usually restricted to accessible portions of a sample population, the number of samples is usually determined by preliminary information, the size of the sample population, field screening results, and the variability of the waste. Composite samples are used to obtain average concentrations of waste units while grab samples are utilized to delineate hot spots or to acquire data for sample variability.

A small wastestream that has a hazardous constituent or characteristic randomly distributed (relatively homogeneous matrix) requires fewer samples than a large wastestream that has a constituent or characteristic of concern which is non-randomly distributed (heterogeneous matrix). For a waste that is randomly distributed, a directed or systematic grid sampling design would be appropriate depending on the objectives, whereas a stratified sampling or very specialize design should be employed for wastes that are non-randomly distributed.

Reviewing the available preliminary information should improve the effectiveness of any sampling investigation. If waste variability cannot be estimated after review of available information, then a preliminary sampling and analytical effort may be necessary. A preliminary sampling investigation would be important when the study's objective is to fully characterize a waste stream using a probabilistic or "statistical" design.

Probabilistic sampling designs similar to the ones used to characterize a site with soil contamination can be used to characterize large units such as waste piles or surface impoundments with random contaminant distributions. Note that an authoritative design is often appropriate to demonstrate the maximum degree of contamination in certain waste management units. Examples include the collection of a sludge sample for inorganic analyses at the inlet to a surface impoundment, or a sample for volatile organic compound analysis from the most recently generated material placed in a waste pile.

A comprehensive probabilistic design may be required to fully characterize unusually complex wastestreams that have a high degree of heterogeneity. For some highly complex, heterogeneous wastes where an average concentration would not be reflected by a design of reasonable scope, an authoritative sampling design based on the sampler's experience may be the only feasible approach.

No background or control samples are required when collecting highly concentrated waste samples.

5.8.4 Waste Sampling Equipment

An extremely important factor in the sampling strategy will be determined by the physical characteristics of the waste material. Selecting appropriate sampling equipment can be one of the most challenging tasks in developing a sampling design. By selecting sampling equipment that will not discriminate against certain physical characteristics (e.g., phase, particle size, etc.), sampling bias can be minimized during waste sampling. Because wastes often stratifies due to different densities of phases, settling of solids, or varying wastes constituents generated at different times, it also may be important to obtain a vertical cross section of the entire unit.

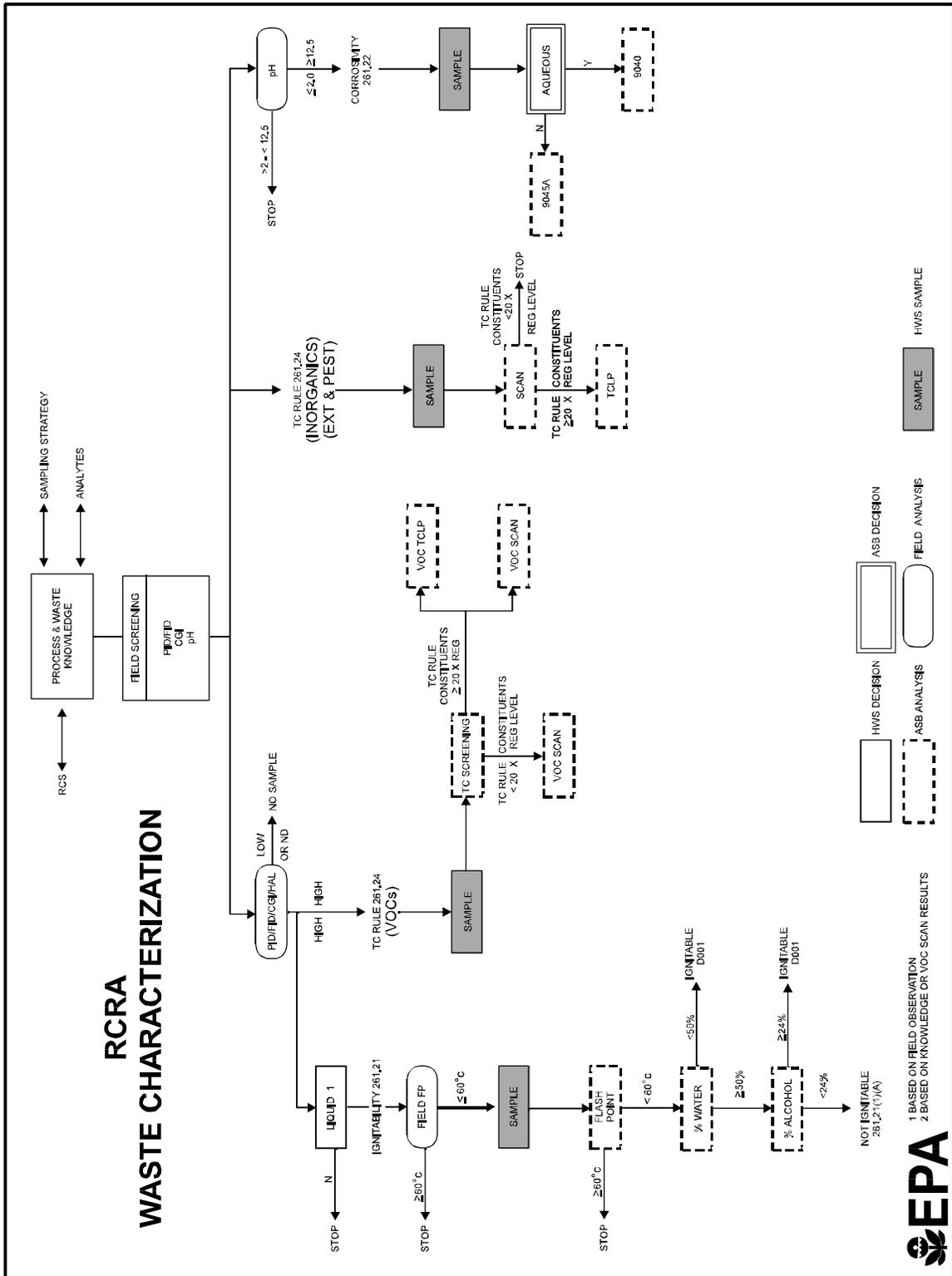
Other desired features of sampling equipment that should be considered during sample design are; the ability to access the desired sampling locations, the ability to maintain sample integrity, the reactivity of equipment with the waste, and the ability to properly decontaminate the sampling apparatus. In addition, analytical requirements such as the sample handling and preparation to correctly analyze physical samples need to be considered. For solidified wastes, samples will often be required to undergo particle size reduction (PSR) prior to chemical analyses.

Sampling equipment should be selected to accommodate all of the known physical characteristics of concern or chosen such that the effect of any sampling bias is understood. Often because of a lack of preliminary information, varying field conditions, or waste heterogeneity, a piece of equipment selected during the sampling design may be unsuccessful for collecting a particular waste sample and another piece of equipment will be required as a substitute. Any sampling bias or deficiencies resulting from the use of substituted equipment should be documented and reviewed with the data.

5.8.5 Field Screening

Field screening can be very effective in waste characterization and extremely valuable in selecting appropriate sampling locations and chemical analyses when little preliminary data exists. Field investigators routinely use observations of the physical characteristics of drum contents, air monitoring equipment, pH meters/paper, and field flash point analyzers to confirm preliminary data or to decide on sampling locations during waste investigations. Figure 5-1 (RCRA Waste Characterization) is a flow diagram that depicts the process that field investigators may use to decide which waste containers to sample and what analyses to perform on particular samples.

FIGURE 5-1
RCRA WASTE CHARACTERIZATION FLOW CHART



5.9 Wastewater Sampling Designs

Introduction

Wastewater sampling studies focus primarily on collecting wastewater samples of the influent or effluent at domestic and non-domestic facilities. The sampling activities are usually conducted for National Pollutant Discharge Elimination System (NPDES) compliance, compliance assistance, civil and criminal investigations, and water quality studies. The collection of wastewater samples is necessary in order to obtain reliable data that can support compliance or enforcement activities. Specific sampling criteria for the collection of wastewater samples is given in Section 9 of this SOP.

The main considerations in developing a wastewater sampling strategy are as follows:

- Type of study (Compliance Sampling Inspection, Diagnostic Evaluation, etc.).
- Regulated or target pollutants in the wastewater stream to be sampled.
- Selection of the projected sampling locations to satisfy the study objectives.
- Quality control criteria of the parameters to be sampled (oil and grease samples need to be collected as grab samples, trip blanks are taken into the field for the collection of samples for volatile organic compound analyses, etc.).

Complexity of the sampling program will vary with a number of factors. Some primary factors are as follows:

- The number of sampling stations to be monitored. This will be dependent on NPDES permit requirements and the type of study (typically Toxic CSIs and DEs require a greater amount of sampling stations than a routine CSI).
- Special handling requirements of the target pollutants (sampling equipment for trace organic compounds require special cleaning procedures, etc.).
- Laboratory conducting the analyses (use of a contract laboratory may require shipping from the field, etc.).
- Accessibility to sampling stations.
- Process and operation criteria of the source generator (e.g., batch operation versus continuous discharge).
- Coordination of participating organizations in the study (e.g., state assistance with the sample collection).
- The length of sampling activities will dictate logistical considerations (e.g., shipment of samples, additional supplies, etc.).

5.10 UST and UIC Sampling Designs

UST and UIC studies focus on determining the quality of the ground water in a target area. Sampling of the ground water in the target area provides the needed scientific data for regional decisions on impacted areas. The main considerations in developing a UST or UIC sampling strategy are as follows:

- Identification of the pollutants in the ground water.
- Identification of the source generator.
- Delineation of the contamination plume.

Complexity of the sampling program will vary based on a number of factors. Some primary factors are as follows:

- Size of the target area.
- Hydrogeological conditions of the target area.
- Accessibility to potable and ground water monitoring wells.
- Process mode of the source generator responsible for the ground water contamination.

Whenever possible, at least one background location (possibly more) should be selected to sample ground water quality representative of an area that is not impacted by any source generator. Background samples should be collected prior to collection of potentially contaminated samples. Enough sampling sites should be utilized to assure a representative sampling of ground water in the target area to adequately characterize the extent of ground water contamination.

Primary impact sampling locations, should be located downgradient of the source generator and at a distance near to the source generator to isolate the contributing process mode responsible for the ground water contamination.

5.11 Air Toxics Monitoring Designs

Ambient air monitoring strategies vary depending upon the monitoring objective. However, some elements are important for any air monitoring objective. Meteorology measurements should be taken concurrent with any major air monitoring effort. At a minimum, these measurements should include wind speed and wind direction.

At least one background sampling location (possibly more) should be selected to sample an air mass that is representative of the area before it is impacted by any emission from the site being monitored. Background samples should be collected concurrent with the site samples. An adequate number of sampling locations should be selected to assure representative sampling of the air mass, and provide enough data to adequately characterize the contaminant concentrations being emitted from the site. Generally, at a site with soil contamination, sampling should be conducted at the areas of high contaminant concentration, near the downwind fence lines, and/or at the fence lines near any residences.

Whenever possible, the sampling sites should be located in an open space and well away from any tall buildings. Attention should be given to avoiding potential local interference such as earth moving equipment, haul roads, etc.

Sampling methods for various ambient air pollutants are given in Section 14 of this SOP.

5.12 Data Quality Objectives

PERFORMANCE OBJECTIVE:

- To ensure that a proper level of QA/QC is performed to match the analytical effort of the study.
- To determine what practical limits are to be placed on the subsequent use of the analytical and field data.

As defined in EPA's "Data Quality Objectives Process for Superfund, Interim Final Guidance" (8), Data Quality Objectives (DQO) are qualitative and quantitative statements derived from the outputs of each step of the DQO process. The DQO process offers a way to plan field investigations so that the quality of data collected can be evaluated with respect to the data's intended use. (For a detailed discussion of the complete DQO process, refer to the referenced guidance document.)

Depending on the study objective and DQOs, different field procedures and analytical methods may be acceptable. Data collected in the field include samples and site information. The methods by which samples are collected may limit the uses of the subsequent analytical data. The methods by which site information, such as physical measurements, photographs, field notes, etc., are collected, may reduce their accuracy. The manner in which sampling equipment is cleaned will also affect the DQO level of the data. Higher quality methods may be substituted for lower level work.

Field methodologies described in this SOP support the highest level of data gathering, unless stated otherwise. These are the standard methods to be used for all studies. Any deviations from these methods must be documented in the field logbook or the approved study plan. Investigators must be aware that such deviations in the field work may reduce the DQO level of the data, with a subsequent reduction in the data uses.

Occasionally, special analytical procedures may require specialized field procedures and equipment. The lead investigator must be aware that these procedures should be specified in the approved study plan prior to beginning the study.

There are four data categories. The first two are defined by Region 4; the latter two are in the "Interim Final Guidance".

- Field Screening -- This level is characterized by the use of portable instruments which can provide real-time data to assist in the optimization of sampling locations and health and safety support. Data can be generated regarding the presence or absence of certain contaminants at sampling locations.
- Field Analyses -- This level is characterized by the use of portable analytical instruments which can be used on site, or in a mobile laboratory stationed near a site. Depending upon the types of contaminants, sample matrix, and personnel skills, qualitative and quantitative data can be obtained.

- Screening Data with Definitive Confirmation -- These data are generated by rapid, less precise methods of analysis with less rigorous sample preparation. Sample preparation steps may be restricted to simple procedures such as dilution with a solvent, instead of elaborate extraction/digestion and cleanup. Screening data provides analyte identification and quantification, although the quantification may be relatively imprecise. At least 10% of the screening data should be confirmed using appropriate analytical methods and QA/QC procedures and criteria associated with definitive data. Screening data without associated confirmation data is not considered to be data of known quality.
- Definitive Data -- These data are generated using rigorous analytical methods, such as approved EPA reference methods. Data are analyte-specific, with confirmation of analyte identity and concentration. These methods produce tangible raw data (e.g., chromatograms, spectra or digital values) in the form of paper printouts or computer-generated electronic files. Data may be generated at the site or at an off-site location, as long as the QA/QC requirements are satisfied. To be definitive, either the analytical or total measurement error must be determined.

DQO information in field study plans should include:

- Sampling locations -- including background and/or control samples.
- Sampling procedures -- reference to this SOP or other guidance documents.
- Sample type -- surface water, ground water, soil, waste, GPS coordinates, etc.
- Use of data -- characterize nature and extent of contamination, accurate sample locations, etc.
- Data types -- field measurements and field analytical data level and laboratory analyses and laboratory analytical data levels.
- Field QA/QC -- percentage of split and duplicate samples, trip blanks, rinse blanks, etc.

5.13 Specific Sample Collection Quality Control Procedures

5.13.1 Introduction

This subsection provides guidelines for establishing quality control procedures for sampling activities. Strict adherence to all of the standard operating procedures outlined in this subsection form the basis for an acceptable sampling quality assurance program.

5.13.2 Experience Requirements

There is no substitute for field experience. Therefore, all professional and paraprofessional investigators shall have the equivalent of six months field experience before they are permitted to select sampling sites on their own initiative. This field experience shall be gained by on-the-job training using the "buddy" system. Each new investigator should accompany an experienced employee on as many different types of field studies as possible. During this training period, the new employee will be permitted to perform all facets of field investigations, including sampling, under the direction and supervision of senior investigators.

5.13.3 Traceability Requirements

All sample collection activities shall be traceable through field records to the person collecting the sample and to the specific piece of sampling equipment (where appropriate) used to collect that sample. All maintenance and calibration records for sampling equipment (where appropriate) shall be kept so that they are similarly traceable. See Sections 3.1 through 3.6 for specific procedures to be utilized that insure traceability.

5.13.4 Chain-of-Custody

Specific chain-of-custody procedures are included in Sections 3.1 through 3.6 of this SOP. These procedures will insure that evidence collected during an investigation will withstand scrutiny during litigation. To assure that procedures are being followed, it is recommended that field investigators or their designees audit chain-of-custody entries, tags, field notes, and any other recorded information for accuracy.

5.13.5 Sampling Equipment Construction Material

Sampling equipment construction materials can affect sample analytical results. Materials used must not contaminate the sample being collected and must be easily decontaminated so that samples are not cross-contaminated.

5.13.6 Sample Preservation

Samples for some analyses must be preserved in order to maintain their integrity. Preservatives required for routine analyses of samples collected are given in Appendix A of this SOP. All chemical preservatives used will be supplied by the Region 4 laboratory. All samples requiring preservation should be preserved immediately upon collection in the field. Samples that **should not** be preserved in the field are:

- Those collected within a hazardous waste site that are known or thought to be highly contaminated with toxic materials which may be highly reactive. Barrel, drum, closed container, spillage, or other source samples from hazardous waste sites are not to be preserved with any chemical. These samples may be preserved by placing the sample container on ice, if necessary.
- Those that have extremely low or high pH or samples that may generate potentially dangerous gases if they were preserved using the procedures given in Appendix A.
- Those for metals analyses which are shipped by air shall not be preserved with nitric acid in excess of the amount specified in Appendix A.

All samples preserved with chemicals shall be clearly identified by indication on the sample tag that the sample is preserved. If samples normally requiring preservation were not preserved, field records should clearly specify the reason.

5.13.7 Special Precautions for Trace Contaminant Sampling

Some contaminants can be detected in the parts per billion and/or parts per trillion range. Extreme care must be taken to prevent cross-contamination of these samples. The following precautions shall be taken when trace contaminants are of concern:

- A clean pair of new, non-powdered, disposable latex gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come into contact with the media being sampled.
- Sample containers for source samples or samples suspected of containing high concentrations of contaminants shall be placed in separate plastic bags immediately after collecting, tagging, etc.
- If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples shall be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples shall never be placed in the same ice chest as environmental samples. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants shall be lined with new, clean, plastic bags.
- If possible, one member of the field sampling team should take all the notes, fill out tags, etc., while the other members collect the samples.
- When sampling surface waters, the water sample should always be collected before the sediment sample is collected.

- Sample collection activities should proceed progressively from the least suspected contaminated area to the most suspected contaminated area.
- Investigators should use equipment constructed of Teflon®, stainless steel, or glass that has been properly precleaned (Appendix B) for collection of samples for trace metals or organic compounds analyses. Teflon® or glass is preferred for collecting samples where trace metals are of concern. Equipment constructed of plastic or PVC shall not be used to collect samples for trace organic compounds analyses.

5.13.8 Sample Handling and Mixing

After collection, all sample handling should be minimized. Investigators should use extreme care to ensure that samples are not contaminated. If samples are placed in an ice chest, investigators should ensure that melted ice cannot cause the sample containers to become submerged, as this may result in sample cross-contamination. Plastic bags, such as Zip-Lock® bags or similar plastic bags sealed with tape, should be used when small sample containers (e.g., VOC vials or bacterial samples) are placed in ice chests to prevent cross-contamination.

Once a sample has been collected, it may have to be transferred into separate containers for different analyses. The best way to transfer liquid samples is to continually stir the sample contents with a clean pipette or precleaned Teflon® rod and allow the contents to be alternately siphoned into respective sample containers using Teflon® or PVC (Tygon® type) tubing (and a siphon bulb to start the flow). Teflon® must be used when analyses for organic compounds or trace metals are to be conducted. Any device used for stirring, or tubing used for siphoning, must be cleaned in the same manner as other equipment (Appendix B). However, samples collected for volatile organic compound, oil and grease, bacteria, sulfides, and phenols analyses may not be transferred using this procedure.

It is extremely important that waste (when appropriate), soil and sediment samples be mixed thoroughly to ensure that the sample is as representative as possible of the sample media. The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:

1. The material in the sample pan should be divided into quarters and each quarter should be mixed individually.
2. Two quarters should then be mixed to form halves.
3. The two halves should be mixed to form a homogenous matrix .

This procedure should be repeated several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion, reversing direction, and occasionally turning the material over.

5.13.9 Special Handling of Samples for Volatile Organic Compounds (VOCs) Analysis

Water samples to be analyzed for volatile organic compounds should be stored in 40-ml septum vials with screw cap and Teflon®-silicone disk in the cap to prevent contamination of the sample by the cap. The disks should be placed in the caps (Teflon® side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program.

The vials should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a convex meniscus. The cap is then applied and some overflow is lost, but the air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles. If any bubbles are present, repeat the procedure with another clean 40-ml vial. Since the VOC vials are pre-preserved, caution should be exercised when the vials are used as the collection device for surface water samples in order to prevent the loss of the preservative. When collecting water samples for VOCs. Three 40-ml vials containing preservative should be filled the with sample.

One 2-oz. glass container with screw caps and Teflon®-silicon disks in the cap are used for the storage of soil and sediment samples for VOC analyses. Soil and sediment samples collected for VOC analyses should not be mixed. The sample container should be filled completely so that no head space remains in the sample containers.

5.13.10 Estimating Variability

Spacial Variability

The following spacial duplicate sampling procedures should be used during the collection of samples as a measure of variability within the area represented by the sample. Spacial duplicate grab and/or composite samples should be collected during all major investigations and studies conducted by the Branch. A "major study" would include all investigations where more than twenty (20) samples were collected, or those studies where the study objectives dictate that additional quality control samples be collected. No more than ten percent of all samples should be collected as spacial duplicates. These samples should be collected at the same time, using the same procedures, the same type of equipment, and in the same types of containers as the original samples, but collected from a different location within the area represented by the original. They should also be preserved in the same manner and submitted for the same analyses as the required samples. The collection of spacial duplicate composite samples requires that the sample aliquots be arrayed in a manner different from the original sample and spaced within the same area of representativeness. Data from spacial duplicates will be examined by the lead investigator to determine if the samples represent the areas intended in the project work plan.

Temporal Variability

When required, temporal variability at a given sampling location will be measured by collecting temporal duplicate samples. These samples will be collected from the same sampling location, using the same techniques and the same type of equipment, but at a time different from the original sample. The time selected for the temporal duplicate sample will be within the same span of time for which the original sample is designed to be representative in the project work plan. Data from temporal duplicates will be examined by the project leader to determine if samples represent the time span intended in the project work plan.

Sample Handling Variability

The effectiveness of sample handling techniques will be measured by collecting split and blank samples.

Split Samples

Split samples will be collected by initially collected twice as much material as normally collected for a sample. After mixing, the material will be apportioned into two sets of containers. Both sets of containers will be submitted for analyses with one set designated as an "original sample", the other designated as a "split sample". Data from split samples will be examined by the Quality Assurance Officer to determine sample handling variability. On large studies (more than 20 samples), no more than 10 percent of all samples will be collected as split samples.

Blank Samples

The following blank samples will be prepared by the laboratory and obtained by the project leader prior to traveling to a sample site.

1. Water Sample VOC Trip Blank -- A water sample VOC trip blank is required for every study where water samples are collected for VOC analysis. Two sealed preserved (or unpreserved if appropriate) 40-ml VOC vials will be transported to the field. For routine studies these samples will be prepared by lab personnel. Investigators shall request that these samples be provided at least one week in advance of scheduled field investigations and inspections and never (except in emergency situations) less than two days in advance of scheduled field investigations and inspections. These samples should not be picked up earlier than the morning of departure for the scheduled inspection/investigation. These field blanks will be handled and treated in the same manner as the water samples collected for volatile organic compounds analysis on that particular study. These samples will be clearly identified on sample tags and Chain-of-Custody Records as trip blanks.
2. Soil Sample VOC Trip Blank -- A soil sample VOC trip blank is required for every study where soil samples are collected for VOC analysis. The preparation and pick up of this sample will be the same as for the water sample VOC trip blank. One 2-oz. soil VOC vial will be transported to the field. This field blank will be handled and treated by Branch personnel in the same manner as the soil samples collected for volatile organic compounds analysis on that particular study. These samples will be clearly identified on sample tags and Chain-Of-Custody Records as trip blanks.

The following blanks are prepared in the field:

1. Inorganic Sample Preservative Blanks -- Metals and general inorganic sample containers filled with analyte-free water will be transported to the field and preserved and submitted for the same analyses as the other inorganic samples collected. These samples will be clearly identified as preservatives blanks on sample tags and the Chain-Of-Custody Record(s). At least one preservative blank for each type of preserved sample should be collected at the end of routine field investigations. A minimum of one preservative blank should be prepared in the field at the beginning and end of all major field investigations that last more than one week.

2. Equipment Field Blanks -- When field cleaning equipment is required during a sampling investigation, a piece of the field-cleaned equipment will be selected for collection of a rinse blank. At least one rinse blank will be collected during each week of sampling operations. After the piece of equipment has been field cleaned and prior to its being used for sample operations, it will be rinsed with organic/analyte free water. The rinse water will be collected and submitted for analyses of all constituents for which normal samples collected with that piece of equipment are being analyzed.
3. Organic/Analyte Free Water System Blanks -- When using a portable organic-free water generating system in the field, a sample of the water generated will be collected at least once during each week of operations. The collected water sample will be submitted for analyses of all constituents for which normal samples are being analyzed.
4. Material Blanks -- When construction materials are being used on a site in such a way as to have a potential impact on constituent concentrations in the sample, a sample of the materials will be submitted for analyses. An example of a situation where construction blanks are required is monitoring well construction. In this situation all materials used in well construction should be submitted for analyses (e.g., grout, sand, tap water, etc.).
5. Automatic Sampler Blanks -- In general, cleaning procedures outlined in Appendix B of this SOP should be adequate to insure sample integrity. However, it is the standard practice of the Branch to submit automatic sampler blanks for analyses when automatic samplers are used to collect samples for organic compounds and metals analyses. Automatic sampler blanks for other standard analyses shall be submitted at least once per quarter.

The Quality Assurance Officer will inform the project leaders and management when blank samples are found to be unacceptably contaminated. The Quality Assurance Officer will immediately initiate an investigation to determine the cause of the problem. The results of this investigation will be promptly reported to appropriate personnel so that corrective action and/or qualifications to the data can be initiated.

5.13.12 Special Quality Control Procedures for Water Samples for Extractable Organic Compounds, Pesticides, or Herbicides Analyses (Matrix Duplicate)

Duplicate water samples shall be submitted to the laboratory for extractable organic compounds, pesticides, and/or herbicides analyses from at least one sampling location per project and laboratory used. These samples should be collected from a location expected to be relatively free from contamination, since the samples will be used for laboratory quality control purposes. The duplicate samples should be clearly identified as "Duplicate Sample for Matrix Spike" on the sample tag, Chain-Of-Custody Record, in the field logbook, and on the Contract Laboratory Program (CLP) Traffic Report Form (if appropriate). This procedure shall be followed for all projects where water samples are collected for the indicated analyses.

5.13.13 Special Quality Control Procedures for EPA Contract Laboratories

On a case-by-case basis, field investigators may be required to collect split samples (or duplicate samples if appropriate) for analyses by both the Region 4 laboratory and contract laboratories. The split samples are to be submitted to the Region 4 laboratory using established procedures. The contract laboratory involved shall not be notified that samples were split, i.e., there should be no indication on Chain-Of-Custody Records or CLP Traffic Report Forms submitted to the contract laboratories that these samples were split with the Region 4 laboratory.

5.13.14 Special Quality Control Procedures for Dioxins and Furans

All samples collected for dioxins and furans analyses are analyzed by other EPA laboratories or through contract laboratories. The Region 4 laboratory does not conduct in-house analyses for dioxins and furans. The Region 4 laboratory should be consulted for the current quality control procedures for dioxin and furan samples prior to the sampling event.

5.14 Internal Quality Control Procedures

5.14.1 Introduction

The focus of this subsection is on Field Equipment Center (FEC) operations involving preparation of sampling and support equipment for field operations as well as for field data generated under the Specific Sample Collection Quality Control Procedures discussed in Section 5.13. Quality control checks of these operations insure that field sampling teams are provided with equipment that is suitable for sampling use, and that field sampling is conducted using proper procedures.

5.14.2 Traceability Requirements

Records, in the form of bound notebooks, will be kept by FEC personnel documenting the dates of operations and the person performing operations for the following:

- Organic/Analyte Free Water System Maintenance (Field and FEC Systems) -- Maintenance on field systems will be performed immediately following every major study, or at least once per calendar quarter. FEC system maintenance will be performed at least once per calendar quarter.
- Air Monitoring Instrumentation Checkouts -- Pre-loadout checks on air monitoring instrumentation will be recorded each time they are performed. Discrepancies will be immediately reported to the Branch Safety Officer.
- Self Contained Breathing Apparatus (SCBA) Checkouts -- Pre-loadout checks on SCBAs will be recorded when they are performed. SCBA checkouts will be performed at least once per calendar quarter in the absence of loadout requests. Any discrepancies will be reported immediately to the Branch Safety Officer.
- Other Equipment Maintenance -- Maintenance performed on equipment other than that listed above will be recorded in a logbook for miscellaneous field equipment. All required repairs will be reported to the FEC coordinator.
- Sampling Containers and Latex Gloves -- A record will be kept of shipments received of sampling containers and latex gloves. Containers and gloves will be recorded by lot numbers. Upon receipt, the Quality Assurance (QA) Officer will be notified. Containers and gloves within a received lot will not be used until they have been checked by the QA Officer.

All equipment cleaned and wrapped for field use will be marked with the date on which preparation was completed. Equipment will be stored in the FEC in specified areas to minimize the risk of contamination while awaiting use.

5.14.3 Specific Quality Control Checks

At least once per calendar quarter, the QA Officer will conduct the following checks and issue a written report on the results.

1. Collect and submit for analyses samples of each lot of containers received during that quarter. Bottles from each lot will be tagged and sealed, then submitted for the following analyses:

One-Gallon Amber -- metals, cyanide, extractable organics, and pesticides.

8-oz. Glass -- metals, cyanide, extractable organics, and pesticides.

1-Liter Polyethylene -- metals and cyanide.

Latex glove samples will be collected as rinse blanks using organic/analyte free water. The rinsate will be submitted for analyses of VOCs, metals, cyanide, extractable organics, and pesticides. A new glove will be rinsed for each parameter (e.g., one glove for VOC sample, another glove for metals, etc.) to avoid dilution of potential contaminants on the gloves.

2. Collect and submit for analyses a sample of water from the FEC organic/analyte free water system. The sample will be submitted for analyses of VOCs, metals, cyanide, extractable organics, and pesticides.
3. Collect and submit for analyses a sample of analyte-free water stored in one-gallon containers at the FEC. The sample will be submitted for analyses of metals and cyanide.
4. Collect and submit for analyses a rinsate blank of at least one piece of sampling or sample related equipment stored at the FEC. The sample will be submitted for analyses of VOCs, metals, cyanide, extractable organics, and pesticides.
5. Collect the results of field quality control samples from the project leaders for the quarter. Normally, field quality control samples consist of the following:
 - Field split samples (not to include inter-lab splits);
 - Water VOC trip blank samples;
 - Soil VOC trip blank samples;
 - Inorganic sample preservative blanks;
 - Equipment field rinse blanks;
 - Field organic/analyte free water system blanks; and
 - Material blanks.

The QA Officer will evaluate all data received and immediately attempt to resolve any problems found. A written report will be issued on the quality control checks during each calendar quarter. The report will be submitted to appropriate personnel.

5.15 Investigation Derived Waste (IDW)

5.15.1 Types of IDW

Materials which may become IDW are:

- Personnel protective equipment (PPE) -- This includes disposable coveralls, gloves, booties, respirator canisters, splash suits, etc.
- Disposable equipment -- This includes plastic ground and equipment covers, aluminum foil, conduit pipe, composite liquid waste samplers (COLIWASAs), Teflon® tubing, broken or unused sample containers, sample container boxes, tape, etc.
- Soil cuttings from drilling or hand augering.
- Drilling mud or water used for water rotary drilling.
- Ground water obtained through well development or well purging.
- Cleaning fluids such as spent solvents and washwater.
- Packing and shipping materials.

Table 5.15.1 lists the types of IDW commonly generated during investigations, and current disposal practices.

5.15.2 Management of Non-Hazardous IDW

Disposal of non-hazardous IDW from hazardous waste sites should be addressed in the study plan. To reduce the volume for transportation back to the FEC, it may be necessary to compact the waste into a reusable container, such as a 55-gallon drum.

If the waste is from an active facility, permission should be sought from the operator of the facility to place the non-hazardous PPE, disposable equipment, and/or paper/cardboard wastes into the facilities' dumpsters. If necessary, these materials may be placed into municipal dumpsters, with the permission of the owner. These materials may also be taken to a nearby permitted landfill. On larger studies, waste hauling services may be obtained and a dumpster located at the study site. Non-hazardous IDW may also be buried on site near the contamination source, with the burial location noted in the field logbook.

Disposal of non-hazardous IDW such as drill cuttings, purge or development water, decontamination washwater, drilling muds, etc., should be specified in the approved study plan. It is recommended that these materials be placed into a unit with an environmental permit such as a landfill or sanitary sewer. These materials must not be placed into dumpsters. If the facility at which the study is being conducted is active, permission should be sought to place these types of IDW into the facilities treatment system. It may be feasible to spread drill cuttings around the borehole, or if the well is temporary, to place the cuttings back into the borehole. Cuttings, purge water, or development water may also be placed in a pit in or near the source area. Monitoring well purge or development water may also be poured onto the ground downgradient of the monitoring well. Purge water from private potable wells which are in service may be discharged directly onto the ground surface.

The minimum requirements of this subsection are:

- Liquid and soil/sediment IDW must be containerized and analyzed before disposal.
- The collection, handling, and proposed disposal method must be specified in the approved study plan.

5.15.3 Management of Hazardous IDW

Disposal of hazardous or suspected hazardous IDW must be specified in the approved study plan. Hazardous IDW must be disposed as specified in US-EPA regulations. If appropriate, these wastes may be placed back in an active facility waste treatment system. These wastes may also be disposed of in the source area from which they originated, if doing so does not endanger human health and the environment.

If on-site disposal is not feasible, and if the wastes are suspected to be hazardous, appropriate tests must be conducted to make that determination. If they are determined to be hazardous wastes, they must be properly contained and labeled. They may be stored on the site for a maximum of 90 days before they must be manifested and shipped to a permitted treatment or disposal facility. Generation of hazardous IDW must be anticipated, if possible, to permit arrangements for proper containerization, labeling, transportation, and disposal/treatment in accordance with US-EPA regulations.

The generation of hazardous IDW should be minimized to conserve Branch resources. Most routine studies should not produce any hazardous IDW, with the exception of spent solvents and possibly purged ground water. Care should be taken to keep non-hazardous materials segregated from hazardous waste contaminated materials. The volume of spent solvents produced during equipment decontamination should be controlled by applying only the minimum amount of solvent necessary, and capturing it separately from the washwater.

At a minimum the requirements of the management of hazardous IDW are as follows:

- Spent solvents must be returned to the FEC for proper disposal or recycling.
- All hazardous IDW must be containerized. Proper handling and disposal should be arranged prior to commencement of field activities.

**TABLE 5.15.1
DISPOSAL of IDW**

TYPE	HAZARDOUS	NON-HAZARDOUS
PPE-Disposable	Containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Double bag waste. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.
PPE-Reusable	Decontaminate as per Appendix B, if possible. If the equipment cannot be decontaminated, containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Decontaminate as per Appendix B.
Spent Solvents	Containerize in original containers. Clearly identify contents. Leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	N/A
Soil Cuttings	Containerize in 55-gallon drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with WMD site manager for testing and disposal.	Containerize in 55-gallon drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with site manager for testing and disposal.
Groundwater	Containerize in 55-gallon drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with WMD site manager for testing and disposal.	Containerize in 55-gallon drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with site manager for testing and disposal.
Decontamination Water	Containerize in 55-gallon drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with WMD site manager for testing and disposal.	Containerize in 55-gallon drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with site manager for testing and disposal.
Disposable Equipment	Containerize in 55-gallon drum or 5-gallon plastic bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with WMD site manager for testing and disposal.	Containerize in 55-gallon drum or 5-gallon plastic bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with site manager for testing and disposal.
Trash	N/A	Double bag waste. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.

5.16 References

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6. US-EPA, Characterization of Hazardous Waste Sites - A Methods Manual, Volume 1 - Site Investigations (EPA 600/4-84/075).
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8. US-EPA, Data Quality Objectives Process for Superfund, Interim Final Guidance, (EPA540-R-93-071), September 1993.

SECTION 12 SOIL SAMPLING

PERFORMANCE OBJECTIVES:

To collect a soil sample that is representative of conditions as they exist at the site

- By selecting the appropriate sampling device(s).
- By taking measures to avoid introducing contamination as a result of poor sampling and/or handling technique.
- By reducing the potential of cross contamination between samples.

12.1 Introduction

Prior to conducting a soil sampling investigation, a sampling strategy should be developed based on the objectives of the investigation (Section 5.5 of this SOP contains a discussion of soil sampling strategies). After designing a soil sampling strategy, the appropriate equipment and techniques must be used to conduct the investigation. This section discusses the sampling equipment available and collection methods which have been shown to be technically appropriate.

Manual techniques and equipment, such as hand augers, are usually used for surface or shallow, subsurface soil sampling. Power operated equipment is usually associated with collecting deep samples, but this equipment can also be used for collecting shallow samples when the auger hole begins to collapse, or when the soil is so tight that manual auguring is not practical. This section discusses the various sample collection methods employed by field investigators.

12.2 Equipment

Soil sampling equipment used for sampling trace contaminants should be constructed of inert materials such as stainless steel. Ancillary equipment such as auger flights, post hole diggers, etc. may be constructed of other materials since this equipment does not come in contact with the samples. However, plastic, chromium, and galvanized equipment should not be used routinely in soil sampling operations. Painted or rusted equipment must be sandblasted before use.

Selection of equipment is usually based on the depth of the samples to be collected, but it is also controlled to a certain extent by the characteristics of the material. Manual techniques and equipment such as hand augers, are usually used for collecting surface or shallow, subsurface soil samples. Power operated equipment is usually associated with deep sampling but can also be used for shallow sampling when the auger hole begins to collapse or when the soil is so tight that manual auguring is not practical.

12.3 Sampling Methodology

This discussion of soil sampling methodology reflects both the equipment used (required/needed) to collect the sample, as well as how the sample is handled and processed after retrieval. Selection of equipment is usually based on the depth of sampling, but it is also controlled, to a certain extent, by the characteristics of the material. Simple, manual techniques and equipment, such as hand augers, are usually selected for surface or shallow, subsurface soil sampling. As the depth of the sampling interval increases, some type of powered sampling equipment is usually needed to overcome torque induced by soil resistance and depth. The following is an overview of the various sample collection methods employed over three general depth classifications: surface, shallow subsurface, and deep subsurface. Any of the deep collection methods described may be used to collect samples from the shallower intervals.

12.3.1 Manual (Hand Operated) Collection Techniques and Equipment

These methods are used primarily to collect surface and shallow subsurface soil samples. Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. The shallow subsurface interval may be considered to extend from approximately 12 inches below ground surface to a site-specific depth at which sample collection using manual methods becomes impractical.

Surface Soils

Surface soils may be collected with a wide variety of equipment. Spoons, shovels, hand-augers, push tubes, and post-hole diggers, made of the appropriate material, may be used to collect surface soil samples. As discussed in the section on powered equipment, surface soil samples may also be collected in conjunction with the use of heavy equipment.

Surface samples are removed from the ground and placed in pans, where mixing, as appropriate (Section 5.13.8), occurs prior to filling of sample containers. Section 12.4.1 contains specific procedures for handling samples for volatile organic compounds analysis. If a thick, matted root zone is encountered at or near the surface, it should be removed before the sample is collected.

Subsurface Soils

Hand-augering is the most common manual method used to collect subsurface samples. Typically, 4-inch auger-buckets with cutting heads are pushed and twisted into the ground and removed as the buckets are filled. The auger holes are advanced one bucket at a time. The practical depth of investigation using a hand-auger is related to the material being sampled. In sands, augering is usually easily accomplished, but the depth of investigation is controlled by the depth at which sands begin to cave. At this point, auger holes usually begin to collapse and cannot practically be advanced to lower depths, and further samples, if required, must be collected using some type of pushed or driven device. Hand-augering may also become difficult in tight clays or cemented sands. At depths approaching 20 feet, torquing of hand-auger extensions becomes so severe that in resistant materials, powered methods must be used if deeper samples are required. Some powered methods, discussed later, are not acceptable for actual sample collection, but are used solely to gain easier access to the required sample depth, where hand-augers or push tubes are generally used to collect the sample.

When a vertical sampling interval has been established, one auger-bucket is used to advance the auger hole to the first desired sampling depth. If the sample at this location is to be a vertical composite of all intervals, the same bucket may be used to advance the hole, as well as to collect subsequent samples in the same hole. However, if discrete grab samples are to be collected to characterize each depth, a new bucket must be placed on the end of the auger extension immediately prior to collecting the next sample. The top several inches of soil should be removed from the bucket to minimize the chances of cross-contamination of the sample from fall-in of material from the upper portions of the hole.

Another hand-operated piece of soil sampling equipment commonly used to collect shallow subsurface soil samples is the Shelby® or "push tube". This is a thin-walled tube, generally of stainless steel construction and having a beveled leading edge, which is twisted and pushed directly into the soil. This type of sampling device is particularly useful if an undisturbed sample is required. The sampling device is removed from the push-head, then the sample is extruded from the tube into the pan with a spoon or special extruder. Even though the push-head is equipped with a check valve to help retain samples, the Shelby tube will generally not retain loose and watery soils, particularly if collected at lower depths.

12.3.2 Powered Sampling Devices

Powered sampling devices and sampling aids may be used to acquire samples from any depth but are generally limited to depths of 20 feet or less. Among the common types of powered equipment used to collect or aid in the collection of subsurface soil samples are Little Beaver® type power augers; split-spoon samplers driven with a drill rig drive-weight assembly or hydraulically pushed using drill rig hydraulics; continuous split-spoon samplers; specialized hydraulic cone penetrometer rigs; and back-hoes. The use of each of these is described below.

Power Augers

Power augers are commonly used to aid in the collection of subsurface soil samples at depths where hand augering is impractical. This equipment is a sampling aid and not a sampling device, and 20 to 25 feet is the typical lower depth range. It is used to advance a hole to the required sampling depth, at which point a hand auger is usually used to collect the sample.

Drill Rigs

Drill rigs offer the capability of collecting soil samples from greater depths. For all practical purposes, the depth of investigation achievable by this method is controlled only by the depth of soil overlying bedrock, which may be in excess of 100 feet.

When used in conjunction with drilling, split-spoon samplers are usually driven either inside a hollow-stem auger or inside an open borehole after rotary drilling equipment has been temporarily removed. The spoon is driven with a 140-pound hammer through a distance of up to 24 inches and removed. If geotechnical data are also required, the number of blows with the hammer for each six-inch interval should be recorded.

Continuous split-spoon samplers may be used to obtain five-foot long, continuous samples approximately 3 to 5 inches in diameter. These devices are located inside a five-foot section of hollow-stem auger and advanced with the auger during drilling. As the auger advances, the central core of soil moves into the sampler and is retained until retrieval.

Cone Penetrometer Rigs

This method uses a standard split-spoon that has been modified with a releasable tip which keeps the spoon closed during the sampling push. Upon arrival at the desired depth, the tip can be remotely released and the push continued. During the subsequent push, the released tip floats freely up the inside of the spoon as the soil core displaces it. Split-spoon soil samples, therefore, can be collected without drilling, as has historically been required, by simply pushing the device to the desired depth. This technique is particularly beneficial at highly contaminated sites, because cuttings are not produced as with drill rigs. The push rods are generally retrieved with very little residue. This results in minimal exposure to sampling personnel and very little contaminated residue is produced as a result of equipment cleaning.

Back-Hoes

Back-hoes are often utilized in shallow subsurface soil sampling programs. Samples may either be collected directly from the back-hoe bucket or they may be collected from the trench wall if proper safety protocols are followed. Trenches offer the ability to collect samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. Prior to collecting samples from trench walls, the wall surface must be dressed with a stainless steel shovel, spatula, knife, or spoon to remove the surface layer of soil which was smeared across the trench wall as the bucket passed. If back-hoe buckets are not cleaned according to the procedures described in Appendix B of this SOP, samples should be collected from material which has not been in contact with the bucket surface.

12.4 Special Techniques and Considerations

12.4.1 Collection of Soil Samples for Volatile Organic Compounds (VOC) Analysis

These samples should be collected in a manner that minimizes disturbance of the sample. For example, when sampling with a hand auger, the sample for VOC analysis may be collected directly from the auger bucket or immediately after an auger bucket is emptied into the pan. The sample should be placed in the appropriate container with no head-space, if possible, as is the practice with water samples. Samples for VOC analysis are not mixed.

12.4.2 Dressing Soil Surfaces

Any time a vertical or near vertical surface, such as is achieved when shovels or back-hoes are used for subsurface sampling, is sampled, the surface should be dressed to remove smeared soil. This is necessary to minimize the effects of cross-contamination due to smearing of material from other levels.

12.4.3 Sample Mixing

It is extremely important that soil samples be mixed as thoroughly as possible to ensure that the sample is representative of the interval sampled. Soil samples should be mixed as specified in Section 5.13.8.

12.4.4 Special Precautions for Trace Contaminant Soil Sampling

The procedures outlined in Section 5.13.7 should be followed. All soil sampling equipment used for sampling for trace contaminants should be constructed of stainless steel where possible. Pans used for mixing should be made of Pyrex® (or equivalent) or glass. In no case will chromium, cadmium, or galvanized plated or coated equipment be used for soil sampling operations when inorganic contamination is of concern. Similarly, no painted or plastic equipment should be used when organic contaminants are of concern. All paint and primer must be removed from soil sampling equipment by sandblasting or other means before such equipment can be used for collecting soil samples.

12.4.5 Specific Sampling Equipment Quality Assurance Techniques

Drilling rigs and other major equipment used to collect soil samples should be identified so that this equipment can be traced through field records. A log book should be established for this equipment so that all cleaning, maintenance, and repair procedures can be traced to the person performing these procedures and to the specific repairs made. Sampling spoons, hand augers, Shelby tubes, and other minor disposable type equipment are exempted from this equipment identification requirement. All equipment used to collect soil samples should be cleaned as outlined in Appendix B and repaired, if necessary, before being stored at the conclusion of field studies. Equipment cleaning conducted in the field (Appendix B) or field repairs should be thoroughly documented in field records.