6/5/2009

ENTERED

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JUN

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Dear Ms. Stewart

Cannon Air Force Base, NM is forwarding two hardbound and one electronic copies of the Draft Final Work Plan for Final Closure of Solid Waste Management Units – 70 and -71 at Cannon Air Force Base, New Mexico, June 2009 for your review and approval.

If you have any questions, please contact Mr. Hugh G. Hanson, Asset Management Flight, at (575) 784-0490.

Sincerely

Ronald A. Lancaster, YC-03

cc:
NMED (D. Cobrain) w/o documents
EPA Region 6 (Bob Sturdivant) w/o documents

Draft Final Work Plan for Final Closure of Solid Waste Management Units-70 and -71 at Cannon Air Force Base, New Mexico

Prepared for:
U.S. Army Corps of Engineers, Omaha District

US Army Corps of Engineers ®
Omaha District

Prepared by:
North Wind, Inc.

June 2009

North Wind

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Draft Final
Work Plan for Final Closure of Solid Waste Management Units-70 and -71 at Cannon Air Force Base, New Mexico

Contract No. W9128F-04-D-0017-0029

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ACRONYMS

°C	degrees Celsius
AFB	Air Force Base
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CoC	chain-of-custody
CQCSM	Contractor Quality Control Site Manager
CSM	conceptual site model
DoD	Department of Defense
DQO	data quality objective
DRO	diesel range organic
ENVP	environmental procedure
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ESL	ecological screening level
FTL	Field Team Leader
GPS	global positioning system
GRO	gasoline range organic
JP-4	jet propellant
North Wind	North Wind, Inc.
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCS	petroleum-contaminated soil
PID	photoionization detector
ppm	parts per million
QA	quality assurance

QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
QC	quality control
RBC	risk-based concentration
SAP	Sampling and Analysis Plan
SIM	selected ion monitoring
SSHO	Site Safety and Health Officer
SSL	soil screening level
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TPH	total petroleum hydrocarbons
USACE	United States Army Corps of Engineers
VOC	volatile organic compound

Draft Final
Work Plan for Final Closure of Solid Waste Management Units-70 and -71 at Cannon Air Force Base, New Mexico

1. INTRODUCTION

The U.S. Army Corps of Engineers (USACE), Omaha District, tasked North Wind, Inc. (North Wind) to perform soil sampling to verify final closure of Solid Waste Management Units (SWMUs)-70 and -71 at Cannon Air Force Base (AFB), New Mexico. To complete the site assessment, project activities include data collection, data analyses, and data processing. Soil and pore gas samples will be collected at SWMU-70 and soil samples will be collected at SWMU-71 to determine concentrations of potential contamination. Sample analyses will determine if contamination concentrations are at or below the New Mexico Environment Department-approved soil screening levels (SSLs) (Appendix A). A completion report will be submitted summarizing all implementation activities, including photographs, manifests, and other support documentation.

This Work Plan includes the following:

- Conceptual site model (CSM) detailing previous Department of Defense (DoD) activities that may have released contamination into the environment (Section 2);
- Sampling and Analysis Plan (SAP) describing the number, type, and location of samples, and the type of analysis required (Section 5);
- Site-Specific Health and Safety Plan (Appendix B);
- Quality Assurance Project Plan (QAPP), including the descriptions of the policies, organization and functional activities, and data quality objectives (DQOs) (Appendix C);
- Spill Prevention and Contingency Plan (Appendix D); and
- Standard operating procedures (Appendix E).

This Work Plan is intended to define specific activities for conducting the site inspection. Any significant changes to the site inspection report will be documented and an addendum will be added to the Work Plan documenting all necessary changes to procedures, design, or site characterization.

2. BACKGROUND

Relevant environmental reports associated with SWMUs-70 and -71 include the following documents:

- Annual Evaluation of Bioventing Soil Remediation at SWMU #70, Oil Water Separator No. 326 Cannon Air Force Base, New Mexico. Analytical Results for Samples Collected September 22–23, 1999.

- Report-Contamination Investigation. Replace Fuel Storage and Loading Facilities, Cannon Air Force Base, New Mexico. USACE-Omaha District, 01-2005.

- Annual Evaluation of Bioventing Soil Remediation at SWMU #70, Oil/Water Separator No. 326 Cannon Air Force Base, New Mexico. Analytical Results for Samples Collected September 10–11, 2002.

2.1 SWMU-70 – Oil/Water Separator #326 with associated Leach Field

SWMU-70 consisted of a 2,000-gallon underground tank that contained petroleum products received from wash water effluent from jet propellant (JP-4) fuel trucks maintenance operations at Building 362. The system became operational in 1960. The effluent contained JP-4 fuel, petroleum products, and synthetic lubricating oils. The tank was separated into two compartments. The purpose of the tank was to separate the oil from the water rinsed down the drain of the vehicle maintenance shop. All effluent discharge was released into the associated leach field, approximately 5 feet in diameter and 5 feet deep and located approximately 10 feet to the north-northwest of the oil/water separator. Overflows from the oil/water separator that discharged into the leach field are the suspected source of contamination (Engineering-Science Inc. 1994a, 1994b; USACE 2000). Previous investigations at SWMU-70 occurred in 1999 and 2002. Six samples were collected from six locations and analyzed for volatile organic compounds (VOCs). Contaminants were detected in four samples and consisted of total petroleum hydrocarbons (TPHs) and ethylbenzene, xylenes, and toluene. Sample results are presented in Table 1.

2.2 SWMU-71 – Jet Propellant Fuel Recovery Tank #390

SWMU-71 consisted of an underground JP-4 fuel recovery tank at Facility 390. The 2,000-gallon tank was constructed of steel and was installed in 1976. The tank was used to collect/recover any JP-4 fuel from the Oil/Water Separator #390 at Facility 390 (SWMU-72). Any recovered JP-4 fuel was pumped out periodically by a contractor. Before 1984, tank sludge was collected and disposed of in a pit at SWMU-76. SWMU-71was never investigated; therefore, no samples have been collected and sample results cannot be reported.

Table 1. SWMU-70 sample detect results.

Sample ID	Date	Time	Sample Depth (feet)	Parameter	Result	Reporting Limit	Units	Analytical Method
MPA5-99	09/23/1999	7:15	5	TPH (as gasoline)	8.6 C	2.50	ppm	EPA-19 TO-3
MPC50-99	09/23/1999	7:20	50	Toluene	4.5	0.81	ppm	EPA-19 TO-3
MPC50-99	09/23/1999	7:20	50	Ethylbenzene	16	0.81	ppm	EPA-19 TO-3
MPC50-99	09/23/1999	7:20	50	Xylenes (total)	38	0.81	ppm	EPA-19 TO-3
MPC50-99	09/23/1999	7:20	50	TPH (as gasoline)	1,500 C	40.00	ppm	EPA-19 TO-3
VW-99	09/23/1999	7:25	N/A	TPH (as gasoline)	0.66 J,C	2.10	ppm	EPA-19 TO-3
MPA5-02	09/11/2002	15:50	5	TPH (as gasoline)	1.0 J,B	2.00	ppm	EPA-19 TO-3
MPA70-02	09/11/2002	16:00	70	TPH (as gasoline)	100 B	2.10	ppm	EPA-19 TO-3
MPB50-02	09/11/2002	16:10	50	Ethylbenzene	5.1	0.56	ppm	EPA-19 TO-3
MPB50-02	09/11/2002	16:10	50	Xylenes (total)	29	0.56	ppm	EPA-19 TO-3
MPB50-02	09/11/2002	16:10	50	TPH (as gasoline)	3,200 B	28.00	ppm	EPA-19 TO-3
MPC50-02	09/11/2002	16:20	50	Ethylbenzene	10	0.55	ppm	EPA-19 TO-3
MPC50-02	09/11/2002	16:20	50	Xylenes (total)	36	0.55	ppm	EPA-19 TO-3
MPC50-02	09/11/2002	16:20	50	TPH (as gasoline)	1,600 B	27.00	ppm	EPA-19 TO-3

EPA = Environmental Protection Agency
ppm = parts per million
TPH = total petroleum hydrocarbon

3. SITE CONDITIONS

3.1 Location and Description

Cannon AFB is located in Curry County, approximately 7 miles west of Clovis, New Mexico (Figure 1). Cannon AFB occupies approximately 4,320 acres south of U.S. Highway 60/84 in Curry County. The area surrounding Cannon AFB is used mainly for farming and ranching. Cannon AFB maintains several satellite facilities.

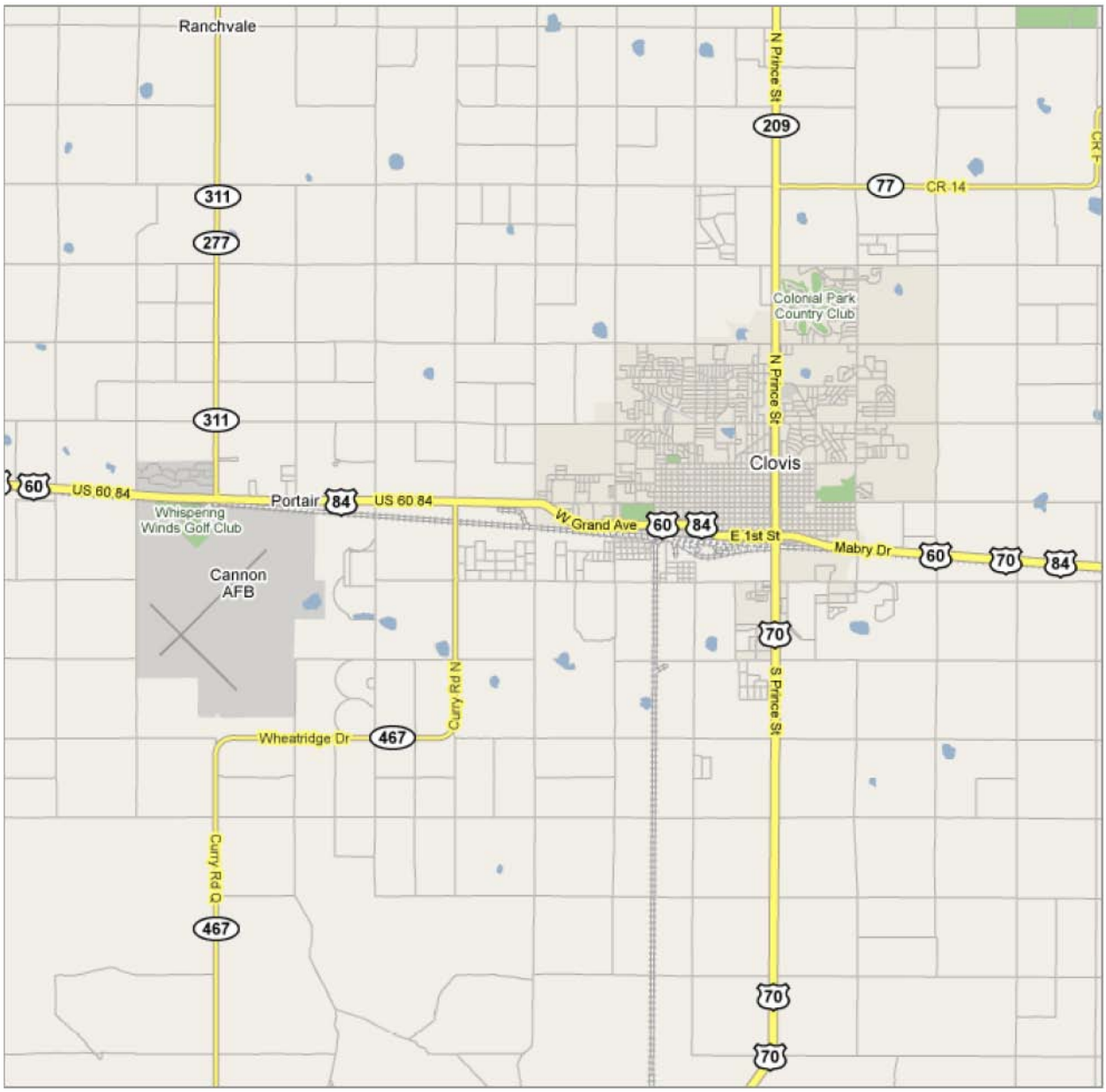

Figure 1. Location of Cannon AFB near Clovis, New Mexico.

3.2 Operational History

In 1942, the DoD established the Clovis Army Air Base as a training facility for B-17, B-24, and B-29 air crews. The base was renamed Clovis Army Airfield in 1945 and was closed in 1947. The base was reactivated in 1951, reassigned to the Tactical Air Command and was renamed Cannon AFB in 1957. In 1975, the 27th Tactical Fighter Wing became the principal United States Air Force unit at Cannon AFB. The base was reassigned to the Air Combat Command in 1992. Finally, the base was reassigned to the Air Force Special Operations Command on October 1, 2007. The base maintains a combat-ready force and provides replacement training of combat air crews for tactical organizations worldwide.

3.3 Natural Setting

The natural setting of Cannon AFB is summarized in the following sections and includes a discussion of the site topography, soils, and surface water.

3.3.1 Topography

Cannon AFB resides in the Southern High Plains Physiographic Province. Topographic relief in the area is minimal and mostly flat. No surface-water bodies are located within Cannon AFB except minor ephermal channels.

3.3.2 Soil

Soil underlying Cannon AFB consists of sandy loam and loamy sand of the Amarillo Soil group and is primarily a fine-grained, well sorted silty/clayey, unconsolidated brown/reddish brown sand. Such soil is generally classified as silty to clayey sand under the Unified Soil Classification System. The near surface stratigraphy consists of Miocene to Pliocene fluvial deposits of the Ogallala Formation. Cannon AFB is underlain by Ogallala fluvial deposits primarily consisting of well-sorted sand classified as silty sand to clayey sand. The total thickness of the Ogallala beneath Cannon AFB is not known. Available regional data indicate it may be up to 390 feet thick. Formation thicknesses are as follows:

- The Chinle formation consists mostly of clay with some intermixed sand and silt and ranges in thickness from 0 to 400 feet for eastern New Mexico (McGowen et al. 1977).

- The Ogallala formation is a stratigraphic layer that sits on top of the Chinle formation and consists of sand, silt, clay, and gravel. Layer thickness ranges from 30 to 600 feet (McLemore 2001, Gustavson 1996).

- The Blackwater Draw formation is a stratigraphic layer that overlies the Ogallala formation and consists of eolion sand deposits and ranges in thickness from 0 to 80 feet (McLemore 2001).
  A caliche layer is typically present in the unsaturated Blackwater or Ogallala formations (Hart and McAda 1985).

3.3.3 Caliche

Review of core collected during drilling at Cannon AFB indicated that caliche is discontinuous, of variable thickness, and typically occurs within 30 feet of the surface.

3.3.4 Surface Water

No streams exist on or near Cannon AFB. Running Water Draw and Frio Draw, located approximately 10 and 20 miles north of Cannon AFB, respectively, are the nearest streams. Surface water at Cannon AFB consists of two isolated playa lakes that contain water during the wet seasons of the year. There are no “Waters of the United States” that occur on the base or to which stormwater runoff discharges.

3.3.5 Conceptual Transport and Media Interactions

The concern at both SWMUs-70 and -71 involves petroleum-contaminated soil (PCS) in the shallow subsurface. Contamination in soil at these reported (shallow) depths is unlikely to reach groundwater since the depth to groundwater in the area is reported to be between 240 and 295 feet.

The sites and the areas surrounding the sites are used for industrial purposes. The area surrounding the base is used primarily for agricultural purposes. There are no special-status ecological species recorded within 1 mile of the sites.

The future residential receptor and the ecological receptors are primarily used to screen chemicals that may pose unacceptable risks. Future construction worker exposure to the subsurface soils is possible if any remedial activity is deemed necessary as a result of the analytical findings or if future base construction occurs in the areas of the SWMUs.

The data initially will be screened against the risk-based concentrations (RBCs) for the resident and the ecological screening levels (ESLs). For the chemicals that exceed the residential and/or ecological thresholds, a media-specific statistical exposure point concentration (EPC) will be developed, if possible, and compared with the recreational and rancher RBCs for a more quantitative statement of risks. Ecological risks will be addressed qualitatively only. The construction worker risks may be evaluated prior to the remedial activities.

4. PROPOSED INVESTIGATION ACTIVITIES

Based on the scope provided by the USACE (2008), North Wind will conduct an investigation to evaluate site environmental concerns at SWMUs-70 and -71. Soil vapor samples will be collected from the existing soil vapor sampling ports at SWMU-70. The soil vapor analytical results will be evaluated to determine if soil borings and soil sampling is still required at SWMU-70. Three soil borings will be installed at SWMU-71, and soil samples will be collected to determine if soil contamination exists in the SWMU-71 area. Required laboratory analytical work for each of the two SWMUs is discussed in Section 5. The two field work sites and the contaminants of interest at each site are summarized in Table 2.

Table 2. Summary of contaminants of interest at SWMUs-70 and -71 at Cannon AFB.

Site Inspection Field Work Site	Contaminants of Interest	Sampling Media
SWMU-70	VOCs (TVPH and BTEX)	Soil vapor
	TPH-DRO, TPH-GRO, VOCs, SVOCs, metals, pesticides, PCBs by fixed laboratory analyses	Subsurface soil
SWMU-71	TPH-DRO, TPH-GRO, VOCs, SVOCs, metals, pesticides, PCBs by fixed laboratory analyses	Subsurface soil

BTEX = benzene, toluene, ethylbenzene, and xylenes
PCB = polychlorinated biphenyl
SVOC = semivolatile organic compound
TPH-DRO = total petroleum hydrocarbon-diesel range organics
TPH-GRO = total petroleum hydrocarbon-gasoline range organics
TVPH = total volatile petroleum hydrocarbons

5. SAMPLING AND ANALYSIS PLAN

This section describes the project and data use objectives, data collection rationale, quality assurance (QA) goals, and requirements for sampling and analysis activities. It also defines the sampling and data collection methods that will be used for this project.

5.1 Sampling and Analysis Rationale

This section outlines the number, type, location, and analysis required for each area of concern at the site. Contaminants of interest for the two SWMUs include:

- TPH-DRO and TPH-GRO;
- VOCs;
- Total volatile petroleum hydrocarbons (TVPH) and benzene, toluene, ethylbenzene, and xylenes (BTEX);
- Metals;
- Polynuclear aromatic hydrocarbons (PAHs);
- Pesticides; and
- Polychlorinated biphenyls (PCBs).

Table 3 shows the extraction and analytical methods to be used.

Tables C-2 through C-7 in the Appendix C present the detection limits, reporting limits, and quality control (QC) acceptance criteria for the proposed methods and sampling media.

Soil boring locations will be marked in the field based on accessibility and visible signs of contamination (e.g., stained soils or stressed vegetation), if any exist. Rationale for the sample locations are presented in the following subsections. All soil boring locations will be surveyed using a survey grade global positioning system (GPS).

Before conducting any intrusive activities in the subsurface, North Wind will locate all underground utilities via the Cannon AFB excavation permit system, the New Mexico One-Call (1-800-321-2537), and other utility companies not participating in the USA North Program.

5.1.1 SWMU-70

Since SWMU-70 has an operating bio-venting system in place, soil vapor samples will be collected from the existing vapor sample ports. Vapor sample analytical results will be reviewed and a final determination will be made if further drilling and soil sampling is necessary. If soil vapor sampling indicates that no soil contamination remains at the SWMU-70 area, then it may not be necessary to collect soil samples.

Table 3. Sample extraction and analysis methods.

Contaminant of Interest	Subsurface Soil	Soil Vapor	Groundwater / Surface Water
TPH-DRO (diesel) (C_{10} to C_{28} hydrocarbons)	SW3550C/8015BM (modified for diesel range)	NA	NA
TPH-GRO (gasoline) (C_6 to C_{10} hydrocarbons)	SW5035/8015BM (modified for gasoline range)	NA	NA
VOCs	SW5035/8260C	NA	NA
TVPH and BTEX	NA	EPA-TO-3	NA
Metals	Fixed laboratory analysis: SW846 method 6020	NA	NA
PAH (SVOCs)	SW3550C/8270D-SIM (modified for SIM)	NA	NA
Pesticides	SW3550C/8081A	NA	NA
PCBs	SW3550C/8082A	NA	NA

BTEX = benzene, toluene, ethylbenzene, and xylenes
EPA = Environmental Protection Agency
NA = not available
PAH = polynuclear aromatic hydrocarbon
PCB = polychlorinated biphenyl
SIM = selected ion monitoring
SVOC = semivolatile organic compound
TPH-DRO = total petroleum hydrocarbon-diesel range organics
TPH-GRO = total petroleum hydrocarbon-gasoline range organics
TVPH = total volatile petroleum hydrocarbons
VOC = volatile organic compound

Figure 2 illustrates the proposed locations for soil borings if it is deemed necessary to collect subsurface soil samples. Once soil vapor analytical results have been reviewed, a determination will be made regarding any soil sampling that may be required. If it is determined that soil sampling is required, it is proposed that in order to verify magnitude and extent of PCS contamination at SWMU-70, North Wind will collect subsurface soil samples from the area of the former oil/water separator. Seven soil borings will be installed to a depth of approximately 20 feet below grade. Two soil samples will be collected from each boring based on odor, visible staining, and/or photo ionization detector (PID) screening. Soil samples will be analyzed for TPH DRO and GRO, VOCs, SVOCs, metals, pesticides, and PCBs.

5.1.2 SWMU-71

To verify magnitude and extent of PCS contamination at SWMU-71, North Wind will collect subsurface soil samples from the area of the former JP-4 overflow storage tank. Three soil borings will be installed to a depth of approximately 15 feet below grade. Two soil samples will be collected from each boring at depths of approximately 8 and 15 feet, or based on odor, visible staining, and/or PID readings. Soil samples will be analyzed for TPH-DRO and TPH-GRO, VOCs, SVOCs, metals, pesticides, and PCBs. Figure 2 illustrates the proposed soil boring locations.

Field screening and sampling will be performed in accordance with environmental procedure (ENVP)-019, *MiniRAE Photoionization Detector* (NWI 2007a).

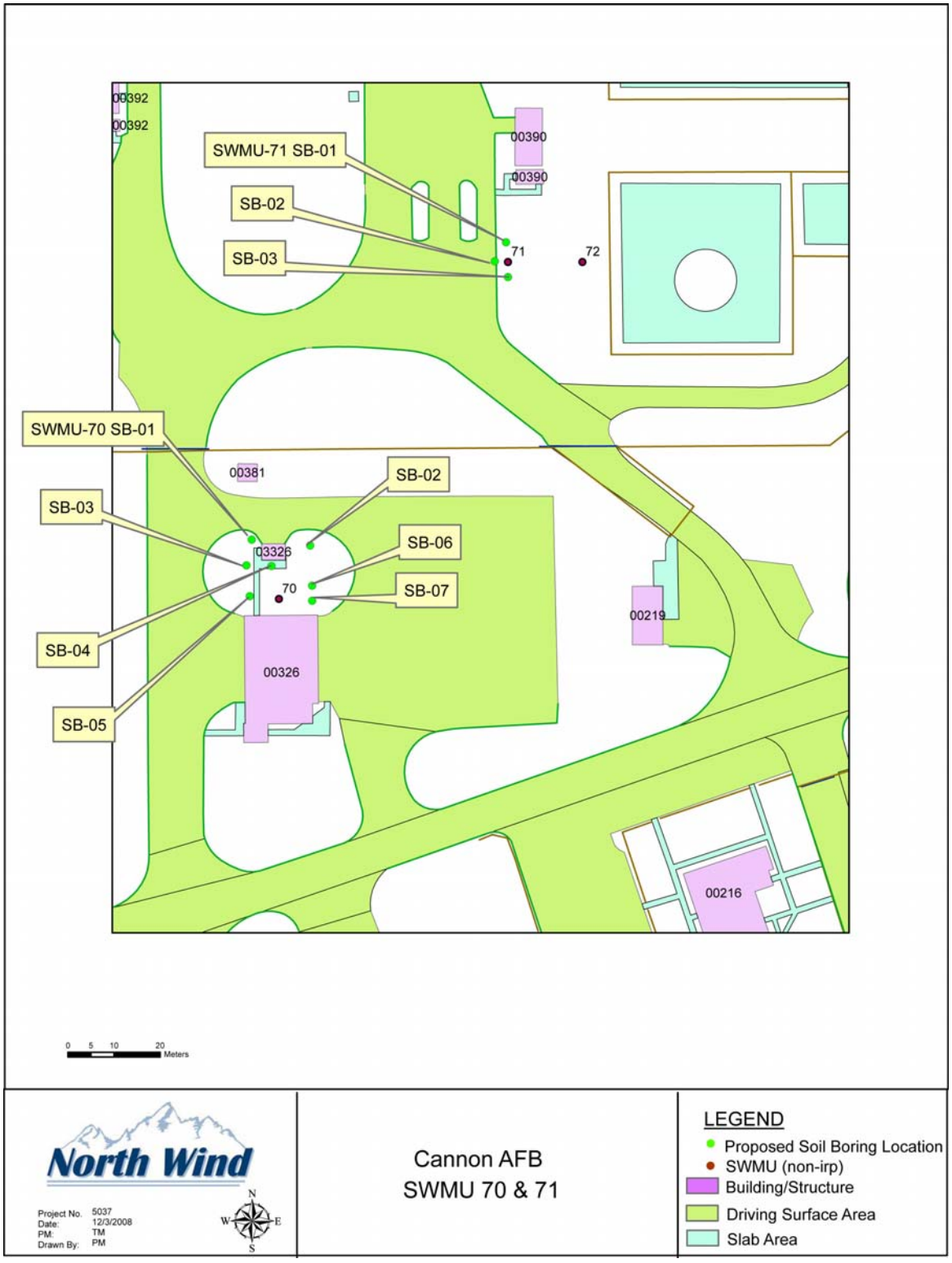

Figure 2. Locations of borings at SWMUs-70 and -71.

5.2 Sample Requirement Summary

Table 4 summarizes the samples to be collected at each site inspection field work site.

5.3 Methods and Procedures

The following subsections summarize the methods and procedures for site characterization and sampling. The Spill Prevention and Contingency Plan is included as Appendix D.

5.3.1 Soil Vapor Investigation

At SWMU-70, soil vapor samples will be collected in accordance with ENVP-013, Rev 1, *Soil Gas Sampling* (NWI 2006a). There are three soil vapor monitoring wells and an air injection well at SWMU-70. Each of the three soil vapor monitoring wells has five vapor monitoring points installed at different depths. A total of 16 soil vapor samples will be collected from existing vapor ports (five samples from each of the three vapor monitoring wells and one sample from the air injection well). A sampling train will be installed at the sampling port to be used for all purge, field-screening measurements, and subsequent sample collection. A Landtec GEM-500 (or equivalent) gas monitor will be used to purge the sampling port and sampling train and to monitor percent levels of carbon dioxide and oxygen until pore gas measurements are stable and representative of subsurface conditions consistent with previously recorded measurements. Following this first purge and stabilization, formation air will be monitored for VOCs using a PID multigas analyzer.

The sampling port is connected in-line to the SUMMA canister for sample collection and subsequent laboratory analysis. All field-screening measurements, field conditions, and sampling will be documented. All field measurements will be collected using instrumentation with confirmed and documented operational checks.

Field screening will be performed before samples are collected. Each port will be purged and monitored with a Landtec GEM-500 instrument (or equivalent) until the percent carbon dioxide and oxygen levels have stabilized at values representative of subsurface pore gas conditions and are consistent with previously recorded measurements. The vapor will then be screened for VOCs using a PID multigas analyzer.

Once sample port purging, field screening, and pore gas sampling using SUMMA canisters are completed, the pore gas samples will be submitted for VOC analysis using Environmental Protection Agency (EPA) Method TO-3. During the sampling event, two types of field QA samples will be collected and analyzed for VOCs using SUMMA canisters: 1) a field-duplicate sample and 2) an equipment blank of zero-grade air (air certified to be free from VOC contamination) or nitrogen drawn through the sampling apparatus in the working area. Analytical laboratory QA for EPA Method TO-3 includes the following:

- Internal standards,
- Surrogates,
- Replicates,
- Blanks,
- Laboratory control samples, and
- Reference standards.

Table 4. Site inspection field work site sample requirement summary.

Site Inspection Field Work Site	Matrix	TPH DRO (8015D)	TPH GRO (8015D)	TVPH and BTEX (TO-3)	VOCs (8260C)	SVOCs (8270D-SIM)	Metals (6010C)	Pesticides/ PCBs
SWMU-70	Surface Soil							
	Subsurface Soil	X	X		X	X	X	X
	Groundwater							
	Surface Water							
	Sediments							
	Soil Vapor			X				
SWMU-71	Surface Soil							
	Subsurface Soil	X	X		X	X	X	X
	Groundwater							
	Surface Water							
	Sediments							

Analytical laboratory QA for EPA Method 906.0 includes the following:

- Instrument performance checks,
- Replicates,
- Blanks,
- Laboratory control samples, and
- Reference standards.

5.3.2 Soil Investigation

Soil samples will be collected in accordance with ENVP-008, *Soil Sampling* (NWI 2006b).

In general, near-surface soil will be collected with unused disposable spoons, sieved, and placed into appropriate sample containers. Soil obtained from potholes will be collected from the excavator bucket; soil obtained using split spoons or direct push tooling will be collected from freshly opened tubes or sleeves. Samples to be analyzed for VOCs will be collected first, followed by samples to be analyzed for less volatile parameters, and finally metals. Samples will be collected and placed into appropriate containers using the sampling methods outlined below.

If applicable, excavations will be completed using standard construction equipment in compliance with USACE EM 385-1-1, Section 25, Excavations (USACE 2003) and with HSP-011, *Excavations* (NWI 2006c). The soil will be stockpiled onsite or placed directly into shipping containers. Samples will be collected from each pothole and the soil will be replaced in the excavation.

All personnel handling sampling equipment or opening sample containers will put on a new pair of nitrile gloves before collecting each sample. Soil samples will be collected with decontaminated or unused disposable equipment. A PID may be used at some locations as a screening tool to measure the organic vapor concentrations during soil sampling and soil excavation activities. If used, PID monitoring will be conducted in accordance with ENVP-019 (NWI 2007a).

5.3.3 Groundwater Investigation

No groundwater sampling is planned for SWMUs-70 or -71. Groundwater in this area is estimated to be 250 feet below ground surface and is unlikely to be encountered at these locations. Groundwater samples, if encountered in potholes/borings, would be collected by using disposable bailers or pumps with disposable tubing. Groundwater sampling activities shall comply with ENVP-006, *Ground Water Sampling* (NWI 2006d). Reusable sampling equipment will be decontaminated before mobilization to the sampling site and in between each sample location in accordance with ENVP-014, *Sampling Equipment Decontamination* (NWI 2006e).

5.3.4 Surface Water and Sediment Investigation

No surface water or sediment is present at either SWMU-70 or SWMU-71.

5.4 Decontamination Procedures

Reusable sampling equipment will be decontaminated before mobilization to the sampling site and in between each sample location in accordance with ENVP-014 (NWI 2006e). Decontamination of sampling equipment must be conducted consistently to assure the quality of samples collected. All nondedicated equipment that comes into contact with potentially contaminated soil or water will be decontaminated. Dedicated equipment intended for one-time use will not be decontaminated but will be packaged for appropriate disposal.

Equipment will be decontaminated in a predesignated area on pallets or plastic sheeting, and clean bulky equipment will be stored on plastic sheeting in uncontaminated areas. Cleaned small equipment will be stored in plastic bags. Materials to be stored more than a few hours will also be covered.

5.5 Sample Handling

The following sections describe requirements for sample identification, sample containers and preservation, and sample packaging and shipping.

5.5.1 Sample Identification

Sample labels are required for properly identifying samples. All field samples will be labeled with the label affixed to the container before or shortly after it is filled and before transportation to the laboratory. The sample label will include the following information:

- Sample identification number (see Appendix E),
- Location identification,
- Date and time of sample collection,
- Initials of person collecting the sample,
- Analysis requested,
- Preservation method, and
- Any other information pertinent to the sample.

5.5.2 Sample Nomenclature

A sample number will be used to identify each sample collected and submitted for analysis (see Appendix E). Each sample name will be made up of an abbreviated site inspection field work site identifier followed by the sample matrix identifier. This will be followed by a designated sample number, which will specify the sample location within the site inspection field work site being sampled.

5.5.3 Sample Containers and Preservation

Sample container types will be consistent with laboratory requirements for the specific parameters of interest. Sample containers will be obtained directly from the analytical laboratory in sealed boxes and will be verified as precleaned by the analytical laboratory with the appropriate certificates. Extra containers will be available in case of breakage, contamination, or collection of additional samples.

All samples collected will be preserved according to EPA protocols. Chemical preservatives and chilling will be used for samples, where required. Appropriate measures will be taken to ensure that storage requirements, with respect to temperature, are maintained in the field, during transport to the laboratory, and during storage at the laboratory. Table 5 identifies required sample container types, preservative requirements, and holding times for soil samples collected during this project.

5.5.4 Sample Packaging and Shipping

Sample packaging, shipping, and security will be conducted in accordance with ENVP-002, *Sample Handling, Packaging and Shipping* (NWI 2006f). North Wind will use properly trained samplers to collect, package, and ship all environmental samples. An experienced Site Safety and Health Officer (SSHO)/Field Team Leader (FTL) will provide oversight of all sampling activities to ensure that all samples are properly preserved and protected from breakage or loss. Before every sampling event, the SSHO/FTL will ensure that the laboratories are aware of the pending shipments and are prepared to meet all requirements of the QAPP. Before the end of each sampling event, the SSHO/FTL will review all field documentation to ensure that instructions to the analytical laboratory are clear and complete and that all of the necessary information to interpret the results is properly recorded (a checklist should be used).

5.6 Field Operations Documentation

The SSHO/FTL will be responsible for controlling and maintaining all field documents and records. The field team will take field notes, as described below, and complete any field forms required by the USACE client. Sample documentation, shipping, and custody procedures for this project are based on EPA-recommended procedures that emphasize careful documentation of sample collection and sample transfer. Any necessary changes to forms, labels, or logbooks will be made by striking out the error with a single straight line and re-entering the correct information. The new entries will be initialed and dated by the person making the change. The following sections describe requirements for maintaining field logbooks, photographs, and chain-of-custody (CoC) records during sampling.

5.6.1 Field Logbooks

All field logbooks will consist of bound, waterproof, serial numbered pages and will be used to record field activities. Typically, one field logbook will be maintained; however, additional logbooks may be maintained if the SSHO/FTL determines it is necessary.

NOTE: *Preprinted field forms, separate from the field logbook, may be used by any member of the field team to record repetitive information (e.g., equipment checklists, sample information, well logs, etc.). Completed field forms may be transcribed into electronic form or simply retained in the North Wind project file.*

Only the SSHO/FTL may authorize the start of a new logbook. The project name, project number, SSHO/FTL name, telephone number, and office address will be listed on the inside cover of all field logbooks. The logbook will only be used to document daily field activities in sufficient detail to allow field personnel to reconstruct events that transpired during the project. This document will contain information pertaining to:

- Daily activities and chronology,
- Observations made during the environmental investigation,
- Equipment calibration results, and
- Significant events.

Table 5. Sample containers, preservation, and holding times for soil samples.

Method Number and Analysis	**TPH DRO (8015BM)**	**TPH GRO (8015BM)**	**TVPH and BTEX (TO-3)**	**VOCs (8260C)**	**SVOCs (8270D-SIM)**	**Metals (6010C)**	**Pesticides/ PCB (8081A/8082)**
Matrix	Soil	Soil	Soil Gas	Soil	Soil	Soil	Soil
Preservatives	Chill to: 4°C ± 2°C	Chill to: 4°C ± 2°C	NA	Chill to: 4°C ± 2°C	Chill to: 4°C ± 2°C		Chill to: 4°C ± 2°C
Analytical Holding Time	14 days	14 days	30 days	14 days	14 days to extraction; 40 days to analysis	6 months	14 days
Sample Volume/ Sample Container	2 × 8 ounce glass jar	3 × 5 gram en core sampler	1-Liter SUMMA canister	3 × 5 gram en core sampler	1 × 8 ounce glass jar	1 × 8 ounce glass jar	1 × 8 ounce glass jar

Logbook entries must be dated, legible, made in black indelible ink, and contain accurate documentation. Language used will be objective, factual, and free of personal opinions. Hypotheses for observed phenomena may be recorded; however, they must be clearly indicated as such and only relate to the subject observation. Corrections to erroneous data will be made by crossing through the entry with a single straight line and entering the correct information. The person making the correction must initial and date where the error occurred. Unused portions of logbook pages will be crossed out, signed, and dated at the end of each workday. Care should be taken to ensure that no lines are skipped on a page. In the event that lines are skipped, they should be lined out, signed, and dated.

Only field team members may be in custody of the logbook during field activities. Personnel with custody of a logbook will sign and date the logbook before initiation of each day's fieldwork. If it is necessary to transfer custody of the logbook during the course of fieldwork, the person relinquishing the logbook will sign and date the logbook at the time the logbook is transferred, and the person receiving the logbook will do the same.

5.6.2 Photographs

Photographs will be used to supplement written descriptions of field activities. Photographs will be recorded on digital media and backed up to secondary media on a daily basis. The first photograph of a new location series will include the site name or location identifier, as appropriate. Photographs will be stored as individual JPG files. All photograph files will be named with site name or location identifier, date of photograph, and sequential photograph number.

5.6.3 CoC Documentation

CoC forms will be used to document the transfer of samples from one person's custody to another (e.g., from the sampler to laboratory personnel) in accordance with ENVP-021, *Chain-of-Custody Documentation* (NWI 2007b). Sample information may also be recorded in field logbooks or field forms. All sample information will be checked to minimize transcription errors before sample shipment. Because the CoC is the formal record of sample identification information and custody, the information contained on the CoC will take precedence over other field documentation.

When custody of the samples is transferred, or when samples are relinquished to a common carrier, the sampler will sign, date, and note the time on the form. A separate form will accompany each delivery of samples to the laboratory. The CoC form will be included inside the cooler used for transport of the samples. In addition to the requirements of ENVP-021, the following project-specific requirements apply:

- Include the laboratory subcontract number,
- Include the location identifier for purposes of completing the electronic deliverable,
- Indicate the sample collection type (e.g., grab vs. composite), and
- Use a checklist to verify the accuracy and completeness of the form before sample shipment.

North Wind will use a laboratory CoC form, ensuring it complies with the procedures outlined in ENVP-021. All entries on the CoC must be recorded in indelible black ink. Any necessary changes to the CoC will be made by striking out the error with a single straight line and re-entering the correct information. The new entries will be initialed and dated by a sampler.

NOTE: *It is common for multiple North Wind personnel to work together to collect, package, and ship samples. In such a case, any single member of the immediate sampling team is considered "the sampler" for purposes of completing CoC forms or other documentation.*

5.7 Data Management

Samples will be collected and logged on a CoC form, as discussed in Section 6.3.3. Samples will be kept secure in the custody of the sampler at all times; the sampler will assure that all preservation parameters are being followed. Samples will be transferred to the laboratory via a certified carrier in a properly custody-sealed container with CoC documentation. The laboratory should note any evidence of tampering upon receipt.

The completed laboratory data report will be submitted to North Wind for validation. The data validation reports and laboratory data summary sheets will be included in the final report. Before submittal, the final report will undergo a technical review to ensure that all data have been reported and discussed correctly.

6. REPORTING

Once all analytical data have been received, a Site Investigation Report will be written that describes all activities performed and reports all analytical results. Analytical results will be compared to New Mexico SSLs to determine if SWMUs-70 and -71 can be closed or if remediation is required at either of the sites. If analytical data indicate that the sites can be closed, North Wind will assist Cannon AFB with submission of No Further Action Proposals to the New Mexico Environment Department.

7. SCHEDULE

The project schedule for performing the field activities and preparing the completion report is provided in Appendix F, Project Organization. As available in Appendix F, field activities are planned to be performed during June and July of 2009. The site inspection report will be prepared following receipt of sample analysis results.

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Appendix A

Sample Soil Screening Level Tables (included on CD)

Appendix B

Site-Specific Health and Safety Plan

Appendix C

Quality Assurance Project Plan

Appendix D

Spill Prevention and Contingency Plan

Appendix E

Standard Operating Procedures (included on CD)

Appendix F

Project Organization

Appendix F

Project Organization

F-1. Project Organization

To manage and execute task orders, North Wind will employ an integrated program organization. Our proposed organizational structure is illustrated in Figure F-1. The project schedule for performing the field activities and preparing the completion report is included in Figure F-2. The roles and responsibilities described below identify which employees will conduct sampling, laboratory review, health and safety oversight, and deliverable and report preparation for this project.

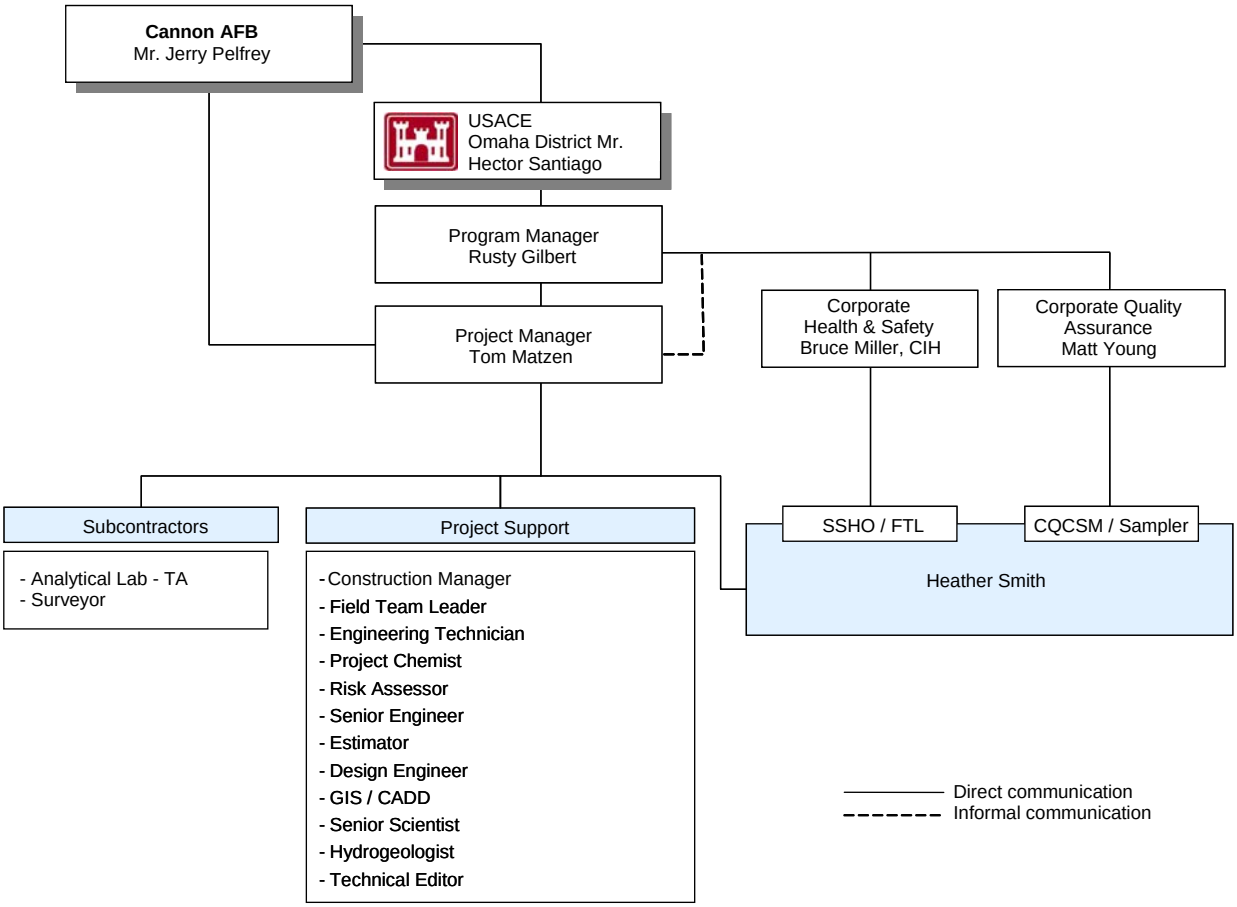
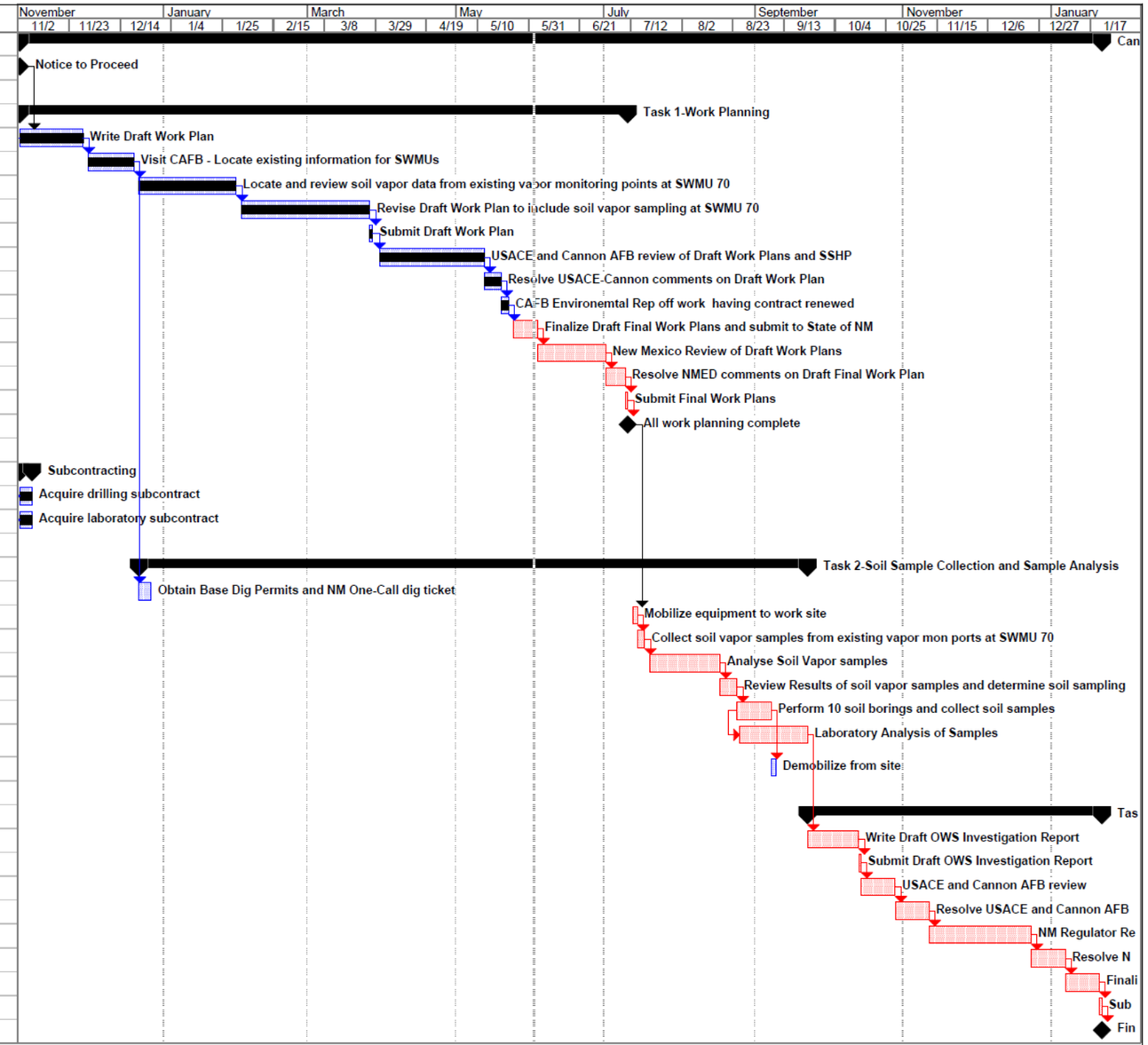


Figure F-1. Project organizational structure.

ID	% Complete	Task Name	Duration	Start	Finish
1	45%	**Cannon AFB Oil Water Separator Investigations**	**319 days**	**Mon 11/3/08**	**Thu 1/21/10**
2	0%	Notice to Proceed	0 days	Mon 11/3/08	Mon 11/3/08
3					
4	81%	**Task 1-Work Planning**	**180 days**	**Mon 11/3/08**	**Fri 7/10/09**
5	100%	Write Draft Work Plan	20 days	Mon 11/3/08	Fri 11/28/08
6	100%	Visit CAFB - Locate existing information for SWMUs	15 days	Mon 12/1/08	Fri 12/19/08
7	100%	Locate and review soil vapor data from existing vapor monitoring points a	30 days	Mon 12/22/08	Fri 1/30/09
8	100%	Revise Draft Work Plan to include soil vapor sampling at SWMU 70	39 days	Mon 2/2/09	Thu 3/26/09
9	100%	Submit Draft Work Plan	1 day	Fri 3/27/09	Fri 3/27/09
10	100%	USACE and Cannon AFB review of Draft Work Plans and SSHP	31 days	Tue 3/31/09	Tue 5/12/09
11	100%	Resolve USACE-Cannon comments on Draft Work Plan	5 days	Wed 5/13/09	Tue 5/19/09
12	100%	CAFB Environemtal Rep off work having contract renewed	3 days	Wed 5/20/09	Fri 5/22/09
13	0%	Finalize Draft Final Work Plans and submit to State of NM	8 days	Mon 5/25/09	Wed 6/3/09
14	0%	New Mexico Review of Draft Work Plans	20 days	Thu 6/4/09	Wed 7/1/09
15	0%	Resolve NMED comments on Draft Final Work Plan	6 days	Thu 7/2/09	Thu 7/9/09
16	0%	Submit Final Work Plans	1 day	Fri 7/10/09	Fri 7/10/09
17	0%	All work planning complete	0 days	Fri 7/10/09	Fri 7/10/09
18					
19	100%	**Subcontracting**	**5 days**	**Mon 11/3/08**	**Fri 11/7/08**
20	100%	Acquire drilling subcontract	5 days	Mon 11/3/08	Fri 11/7/08
21	100%	Acquire laboratory subcontract	5 days	Mon 11/3/08	Fri 11/7/08
22					
23	0%	**Task 2-Soil Sample Collection and Sample Analysis**	**197 days**	**Mon 12/22/08**	**Tue 9/22/09**
24	0%	Obtain Base Dig Permits and NM One-Call dig ticket	5 days	Mon 12/22/08	Fri 12/26/08
25	0%	Mobilize equipment to work site	2 days	Mon 7/13/09	Tue 7/14/09
26	0%	Collect soil vapor samples from existing vapor mon ports at SWMU 70	3 days	Wed 7/15/09	Fri 7/17/09
27	0%	Analyse Soil Vapor samples	21 days	Mon 7/20/09	Mon 8/17/09
28	0%	Review Results of soil vapor samples and determine soil sampling effort	5 days	Tue 8/18/09	Mon 8/24/09
29	0%	Perform 10 soil borings and collect soil samples	10 days	Tue 8/25/09	Mon 9/7/09
30	0%	Laboratory Analysis of Samples	20 days	Wed 8/26/09	Tue 9/22/09
31	0%	Demobilize from site	2 days	Tue 9/8/09	Wed 9/9/09
32					
33	0%	**Task 4-Final Reporting**	**87 days**	**Wed 9/23/09**	**Thu 1/21/10**
34	0%	Write Draft OWS Investigation Report	15 days	Wed 9/23/09	Tue 10/13/09
35	0%	Submit Draft OWS Investigation Report	1 day	Wed 10/14/09	Wed 10/14/09
36	0%	USACE and Cannon AFB review	10 days	Thu 10/15/09	Wed 10/28/09
37	0%	Resolve USACE and Cannon AFB comments	10 days	Thu 10/29/09	Wed 11/11/09
38	0%	NM Regulator Review	30 days	Thu 11/12/09	Wed 12/23/09
39	0%	Resolve NM Reg Comments	10 days	Thu 12/24/09	Wed 1/6/10
40	0%	Finalize Task Summary Report	10 days	Thu 1/7/10	Wed 1/20/10
41	0%	Submit Final Task Summary Report	1 day	Thu 1/21/10	Thu 1/21/10
42	0%	Final reporting complete	0 days	Thu 1/21/10	Thu 1/21/10



Cannon AFB OWS Investigation

Task		Milestone		Rolled Up Critical Task		Split		Group By Summary	
Critical Task		Summary		Rolled Up Milestone		External Tasks		Deadline	
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

Page 1

Figure F-2. Project schedule.

F-2. Roles and Responsibilities

All personnel are responsible and obliged to personally stop any work they determine unsafe. Project personnel are also responsible for identifying practices or conditions that are or may be adverse to quality and for recommending cessation of work to a Line Manager, Project Manager (PM), or the Quality Assurance Manager. Line Managers and PMs are responsible for assessing conditions potentially adverse to quality and for taking appropriate action, including stopping work. In all cases, these responsibilities override planning and scheduling considerations.

The following sections describe specific roles and responsibilities for key project personnel (i.e., PM, Site Safety and Health Officer [SSHO]/Field Team Leader [FTL], and Contractor Quality Control Site Manager [CQCSM]/Sampler).

F-3. Special Training Requirements/Certifications

There are no special training or certification requirements specific to this project. Training requirements relevant to North Wind's health and safety program comply with 29 Code of Federal Regulations (CFR) 1910.120, "Hazardous Waste Operations and Emergency Response." The Site-Specific Health and Safety Plan is presented in Appendix B of this Work Plan.

F-3.1.1 Project Manager (PM)

Mr. Tom Matzen will serve as the PM. Mr. Matzen will provide day-to-day supervision and ensure that the scope is executed according to schedule and budget. Mr. Matzen will frequently communicate with the U.S. Army Corps of Engineers (USACE), as appropriate, to discuss progress and/or to resolve any issues that may arise and will be responsible to provide required project reporting and final closeout of the project. Other duties of the PM include:

- Serving as the primary point of contact (POC) to client for all aspects of task order execution,
- Ensuring routine compliance with the project work plans,
- Verifying training and qualifications of personnel conducting quality-affecting work,
- Responding and correcting quality problems and deviations,
- Directing staff to prepare deliverables and execute field work,
- Coordinating, managing, and overseeing all subcontractors involved in each project,
- Negotiating subcontract agreements and approving subcontractor invoices,
- Reviewing and approving all task order submittals, and
- Ensuring compliance with all applicable federal, state, and local regulations.

F-3.1.2 Site Safety Health Officer/Field Team Leader (SSHO/FTL)

The SSHO/FTL will be on site when work is being performed. The SSHO/FTL is responsible for safety of the field team and oversees implementation of the Work Plan. The SSHO/FTL is often a working team member and may contribute to any aspect of the fieldwork, as necessary. The SSHO/FTL is required to work cooperatively with the CQCSM to accomplish the work safely, on schedule, and in accordance with applicable quality requirements. Specific duties include:

- Supervising field activities, ensuring that health and safety procedures are understood and followed by all field personnel, and reporting and correcting any violations of policy or regulation.
- Conducting daily meetings where the tasks for the day will be outlined and explained (as necessary) and safety issues discussed.
- Verifying that all safety and health training requirements have been met.
- Ensuring that health and safety procedures are understood and followed by field personnel, and for reporting and correcting any violations of policy or regulation.
- Serving as the emergency coordinator for any safety related incidents.
- Implementing the work scope according to approved work plans. Ensuring that all procedures and quality assurance/quality control (QA/QC) provisions are adhered to in the field.
- Ensuring that field equipment is properly calibrated and maintained and that records are maintained.
- Ensuring that individual samples are properly handled and appropriate custody documentation is prepared to allow for tracking sample possession from field collection through laboratory receipt.
- Directing all subcontractor activities in the field, ensuring that subcontractors adhere to site-specific installation requirements as well as contractual requirements.

F-3.1.3 Contractor Quality Control Site Manager (CQCSM)

The CQCSM, or his/her delegate, will be on-site when definable features of work are being performed. The CQCSM is accountable for the quality of the fieldwork and reports directly to the PM. Responsibilities of the CQCSM include:

- Monitoring the methods used to meet the level of quality.
- Maintaining acceptable records of the QC activities, including daily QC reports.
- Communicating and coordinating any corrective actions taken with the USACE on-site representative and North Wind QA Manager, as applicable.
- Verifying that work performed is in compliance with USACE and approved site-specific work plans.
- Ensuring that documentation (i.e., chain of custody forms, sample request forms, and labels) are complete and accurate.
- Ensuring that there are no uncorrected deviations from approved procedures.
- Ensuring that corrective actions are taken.
- Ensuring that individual samples are properly handled and appropriate custody documentation is prepared to allow for tracking sample possession from field collection through laboratory receipt.
- Directing all subcontractor activities in the field, ensuring that subcontractors adhere to site-specific installation requirements as well as contractual requirements.

NEW MEXICO ENVIRONMENT DEPARTMENT

Hazardous Waste Bureau
and
Ground Water Quality Bureau
Voluntary Remediation Program

TECHNICAL BACKGROUND DOCUMENT FOR DEVELOPMENT OF SOIL SCREENING LEVELS
REVISION 4.0

June 2006

Volume 1

TIER 1: SOIL SCREENING GUIDANCE TECHNICAL BACKGROUND DOCUMENT

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Attachment A: Screening-Level Ecological Risk Assessment Scoping Assessment: Site Assessment Checklist
Table 1: Examples of Sensitive Environments
Attachment B: Ecological Site Exclusion Checklist and Decision Tree

LIST OF ACRONYMS

ASTDR	Agency for Toxic Substances and Disease Registry
CMTP	Composite Model for Leachate Migration with Transformation Products
COPC	Contaminants of Potential Concern
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
DAF	Dilution Attenuation Factor
DQO	Data Quality Objectives
EPA/ORD	Environmental Protection Agency Office of Research and Development
GWQB	Groundwater Quality Bureau
HEAST	Health Effects Assessment Summary Tables
HWB	Hazardous Waste Bureau
IEUBK	Integrated Exposure Uptake Biokinetic
IRIS	Integrated Risk Information System
MCL	Maximum Contaminant Level
MCLG	Nonzero Maximum Contaminant Level
MRL	Minimum Risk Level
NAPL	Non-aqueous Phase Liquid
NCEA	National Center for Environmental Assessment
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NRCS	National Resource Conservation Service
PEF	Particulate Emission Factor
PRG	Preliminary Remediation Goal
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
SCEM	Site Conceptual Exposure Model
SSG	Soil Screening Guidance
SSL	Soil Screening Level
SVOC	Semi-volatile Organic Compound
UCL	Upper Confidence Limit
URF	Unit Risk Factor
USEPA	United States Environmental Protection Agency
VFs	Volatilization Factor for Soil
VFw	Volatilization Factor for Groundwater
VOC	Volatile Organic Compound
WQCC	Water Quality Control Commission

1. Introduction

The New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB) and the Ground Water Quality Bureau (GWQB) have developed this soil screening guidance (SSG) for internal department use for corrective action programs. The SSG discusses the methodology used to derive chemical-specific soil screening levels (SSLs). In addition, guidance is provided to assist in identifying and evaluating appropriate exposure pathways and receptors. Finally, this document provides generic SSLs for chemicals commonly found at contaminated sites based on default exposure parameters under residential and non-residential land-use scenarios.

The SSG provides site managers with a framework for developing and applying the SSLs, and is likely to be most useful for determining whether areas or entire sites are contaminated to an extent that warrants further investigation. It is intended to assist and streamline the site investigation and corrective action process by focusing resources on those sites or areas that pose the greatest risk to human health and the environment. Implementation of the methodologies outlined within this SSG may significantly reduce the time necessary to complete site investigations and cleanup actions at certain sites, as well as improve the consistency of these investigations.

Between various sites there can exist a wide spectrum of contaminant types and concentrations. The level of concern associated with those concentrations depends on several factors, including the likelihood of exposure to levels of potential concern to human health or to ecological receptors. At one end of the spectrum are levels that clearly warrant a response action; at the other end are levels that are below regulatory concern. Appropriate cleanup goals for a site may fall anywhere within this range depending on site-specific conditions. It is important to note that SSLs do not in themselves represent cleanup standards, and the SSLs alone do not trigger the need for a response action or define "unacceptable" levels of contamination in soil. Screening levels such as SSLs identify the lower end of this spectrum – levels below which there is generally no need for further concern—provided the conditions associated with the development of the SSLs are consistent.

1.1 Organization of the Document

The NMED SSG is organized into five major sections with supporting appendices. The remainder of Section 1 addresses the purpose of the NMED SSLs and outlines the scope of the document. Section 2 outlines the receptors, exposure pathways, and exposure assumptions used in calculating the NMED SSLs. It also discusses the risk levels on which the SSLs are predicated and presents the SSL model assumptions. Finally, Section 2 discusses site assessment/characterization activities that should be completed prior to comparing site contaminant concentrations with SSLs. These activities include development of data quality objectives, conducting site sampling, preparation of a preliminary conceptual site model (CSM), and identification of contaminants of potential concern (COPCs). Section 3 provides a detailed description of the process used to develop pathway-specific SSLs. Included in this section is a discussion of the human health basis for the SSLs, additive risk, and acute exposures. Additional topics discussed in Section 3 include chemical specific parameters used to develop the SSLs and calculating volatilization factors, particulate emission factors and soil saturation limits. Section 4 presents methodologies for assessing the potential for migration of contaminants to groundwater from contaminated soil in concert with generic and site-specific leaching models. Finally, Section 5 addresses special use considerations for addressing contaminant concentrations in soil and notes specific problems that can arise when applying the SSLs to specific

sites. Generic SSLs for contaminants are presented in Table A-1 of Appendix A. Table A-2 of Appendix A presents the default exposure factor values used in the generation of the NMED SSLs. Physical-chemical values in the calculation of the SSLs are presented in Table B-1 of Appendix B. Toxicity criteria are presented in Table C-1 of Appendix C.

1.2 Scope of the Soil Screening Guidance

The SSG incorporates readily obtainable site data and utilizes methods from various United States Environmental Protection Agency (US EPA) risk assessment guidance and derives site-specific screening levels for selected contaminants and exposure pathways. Key attributes of the SSG include default values for generic SSLs where site-specific information is unavailable, and the identification of parameters for which site-specific information is needed for the development of site-specific SSLs. The goal of the SSG is to provide a consistent approach for developing site-specific SSLs for evaluating facilities under the auspices of the corrective action process within NMED.

The NMED SSLs are based on a 1E-05 target risk for carcinogens, or a hazard quotient of 1 for noncarcinogens. In instances where an individual contaminant has the capacity to elicit both types of responses, the SSLs preferentially report the screening value representative of the lowest (most stringent) contaminant concentration in environmental media. SSLs for migration to groundwater are based on NMED-specific tapwater SSLs. As such, the NMED SSLs serve as a generic benchmark for screening level comparisons of contaminant concentrations in soil. NMED anticipates that the SSLs will be used as a tool to facilitate prompt identification of those contaminants and areas that represent the greatest risks to human health and the environment. While concentrations above the NMED SSLs presented in this document do not automatically designate a site as "contaminated" or trigger the need for a response action, detected concentrations in site soils exceeding screening levels suggest that further evaluation is appropriate. Further evaluation may include additional sampling to further characterize the nature and extent of contamination, consideration of background levels, reevaluation of COPCs or associated risk and hazard using site-specific parameters, and/or a reassessment of the assumptions associated with the generic SSLs (e.g., appropriateness of route-to-route extrapolations, use of chronic toxicity values to evaluate childhood and construction-worker exposures).

1.2.1 Exposure Pathways

A complete exposure pathway consists of (1) a source, (2) a mechanism of contaminant release, (3) a receiving or contact medium, (4) a potential receptor population, and (5) an exposure route. All five elements must be present for the exposure pathway to be considered complete.

SSLs have been developed for use in evaluating three discrete exposure scenarios representing a variety of potential land uses: residential, commercial/industrial, and construction. The SSG presents lists of potential pathways for each scenario, though these lists are not intended to be exhaustive. Instead, each list represents a set of typical exposure pathways likely to account for the majority of exposure to contaminants in soil at a given site. These include:

- Direct (or incidental) ingestion of soil,
- Dermal contact with soil,
- Inhalation of volatiles and fugitive dusts from contaminated soil, and
- Migration of chemicals through soil to an underlying potable aquifer or water-

bearing unit.

Under some site-specific situations, additional complete exposure pathways may be identified. In these cases, a site-specific evaluation of risk is warranted in which additional exposure pathways can be considered. If other land uses and exposure scenarios are determined to be more appropriate for a site (e.g., Native American land use), the exposure pathways addressed in this document should be modified accordingly or a site-specific risk assessment should be conducted. Early identification of the need for additional information is important because it facilitates development of a defensible sampling and analysis strategy.

The exposure pathways evaluated, by land-use scenario, are presented in Table 1-1.

Table 1-1

Exposure Pathways Evaluated in Soil Screening Guidance			
Potential Exposure Pathway	Residential	Commercial/industrial	Construction
Direct ingestion			
Dermal contact			
Inhalation of volatiles outdoors			
Inhalation of fugitive dusts outdoors			
Inhalation of volatiles indoors			

1.2.2 Exposure Assumptions

SSLs represent risk-based concentrations in soil derived from equations combining exposure assumptions with toxicity criteria developed by US EPA (US EPA 2006 and 1997a) and the National Center for Environmental Assessment (NCEA) (USEPA 2003c). The models and assumptions used were developed to be consistent with the Superfund concept of "reasonable maximum exposure" (US EPA 1989). This is intended to provide an upper-bound estimate of chronic exposure by combining both average and conservative (i.e., 90th to 95th percentile) values in the calculations. The default intake and duration assumptions presented here are intended to be protective of all potentially exposed populations for each land use consideration. Exposure point concentrations in soil should reflect either directly measured or estimated values using fate and transport models. An average concentration is typically used where the focus is on estimating long-term, chronic exposures and there are sufficient site data to allow for an accurate estimation of the mean. Where the potential for acute toxicity may be of concern, estimates based on the maximum exposure may be more appropriate.

The resulting estimate of exposure is then compared with chemical-specific toxicity criteria. To calculate the SSLs, the exposure equations and pathway models are rearranged to backcalculate an "acceptable level" of a contaminant in soil corresponding to a specific level of target risk or hazard.

1.2.3 Target Risk and Hazard

Target risk and hazard levels for human health are risk management-based criteria for carcinogenic and non-carcinogenic responses, respectively, to determine (1) whether site-related contamination poses an unacceptable risk to human health and requires corrective action or (2) whether implemented corrective action(s) sufficiently protects human health. If an estimated risk or hazard falls within the target range, the risk manager may conclude that a site does not pose an unacceptable risk. This decision should take into account the degree of inherent conservatism or level of uncertainty associated with the site-specific estimates of risk and hazard. An estimated risk

that exceeds these targets, however, does not necessarily indicate that the current conditions are not safe or that they present an unacceptable risk. Rather, a site risk calculation that exceeds a target value may simply indicate the need for further evaluation or refinement of the exposure model.

For cumulative exposure via the ingestion, inhalation, and dermal pathways, toxicity criteria are used to calculate an acceptable level of contamination in soil. SSLs are based on a carcinogenic risk level of one-in-one-hundred thousand (1E-05) and a non-carcinogenic hazard quotient of 1. A carcinogenic risk level is defined as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. The non-carcinogenic hazard quotient assumes that there is a level of exposure below which it is unlikely for even sensitive populations to experience adverse health effects.

1.2.4 SSL Model Assumptions

The models used to calculate inhalation exposure and protection of groundwater based on potential migration of contaminants in soil are intended to be utilized at an early stage in the site investigation process when information regarding the site may be limited. For this reason, the models incorporate a number of simplifying assumptions. For instance, the models assume an infinite contaminant source, i.e. a constant concentration is maintained for the duration of the exposure period. Although this is a highly conservative assumption, finite source models require accurate data regarding source size and volume. Such data are unlikely to be available from limited sampling efforts. The models also assume that contamination is homogeneous throughout the source and that no biological or chemical degradation occurs. Where sufficient site-specific data are available, more-detailed finite-source models may be used in place of the default assumptions presented in this SSG.

2. Development of Pathway Specific Soil Screening Levels

The following sections present the technical basis and limitations used to calculate SSLs for residential, commercial/industrial, and construction land use scenarios. The equations used to evaluate inhalation and migration to groundwater include a number of easily obtainable site-specific input parameters. Where site-specific data are not available, conservative default values are presented. The equations used are presented in Sections 2.2, 2.3 and 2.4. Generic SSLs calculated for 208 chemicals, using these default values, are presented in Table A-1 of Appendix A.

2.1 Human Health Basis

The toxicity criteria used for calculating the SSLs are presented in Table C-1 of Appendix C. The primary sources for the human health benchmarks are US EPA's Integrated Risk Information System (IRIS) (US EPA 2006), US EPA's NCEA (US EPA 2005), and the Health Effects Assessment Summary Tables (HEAST) (US EPA 1997a). Additional sources include the minimal risk levels (MRLs) developed by the Agency for Toxic Substances and Disease Registry (ATSDR). For soil ingestion, inhalation of volatile organic compounds (VOCs) and fugitive dusts, and dermal contact, the NMED SSLs correspond to a 1E-05 level for carcinogens and/or a hazard quotient of 1 for noncarcinogens, whichever is lower (i.e., more protective).

2.1.1 Additive Risk

It is important to note that no consideration is provided in the calculation of individual NMED

SSLs for additive risk when exposures to multiple chemicals occur. The SSG addresses this issue in Section 5. Because the NMED SSLs for carcinogenic effects correspond to a 1E-05 risk level individually, exposure to multiple contaminants may result in a cumulative site risk that is above the anticipated risk management range. While carcinogenic risks of multiple chemicals are simply added together, the issue of additive hazard is more complex for noncarcinogens because of the theory that a threshold exists for noncarcinogenic effects. This threshold is defined as the level below which adverse effects are not expected to occur, and represents the basis for the reference dose (RfD) and reference concentration (RfC). Since adverse effects are not expected to occur at the RfD or RfC and the SSLs are derived by setting the potential exposure dose to the RfD or RfC, the SSLs do not address the risk of exposure to multiple chemicals at levels where the individual chemicals alone would not be expected to cause any adverse effects. In such cases, the SSLs may not provide an accurate indicator for the likelihood of harmful effects. However, noncarcinogenic effects should only be considered additive for those chemicals with the same toxic endpoint and/or mechanism of action. The sources provided in Section 2.1 should be consulted to determine the endpoint and/or target organ system prior to attempting to evaluate the additive health effects resulting from simultaneous exposure to multiple contaminants.

Additivity of the SSLs is further complicated by the fact that not all of the SSLs are based on toxicity. SSLs for certain volatile chemicals are determined based on a ceiling limit concentration termed the soil saturation limit (and denoted as C_{sat}) above which these chemicals may occur as nonaqueous phase liquids (NAPLs) in soil. These are noted as "sat" in the tables. This is discussed further in Section 3.2. Further, for certain inorganic and semivolatile organic compounds (SVOCs) that exhibit relatively low toxicity, a non risk-based maximum concentration of 1E+05 mg/kg is given when the risk-based SSL exceeds that level. These are noted as "max" in the tables.

2.1.2 Acute Exposures

The exposure assumptions used to develop the SSLs are based on a chronic exposure scenario and do not account for situations where high-level exposures may result in acute toxic effects. Such situations may arise when contaminant concentrations are very high, or may result from specific site-related conditions and/or behavioral patterns (i.e., pica behavior in children). Such exposures may be of concern for those contaminants that primarily exhibit acute health effects. Toxicological information regarding cyanide and phenol indicate that acute effects may be of concern for children exhibiting pica behavior. Pica is typically described as a compulsive craving to ingest non-food items (such as clay or paint). Although it can be exhibited by adults as well, it is typically of greatest concern in children because they often exhibit behavior (e.g., outdoor play activities and greater hand-to-mouth contact) that results in greater exposure to soil than for a typical adult. In addition, children also have a lower overall body weight relative to the predicted intake.

2.1.3 Route-to-Route Extrapolation

As of January 1991, IRIS and NCEA databases no longer present RfDs or cancer slope factors (CSFs) for the inhalation route. These criteria have been replaced with RfCs for noncarcinogenic effects and unit risk factors (URFs) for carcinogenic effects. However, for the purposes of estimating risk and calculating risk-based concentrations, inhalation reference doses (RfD_i) and inhalation slope factors (CSF_i) are preferred. Route-to-route extrapolations were also frequently used when there were no toxicity values available for a given route of exposure. However, route extrapolations were not performed for inorganics due to portal of entry effects and known

differences in absorption efficiency between the oral and dermal routes of exposure. To calculate an RfD_i from an RfC, the following equation and assumptions may be used for most chemicals:

$$RfD_i \ \frac{mg}{(kg - day)} = RfC\,(mg / m^3) \times \frac{20m^3}{day} \times \frac{1}{70kg}$$

The SF_i was calculated from the URF using the following equation and assumptions:

$$CSF_i \ \frac{(kg - day)}{(mg)} = URF\left(m^3/ug\right) \times \frac{day}{20m^3} \times 70kg \times \frac{10^3\ ug}{mg}$$

An additional route extrapolation is the use of oral toxicity values for evaluating dermal exposures. Because no toxicity data are presently available for evaluating dermal exposure to contaminants, US EPA has developed a methodology for use in dermal assessments. Most oral RfDs and oral cancer slope factors (CSF_o) are based on an administered dose while dermal equations estimate an absorbed dose. Gastrointestinal and pulmonary absorption of many chemicals is typically much greater than absorption through intact skin. Thus, for evaluating the effects of dermal exposure to contaminants in soil, the oral toxicity value should be adjusted from an administered dose to an absorbed dose by accounting for the absorption efficiency of the chemical. Assuming 100 percent absorption via the oral exposure route may result in an overestimation of the absorbed dose, resulting in an overestimation of the dose at the site of toxic injury and underestimating the actual potency of the chemical to exert an observed effect. The magnitude of the underestimation is inversely proportional to the true oral absorption of the compound. Based on the current guidance (US EPA 2004c), the only chemical for which an adjustment is recommended is cadmium. An oral absorption efficiency of five (5) percent is assumed for cadmium, which leads to an estimated dermal reference dose (RfD_d) of 2.5E-05 mg/kg-day.

2.1.4 Direct Ingestion

Exposure to contaminants through incidental ingestion of soil can result from the inadvertent consumption of soils adhering to the hands, food items, or objects that are placed into the mouth. It can also result from swallowing dust particles that have been inhaled and deposited in the mouth and subsequently swallowed. Commercial/industrial and construction workers and residential receptors may inadvertently ingest soil that adheres to their hands while involved in work- or recreation-related activities. Calculation of SSLs for direct ingestion are based on the methodology presented in US EPA's *Risk Assessment Guidance for Superfund (RAGS): Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim* (US EPA 1991 2001), *Soil Screening Guidance: Technical Background Document* (US EPA 1996a), and *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2001a).

2.1.5 Dermal Absorption

Exposure to soil contaminants may result from dermal contact with contaminated soil and the subsequent absorption of contaminants through the skin. Contact with soil is most likely to occur as a result of digging, gardening, landscaping, or outdoor recreation activities. Excavation activities may also be a potential source of exposure to contaminants, particularly for construction workers. Calculation of the screening levels for ingestion of soil under the residential exposure scenario is

based on the methodology presented in EPA's *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim* (1991), and *Soil Screening Guidance: Technical Background Document* (US EPA 1996a). The suggested default input values used to develop the NMED SSLs are consistent with EPA's interim *RAGS, Part E, Supplemental Guidance for Dermal Risk Assessment* (US EPA 2004).

2.1.6 Inhalation of Volatiles and Fugitive Dusts

EPA toxicity data indicate that risks from exposure to some chemicals via the inhalation pathway far outweigh the risk via ingestion or dermal contact; therefore, the NMED SSLs have been designed to address inhalation of volatiles and fugitive dusts. To address the soil/sediment-to-air pathways, the SSL calculations incorporate a volatilization factor (VF_s) for volatile contaminants (See Section 3.1) and a particulate emission factor (PEF)(See Section 3.3) for nonvolatile contaminants. The SSLs follow the procedures for evaluating inhalation of VOCs and fugitive dust particles presented in EPA's *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim* (US EPA 1991), *Soil Screening Guidance: Technical Background Document* (US EPA 1996a), *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (US EPA 1998a), and *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2001a).

VOCs may adhere to soil particles or be present in interstitial air spaces in soil, and may volatilize into ambient air. This pathway may be particularly significant if the VOC emissions are concentrated in indoor spaces of onsite buildings. The NMED SSLs do not account for vapor intrusion and inhalation of volatile organics volatilized into indoor air. If vapor intrusion into indoor air is a concern, additional analysis of this pathway may be necessary and the latest guidance on evaluating the vapor intrusion pathway should be consulted: for example, the US EPA's 2002 *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Soil Vapor Intrusion Guidance.* For the purpose of calculating the NMED SSLs, VOCs are considered those chemicals having a Henry's Law constant greater than 1E-05 atm-m^3/mole-^oK and a molecular weight less than 200 g/mole.

Inhalation of contaminants via inhalation of fugitive dusts is assessed using a PEF that relates the contaminant concentration in soil/sediment with the concentration of respirable particles in the air due to fugitive dust emissions. It is important to note that the PEF used to address residential and commercial/industrial exposures evaluates only windborne dust emissions and does not consider emissions from traffic or other forms of mechanical disturbance which could lead to a greater level of exposure. The PEF used to address construction worker exposures evaluates windborne dust emissions and emissions from vehicle traffic associated with construction activities. Therefore, the fugitive dust pathway should be considered carefully when developing the CSM at sites where receptors may be exposed to fugitive dusts by other mechanisms. The development of the PEF for both residential and non-residential land uses is discussed further in Section 3.3.

2.2 RESIDENTIAL LAND USES

Residential exposures are assessed based on child and adult receptors. As discussed below, the child forms the basis for evaluation of noncarcinogenic effects incurred under residential exposures, while carcinogenic responses are modeled based upon age-adjusted values to account for exposures averaged over a lifetime. Under most circumstances, onsite residential receptors are expected to be the most conservative receptor basis for risk assessment purposes due to the assumption that

exposure occurs 24 hours a day, 350 days per year, extending over a 30-year exposure duration. Table 2-1 provides a summary of the exposure characteristics and parameters associated with a residential land use receptor.

Table 2-1

Summary of the Residential Land Use Receptors	
Exposure Characteristics	Substantial soil exposure (esp. children) High soil ingestion rate (esp. children) Significant time spent indoors Long-term exposure
Default Exposure Parameters	
Exposure frequency (days/yr)	350
Exposure duration (yr)	6 (child) 24 (adult)
Soil ingestion rate (mg/day)	200 (child) 100 (adult)
Body Weight (kg)	15 (child) 70 (adult)
Skin surface area exposed (cm^2)	2,800 (child) 5,700 (adult)
Skin-soil adherence factor (mg/cm^2)	0.2 (child) 0.07 (adult)
Air inhalation rate (m^3/day)	10 (child) 20 (adult)

2.2.1 Residential Receptors

A residential receptor is assumed to be a long-term receptor occupying a dwelling within the site boundaries and thus is exposed to contaminants 24 hours per day, and is assumed to live at the site for 30 years (representing the 90th percentile of the length of time someone lives in a single location), remaining onsite for 350 days per year. Exposure to soil is expected to occur during home maintenance activities, yard work and landscaping, and outdoor play activities. Contaminant intake is assumed to occur via three exposure pathways – direct ingestion, dermal absorption, and inhalation of volatiles and fugitive dusts. For the residential scenario, both adult and child receptors were evaluated because children often exhibit behavior (e.g., greater hand-to-mouth contact) that can result in greater exposure to soils than those associated with a typical adult. In addition, children also have a lower overall body weight relative to the predicted intake.

Equations 1 and 2 are used to calculate cumulative SSLs for a residential receptor exposed to non-carcinogenic and carcinogenic contaminants via all three exposure pathways. Default exposure parameters are provided for use when site-specific data are not available.

Equation 1
Combined Exposures to Noncarcinogenic Contaminants in Soil
Residential Scenario

$$C = \frac{THQ \times BW_c \times AT_n}{EF_r \times ED_c \left[\left(\frac{1}{RfD_o} \times \frac{IRS_c}{10^6 \, mg/kg} \right) + \left(\frac{1}{RfD_o} \times \frac{SA_c \times AF_c \times ABS}{10^6 \, mg/kg} \right) + \left(\frac{1}{RfD_i} \times \frac{IRA_c}{VF_s \text{ or } PEF} \right) \right]}$$

Parameter	Definition (units)	Default
C	Contaminant concentration (mg/kg)	Chemical-specific
THQ	Target hazard quotient	1
BW_c	Body weight, child (kg)	15
AT_n	Averaging time, noncarcinogens (days)	ED x 365
EF_r	Exposure frequency, resident (day/yr)	350
ED_c	Exposure duration, child (years)	6
IRS_c	Soil ingestion rate, child (mg/day)	200
RfD_o	Oral reference dose (mg/kg-day)	Chemical-specific
SA_c	Dermal surface area, child (cm^2/day)	2,800
AF_c	Soil adherence factor, child (mg/cm^2)	0.2
ABS	Skin absorption factor (unitless)	Chemical-specific
IRA_c	Inhalation rate, child (m^3/day)	10
RfD_I	Inhalation reference dose (mg/kg-day)	Chemical-specific
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 12
PEF	Particulate emission factor (m^3/kg)	See Equation 14

Equation 2
Combined Exposures to Carcinogenic Contaminants in Soil
Residential Scenario

$$C = \frac{TR \times AT_c}{EF_r\left[\left(\frac{IFS_{adj} \times CSF_o}{10^6\,mg/kg}\right) + \left(\frac{SFS_{adj} \times ABS \times CSF_o}{10^6\,mg/kg}\right) + \left(\frac{InhF_{adj} \times CSF_i}{VF_s \text{ or } PEF}\right)\right]}$$

Parameter	Definition (units)	Default
C	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target cancer risk	1E-05
AT_c	Averaging time, carcinogens (days)	25,550
EF_r	Exposure frequency, resident (day/yr)	350
IFS_{adj}	Age-adjusted soil ingestion factor ([mg-yr]/[kg-day])	114
CSF_o	Oral cancer slope factor (mg/kg-day)$^{-1}$	Chemical-specific
SFS_{adj}	Age-adjusted dermal factor ([mg-yr]/[kg-day])	361
ABS	Skin absorption factor (unitless)	Chemical-specific
$InhF_{adj}$	Age-adjusted inhalation factor ([m^3-yr]/[kg-day])	11
CSF_i	Inhalation cancer slope factor (mg/kg-day)$^{-1}$	Chemical-specific
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 12
PEF	Particulate emission factor (m^3/kg)	See Equation 14

Noncarcinogenic contaminants are evaluated based solely on childhood exposures using Equation 1. By combining the higher contaminant intake rates with the lower relative body weight, "childhood only" exposures lead to a lower, or more conservative, risk-based concentration compared to an adult-only exposure. In addition, this approach is considered conservative because it combines the higher 6-year exposure for children with chronic toxicity criteria.

Unlike non-carcinogens, the duration of exposure to carcinogens is averaged over the lifetime of the receptor because of the assumption that cancer may develop even after actual exposure has ceased. As a result, the total dose received is averaged over a lifetime of 70 years. In addition, to be protective of exposures in a residential setting, the carcinogenic exposure parameter values are age-adjusted to account for exposures incurred in children (1-6 years of age) and adults (7-31 years of age). Carcinogenic exposures are age-adjusted to account for the physiological differences between children and adults as well as behavioral differences that result in markedly different relative rates of exposure. Equations 3, 4, and 5 are used to calculate age-adjusted ingestion, dermal and inhalation factors which account for the differences in soil ingestion rate, skin surface area, soil adherence factors, inhalation rate, and body weight for children versus adults. The age-adjusted factors calculated using these equations are used in Equation 2 to develop generic NMED SSLs for carcinogenic effects.

Equation 3
Calculation of Age-Adjusted Ingestion Factor

$$IFS_{adj} = \frac{ED_c \times IRS_c}{BW_c} + \frac{\left(ED_r - ED_c\right) \times IRS_a}{BW_a}$$

Parameter	Definition (units)	Default
IFS_{adj}	Age-adjusted soil ingestion factor for carcinogens [(mg-yr)/(kg-day)]	114
ED_c	Exposure duration, child (years)	6
IRS_c	Soil ingestion rate, child (mg/day)	200
BW_c	Body weight, child (kg)	15
ED_r	Exposure duration, resident (years)	30
IRS_a	Soil ingestion rate, adult (mg/day)	100
BW_a	Body weight, adult (kg)	70

Equation 4
Calculation of Age-Adjusted Dermal Factor

$$SFS_{adj} = \frac{ED_c \times AF_c \times SA_c}{BW_c} + \frac{\left(ED_r - ED_c\right) \times AF_a \times SA_a}{BW_a}$$

Parameter	Definition (units)	Default
SFS_{adj}	Age-adjusted dermal factor for carcinogens [(mg-yr)/(kg-day)]	361
ED_c	Exposure duration, child (years)	6
AF_c	Soil adherence factor, child (mg/cm^2)	0.2
SA_c	Dermal surface area, child (cm^2/day)	2,800
BW_c	Body weight, child (kg)	15
ED_r	Exposure duration, resident (years)	30
AF_a	Soil adherence factor, adult (mg/cm^2)	0.07
SA_a	Dermal surface area, adult (cm^2/day)	5,700
BW_a	Body weight, adult (kg)	70

Equation 5
Calculation of Age-Adjusted Inhalation Factor

$$InhF_{adj} = \frac{Ed_c \times IRA_c}{BW_c} + \frac{\left(ED_r - ED_c\right) \times IRA_a}{BW_a}$$

Parameter	Definition (units)	Default
$InhF_{adj}$	Age-adjusted inhalation factor for carcinogens [(m^3-yr)/(kg-day)]	11
ED_c	Exposure duration, child (years)	6
IRA_c	Inhalation rate, child (m^3/day)	10
BW_c	Body weight, child (kg)	15
ED_r	Exposure duration, resident (years)	30
IRA_a	Inhalation rate, adult (m^3/day)	20
BW_a	Body weight, adult (kg)	70

2.3 NON-RESIDENTIAL LAND USES

Non-residential land uses encompass all commercial and industrial land uses and focus on two very different receptors – a commercial/industrial worker and a construction worker. Unlike those calculated for residential land-uses, NMED SSLs for non-residential land uses are based solely on exposures to adults. Consequently, exposures to carcinogens are not age-adjusted. Due to the wide range of activities and exposure levels a non-residential receptor may be exposed to during various work-related activities, it is important to ensure that the default exposure parameters are representative of site-specific conditions. Table 2-2 provides a summary of the exposure characteristics and parameters for non-residential land use receptors.

Table 2-2
Summary of Non-Residential Land Use Receptors

Receptor	Commercial/Industrial Worker	Construction Worker
Exposure Characteristics	Substantial soil exposures High soil ingestion rate Long-term exposure Exposure to surface and shallow subsurface soils Adult-only exposure	Exposed during construction activities only Short-term exposure Very high soil ingestion and dust inhalation rates Exposure to surface and subsurface soils
Default Exposure Parameters		
Exposure frequency (days/yr)	225	250
Exposure duration (yr)	25	1
Soil ingestion rate (mg/day)	100	330
Body Weight (kg)	70	70
Skin surface area exposed (cm^2)	3,300	3,300
Skin-soil adherence factor (mg/ cm^2)	0.2	0.3
Air inhalation rate (m^3/day)	20	20

2.3.1 Commercial/Industrial Worker

The commercial/industrial scenario is considered representative of on-site workers who spend all or most of their workday outdoors. A commercial/industrial worker is assumed to be a long-term receptor exposed during the course of a work day as either (1) a full time employee of a company operating on-site who spends most of the work day conducting maintenance or manual labor activities outdoors or (2) a worker who is assumed to regularly perform grounds-keeping activities as part of his/her daily responsibilities. Exposure to surface and shallow subsurface soils (i.e., at depths of zero to two feet below ground surface) is expected to occur during moderate digging associated with routine maintenance and grounds-keeping activities. A commercial/industrial receptor is expected to be the most highly exposed receptor in the outdoor environment under generic or day-to-day commercial/industrial conditions. Thus, the screening levels for this receptor are expected to be protective of other reasonably anticipated indoor and outdoor workers at a commercial/industrial facility. However, screening levels developed for the commercial/industrial worker may not be protective of a construction worker due to the latter's increased soil contact rate during construction activities. Equations 6 and 7 were used to develop generic SSLs for cumulative exposure to carcinogenic and non-carcinogenic contaminants by all exposure pathways. Default exposure parameters (US EPA 2001) are provided and were used in calculating the NMED SSLs.

Equation 6
Combined Exposures to Carcinogenic Contaminants in Soil
Commercial/Industrial Scenario

$$C = \frac{TR \times BW_a \times AT_c}{EF_{CI} \times ED_{CI}\left[\left(\frac{IRS_{CI} \times CSF_o}{10^6\ mg/kg}\right) + \left(\frac{SA_{CI} \times AF_{CI} \times ABS \times CSF_o}{10^6\ mg/kg}\right) + \left(\frac{IRA_c \times CSF_i}{VF_s \text{ or } PEF}\right)\right]}$$

Parameter	Definition (units)	Default
C	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target Risk	1E-05
BW_a	Body weight, adult (kg)	70
AT_c	Averaging time, carcinogens (days)	25,550
EF_{CI}	Exposure frequency, commercial/industrial (day/yr)	225
ED_{CI}	Exposure duration, commercial/industrial (years)	25
IRS_{CI}	Soil ingestion rate, commercial/industrial (mg/day)	100
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
SA_{CI}	Dermal surface area, commercial/industrial (cm^2/day)	3,300
AF_{CI}	Soil adherence factor, commercial/industrial (mg/cm^2)	0.2
ABS	Skin absorption factor (unitless)	Chemical-specific
IRA_{CI}	Inhalation rate, commercial/industrial (m^3/day)	20
CSF_i	Inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 12
PEF	Particulate emission factor (m^3/kg)	See Equation 14

Equation 7
Combined Exposures to Noncarcinogenic Contaminants in Soil
Commercial/Industrial Scenario

$$C = \frac{THQ \times BW_a \times AT_n}{EF_{CI} \times ED_{CI}\left[\left(\frac{1}{RfD_o} \times \frac{IRS_{CI}}{10^6\,mg/kg}\right) + \left(\frac{1}{RfD_o} \times \frac{SA_{CI} \times AF_{CI} \times ABS}{10^6\,mg/kg}\right) + \left(\frac{1}{RfD_i} \times \frac{IRA_{CI}}{VF_s \text{ or } PEF}\right)\right]}$$

Parameter	Definition (units)	Default
C	Contaminant concentration (mg/kg)	Chemical-specific
THQ	Target hazard quotient	1
BW_a	Body weight, adult (kg)	70
AT_n	Averaging time, noncarcinogens (days)	ED x 365
EF_{CI}	Exposure frequency, commercial/industrial (day/yr)	225
ED_{CI}	Exposure duration, commercial/industrial (years)	25
IRS_{CI}	Soil ingestion rate, commercial/industrial (mg/day)	100
RfD_o	Oral reference dose (mg/kg-day)	Chemical-specific
SA_{CI}	Dermal surface area, commercial/industrial (cm^2/day)	3,300
AF_{CI}	Soil adherence factor, commercial/industrial (mg/cm^2)	0.2
ABS	Skin absorption factor (unitless)	Chemical-specific
IRA_{CI}	Inhalation rate, commercial/industrial (m^3/day)	20
RfD_i	Inhalation reference dose (mg/kg-day)	Chemical-specific
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 12
PEF	Particulate emission factor (m^3/kg)	See Equation 14

2.3.2 Construction Worker

A construction worker is assumed to be a receptor that is exposed to contaminated soil during the work day for the duration of a single on-site construction project. If multiple construction projects are anticipated, it is assumed that different workers will be employed for each project. The activities for this receptor typically involve substantial exposures to surface and subsurface soils (i.e., at depths of zero to 10 feet below ground surface) during excavation, maintenance and building construction projects (intrusive operations). A construction worker is assumed to be exposed to contaminants via the following pathways: incidental soil ingestion, dermal contact with soil, and inhalation of contaminated outdoor air (volatile and particulate emissions). While a construction worker receptor is assumed to have a higher soil ingestion rate than a commercial/industrial worker due to the type of activities performed during construction projects, the exposure frequency and duration are assumed to be significantly shorter due to the short-term nature of construction projects. However, chronic toxicity information was used when developing screening levels for a construction worker receptor. This approach is significantly more conservative than using sub-chronic toxicity data because it combines the higher soil exposures for construction workers with chronic toxicity criteria. Equations 8 and 9 were used to develop generic SSLs for cumulative exposure to carcinogenic and non-carcinogenic contaminants by all exposure pathways. Default exposure parameters (US EPA 2001) are provided and were used in calculating the NMED SSLs.

Equation 8
Combined Exposures to Carcinogenic Contaminants in Soil
Construction Worker Scenarios

$$C = \frac{TR \times BW_a \times AT_c}{EF_{CW} \times ED_{CW}\left[\left(\frac{IRS_{CW} \times CSF_o}{10^6\,mg/kg}\right) + \left(\frac{SA_{CW} \times AF_{CW} \times ABS \times CSF_o}{10^6\,mg/kg}\right) + \left(\frac{IRA_{CW} \times CSF_i}{VF_s \text{ or } PEF_{cw}}\right)\right]}$$

Parameter	Definition (units)	Default
C	Contaminant concentration (mg/kg)	Chemical-specific
TR	Target risk	1E-05
BW_a	Body weight, adult (kg)	70
AT_c	Averaging time, carcinogens (days)	25,550
EF_{CW}	Exposure frequency, construction worker (day/yr)	250
ED_{CW}	Exposure duration, construction worker (years)	1
IRS_{CW}	Soil ingestion rate, construction worker (mg/day)	330
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
SA_{CW}	Dermal surface area, construction worker (cm^2/day)	3,300
AF_{CW}	Soil adherence factor, construction worker (mg/cm^2)	0.3
ABS	Skin absorption factor (unitless)	Chemical-specific
IRA_{CW}	Inhalation rate, construction worker (m^3/day)	20
CSF_i	Inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 12
PEF_{cw}	Particulate emission factor for a construction worker (m^3/kg)	See Equation 15

Equation 9
Combined Exposures to Noncarcinogenic Contaminants in Soil
Construction Worker Scenario

$$C = \frac{THQ \times BW_a \times AT_n}{EF_{CW} \times ED_{CW}\left[\left(\frac{1}{RfD_o} \times \frac{IRS_{CW}}{10^6\,mg/kg}\right) + \left(\frac{1}{RfD_o} \times \frac{SA_{CW} \times AF_{CW} \times ABS}{10^6\,mg/kg}\right) + \left(\frac{1}{RfD_i} \times \frac{IRA_{CW}}{VF_s \text{ or } PEF_{CW}}\right)\right]}$$

Parameter	Definition (units)	Default
C	Contaminant concentration (mg/kg)	Chemical-specific
THQ	Target hazard quotient	1
BW_a	Body weight, adult (kg)	70
AT_n	Averaging time, noncarcinogens (days)	ED x 365
EF_{CW}	Exposure frequency, construction (day/yr)	250
ED_{CW}	Exposure duration, construction (years)	1
IRS_{CW}	Soil ingestion rate, construction (mg/day)	330
RfD_o	Oral reference dose (mg/kg-day)	Chemical-specific
SA_{CW}	Dermal surface area, construction (cm^2/day)	3,300
AF_{CW}	Soil adherence factor, construction (mg/cm^2)	0.3
ABS	Skin absorption factor (unitless)	Chemical-specific
IRA_{CW}	Inhalation rate, construction (m^3/day)	20
RfD_i	Inhalation reference dose (mg/kg-day)	Chemical-specific
VF_s	Volatilization factor for soil (m^3/kg)	See Equation 12
PEF_{cw}	Particulate emission factor for a construction worker (m^3/kg)	See Equation 15

2.3.3 Alternative Evaluation for Lead

Exposure to lead can result in neurotoxic and developmental effects. The primary receptors of concern are children, whose nervous systems are still undergoing development and who also exhibit behavioral tendencies that increase their likelihood of exposure (e.g., pica). These effects may occur at exposures so low that they may be considered to have no threshold, and are evaluated based on a blood lead level (rather than the external dose as reflected the RfD/RfC methodology). Therefore, US EPA views it to be inappropriate to develop noncarcinogenic "safe" exposure levels (i.e., RfDs) for lead. Instead, US EPA's lead assessment workgroup has recommended the use of the Integrated Exposure Uptake Biokinetic (IEUBK) model that relates measured lead concentrations in environmental media with an estimated blood-lead level (US EPA 1994 and 1998b). The model is used to calculate a blood lead level in children when evaluating residential land use and in adults (based on a pregnant mother's capacity to contribute to fetal blood lead levels), or when evaluating occupational scenarios at sites where access by children is reliably restricted. The NMED SSLs presented in Appendix A include values for lead that were calculated by using the IEUBK to backcalculate a soil concentration for each receptor that would not result in an estimated blood-lead concentration of 10 micrograms per deciliter (μg/dL) or greater (residential adult of 400 mg/kg and industrial and construction worker of 800 mg/kg)

2.4 TAP WATER SCREENING LEVELS

Exposure to contaminants can occur through the ingestion of domestic/household water. The calculations of the NMED tap water screening levels for domestic water are based upon the methodology presented in RAGS, part B (USEPA 1991). The screening levels are based upon ingestion and inhalation of contaminants in water. While ingestion is appropriate for all chemicals, inhalation of volatiles from water was considered for those chemicals with a minimum Henry's Law constant of 1E-05 atm-m^3/mole and with a maximum molecular weight of 200 g/mole. To address the groundwater-to-air pathways, the tap water screening levels incorporate a volatilization factor (VF_w) of 0.5 L/m^3 for volatile contaminants (USEPA, 1991); this derived value defines the relationship between the concentration of a contaminant in household water and the average concentration of the volatilized contaminant in air as a result of all uses of household water (i.e., showering, laundering, dish washing).

As ingestion and inhalation rates may be different for children and adults, carcinogenic risks during the first 30 years were calculated using age-adjusted factors (IFW_{adj} and $InhF_{adj}$), which were obtained from RAGS, part B (USEPA 1991).

Equation 10
Ingestion and Inhalation Exposures to Carcinogenic Contaminants in Tap Water
Residential Scenario

$$C = \frac{TR \times AT_c \times 1000ug/mg}{EF_r\left[\left(IFW_{adj} \times CSF_o\right) + \left(VF_w \times InhF_{adj} \times CSF_i\right)\right]}$$

Parameter	Definition (units)	Default
C	Contaminant concentration (ug/L)	Chemical-specific
TR	Target risk	1E-05
AT_c	Averaging time, carcinogens (days)	25,550
EF_r	Exposure frequency, resident (day/yr)	350
IFW_{adj}	Age-adjusted water ingestion rate, resident (L-yr/kg-day)	1.1
SF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific
VF_w	Volatilization factor for water (m^3/kg)	0.5
$InhF_{adj}$	Age-adjusted inhalation factor, resident (m^3-yr/kg-day)	11
SF_i	Inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	Chemical-specific

Equation 11
Ingestion and Inhalation Exposures to Noncarcinogenic Contaminants in Tap Water
Residential Scenario

$$C = \frac{THQ \times BW_a \times AT_n \times 1000\,ug/mg}{EF_r \times ED_r \left[\left(\frac{IRW_a}{RfD_o} \right) + \left(\frac{VF_w \times IRA_a}{RfD_i} \right) \right]}$$

Parameter	Definition (units)	Default
C	Contaminant concentration (ug/L)	Chemical-specific
THQ	Target hazard quotient	1
BW_a	Body weight, adult (kg)	70
AT_n	Averaging time, noncarcinogens (days)	ED x 365
EF_r	Exposure frequency, resident (day/yr)	350
ED_r	Exposure duration, resident (years)	30
IRW_a	Water ingestion rate, resident (L/day)	2
RfD_o	Oral reference dose(mg/kg-day)	Chemical-specific
VF_w	Volatilization factor for water (m^3/kg)	0.5
IRA_a	Inhalation rate, resident (m^3/day)	20
RfD_i	Inhalation reference dose (mg/kg-day)	Chemical-specific

2.5 SITE ASSESSMENT AND CHARACTERIZATION

The Site Assessment/Site Characterization phase is intended to provide additional spatial and contextual information about the site, which may be used to determine if there is any reason to believe that receptors and/or complete exposure pathways may exist at or in the locality of the site where a release of hazardous waste/constituents has occurred. In addition, the site assessment phase serves as the initial information gathering phase to determine whether potential exposures are sufficiently similar to those upon which the NMED SSLs are predicated to support comparison. Finally, this phase can help to identify for sites in need of a more detailed assessment of potential risk. The approach outlined herein is discussed in greater detail in the NMED Hazardous and Radioactive Material Bureau (HRMB) guidance document *Assessing Human Health Risks Posed by Chemicals: Screening-level Risk Assessment* (NMED 2000). A CSM providing a list of the potentially exposed receptors and potentially complete exposure pathways in the scoping report is used to determine whether further assessment (i.e., a screening level assessment) and/or interim measures are required or whether the site poses minimal threat to human and ecological receptors at or near the site.

The ultimate purpose of the site assessment phase is to address the question: Are exposure pathways complete with regard to contaminant contact by receptors? A complete site assessment will consists of several steps:

- Develop data quality objectives and conduct site sampling;
- Identify preliminary COPCs;
- Develop a preliminary site conceptual exposure model (SCEM); and
- Compare maximum (or, if deemed appropriate by NMED, the 95% upper confidence limit (UCL) value) for contaminant concentrations (or

detection/quantitation limits for non-detect results) for consideration of complete exposure pathways with SSLs.

2.5.1 Development of Data Quality Objectives

Before any additional environmental samples are collected, data quality objectives (DQOs) should be developed. The DQOs should address the qualitative and quantitative nature of the sampling data, in terms of relative quality and intent for use, to ensure that any data collected will be appropriate for the intended objective. Development of the DQOs should consider not only precision, accuracy, representativeness, completeness, and comparability of the data, but also the sampling locations, types of laboratory analyses used, sensitivity of detection limits of the analytical techniques, the resulting data quality, and the employment of adequate quality assurance/quality control measures.

2.5.2 Identification of COPCs

COPCs are those substances (including transformation or breakdown compounds and companion products) likely to be present in environmental media affected by a release. Identification of COPCs should begin with existing knowledge of the process, product, or waste from which the release originated. For example, if facility operations deal primarily with pesticide manufacturing then pesticides should be considered COPCs. Contaminants identified during current or previous site investigation activities should also be evaluated as COPCs. A site-specific COPC list for soil may be generated based on maximum detected (or, if deemed appropriate by NMED, the 95% UCL value) concentrations (US EPA 2002b) and a comparison of detection/quantitation limits for non-detect results to the NMED SSLs. This list may be refined through a site-specific risk assessment.

2.5.3 Development of a Preliminary Conceptual Site Model

A CSM is a graphical representation of three-dimensional site conditions that conveys what is known or suspected, at a discrete point in time, about the site-specific sources, releases, release mechanisms, contaminant fate and transport, exposure routes, and potential receptors. The CSM is generally documented by written descriptions and supported by maps, geological cross-sections, tables, diagrams and other illustrations to communicate site conditions. When preparing a CSM, the facility should decide the scope, quantity, and relevance of information to be included, balancing the need to present as complete a picture as possible to document current site conditions and justify risk management actions, with the need to keep the information focused and exclude extraneous data.

As a final check, the CSM should answer the following questions:

- Are there potential land uses present (now or in the foreseeable future) other than those covered by the SSLs (refer to US EPA 1989).
- Are there other likely human exposure pathways that were not considered in development of the SSLs (e.g. direct exposure to groundwater, local fish consumption, raising beef, dairy, or other livestock)? (refer to US EPA 1989)
- Are there potential ecological concerns? (*Guidance for Assessing Ecological Risks Posed by Chemicals: Screening Level Ecological Risk Assessment*; NMED 2000)

If any conditions such as these exist, the SSLs may need to be adjusted to reflect this new information.

2.5.4 Compare COPC Maximum Concentrations With SSLs

The final step in the site assessment phase is to compare maximum detected COPC concentrations in soil (or, if deemed appropriate by NMED, the 95% UCL value on the mean of the dataset (US EPA 2002b)) with SSLs based on the complete exposure pathways identified by the preliminary CSM. These concentrations should also be compared against the SSL leaching values to determine which contaminants present in soil have the capacity to leach to underlying groundwater and impact these resources adversely. As stated earlier, those contaminants exhibiting concentrations in excess of the SSLs represent the initial soil COPC list for a given site. Refinement of this list may be necessary based on a host of factors, including elevated detection or quantitation limits.

3. Chemical-Specific and Physical-Chemical Parameters

Chemical-specific parameters required for calculating SSLs include the organic carbon normalized soil-water partition coefficient for organic compounds (K_{oc}), the soil-water partition coefficient (K_d), water solubility (S), octanol-water partition coefficient (K_{ow}), Henry's Law constant (H), diffusivity in air (D_a), and diffusivity in water (D_w). The following sections describe these values and present methodologies for calculating additional values necessary for calculating the NMED SSLs.

3.1 Volatilization Factor for Soil

Volatile chemicals, defined as those chemicals having a Henry's Law constant greater than 1E-05 atm-m^3/mole-^{o}K and a molecular weight less than 200 g/mole, were screened for inhalation exposures using a volatilization factor (VF_s) for soils. The soil-to-air VF_s is used to define the relationship between the concentration of the contaminant in soil and the flux of the volatilized contaminant to ambient air. The emission terms used in the VF_s are chemical-specific and were calculated from physical-chemical information obtained from several sources including: US EPA's *Soil Screening Guidance: Technical Background Document* (US EPA, 1996a and 2001a), USEPA Master Physical and Chemical Parameter table for development of PRGS (USEPA 2004), the US EPA Regions 6 and 9 *Preliminary Remediation Goals* (US EPA 2004), EPA's *Basics of Pump and Treat Groundwater Remediation Technology* (US EPA 1990), US EPA's *Dermal Exposure Assessment* (US EPA 1992a*), Superfund Public Health Evaluation Manual* (US EPA 1986), EPA's *Additional Environmental Fate Constants* (US EPA 1995), Hazardous Substance Release/Health Effects Database (ATSDR 2003), the RAIS database (DOE 2005), and the CHEMFACTS database (US EPA 2000c). The VF_s is calculated using Equation 12.

Equation 12
Derivation of the Volatilization Factor for Residential and Commercial/Industrial Scenarios

$$VF_s = \frac{Q/C_{vol} \times \left(3.14 \times D_A \times T\right)^{0.5} \times 10^{-4}}{\left(2 \times \rho_b \times D_A\right)}$$

Where:

$$D_A = \frac{\left[\dfrac{\left(\theta_a^{10/3} D_a H' + \theta_w^{10/3} D_w\right)}{n^2}\right]}{\rho_b K_d + \theta_w + \theta_a H'}$$

Parameter	Definition (units)	Default
VF_s	Volatilization factor for soil (m^3/kg)	Chemical-specific
D_A	Apparent diffusivity (cm^2/s)	Chemical-specific
Q/C_{vol}	Inverse of the mean concentration at the center of a 0.5-acre-square source (g/m^2-s per kg/m^3)	68.18
T	Exposure interval (s)	9.5E+08
ρ_b	Dry soil bulk density (g/cm^3)	1.5
n	Total soil porosity 1 - (ρ_b/ρ_s)	0.43
θ_a	Air-filled soil porosity (n - θ_w)	0.17
θ_w	Water-filled soil porosity	0.26
ρ_s	Soil particle density (g/cm^3)	2.65
D_a	Diffusivity in air (cm^2/s)	Chemical-specific
H'	Dimensionless Henry's Law constant	Chemical-specific
D_w	Diffusivity in water (cm^2/s)	Chemical-specific
K_d	Soil-water partition coefficient (cm^3/g) = K_{oc} x f_{oc} (organics)	Chemical-specific
K_{oc}	Soil organic carbon partition coefficient (cm^3/g)	Chemical-specific
f_{oc}	Fraction organic carbon in soil (g/g)	0.0015

While most of the parameters used to calculate apparent diffusivity (D_A) are either chemical-specific or default values, several state-specific values were used which are more representative of soil conditions found in New Mexico. The default values for θ_w, θ_a, and ρ_b in Equation 12 are 0.26, 0.17 and 1.5 g/cm^3, respectively. These values represent the mean value from a National Resources Conservation Service (NRCS) soil survey database for New Mexico that includes over 1200 sample points (U.S. Department of Agriculture 2000). USEPA guidance (2001a) provides additional methodologies for estimating site-specific air-filled soil porosities and water-filled soil porosities.

It should be noted that the basic principle of the VF model (Henry's Law) is applicable only if the soil contaminant concentration is at or below soil saturation, C_{sat}. Above the soil saturation limit, the model cannot predict an accurate VF-based SSL.

3.2 SOIL SATURATION LIMIT

C_{sat} describes a chemical-physical soil condition that integrates certain chemical-specific properties with physical attributes of the soil to estimate the contaminant concentration at which the soil pore water, pore air, and surface sorption sites are saturated with contaminants. Above this concentration, the contaminants may be present in free phase within the soil matrix – as non-aqueous phase liquids (NAPLs) for substances that are liquid at ambient soil temperatures, and pure solid phases for compounds that are solids at ambient soil temperatures (EPA 1996a). Generic C_{sat} concentrations should not be interpreted as confirmation of a saturated soil condition, but as estimates of when this condition may occur. It should be noted that C_{sat} concentrations are not risk-based values. Instead, they correspond to a theoretical threshold above which free phase contaminant may exist. C_{sat} concentrations, therefore, serve to identify an upper limit to the applicability of generic risk-based soil criteria, because certain default assumptions and models used in the generic algorithms are not applicable when free phase contaminant is present in soil. It should be noted that a basic principle of the volatilization model is not applicable when free-phase contaminants are present. How these cases are handled depends on whether the contaminant is liquid or solid at ambient temperatures. Liquid contaminants that have volatilization factor (VF_s)-based screening levels that exceed the "sat" concentration are set equal to "sat" whereas for solids (e.g., PAHs), soil screening decisions are based on appropriate other pathways of concern at the site (e.g., ingestion and dermal contact). Equation 13, given below is used to calculate C_{sat} for each volatile contaminant considered within the SSLs.

Equation 13
Derivation of the Soil Saturation Limit

$$C_{sat} = \frac{S}{\rho_b}\left(K_d \rho_b + \theta_w + H'\theta_a\right)$$

Parameter	Definition (units)	Default
C_{sat}	Soil saturation concentration (mg/kg)	Chemical-specific
S	Solubility in water (mg/L-water)	Chemical-specific
ρ_b	Dry soil bulk density (kg/L)	1.5
K_d	Soil-water partition coefficient (L/kg; $K_{oc} \times f_{oc}$)	Chemical-specific
K_{oc}	Soil organic carbon/water partition coefficient (L/kg)	Chemical-specific
f_{oc}	Fraction organic carbon in soil (g/g)	0.0015
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.26
H´	Dimensionless Henry's Law constant	Chemical-specific

θ_a	Air-filled soil porosity (n- θ_w),(L_{air}/L_{soil})	0.17
n	Total soil porosity (1 – (ρ_b/ρ_s)), (L_{pore}/L_{soil})	0.43
ρ_s	Soil particle density (kg/L)	2.65

Chemical-specific parameters used in Equation 11 were obtained from physical-chemical information obtained from several sources including: US EPA's *Soil Screening Guidance: Technical Background Document* (US EPA 1996a), the US EPA Regions 6 and 9 *Preliminary Remediation Goals* (US EPA 2004), US EPA's *Basics of Pump and Treat Groundwater remediation Technology* (US EPA 1990), US EPA's *Dermal Exposure Assessment* (US EPA 1992a*), Superfund Public Health Evaluation Manual* (US EPA 1986), US EPA's *Additional Environmental Fate Constants* (US EPA 1995), Hazardous Substance Release/Health Effects Database (ATSDR 2003), the RAIS database, and the CHEMFACTS database.

3.3 PARTICULATE EMISSION FACTOR

Inhalation of chemicals adsorbed to suspended respirable particles is assessed using a chemical-specific PEF, which relates the contaminant concentration in soil to the concentration of respirable particles in the air due to fugitive dust emissions from contaminated soils. This guidance addresses dust generated from open sources, which is termed "fugitive" because it is not discharged into the atmosphere in a confined flow stream. For further details on the methodology associated with the PEF model, the reader is referred to US EPA's *Soil Screening Guidance: Technical Background Document* (US EPA 1996a), *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (US EPA 2001a) and *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (US EPA 1998a).

It is important to note that the PEF for use in evaluating exposures of the residential and commercial/industrial receptors addresses only windborne dust emissions and does not consider emissions from traffic or other forms of mechanical disturbance, which could lead to a greater level of exposure. The PEF for use in evaluating the construction worker exposures considers windborne dust emissions and emissions from vehicle traffic associated with construction activities. Therefore, the fugitive dust pathway should be considered carefully when developing the CSM at sites where receptors may be exposed to fugitive dusts by other mechanisms. Equation 14 is used to calculate a New-Mexico region-specific PEF value, used for both the residential and commercial/industrial exposure scenarios. A scenario-specific PEF value was calculated for a construction worker receptor (PEF_{cw}) using Equation 15.

Equation 14
Derivation of the Particulate Emission Factor
Residential and Commercial/Industrial Scenarios

$$PEF = Q / C_{wind} \times \frac{3{,}600 \text{ sec / hr}}{0.036 \times (1 - V) \times \left(\frac{U_m}{U_t}\right)^3 \times F(x)}$$

Parameter	Definition (units)	Default
PEF	Particulate emission factor (m^3/kg)	6.61E+09
Q/C_{wind}	Inverse of a mean concentration at center of a 0.5-acre-square source (g/m^2-s per kg/m^3)	81.85
V	Fraction of vegetative cover (unitless)	0.5
U_m	Mean annual windspeed (m/s)	4.02
U_t	Equivalent threshold value of windspeed at 7 m (m/s)	11.32
F(x)	Function dependent on U_m/U_t derived using Cowherd et al. (1985) (unitless)	0.0553

Equation 15
Derivation of the Particulate Emission Factor
Construction Worker Scenario

$$PEF_{CW} = Q / C_{CW} \times \frac{1}{F_D} \left[\frac{T \times A_R}{556 \times \left(\frac{W}{3}\right)^{0.4} \times \frac{(365 \text{ days / yr} - P)}{365 \text{ days / yr}} \times \sum VKT} \right]$$

Parameter	Definition (units)	Default
PEF_{CW}	Particulate emission factor for a construction worker (m^3/kg)	2.1E+06
Q/C_{CW}	Inverse of a mean concentration at center of a 0.5-acre-square source (g/m^2-s per kg/m^3)	23.02
F_D	Dispersion correction factor (unitless)	0.185
T	Total time over which construction occurs (s)	7.2E+06
A_R	Surface area of road segment (m^2)	274.2
W	Mean vehicle weight (tons)	8
P	Number of days with at least 0.01 inches of precipitation (days/yr)	60
ΣVKT	sum of fleet vehicle kilometers traveled during the exposure duration (km)	168.75

3.4 PHYSICAL-CHEMICAL PARAMETERS

Several chemical-specific parameters are required for calculating SSLs including the organic carbon normalized soil-organic carbon/water partition coefficients for organic compounds (K_{oc}), the soil-

water partition coefficient for organic and inorganic constituents (K_d), the solubility of a compound in water (S), Henry's Law constant (H), air diffusivity (D_a), water diffusivity (D_w), and the octanol-water partition coefficient (K_{ow}). Prior to calculating site-specific SSLs, each relevant chemical specific parameter value presented in Appendix B should be checked against the most recent version of its source to determine if updated data are available. Table B-1 in Appendix B provides the chemical-specific parameters used in calculating the NMED SSLs.

Chemical-specific values were obtained from EPA's *Soil Screening Guidance: Technical Background Document* (US EPA 1996a), the EPA Region 6 *Media-Specific Screening Levels* (US EPA, 2005) and EPA Region 9 *Preliminary Remediation Goals* (US EPA 2004b), US EPA's *Basics of Pump and Treat Groundwater remediation Technology* (US EPA 1990), US EPA's *Dermal Exposure Assessment* (US EPA 1992a), *Superfund Public Health Evaluation Manual* (US EPA 1986), US EPA's *Additional Environmental Fate Constants* (US EPA 1995), Hazardous Substance Release/Health Effects Database (ATSDR 2003), the RAIS database, and the CHEMFACTS database.

3.4.1 Solubility, Henry's Law Constant, and K_{ow}

The solubility of a contaminant refers to the maximum amount that can be dissolved in a fixed volume of solvent, usually pure water, at a specific temperature and pH. A chemical with a high solubility readily dissolves in water, while a low solubility indicates an inability to dissolve. Water solubility is generally predicted based on correlations with the octanol-water partition coefficient (K_{ow}). Solubility is used to calculate soil saturation limits for the NMED SSLs.

The octanol-water partition coefficient (K_{ow}) of a chemical is the ratio of a chemical's solubility in octanol versus its solubility in water at equilibrium. Essentially, this chemical-specific property is used as an indication of a contaminant's propensity to migrate from soil to water. It is an important parameter and is used in the assessment of environmental fate and transport for organic chemicals.

The Henry's Law constant (H) is used when evaluating air exposure pathways. For all chemicals that are capable of exchanging across the air-water interface, there is a point at which the rate of volatilization into the air and dissolution to the water or soil will be equal. The ratio of gas- and liquid-phase concentrations of the chemical at this equilibrium point is represented by H, which is used to determine the rate at which a contaminant will volatilize from soil to air. Values for H may be calculated using the following equation and the values for solubility (S), vapor pressure (VP), and molecular weight (MW).

$$H = \frac{VP \text{ x } MW}{S}$$

The dimensionless form of Henry's Law constant (H´) used in calculating soil saturation limits and volatilization factors for the NMED SSLs was calculated by multiplying H by a factor of 41 to convert the Henry's Law constant to a unitless value.

3.4.2 Soil Organic Carbon/Water Partition Coefficients (K_{oc})

The soil organic carbon-water partition coefficient (K_{oc}) is a measure of a chemical's tendency to adsorb to organic carbon present in soil. High K_{oc} values indicate a tendency for the chemical to adsorb to soil particles rather than remain dissolved in the soil solution. Strongly adsorbed

molecules will not unless the soil particle to which they are adsorbed moves (as in erosion). K_{oc} values of less than 500 indicate weak adsorption and a potential for leaching. K_{oc} is calculated using the following equation:

$$K_{oc} = \frac{\text{conc. adsorbed/conc. dissolved}}{\text{\% organic carbon in soil}}$$

K_{oc} can also be calculated by dividing the K_d value by the fraction of organic carbon (f_{oc}) present in the soil or sediment. It should be noted that a strong linear relationship exists between K_{oc} and K_{ow} and that this relationship can be used to predict K_{oc}.

3.4.3 Soil/Water Partition Coefficients (K_d)

Soil-water partition coefficient (K_d) for organic chemicals is the ratio of a contaminant's distribution between soil and water particles. The soil-water partitioning behavior of nonionizing and ionizing organic compounds differs because the partitioning of ionizing organics can be influenced by soil pH. K_d values were used in calculating soil saturation limits and volatilization factors used in developing the NMED SSLs.

For organic compounds, K_d represents the tendency of a chemical to adsorb to the organic carbon fraction in soils, and is represented by:

$$K_d = K_{oc} \text{ x } f_{oc}$$

where

K_{oc} = organic carbon partition coefficient (L/kg or cm^3/g); and
f_{oc} = fraction of organic carbon in soil (mg/mg).

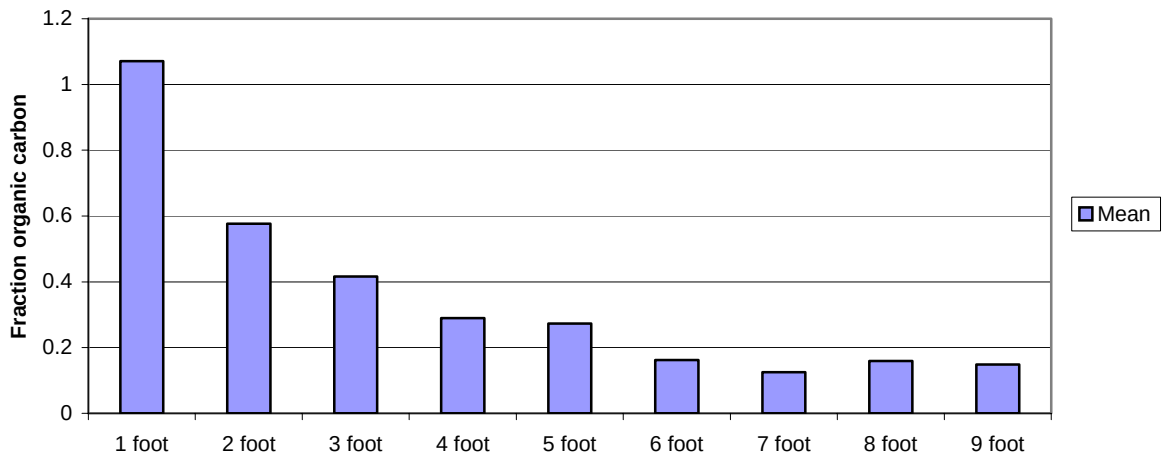
This relationship is generally valid for volatile halogenated hydrocarbons as long as the fraction of organic carbon in soil is above approximately 0.001 (0.1 percent) (Piwoni and Banaerjee, 1989 Schwarzenbach and Westall 1981). For low organic carbon soils ($f_{oc} < 0.001$), Piwoni and Banerjee (1989) developed the following empirical correlation for organic chemicals:

$$\log K_d = 1.01 \log K_{ow} - 0.36$$

The use of a fixed K_{oc} value in the soil-water partition equation for the migration to groundwater pathway is only valid for hydrophobic non-ionizing organic chemicals. For organic chemicals that ionize in the soil environment, existing in both neutral and ionized forms within the normal soil pH range, K_{oc} values must consider the relative proportions and differences in sorptive properties of these forms. For the equations and applications of developing K_{oc} values for ionizing organic acids as a function of pH, the reader is referred to US EPA 1996. The default value used for f_{oc} in development of NMED SSLs is 0.0015 (0.15%). This value represents the median value of 212 data points included in the NRCS soil survey database for New Mexico (U.S. Department of Agriculture 2000). Only samples collected from a depth of greater than 5 feet were included in the

calculation of the mean f_{oc} value. Shallow soil samples tend to have higher f_{oc} values as shown in Figure 2-1. There is a steady decline in f_{oc} value with depth until approximately 5 feet bgs. Below 5 feet, there is little variability in the f_{oc} value. Because a lower f_{oc} value provides a more conservative calculation of SSL, a value representative of deeper soil conditions is used as the default value.

Figure 2-1 Mean Value - Fraction Organic Carbon (f_{oc})-
All counties in New Mexico



As with organic chemicals, development of the NMED SSLs for inorganic constituents (i.e., metals) requires a soil-water partition coefficient (K_d) for each contaminant. K_d values for metals are affected by a variety of soil conditions, most notably pH, oxidation-reduction conditions, iron oxide content, soil organic matter content, cation exchange capacity and major ion chemistry. US EPA developed default K_d values for metals using either an equilibrium geochemical speciation model (MINTEQ2) or from empirical pH-dependent adsorption relationships developed by Environmental Protection Agency's Office of Research and Development (EPA/ORD) (US EPA 1996a).

4. Migration of Contaminants to Groundwater

Generic SSLs were developed which address the potential for migration of contaminants from soil to groundwater. The methodology used to calculate generic SSLs addresses the potential leaching of contaminants from the vadose zone to groundwater. This method does not take into account any additional attenuation associated with contaminant transport in groundwater. The SSLs developed from this analysis are based on NMED-specific tap water SLLS or the more conservative of the New Mexico water quality standards, maximum contaminant levels (MCLs), or Region 6 tap water PRGs and are protective of groundwater under a wide range of site conditions. This methodology is modeled after US EPA's *Soil Screening Guidance: Technical Background Document* (US EPA 1996a).

4.1 Overview of the SSL Model Approach

Two approaches to developing soil leachate-based SSLs are presented, the generic model and the site-specific model. Both models use the same set of equations to calculate SSLs and are based on

leaching to groundwater scenarios that NMED believes are protective of groundwater. The generic model calculates SSLs using default parameter values generally representative of conditions in New Mexico. These values are presented in Table B-1 of Appendix B. The site-specific model provides the flexibility of using site-specific meteorological, soil and hydrological data to calculate SSLs, while retaining the simplicity and ease of use associated with the generic model.

The development of soil leachate SSLs is based upon a two step process. The first step is the development of a Dilution Attenuation Factor (DAF). The DAF accounts for leachate mixing in the aquifer. A leachate concentration that is protective of ground water is back calculated by multiplying the ground water standard for a given constituent by the DAF. That leachate concentration is then used to back calculate an SSL that is protective of groundwater using a simple linear equilibrium soil/water partition equation. For the generic SSL approach, default parameter values are used for all non-chemical specific parameters. At sites that are not adequately represented by the default values and where more site-specific data are available, it may be more appropriate to use the site-specific SSL model. The site-specific model uses the same spreadsheet equations to calculate SSLs as those in the generic look-up table. However, site-specific data are used in the site-specific model.

The following sections of this document provide a general description of the leaching to groundwater pathway SSL model (generic and site-specific) including the assumptions, equations, and input parameters. Justification for the default parameters used in the generic model is also provided. Additionally, a sensitivity analysis was performed on each of the input parameters to provide guidance on when use of the site-specific model may be warranted. Applicability and limitations of the generic and site-specific models are also presented.

4.2 Model Assumptions

Assumptions regarding the release and distribution of contaminants in the subsurface that are incorporated into the SSL methodology include the following.

- The source is infinite (a constant concentration is maintained for the duration of the exposure period).
- Contamination is uniformly distributed from the surface to the water table.
- Soil/water partitioning is instantaneous and follows a linear equilibrium isotherm.
- There is no attenuation of the contaminant in soil or the aquifer (i.e., irreversible adsorption, chemical transformation or biological degradation).
- The potentially impacted aquifer is unconfined and unconsolidated with homogenous and isotropic hydrologic properties.
- The receptor well (point of exposure) is at the downgradient edge of the source and is screened within the potentially impacted aquifer.
- Non-aqueous phase liquids (NAPLs) are not present.

4.3 Soil Water Partition Equation

US EPA's *Supplemental Soil Screening Guidance: Technical Background Document* (US EPA 2001) developed an equation to estimate contaminant release in soil leachate based on the Freundlich adsorption

isotherm. The Freundlich equation was modified to relate the sorbed concentration to the total concentration measured in a soil sample (which includes contaminants associated with solid soil, soil-water and soil-air components) (Feenstra 1991). Equation 16, given below, is used to calculate SSLs corresponding to target soil leachate concentrations (C_w).

Equation 16
Soil Screening Level For Leaching To Groundwater Pathway

$$SSL = C_w \text{ x} \left[K_d + \left(\frac{\theta_w + \theta_a H'}{\rho_b} \right) \right]$$

Parameter	Definition (units)	Default
SSL	Soil Screening Level for migration to groundwater pathway (mg/kg)	Chemical-Specific
C_w	Target soil leachate concentration (mg/L)	Chemical-Specific
K_d	Soil /water partition coefficient (L/kg)	Chemical-Specific
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.26
θ_a	Air-filled soil porosity (L_{air}/L_{soil}), n - θ_w	0.17
n	Total soil porosity (L_{pore}/L_{soil}), 1 - (ρ_b/ρ_s)	0.43
ρ_s	Soil particle density (kg/L)	2.65
ρ_b	Dry soil bulk density (kg/L)	1.5
H´	Dimensionless Henry's Law constant	Chemical-Specific

Target soil leachate concentrations (C_w) are equivalent to the NMED-specific tap water screening levels multiplied by a Dilution Attenuation Factor (DAF).

$$C_w = \text{Tap Water SSL x DAF}$$

The derivation of the DAF is discussed in subsequent sections of this document.

4.4 Dilution Attenuation Factor

Contaminants transported as a leachate through soil to groundwater are affected by physical, chemical and biological processes that can significantly reduce their concentration. These processes include adsorption, biological degradation, chemical transformation and dilution from mixing of the leachate with groundwater. The total reduction in concentration between the source of the contaminant (vadose zone soil) and the point of ground water withdrawal is defined as the ratio of contaminant concentration in soil leachate to the concentration in groundwater at the point of withdrawal. This ratio is termed a dilution/attenuation factor (DAF; US EPA 1996a and 1996b). The higher the DAF value, the greater the degree of dilution and attenuation of contaminants along the migration flowpath. A DAF of 1 implies no reduction in contaminant concentration occurs.

Development of New Mexico SSLs considers only the dilution of contaminant concentration through mixing with groundwater in the aquifer directly beneath the source. This is consistent with the conservative assumptions used in the SSL methodology including an infinite source, soil contamination extending from surface to groundwater and the point of exposure occurring at the

downgradient edge of the source. The ratio of contaminant concentration in soil leachate to the concentration in groundwater at the point of withdrawal that considers only dilution processes is calculated from a simple water balance equation (Equation 17), described below.

Equation 17
Dilution/Attenuation Factor (DAF)

$$DAF = 1 + \left(\frac{K \times i \times D}{I \times L} \right)$$

Where:

$$D = \left(0.0112 \times L^2\right)^{0.5} + D_a \left(1 - \exp\left[\frac{-L \times I}{K \times i \times D_a} \right] \right)$$

Parameter	Definition (units)	Default
DAF	Dilution/attenuation factor (unitless)	Site-Specific
K	Aquifer hydraulic conductivity (m/yr)	Site-Specific
i	Hydraulic gradient (m/m)	Site-Specific
D	Mixing zone depth (m)	Site-Specific
I	Infiltration rate (m/yr)	Site-Specific
L	Source length parallel to groundwater flow (m)	Site-Specific
D_a	Aquifer thickness (m)	Site-Specific

Most of these parameters are available from routine environmental site investigations. The mixing zone depth incorporates one additional parameter, the aquifer thickness (D_a).

For the calculation of SSLs, the DAF is used to back calculate the target soil leachate concentration from an appropriate groundwater concentration, such as the WQCC standard (C_w in Equation 16). For example, if the WQCC standard for a constituent is 0.1 mg/L and the DAF is 20, the target soil leachate concentration would be 2 mg/L.

The US EPA conducted an extensive evaluation of the range and distribution of DAFs to select a default value to be used for developing generic SSLs that would be reasonably protective of groundwater quality (US EPA 1996a, 1996b, and 2001). The evaluation included a probabilistic modeling exercise using US EPA's Composite Model for Leachate Migration with Transformation Products (CMTP). A cumulative frequency distribution of DAF values was developed from the model output. Results of the Monte Carlo modeling analysis indicate that for a 0.5 acre source area a DAF of approximately 170 is protective of groundwater at 90 percent of the sites. Groundwater is protected at 95 percent of the sites with a DAF of 7.

US EPA applied the simple SSL water balance dilution model (Equation 17) to 300 sites included in surveys of hydrogeologic investigations to further evaluate the range and distribution of DAF values. Results of this analysis indicated that a DAF of 10 was protective of groundwater for a 30-acre source and that a DAF of 20 was protective of groundwater for a 0.5 acre-source (US EPA 1996a, 1996b, and 2001).

An assessment was performed of US EPA's methodology to determine whether a default DAF value of 20 for a 0.5 acre source, and a DAF of 10 for a 30 acre source, would be appropriate for use as default values for sites in New Mexico. Typical New Mexico conditions may be notably different than conditions represented by areas included in the US EPA analysis of DAFs. For example, infiltration rates across much of New Mexico are substantially less than the average range of 0.15 to 0.24 m/yr reported for many of the hydrogeologic regions used in the US EPA analysis. In addition, effective porosity was assumed to be 0.35, presumably because this value is representative of the most prevalent aquifer type in the databases used (US EPA 1996a). However, the regions included in the EPA analysis also contain extensive glacial, regolith, lacustrine, swamp and marsh deposits which have high percentages of fine-grained sediments and thus are not representative of typical New Mexico sandy soils. Sandy soils typically have higher hydraulic conductivities than more fine-grained soils and subsequently higher Darcian velocities, under equal hydraulic gradient. According to the DAF equation (Equation 17), soils with relatively greater hydraulic conductivities will tend to result in a higher calculated DAF.

An assessment was made of input parameters to the DAF equation. In order to support a DAF that is protective of the most vulnerable groundwater environments in New Mexico (i.e. areas close to perennial streams or where ground water is very shallow), environmental parameters typical of those areas in New Mexico were used to assess the DAF. This assessment indicated that the DAF is most sensitive to variations in hydraulic conductivity. This is because this value shows such large variations in the natural environment. If a hydraulic conductivity value representative of a fine-grained sand is used in the DAF equation, along with an infiltration rate representative of New Mexico's arid to semi-arid environments, then the result is a DAF of approximately 20. NMED believes that a DAF of 20 for a 0.5 acre source area is protective of groundwater in New Mexico. If the default DAF is not representative of conditions at a specific site, then it is appropriate to calculate a site-specific DAF based upon available site data.

4.5 LIMITATIONS ON THE USE OF THE DILUTION ATTENUATION FACTOR

Because of assumptions used in SSL model approach, use of the DAF model may be inappropriate for certain conditions, including sites where:

- adsorption or degradation processes are expected to significantly attenuate contaminant concentrations in the soil or aquifer media;
- Saturated thickness is significantly less than 12 meters thick;
- fractured rock or karst aquifer types exist (violates the unconfined, unconsolidated, homogeneous, isotropic assumptions);
- facilitated transport is significant (colloidal transport, transport via dissolved organic matter, or transport via solvents other than water; and/or
- NAPLs are present.

For sites that have these types of conditions, consideration should be given to application of a more detailed site-specific analysis than either the generic or site-specific models described herein.

4.6 GENERIC SSLS FOR PROTECTION OF GROUNDWATER

The migration to groundwater pathway model, incorporating the assumptions, soil-water partition equation and the DAF, was used to develop NMED SSLs. Default values based on conditions predominant in New Mexico were used for the input parameters in the soil-water partition equation. The NMED SSLs were developed using default DAF values of 1 and 20.

Target soil leachate concentrations (C_w) are equivalent to the appropriate groundwater standards multiplied by a DAF. To maintain an approach that is protective of groundwater quality in the development of generic SSLs, a DAF of 20 is selected as reasonably protective. However SSLs are provided for two DAFs in Appendix A. The use of the SSL listed for a DAF of 20 is advised unless site-specific data on hydrologic conditions are available, and these indicate that the generic DAF is not representative of site conditions. As will be demonstrated in the sensitivity analysis section of this document, calculation of an SSL using the migration to groundwater pathway model is most sensitive to the DAF. The inclusion of the SSL for a DAF of 1 is provided for convenience to the user. If data on hydrologic conditions are readily available, a site specific DAF can be calculated and multiplied by the generic SSL for a DAF of 1 to provide a site-specific SSL.

The generic approach may be inappropriate for use at sites where conditions are substantially different from the default values used to develop the generic soil leachate SSLs.

4.7 DEVELOPMENT OF SITE SPECIFIC SSLS FOR PROTECTION OF GROUNDWATER

New Mexico, as with any other state, offers a variety of geologic and hydrologic conditions that may not be readily represented by a single default parameter value.

Site specific conditions may differ considerably from the typical or average conditions represented by the default values used to calculate generic SSLs. The site-specific model can be used to address the variability inherent in environmental conditions across and within the state.

Application of the site-specific model to develop soil leachate SSLs is the same as the generic approach except that site-specific values are used. Use of the site-specific model approach may incorporate replacement of all default values used for the generic SSLs with site-specific values, or may only include substitution of a single key parameter, such as hydraulic conductivity. The decision to use the site-specific model approach instead of the generic approach should be based on consideration of the sensitivity of the calculated SSL to specific parameters and the availability of those parameters as site-specific data. Sufficient site-specific data may be available such that each of the default values used for developing generic SSLs can be readily substituted with a more representative site-derived value. Conversely, limited site-specific data may restrict the number of default values to be replaced.

The NMED SSLs are generally more sensitive to the dilution factor than to other parameters in the soil-water partition equation. Fortunately, information needed to derive the DAF is usually available for sites that have undergone even the most basic levels of environmental investigation. Apart from the dilution factor, SSLs are most sensitive to the soil-water partition coefficient (K_d) as the values for this parameter can range over several orders of magnitude, particularly for metals. Although the K_d term may be critical in developing protective SSLs, information required to evaluate this parameter is more difficult to obtain and less likely to be available. Porosity and bulk density are not

particularly sensitive because of the relatively small range of values encountered in subsurface conditions.

Using benzene as a representative contaminant, a sensitivity analysis was performed to compare a generic soil leachate SSL to site-specific model results simulating a range of model input parameters that might be representative of different conditions in New Mexico. The generic soil leachate SSL calculated using the New Mexico default values and a DAF of 1 is 2.8 µg/kg. These results are summarized in Table 4-1. As shown, the resulting SSLs for benzene range from 1.3 to 6.1 µg/kg for the various sensitivity simulations compared to the generic SSL of 2.8 µg/kg. These results indicate that the calculation of SSLs using the site-specific approach is not overly sensitive to the reasonable range of porosity (air and water filled), bulk density and fraction of organic carbon expected for New Mexico or even for a range of values for chemical-specific properties. The generic SSL for benzene of 2.8 µg/kg is representative of values that could be calculated using a spectrum of input parameters, exclusive of the DAF term. Unless there are sufficient data to calculate a site-specific DAF, there is little benefit derived from using the site-specific model approach instead of the generic SSL.

Table 4-1

Input Parameters and Resulting SSLs for the Sensitivity Analysis of the Soil-Water Partition Equation - Migration to Groundwater Pathway Model		
Input parameter (NMED default value)	Sensitivity Analysis Values	Resulting SSLs
Bulk density (default value = 1.55 gm/cm)	Lower Limit = 1.20 Upper Limit = 1.90	3.4 2.5
Air filled porosity (default value = 0.18)	Lower Limit = 0.04[a] Upper Limit = 0.25[b]	1.3 3.5
Fraction organic carbon (default value = 0.0015)	Lower Limit = 0.0005 Upper Limit = 0.007	2.2 6.1
Volume water content (default value = 0.26)	Lower Limit = 0.05[c] Upper Limit = 0.40[c]	1.8 3.5
K_{oc} (default value = 58.9 ml/g)	Lower Limit = 30 Upper Limit = 120	2.4 3.7
Dimensionless Henry's Law constant (default value = 0.228)	Lower Limit = 0.1 Upper Limit = 0.4	2.7 3.0

[a] total porosity was reduced from 0.44 to 0.10 for this simulation
[b] total porosity was increased from 0.44 to 0.6 for this simulation
[c] total porosity remained at 0.44 for this simulation.

As previously stated, calculation of SSLs is most sensitive to the DAF term. The input parameter values and resulting DAFs for the sensitivity analysis are included in Table 4-2. Effects on the DAFs are, from greatest to least, the Darcian velocity (hydraulic conductivity multiplied by the hydraulic gradient), infiltration rates, size of the contaminated area, and the aquifer thickness. Corresponding effects on DAFs for each of these parameters and discussion of the relevance of the use of default values versus site-specific conditions are summarized below:

Table 4-2

Input Parameters and Resulting DAFs for the Sensitivity Analysis of the Dilution Attenuation Factor-Migration to Groundwater Pathway Model						
Parameter	Groundwater Velocity (m/yr)	Infiltration Rate (m/yr)	Source Length (m)	Aquifer thickness (m)	Mixing Zone Depth (m)	Dilution Attenuation Factor (DAF)
Groundwater velocity	2.2	0.13	45	12	7.15	3.7
Groundwater velocity	22	0.13	45	12	5.03	19.9
Groundwater velocity	220	0.13	45	12	4.79	181.1
Infiltration Rate	22	0.065	45	12	4.89	37.8
Infiltration Rate	22	0.13	45	12	5.03	19.9
Infiltration Rate	22	0.26	45	12	5.28	10.9
Source Length	22	0.13	22.5	12	2.51	19.9
Source Length	22	0.13	45	12	5.03	19.9
Source Length	22	0.13	348.4	12	38.76*	6.8
Aquifer Thickness	22	0.13	45	3	5.02*	12.3
Aquifer Thickness	22	0.13	45	12	5.03	19.9
Aquifer Thickness	22	0.13	45	48	5.03	19.9

Note: If mixing zone depth calculation is greater than aquifer thickness, then aquifer thickness is used to calculate the DAF.

Higher Darcian velocity results in higher DAFs. Slower mixing of groundwater with soil leachate occurs at lower groundwater velocity. Thus, using a lower velocity will be a more conservative approach. Sandy soils typically have higher hydraulic conductivities than more fine-grained soils and subsequently higher Darcian velocity (under equal hydraulic gradient). Use of a sandy soil type will generally be less conservative (result in higher DAFs) with respect to protection of groundwater quality.

Lower infiltration rates result in higher DAFs. Therefore, using a higher infiltration rate is a more conservative approach (results in a lower DAF).

Larger source sizes result in lower DAFs. The default DAF used to develop SSLs for a 0.5 acre source may not be protective of groundwater at sites larger than 0.5 acre. However, the selection of a second source size is arbitrary. If generic SSLs are developed for a 30 acre source, then those values are considered overly conservative for a 12 acre source. Conversely, SSLs developed for a 30 acre source will be less protective of a 40 acre source. Rather than develop a separate set of generic SSLs for a second (or third or fourth) source size, the following two approaches are proposed.

- As the size of the source area increases, the assumptions underlying the generic model are less applicable. One of the conservative assumptions in the generic SSL approach is the uniform distribution of contaminants throughout the vadose zone. There are few sites that have relatively uniform soil contamination (both laterally and vertically) of a single constituent in an area of greater than 0.5 acres (22,000 ft^2). Soil contamination at large facilities (such as federal facilities) are usually concentrated in discrete portions of the site. Contamination at large sites is commonly the result of multiple sources. It is advisable to attempt to subdivide the facility by source and contaminant type and then apply generic SSLs to those smaller source areas.

- If this approach is not practical, calculation of site specific DAFs is recommended. Most of the parameters required for these calculations are available from routine environmental site investigations or can be reasonably estimated from general

geologic and hydrologic studies.

Thin aquifers will result in lower DAFs. The nominal aquifer thickness used in the sensitivity analysis was 12 m. Reducing the aquifer thickness to 3 m results in a 40 percent reduction in the DAF. Increasing the aquifer thickness beyond the nominal value has very little impact.

The significant effects of the DAF on the calculation of SSLs, coupled with the common availability of site-specific data used to calculate the DAF, suggest that use of the site specific modeling approach should at least incorporate recalculation of the DAF term. If data are available that indicate soil properties significantly different than the default values (such as high or low f_{oc} for organic contaminants, or highly acidic or basic conditions for metal contaminants) the K_d term should also be evaluated and recalculated.

4.8 Detailed Model Analysis for SSL Development

Sites that have complex or heterogeneous subsurface conditions may require more detailed evaluation for development of SSLs that are reasonably, but not overly, protective of groundwater and surface water resources. These types of sites may require more complex models that can address a wide range of variability in environmental site conditions including soil properties, contaminant mass concentration and distribution, contaminant degradation and transformation, recharge rates and recharge concentration, and depth to the water table. Model codes suitable for these types of more detailed analysis range from simple one-dimensional analytical models to complex three-dimensional numerical models. Resource requirements (data, time and cost) increase for the more complex codes. The selection of an appropriate code needs to balance the required accuracy of the output with the level of effort necessary to develop the model.

4.9 Summary of the Migration to Groundwater Pathway SSLs

SSLs for New Mexico have been developed for the migration to groundwater pathway, and are provided in Table A-1 of Appendix A. The NMED SSLs were developed using default parameter values representative of environmental conditions in New Mexico and utilize a DAF of 20. This approach maintains the conservative approach of the SSL methodology and is protective of groundwater quality under a wide range of site conditions. Soil contaminant concentrations can be compared directly to the generic SSLs to determine if additional investigation is necessary to evaluate potential leaching and migration of contaminants from the vadose zone to groundwater in excess of NMED-specific tapwater SSLs.

Site-specific SSLs can be developed by substituting site-related data for the default values in the leaching to groundwater pathway model. SSLs developed from this model are most sensitive to the DAF. SSLs are also provided in the lookup table for a DAF of 1. If data on hydrologic conditions are readily available, a site specific DAF can be calculated and multiplied by the generic SSL for a DAF of 1 to provide a site specific SSL.

5. Use of the SSLs

For screening sites with multiple contaminants, the following procedure should be followed: take the site-specific concentration (represented by the maximum reported concentration or, if deemed appropriate by NMED, the 95% UCL value for the concentration) and divide by the SSL

concentration for each analyte. For multiple contaminants, simply add the ratio for each chemical.

$$\text{Site Risk} = \left(\frac{\text{conc}_x}{\text{SSL}_x} + \frac{\text{conc}_y}{\text{SSL}_y} + \frac{\text{conc}_z}{\text{SSL}_z} + \ldots + \frac{\text{conc}_i}{\text{SSL}_i} \right)$$

If the total ratio is greater than 1, then the concentrations at the site warrant further, site-specific evaluation. A ratio less than 1 indicates that the concentrations at the site are unlikely to result in adverse health impacts, or contaminate groundwater above State of New Mexico water quality standards.

As with any risk-based tool, the potential exists for misapplication. In most cases the root cause will be a lack of understanding of the intended use of NMED SSLs. In order to prevent misuse of SSLs, the following should be avoided:

- Applying SSLs to a site without adequately developing a conceptual site model that identifies relevant exposure pathways and exposure scenarios,
- Use of SSLs as cleanup levels without verifying numbers with a toxicologist or risk assessor, and
- Not considering the effects of additivity when screening multiple chemicals.

It is important to note that the generic NMED SSLs were developed assuming distinct soil horizons for each receptor. The soils of interest differ according to the exposure pathway being addressed. For direct ingestion, dermal, and fugitive dust exposure pathways, the primary soil horizon of concern are surface soils. For inhalation of volatiles and migration to groundwater, subsurface soils are of primary concern. Both a residential receptor and a commercial/industrial worker are typically exposed only to surface soil, which may be defined as extending to a depth of approximately two feet below ground surface, depending on site-specific conditions and the amount of intrusive activity that may occur. Construction workers will typically have much greater exposures to subsurface soils. Therefore, when generic SSLs are used for screening level evaluations at a facility, site-specific conditions must be evaluated for each receptor to determine if the assumptions associated with the generic SSLs are appropriate for comparison with the available site data.

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APPENDIX A

Appendix A

State of New Mexico Soil Screening Levels

Table A-1 provides State of New Mexico Soil Screening Levels (SSLs), as developed by the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB) and the Ground Water Quality Bureau Voluntary Remediation Program for 208 chemicals most commonly associated with environmental releases within the state. These NMED SSLs are derived using default exposure parameter values (as presented in Table A-2) and chemical- and State of New Mexico-specific physical parameters (as presented in Table B-1 of Appendix B). These default values are assumed to be appropriately conservative in the face of uncertainty and are likely to be protective for the majority of site conditions relevant to soil exposures within New Mexico.

However, the NMED SSLs are not necessarily protective of all known human exposure pathways, reasonable land uses or ecological threats. Thus, before applying NMED SSLs at a site, it is extremely important to compare the conceptual site model (CSM) with the assumptions upon which the NMED SSLs are predicated to ensure that the site conditions and exposure pathways match those used to develop the NMED SSLs. If this comparison indicates that the site at issue is more complex than the corresponding SSL scenarios, or that there are significant exposure pathways not accounted for by the NMED SSLs, then the NMED SSLs are insufficient for use in a defensible assessment of the site. A more detailed site-specific approach will be necessary to evaluate the additional pathways or site conditions.

Table A-1

Column 1: The first column in Table A-1 presents the names of the chemicals for which NMED has developed SSLs.

Column 2: The second column presents NMED SSLs predicated on residential soil exposures.

Column 3, 5, 7, and 10: These columns present indicator categories for the NMED SSL residential, industrial, construction, and tap water basis, whether predicated on carcinogenic effects (ca), noncarcinogenic effects (nc), soil saturation limits (sat) or a non-risk based "max" determination. NMED SSLs predicated on a carcinogenic endpoint reflect age-adjusted child-to-adult exposures. NMED SSLs predicated on a noncarcinogenic endpoint reflect child-only exposures. Detected concentrations above the "sat" value may indicate the presence of nonaqueous phase liquid (NAPL). For certain inorganic and semivolatile organic compounds (SVOCs) that exhibit relatively low toxicity, a non risk-based maximum concentration of 10^5 mg/kg is given when the risk-based SSL exceeds that level. These are noted as "max" in the tables.

Columns 4 and 6: The fourth and sixth columns present NMED SSLs analogous to Column 1, with the exception that these values correspond to Industrial/Occupational and Construction worker (adult-only) exposures, respectively.

Columns 5 and 7: The fifth and seventh columns present endpoint bases analogous to Column 3

for the Industrial/Occupational and Construction worker receptor populations, respectively. Unlike the Residential population, noncarcinogenic endpoint notes for these receptor populations are predicated on adult-only exposures.

Column 8: The eighth column notes which chemicals are considered VOCs (for inhalation considerations). Those chemicals not considered VOCs are evaluated within the SSLs relative to inhalation of particulate emissions.

Column 9: Presents the tap water SSL for the residential scenario.

Columns 11 and 12: The ninth column presents NMED SSLs for the migration to groundwater pathway developed using a default dilution attenuation factor (DAF) of 1, which assumes no effective dilution or attenuation. These values can be considered at sites where little or no dilution or attenuation of soil leachate concentrations is expected (e.g., shallow water tables, karst topography). Column 10 presents NMED SSLs for the migration to groundwater pathway developed using a DAF of 20 to account for natural processes that reduce contaminant concentrations in the subsurface.

As noted above, separate NMED SSLs are presented for use in evaluating three discrete potential receptor populations: Residential, Industrial/Occupational, and Construction. Each NMED SSL considers incidental ingestion of soil, inhalation of volatiles (limited to those chemicals noted as volatile organic compounds [VOCs] within Table A-1) or particulate emissions from impacted soil, and dermal contact with soil.

Generally, if a contaminant is detected at a level in soil exceeding the most relevant NMED SSL, and the site-specific CSM is in general agreement with the underlying assumptions upon which the NMED SSLs are predicated, this result indicates the potential for adverse human health effects to occur. Conversely, if no contaminants are detected above the most relevant NMED SSL, this tends to indicate to the user that environmental conditions may not necessitate remedial action of the surface soil or the vadose zone.

A detection above an NMED SSL does not indicate that unacceptable exposures are, in fact, occurring. The NMED SSLs are predicated on relatively conservative exposure assumptions and an exceedance only tends to indicate the potential for adverse effects. The NMED SSLs do not account for additive exposures, whether for carcinogenic or noncarcinogenic endpoints. Section 5 of Part A addresses a methodology by which an environmental manager may determine whether further site-evaluation is warranted, however, this methodology does not replace the need for defensible risk assessment where indicated.

The NMED SSLs address a basic subset of exposures fundamental to the widest array of environmentally-impacted sites within the State of New Mexico. The NMED SSLs cannot address all relevant exposure pathways associated with all sites. The utility of the NMED SSLs depends heavily upon the understanding of site conditions as accurately reflected in the CSM and nature and extent of contamination determinations. Consideration of the NMED SSLs does not preclude the need for site-specific risk assessment in all instances.

Table A-1: NMED Soil Screening Levels

Chemical	Residential Soil (mg/kg)	End-point	Industrial/ Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	VOC	Tap Water (ug/L)	End-point	DAF 1 (mg/kg)	DAF 20 (mg/kg)
Acenaphthene	3.73E+03	nc	3.35E+04	nc	1.41E+04	nc	x	3.65E+02	nc	2.75E+00	5.49E+01
Acetaldehyde	1.06E+02	nc	3.84E+02	nc	3.45E+02	nc	x	1.72E+01	ca		
Acetone	2.81E+04	nc	1.00E+05	max	9.85E+04	nc	x	5.48E+03	nc	9.55E-01	1.91E+01
Acrylonitrile	4.27E+00	ca	1.26E+01	ca	5.75E+01	nc	x	3.81E-01	ca	6.68E-05	1.34E-03
Acetophenone	1.48E+03	sat	1.48E+03	sat	1.48E+03	sat	x	6.08E+02	nc	1.48E-01	2.95E+00
Acrolein	2.06E-01	nc	7.52E-01	nc	6.75E-01	nc	x	4.16E-02	nc	8.55E-06	1.71E-04
Aldrin	2.84E-01	ca	1.12E+00	ca	6.99E+00	nc		3.87E-02	ca	1.42E-01	2.84E+00
Aluminum	7.78E+04	nc	1.00E+05	max	1.44E+04	nc		3.65E+04	nc	5.48E+04	1.10E+06
Anthracene	2.20E+04	nc	1.00E+05	max	8.60E+04	nc	x	1.83E+03	nc	8.11E+01	1.62E+03
Antimony	3.13E+01	nc	4.54E+02	nc	1.24E+02	nc		1.46E+01	nc	6.61E-01	1.32E+01
Arsenic	3.90E+00	ca	1.77E+01	ca	8.52E+01	nc		4.42E-01	ca	1.45E-02	2.90E-01
Barium	1.56E+04	nc	1.00E+05	max	6.02E+04	nc		7.30E+03	nc	3.01E+02	6.03E+03
Benzene	1.03E+01	ca	2.58E+01	ca	1.74E+02	nc	x	3.49E+00	ca	1.00E-03	2.01E-02
Benzidine	2.11E-02	ca	8.33E-02	ca	7.09E-01	ca		2.89E-03	ca	1.24E-05	2.47E-04
Benzo(a)anthracene	6.21E+00	ca	2.34E+01	ca	2.12E+02	ca		9.09E-01	ca	5.43E-01	1.09E+01
Benzo(a)pyrene	6.21E-01	ca	2.34E+00	ca	2.12E+01	ca		9.09E-02	ca	1.39E-01	2.78E+00
Benzo(b)fluoranthene	6.21E+00	ca	2.34E+01	ca	2.12E+02	ca		9.09E-01	ca	1.68E+00	3.35E+01
Benzo(k)fluoranthene	6.21E+01	ca	2.34E+02	ca	2.12E+03	ca		9.09E+00	ca	1.68E+01	3.35E+02
Beryllium	1.56E+02	nc	2.25E+03	nc	5.62E+01	nc		7.30E+01	nc	5.77E+01	1.15E+03
a-BHC (HCH)	9.02E-01	ca	3.99E+00	ca	3.00E+01	ca		1.05E-01	ca	2.13E-04	4.25E-03
b-BHC (HCH)	3.16E+00	ca	1.40E+01	ca	5.39E+01	nc		3.69E-01	ca	7.61E-04	1.52E-02
g-BHC	4.37E+00	ca	1.93E+01	ca	8.09E+01	nc		5.10E-01	ca	9.08E-04	1.82E-02
1,1-Biphenyl	3.08E+03	nc	2.73E+04	nc	1.17E+04	nc	x	3.04E+02	nc	3.61E+00	7.22E+01
Bis(2-chloroethyl) ether	2.44E+00	ca	7.45E+00	ca	1.05E+02	ca	x	9.65E-02	ca	2.77E-05	5.55E-04
Bis(2-chloroisopropyl) ether	3.87E+01	ca	1.19E+02	ca	4.53E+02	sat	x	2.71E+00	ca	7.21E-04	1.44E-02
Bis(2-ethylhexyl) phthalate	3.47E+02	ca	1.37E+03	ca	4.66E+03	nc		4.74E+01	ca	1.07E+03	2.15E+04
Bis(chloromethyl) ether	4.72E-03	ca	1.23E-02	ca	2.32E-01	ca	x	5.09E-04	ca	8.95E-08	1.79E-06
Boron	1.56E+04	nc	1.00E+05	max	3.09E+04	nc		7.30E+03	nc	2.40E+01	4.80E+02
Bromobenzene	3.70E+01	nc	1.37E+02	nc	1.21E+02	nc	x	2.06E+01	nc	1.07E-02	2.14E-01
Bromodichloromethane	1.44E+01	ca	3.72E+01	ca	7.17E+02	ca	x	1.78E+00	ca	5.90E-04	1.18E-02

Chemical	Residential Soil (mg/kg)	End-point	Industrial/ Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	VOC	Tap Water (ug/L)	End-point	DAF 1 (mg/kg)	DAF 20 (mg/kg)
Bromomethane	8.51E+00	nc	3.28E+01	nc	2.82E+01	nc	x	8.66E+00	nc	1.87E-03	3.74E-02
1,3-Butadiene	9.93E-01	ca	2.38E+00	ca	4.59E+00	nc	x	1.26E+00	ca		
2-Butanone (MEK)	3.18E+04	nc	4.87E+04	sat	4.87E+04	sat	x	7.06E+03	nc	1.27E+00	2.55E+01
tert-Butyl methyl ether (MTBE)	3.88E+02	ca	9.84E+02	ca	1.96E+04	ca	x	6.14E+01	ca		
n-Butylbenzene	6.21E+01	sat	6.21E+01	sat	6.21E+01	sat	x	6.08E+01	nc	2.70E-01	5.40E+00
sec-Butylbenzene	6.06E+01	sat	6.06E+01	sat	6.06E+01	sat	x	6.08E+01	nc	2.17E-01	4.33E+00
tert-Butylbenzene	1.06E+02	sat	1.06E+02	sat	1.06E+02	sat	x	6.08E+01	nc	2.15E-01	4.30E+00
Cadmium	3.90E+01	nc	5.64E+02	nc	1.54E+02	nc		1.83E+01	nc	1.37E+00	2.75E+01
Carbon disulfide	4.60E+02	sat	4.60E+02	sat	4.60E+02	sat	x	1.04E+03	nc	3.95E-01	7.89E+00
Carbon tetrachloride	3.47E+00	ca	8.64E+00	ca	1.80E+02	ca	x	1.69E+00	ca	9.74E-04	1.95E-02
Chlordane	1.62E+01	ca	7.19E+01	ca	1.30E+02	nc		1.90E+00	ca	3.42E-01	6.83E+00
2-Chloroacetophenone	4.25E-02	nc	1.62E-01	nc	1.41E-01	nc	x	5.22E-02	nc	4.37E-05	8.75E-04
2-Chloro-1,3-butadiene	6.32E+00	nc	2.30E+01	nc	2.06E+01	nc	x	1.43E+01	nc	5.66E-03	1.13E-01
1-Chloro-1,1-difluoroethane	2.11E+02	sat	2.11E+02	sat	2.11E+02	sat	x	8.66E+04	nc	6.28E+01	1.26E+03
Chlorobenzene	1.94E+02	nc	2.45E+02	sat	2.45E+02	sat	x	1.06E+02	nc	5.50E-02	1.10E+00
1-Chlorobutane	1.22E+02	nc	2.99E+02	sat	2.99E+02	sat	x	2.43E+02	nc	9.63E-02	1.93E+00
Chlorodifluoromethane	2.11E+02	sat	2.11E+02	sat	2.11E+02	sat	x	9.75E+04	nc	7.07E+01	1.41E+03
Chloroethane	6.33E+01	ca	1.54E+02	ca	1.42E+03	sat	x	3.81E+01	ca	9.41E-03	1.88E-01
Chloroform	4.00E+00	ca	9.59E+00	ca	2.16E+02	ca	x	1.65E+00	ca	4.12E-04	8.25E-03
Chloromethane	2.18E+01	ca	5.34E+01	ca	2.84E+02	nc	x	1.49E+01	ca	5.02E-03	1.00E-01
b-Chloronaphthalene	3.99E+03	nc	2.78E+04	nc	1.47E+04	nc	x	4.87E+02	nc	1.25E+00	2.51E+01
o-Chloronitrobenzene	1.49E+00	nc	5.48E+00	nc	4.88E+00	nc	x	1.45E-01	nc	3.94E-05	7.88E-04
p-Chloronitrobenzene	1.05E+01	nc	4.23E+01	nc	3.51E+01	nc	x	1.20E+00	nc	3.25E-04	6.51E-03
2-Chlorophenol	1.66E+02	nc	8.85E+02	nc	5.86E+02	nc	x	3.04E+01	nc	2.36E-02	4.72E-01
2-Chloropropane	2.83E+02	nc	7.05E+02	sat	7.05E+02	sat	x	1.76E+02	nc	4.60E-02	9.19E-01
o-Chlorotoluene	2.02E+02	sat	2.02E+02	sat	2.02E+02	sat	x	1.22E+02	nc	5.22E-02	1.04E+00
Chromium III	1.00E+05	max	1.00E+05	max	1.00E+05	max		5.48E+04	nc	9.86E+07	1.97E+09
Chromium VI	2.34E+02	nc	3.40E+03	nc	2.61E+01	ca		1.10E+02	nc	2.10E+00	4.20E+01
Chrysene	6.15E+02	ca	2.31E+03	ca	2.12E+04	ca	x	2.91E+01	ca	1.74E+01	3.48E+02
Cobalt	1.52E+03	nc	2.05E+04	nc	6.10E+01	nc		7.30E+02	nc	3.31E+01	6.61E+02
Copper	3.13E+03	nc	4.54E+04	nc	1.24E+04	nc		1.46E+03	nc	5.15E+01	1.03E+03
Crotonaldehyde	7.01E-02	ca	1.70E-01	ca	3.73E+00	ca	x	5.82E-02	ca	1.49E-04	2.99E-03

Chemical	Residential Soil (mg/kg)	End-point	Industrial/ Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	VOC	Tap Water (ug/L)	End-point	DAF 1 (mg/kg)	DAF 20 (mg/kg)
Cumene (isopropylbenzene)	2.71E+02	nc	3.89E+02	sat	3.89E+02	sat	x	6.78E+02	nc	4.10E+00	8.21E+01
Cyanide	1.22E+03	nc	1.37E+04	nc	4.76E+03	nc		7.30E+02	nc	7.35E+00	1.47E+02
Cyanogen	1.71E+03	sat	1.71E+03	sat	1.71E+03	sat	x	1.46E+03	nc	2.91E-01	5.82E+00
Cyanogen bromide	2.02E+03	sat	2.02E+03	sat	2.02E+03	sat	x	3.29E+03	nc	7.76E-01	1.55E+01
Cyanogen chloride	2.02E+03	sat	2.02E+03	sat	2.02E+03	sat	x	1.83E+03	nc	4.31E-01	8.62E+00
DDD	2.44E+01	ca	1.11E+02	ca	8.07E+02	ca		2.77E+00	ca	4.15E+00	8.30E+01
DDE	1.72E+01	ca	7.81E+01	ca	5.70E+02	ca		1.95E+00	ca	1.31E+01	2.62E+02
DDT	1.72E+01	ca	7.81E+01	ca	1.38E+02	nc		1.95E+00	ca	7.70E+00	1.54E+02
Dibenz(a,h)anthracene	6.21E-01	ca	2.34E+00	ca	2.12E+01	ca		9.09E-02	ca	5.18E-01	1.04E+01
Dibenzofuran	1.42E+02	nc	1.62E+03	nc	5.52E+02	nc	x	1.22E+01	nc	1.44E-01	2.87E+00
1,2-Dibromo-3-chloropropane	1.84E+00	nc	9.68E+00	nc	6.48E+00	nc	x	3.47E-01	nc	1.49E-04	2.98E-03
Dibromochloromethane	1.48E+01	ca	3.95E+01	ca	7.16E+02	ca	x	1.32E+00	ca	3.58E-04	7.16E-03
1,2-Dibromoethane	5.04E-01	ca	1.31E+00	ca	2.48E+01	ca	x	5.53E-02	ca	1.20E-05	2.40E-04
1,4-Dichloro-2-butene	1.22E-01	ca	3.23E-01	ca	5.97E+00	ca	x	1.19E-02	ca	2.93E-06	5.87E-05
1,2-Dichlorobenzene	3.74E+01	sat	3.74E+01	sat	3.74E+01	sat	x	4.96E+01	nc	1.19E-02	2.37E-01
1,3-Dichlorobenzene	3.26E+01	nc	3.74E+01	sat	3.74E+01	sat	x	1.83E+01	nc	4.36E-03	8.73E-02
1,4-Dichlorobenzene	3.95E+01	ca	1.03E+02	ca	1.96E+03	ca	x	4.95E+00	ca	5.49E-03	1.10E-01
3,3-Dichlorobenzidine	1.08E+01	ca	4.26E+01	ca	3.63E+02	ca		1.47E+00	ca	1.86E-03	3.71E-02
Dichlorodifluoromethane	1.61E+02	nc	2.11E+02	sat	2.11E+02	sat	x	3.95E+02	nc	2.86E-01	5.72E+00
1,1-Dichloroethane	1.40E+03	nc	1.42E+03	sat	1.42E+03	sat	x	1.22E+03	nc	3.39E-01	6.79E+00
1,2-Dichloroethane	6.04E+00	ca	1.52E+01	ca	6.42E+01	nc	x	1.22E+00	ca	2.85E-04	5.71E-03
cis-1,2-Dichloroethene	7.65E+01	nc	3.00E+02	nc	2.54E+02	nc	x	6.08E+01	nc	1.49E-02	2.99E-01
trans-1,2-Dichloroethene	1.12E+02	nc	4.29E+02	nc	3.70E+02	nc	x	1.22E+02	nc	3.33E-02	6.67E-01
1,1-Dichloroethene	2.06E+02	nc	7.77E+02	nc	6.78E+02	nc	x	3.39E+02	nc	1.34E-01	2.68E+00
2,4-Dichlorophenol	1.83E+02	nc	2.05E+03	nc	6.99E+02	nc		1.10E+02	nc	4.31E-02	8.63E-01
1,2-Dichloropropane	6.00E+00	ca	1.49E+01	ca	3.33E+01	nc	x	1.63E+00	ca	4.10E-04	8.19E-03
1,3-Dichloropropene	1.20E+01	ca	3.17E+01	ca	8.98E+01	nc	x	3.90E+00	ca	1.16E-03	2.31E-02
Dicyclopentadiene	2.21E+01	nc	8.26E+01	nc	7.28E+01	nc	x	1.39E+01	nc	1.50E-02	3.00E-01
Dieldrin	3.04E-01	ca	1.20E+00	ca	1.02E+01	ca		4.15E-02	ca	1.34E-03	2.68E-02
Diethyl phthalate	4.89E+04	nc	1.00E+05	max	1.00E+05	max		2.92E+04	nc	1.77E+01	3.54E+02
Dimethyl phthalate	1.00E+05	max	1.00E+05	max	1.00E+05	max		3.65E+05	nc	8.36E+01	1.67E+03
Di-n-butyl phthalate	6.11E+03	nc	6.84E+04	nc	2.33E+04	nc		3.65E+03	nc	1.86E+02	3.72E+03

Chemical	Residential Soil (mg/kg)	End-point	Industrial/ Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	VOC	Tap Water (ug/L)	End-point	DAF 1 (mg/kg)	DAF 20 (mg/kg)
2,4-Dimethylphenol	1.22E+03	nc	1.37E+04	nc	4.66E+03	nc		7.30E+02	nc	3.55E-01	7.11E+00
4,6-Dinitro-o-cresol	6.11E+00	nc	6.84E+01	nc	2.33E+01	nc		3.65E+00	nc	3.93E-03	7.85E-02
2,4-Dinitrophenol	1.22E+02	nc	1.37E+03	nc	4.66E+02	nc		7.30E+01	nc	5.25E-02	1.05E+00
2,4-Dinitrotoluene	1.22E+02	nc	1.37E+03	nc	4.66E+02	nc		7.30E+01	nc	2.31E-02	4.62E-01
1,2-Diphenylhydrazine	6.08E+00	ca	2.39E+01	ca	2.04E+02	ca		8.30E-01	ca	4.48E-03	8.95E-02
Endosulfan	3.67E+02	nc	4.10E+03	nc	1.40E+03	nc		2.19E+02	nc	7.41E-01	1.48E+01
Endrin	1.83E+01	nc	2.05E+02	nc	6.99E+01	nc		1.10E+01	nc	2.04E-01	4.08E+00
Epichlorohydrin	1.66E+01	nc	6.56E+01	nc	5.54E+01	nc	x	2.03E+00	nc	3.62E-04	7.25E-03
Ethyl acetate	2.10E+04	sat	2.10E+04	sat	2.10E+04	sat	x	5.48E+03	nc	1.44E+00	2.87E+01
Ethyl acrylate	2.79E+00	ca	6.75E+00	ca	5.22E+01	sat	x	2.30E+00	ca	5.86E-03	1.17E-01
Ethyl chloride	6.33E+01	ca	1.54E+02	ca	1.42E+03	sat	x	3.81E+01	ca	9.41E-03	1.88E-01
Ethyl ether	1.94E+03	sat	1.94E+03	sat	1.94E+03	sat	x	1.22E+03	nc	2.37E-01	4.73E+00
Ethyl methacrylate	5.27E+01	sat	5.27E+01	sat	5.27E+01	sat	x	5.48E+02	nc	1.41E+00	2.81E+01
Ethylbenzene	1.28E+02	sat	1.28E+02	sat	1.28E+02	sat	x	1.34E+03	nc	1.01E+00	2.02E+01
Ethylene oxide	2.65E+00	ca	8.07E+00	ca	1.15E+02	ca	x	2.41E-01	ca	4.27E-05	8.54E-04
Fluoranthene	2.29E+03	nc	2.44E+04	nc	8.73E+03	nc		1.46E+03	nc	2.35E+02	4.69E+03
Fluorene	2.66E+03	nc	2.65E+04	nc	1.02E+04	nc	x	2.43E+02	nc	2.93E+00	5.85E+01
Fluoride	3.67E+03	nc	4.10E+04	nc	1.43E+04	nc		2.19E+03	nc	3.29E+02	6.58E+03
Furan	5.53E+00	nc	2.12E+01	nc	1.83E+01	nc	x	6.08E+00	nc	1.32E-03	2.63E-02
Heptachlor	1.08E+00	ca	4.26E+00	ca	3.63E+01	ca		1.47E-01	ca	3.12E-01	6.24E+00
Hexachlorobenzene	3.04E+00	ca	1.20E+01	ca	1.02E+02	ca		4.15E-01	ca	3.43E-02	6.86E-01
Hexachloro-1,3-butadiene	1.22E+01	nc	1.37E+02	nc	4.66E+01	nc		7.30E+00	nc	5.90E-01	1.18E+01
Hexachlorocyclopentadiene	3.66E+02	nc	4.10E+03	nc	4.31E+02	nc		2.19E+02	nc	6.58E+01	1.32E+03
Hexachloroethane	6.11E+01	nc	6.84E+02	nc	2.33E+02	nc		3.65E+01	nc	1.04E-01	2.09E+00
n-Hexane	3.80E+01	sat	3.80E+01	sat	3.80E+01	sat	x	4.16E+02	nc	8.64E-01	1.73E+01
HMX	3.06E+03	nc	3.42E+04	nc	1.17E+04	nc		1.83E+03	nc	5.39E+00	1.08E+02
Hydrogen cyanide	2.24E+01	nc	8.22E+01	nc	7.33E+01	nc	x	6.20E+00	nc	1.24E-03	2.47E-02
Indeno(1,2,3-c,d)pyrene	6.21E+00	ca	2.34E+01	ca	2.12E+02	ca		9.09E-01	ca	4.73E+00	9.46E+01
Iron	2.35E+04	nc	1.00E+05	max	9.29E+04	nc		1.10E+04	nc	2.77E+02	5.54E+03
Isobutanol	1.38E+04	nc	2.26E+04	sat	2.26E+04	sat	x	1.83E+03	nc	4.86E-01	9.72E+00
Isophorone	5.12E+03	ca	2.02E+04	ca	4.66E+04	nc		6.99E+02	ca	1.70E-01	3.40E+00
Lead	4.00E+02	IEUBK	8.00E+02	IEUBK	8.00E+02	IEUBK					

Chemical	Residential Soil (mg/kg)	End-point	Industrial/ Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	VOC	Tap Water (ug/L)	End-point	DAF 1 (mg/kg)	DAF 20 (mg/kg)
Lead (tetraethyl-)	6.11E-03	nc	6.84E-02	nc	2.38E-02	nc		3.65E-03	nc	6.33E-07	1.27E-05
Maleic hydrazide	1.61E+03	sat	1.61E+03	sat	1.61E+03	sat	x	3.04E+03	nc	8.12E-01	1.62E+01
Manganese	3.59E+03	nc	4.84E+04	nc	1.50E+02	nc		1.72E+03	nc	1.12E+02	2.24E+03
Mercury (elemental)	1.00E+05	max	1.00E+05	max	9.27E+02	nc				1.05E-01	2.09E-03
Mercury (methyl)	6.11E+00	nc	6.84E+01	nc	2.38E+01	nc		3.65E+00	nc	8.26E-04	1.65E-02
Methacrylonitrile	3.84E+00	nc	2.20E+01	nc	1.37E+01	nc	x	1.04E+00	nc	1.83E-04	3.65E-03
Methomyl	8.44E+01	nc	3.17E+02	nc	2.78E+02	nc	x	1.52E+02	nc	5.74E-02	1.15E+00
Methyl acetate	3.76E+04	nc	1.00E+05	max	1.00E+05	max	x	6.08E+03	nc	1.08E+00	2.15E+01
Methyl acrylate	9.28E+01	nc	1.57E+02	sat	1.57E+02	sat	x	1.83E+02	nc	4.64E-01	9.29E+00
Methyl isobutyl ketone	5.51E+03	nc	7.01E+03	sat	7.01E+03	sat	x	1.99E+03	nc	7.35E-01	1.47E+01
Methyl methacrylate	2.92E+03	sat	2.92E+03	sat	2.92E+03	sat	x	1.42E+03	nc	2.76E-01	5.52E+00
Methyl styrene (alpha)	2.17E+02	sat	2.17E+02	sat	2.17E+02	sat	x	4.26E+02	nc	3.08E-01	6.17E+00
Methyl styrene (mixture)	1.39E+02	nc	2.17E+02	sat	2.17E+02	sat	x	5.48E+01	nc	3.96E-02	7.93E-01
Methylcyclohexane	7.89E+01	sat	7.89E+01	sat	7.89E+01	sat	x	5.23E+03	nc	2.88E+01	5.77E+02
Methylene bromide	1.79E+02	nc	7.85E+02	nc	6.09E+02	nc	x	6.08E+01	nc	2.72E-02	5.44E-01
Methylene chloride	1.82E+02	ca	4.90E+02	ca	2.63E+03	sat	x	4.22E+01	ca	8.51E-03	1.70E-01
Molybdenum	3.91E+02	nc	5.68E+03	nc	1.55E+03	nc		1.83E+02	nc	3.70E+00	7.40E+01
Naphthalene	7.95E+01	nc	3.00E+02	nc	2.62E+02	nc	x	6.20E+00	nc	1.97E-02	3.94E-01
Nickel	1.56E+03	nc	2.27E+04	nc	6.19E+03	nc		7.30E+02	nc	4.77E+01	9.53E+02
Nitrate	1.00E+05	max	1.00E+05	max	1.00E+05	max		5.84E+04	nc	1.67E+01	3.35E+02
Nitrite	7.82E+03	nc	1.00E+05	max	3.10E+04	nc		3.65E+03	nc	7.63E-01	1.53E+01
Nitrobenzene	2.28E+01	nc	1.47E+02	nc	8.28E+01	nc	x	3.40E+00	nc	9.18E-04	1.84E-02
Nitroglycerin	3.47E+02	ca	1.37E+03	ca	1.17E+04	ca		4.74E+01	ca	2.80E-02	5.61E-01
N-Nitrosodiethylamine	3.24E-02	ca	1.28E-01	ca	1.09E+00	ca		4.42E-03	ca	8.73E-06	1.75E-04
N-Nitrosodimethylamine	9.54E-02	ca	3.76E-01	ca	1.86E+00	nc		1.30E-02	ca	1.17E-05	2.34E-04
N-Nitrosodi-n-butylamine	2.69E-01	ca	7.28E-01	ca	1.24E+01	ca	x	1.99E-02	ca	1.12E-05	2.24E-04
N-Nitrosodiphenylamine	9.93E+02	ca	3.91E+03	ca	4.66E+03	nc		1.35E+02	ca	2.86E-01	5.71E+00
N-Nitrosopyrrolidine	2.32E+00	ca	9.12E+00	ca	7.77E+01	ca		3.16E-01	ca	1.30E-04	2.60E-03
m-Nitrotoluene	5.69E+02	sat	5.69E+02	sat	5.69E+02	sat	x	1.22E+02	nc	3.30E-02	6.59E-01
o-Nitrotoluene	1.08E+01	ca	3.23E+01	ca	4.73E+02	ca	x	4.81E-01	ca	1.30E-04	2.61E-03
p-Nitrotoluene	1.46E+02	ca	4.37E+02	ca	1.55E+03	nc	x	6.51E+00	ca	1.76E-03	3.53E-02
Pentachlorobenzene	4.89E+01	nc	5.47E+02	nc	1.86E+02	nc		2.92E+01	nc	9.37E-02	1.87E+00

Chemical	Residential Soil (mg/kg)	End-point	Industrial/ Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	VOC	Tap Water (ug/L)	End-point	DAF 1 (mg/kg)	DAF 20 (mg/kg)
Pentachlorophenol	2.98E+01	ca	1.00E+02	ca	1.02E+03	ca		5.53E+00	ca	5.87E-03	1.17E-01
Phenanthrene	1.83E+03	nc	2.05E+04	nc	6.99E+03	nc		1.10E+03	nc	2.32E+01	4.64E+02
Phenol	1.83E+04	nc	1.00E+05	max	6.99E+04	nc		1.10E+04	nc	2.37E+00	4.74E+01
Polychlorinatedbiphenyls											
Aroclor 1016	3.93E+00	nc	4.13E+01	nc	1.50E+01	nc		2.56E+00	nc	1.73E-01	3.45E+00
Aroclor 1221	1.12E+00	nc	8.26E+00	ca	4.28E+00	nc		3.32E-01	ca	2.24E-02	4.47E-01
Aroclor 1232	1.12E+00	nc	8.26E+00	ca	4.28E+00	nc		3.32E-01	ca	2.24E-02	4.47E-01
Aroclor 1242	1.12E+00	nc	8.26E+00	ca	4.28E+00	nc		3.32E-01	ca	2.24E-02	4.47E-01
Aroclor 1248	1.12E+00	nc	8.26E+00	ca	4.28E+00	nc		3.32E-01	ca	2.64E-01	5.28E+00
Aroclor 1254	1.12E+00	nc	8.26E+00	ca	4.28E+00	nc		3.32E-01	ca	2.64E-01	5.28E+00
Aroclor 1260	1.12E+00	nc	8.26E+00	ca	4.28E+00	nc		3.32E-01	ca	2.64E-01	5.28E+00
n-Propylbenzene	6.21E+01	sat	6.21E+01	sat	6.21E+01	sat	x	6.08E+01	nc	2.70E-01	5.40E+00
Propylene oxide	2.22E+01	ca	9.33E+01	ca	7.92E+02	nc	x	2.18E+00	ca	4.60E-04	9.20E-03
Pyrene	2.29E+03	nc	3.09E+04	nc	9.01E+03	nc	x	1.83E+02	nc	1.86E+01	3.73E+02
RDX	4.42E+01	ca	1.74E+02	ca	6.99E+02	nc		6.03E+00	ca	1.68E-03	3.36E-02
Selenium	3.91E+02	nc	5.68E+03	nc	1.55E+03	nc		1.83E+02	nc	9.52E-01	1.90E+01
Silver	3.91E+02	nc	5.68E+03	nc	1.55E+03	nc		1.83E+02	nc	1.57E+00	3.13E+01
Strontium	4.69E+04	nc	1.00E+05	max	1.00E+05	max		2.19E+04	nc	7.73E+02	1.55E+04
Styrene	1.00E+02	sat	1.00E+02	sat	1.00E+02	sat	x	1.62E+03	nc	5.23E-01	1.05E+01
1,2,4,5-Tetrachlorobenzene	1.83E+01	nc	2.05E+02	nc	6.99E+01	nc		1.10E+01	nc	2.14E-02	4.29E-01
1,1,1,2-Tetrachloroethane	4.32E+01	ca	1.14E+02	ca	2.11E+03	ca	x	4.27E+00	ca	1.25E-03	2.50E-02
1,1,2,2-Tetrachloroethane	5.55E+00	ca	1.46E+01	ca	2.71E+02	ca	x	5.46E-01	ca	1.60E-04	3.21E-03
Tetrachloroethene	1.25E+01	ca	3.16E+01	ca	1.34E+02	sat	x	4.32E+00	ca	2.87E-03	5.74E-02
Thallium	5.16E+00	nc	7.49E+01	nc	2.04E+01	nc		2.41E+00	nc	1.72E-01	3.43E+00
Toluene	2.52E+02	sat	2.52E+02	sat	2.52E+02	sat	x	2.27E+03	nc	1.08E+00	2.17E+01
Toxaphene	4.42E+00	ca	1.74E+01	ca	1.48E+02	ca		6.03E-01	ca	2.33E-01	4.65E+00
Tribromomethane	6.21E+02	ca	2.46E+03	ca	4.44E+03	nc		2.44E+01	ca	1.73E-01	3.47E+00
1,1,2-Trichloro-1,2,2-trifluoroethane	3.28E+03	sat	3.28E+03	sat	3.28E+03	sat	x	5.92E+04	nc	1.68E+02	3.36E+03
1,2,4-Trichlorobenzene	6.93E+01	nc	2.69E+02	nc	2.30E+02	nc	x	7.16E+00	nc	2.04E-02	4.08E-01
1,1,1-Trichloroethane	5.63E+02	sat	5.63E+02	sat	5.63E+02	sat	x	3.17E+03	nc	1.33E+00	2.65E+01
1,1,2-Trichloroethane	1.19E+01	ca	3.02E+01	ca	1.94E+02	nc	x	1.97E+00	ca	4.98E-04	9.95E-03
Trichloroethylene	6.38E-01	ca	1.56E+00	ca	3.36E+01	ca	x	2.77E-01	ca	1.00E-04	2.00E-03

Chemical	Residential Soil (mg/kg)	End-point	Industrial/ Occupational Soil (mg/kg)	End-point	Construction Worker Soil (mg/kg)	End-point	VOC	Tap Water (ug/L)	End-point	DAF 1 (mg/kg)	DAF 20 (mg/kg)
Trichlorofluoromethane	5.88E+02	nc	9.83E+02	sat	9.83E+02	sat	x	1.29E+03	nc	1.12E+00	2.23E+01
2,4,5-Trichlorophenol	6.11E+03	nc	6.84E+04	nc	2.33E+04	nc		3.65E+03	nc	7.13E+00	1.43E+02
2,4,6-Trichlorophenol	6.11E+00	nc	6.84E+01	nc	2.33E+01	nc		3.65E+00	nc	7.13E-03	1.43E-01
1,1,2-Trichloropropane	2.53E+01	nc	9.64E+01	nc	8.35E+01	nc	x	3.04E+01	nc	1.17E-02	2.35E-01
1,2,3-Trichloropropane	8.61E-02	ca	2.09E-01	ca	4.57E+00	ca	x	5.53E-02	ca	2.07E-05	4.14E-04
1,2,3-Trichloropropene	1.21E+00	nc	4.39E+00	nc	3.95E+00	nc	x	2.10E+00	nc	7.88E-04	1.58E-02
Triethylamine	4.90E+01	nc	2.33E+02	nc	1.69E+02	nc	x	1.21E+01	nc	2.14E-03	4.29E-02
1,2,4-Trimethylbenzene	5.80E+01	nc	2.13E+02	nc	1.90E+02	nc	x	1.23E+01	nc	7.09E-02	1.42E+00
1,3,5-Trimethylbenzene	2.48E+01	nc	6.92E+01	sat	6.92E+01	sat	x	1.23E+01	nc	1.77E-02	3.55E-01
2,4,6-Trinitrotoluene	3.06E+01	nc	3.42E+02	nc	1.17E+02	nc		1.83E+01	nc	5.34E-02	1.07E+00
Vanadium	7.82E+01	nc	1.14E+03	nc	3.10E+02	nc		3.65E+01	nc	3.65E+01	7.30E+02
Vinyl acetate	1.07E+03	nc	3.68E+03	sat	3.52E+03	nc	x	4.12E+02	nc	7.57E-02	1.51E+00
Vinyl bromide	2.85E+00	ca	6.84E+00	ca	1.93E+01	nc	x	1.18E+00	ca	4.71E-04	9.41E-03
Vinyl chloride (Child)	2.25E+00	ca					x	4.28E-01	ca	1.40E-04	2.80E-03
Vinyl chloride (adult)	4.37E+00	ca	1.40E+01	ca	1.82E+02	ca	x	8.33E-01	ca	2.72E-04	5.45E-03
m-Xylene	8.20E+01	sat	8.20E+01	sat	8.20E+01	sat	x	2.03E+02	nc	1.03E-01	2.06E+00
o-Xylene	9.95E+01	sat	9.95E+01	sat	9.95E+01	sat	x	7.30E+03	nc	4.07E+00	8.14E+01
Xylenes	8.20E+01	sat	8.20E+01	sat	8.20E+01	sat	x	2.03E+02	nc	1.03E-01	2.06E+00
Zinc	2.35E+04	nc	1.00E+05	max	9.29E+04	nc		1.10E+04	nc	6.82E+02	1.36E+04

Table A-2

Default Exposure Factors			
Symbol	Definition (units)	Default	Reference
CSF_o	Cancer slope factor oral $(mg/kg\text{-}day)^{-1}$	Chem.-spec.	IRIS, HEAST, or NCEA
CSF_i	Cancer slope factor inhaled $(mg/kg\text{-}day)^{-1}$	Chem.-spec.	IRIS, HEAST, or NCEA
RfD_o	Reference dose oral (mg/kg-day)	Chem.-spec.	IRIS, HEAST, or NCEA
RfD_i	Reference dose inhaled (mg/kg-day)	Chem.-spec.	IRIS, HEAST, or NCEA
TR	Target cancer risk	1E-05	NMED-specific value
THQ	Target hazard quotient	1	US EPA, 1989
BW	Body weight (kg)		
	-- adult	70	US EPA, 1989
	-- child	15	US EPA, 1991
AT	Averaging time (days)		
	-- carcinogens	25550	US EPA, 1989
	-- noncarcinogens	ED*365	
SA	Exposed surface area for soil/dust (cm^2/day)		US EPA, 1989
	– adult resident	5700	US EPA, 1996a
	– adult worker	3300	US EPA, 1996a
	-- child	2800	US EPA, 1989
AF	Adherence factor, soils (mg/cm^2)		US EPA, 1989
	– adult resident	0.07	US EPA, 1996a
	– adult worker	0.2	US EPA, 1996a
	-- child resident	0.2	US EPA, 1989
	– construction worker	0.3	NMED-specific value
ABS	Skin absorption defaults (unitless):		
	– semi-volatile organics	0.1	US EPA, 1989
	– volatile organics	na	US EPA, 2003a
	– inorganics	na	US EPA, 2000s
IRA	Inhalation rate (m^3/day)		
	-- adult resident	20	US EPA, 1991
	– adult worker	20	US EPA, 2001a
	-- child resident	10	Exposure Factors, (US EPA, 1997)
IRW	Drinking water ingestion rate (L/day)		
	-- adult	2	US EPA, 2004b
	-- child	1	US EPA, 2004b
IRS	Soil ingestion (mg/day)		
	-- adult resident	100	US EPA, 1991
	-- child resident	200	US EPA, 1991
	-- commercial/industrial worker	100	US EPA, 2001a
	construction worker	330	US EPA, 1991
EF	Exposure frequency (days/yr)		
	-- residential	350	US EPA, 1991
	-- commercial/industrial	225	US EPA, 2001a
	– construction worker	250	NMED-specific value
ED	Exposure duration (years)		
	-- residential	30[a]	US EPA, 1991)
	-- child	6	(US EPA, 1991)
	-- commercial/industrial	25	(US EPA, 1999)
	– construction worker	1	NMED-specific value
	Age-adjusted factors for carcinogens		
IFSadj	Ingestion factor, soils ([mg-yr]/[kg-day])	114	US EPA, 2001a
SFSadj	Dermal factor, soils ([mg-yr]/[kg-day])	361	US EPA, 2001a
InhFadj	Inhalation factor, air ([m^3-yr]/[kg-day])	11	By analogy to RAGS: Part B, (US EPA, 1991)
IFWadj	Ingestion factor, water ([L-yr]/[kg-day])	1.1	By analogy to RAGS: Part B, (US EPA, 1991)
PEF	Particulate emission factor (m^3/kg)	Chem.-spec.	US EPA, 2001a
VFs	Volatilization factor for soil (m^3/kg)	Chem.-spec.	US EPA, 2001a
VFw	Volatilization factor for water (L/m^3)	0.5	US EPA, 1991
Csat	Soil saturation concentration (mg/kg)	Chem.-spec.	US EPA, 2001a

[a]Exposure duration for lifetime residents is assumed to be 30 years total. For carcinogens, exposures are combined for children (6 years) and adults (24 years).

Chem.-spec.- Chemical-specific value na - not applicable
RAGS – Risk Assessment Guidance for Superfund IRIS – Integrated Risk Information System, USEPA, 2003b
HEAST – Health Effects Assessment Summary Tables, USEPA, 1997
NCEA – National Center for Environmental Assessment, Office of Research and Development (USEPA, 2003c)
NMED – New Mexico Environment Department

APPENDIX B

Table B-1: Physical and Chemical Properties

Chemical	MW (g/mole)	H (atm-m^3/mole)	H' (dimensionless)	D_a (cm^2/s)	D_w (cm^2/s)	K_{oc} (cm^3/g)	K_d (cm^3/g)	S (mg/L-water)	D_A (cm^2/s)	VF (m^3/kg)	SAT (mg/kg)
Acenaphthene	154.21	1.6E-04	6.36E-03	4.21E-02	7.69E-06	4.90E+03	7.35E+00	4.24E+00	4.13E-07	1.93E+05	3.19E+01
Acetaldehyde	44	7.8E-05	3.20E-03	1.20E-01	1.40E-05	1.80E+01	2.70E-02	1.00E+06	2.28E-05	2.60E+04	2.01E+05
Acetone	58	3.9E-05	1.60E-03	1.20E-01	1.10E-05	5.80E-01	8.70E-04	1.00E+06	1.40E-05	3.31E+04	1.74E+05
Acrylonitrile	53	8.8E-05	3.60E-03	1.08E-01	1.34E-05	8.50E-01	1.28E-03	7.90E+04	2.64E-05	2.42E+04	1.38E+04
Acetophenone	120	1.1E-05	4.51E-04	6.00E-02	8.70E-06	4.62E+01	6.93E-02	6.10E+03	2.59E-06	7.71E+04	1.48E+03
Acrolein	56	1.2E-04	4.90E-03	1.05E-01	1.22E-05	2.10E+01	3.15E-02	2.10E+05	2.86E-05	2.32E+04	4.31E+04
Aldrin	365	1.7E-04	6.97E-03	1.32E-02	4.86E-06	2.45E+06	3.68E+03	1.80E-01			
Aluminum	26.98	2.4E-02	1.00E+00			1.43E+01	1.50E+03				
Anthracene	178	6.5E-05	2.67E-03	3.24E-02	7.74E-06	2.95E+04	4.43E+01	4.34E-02	2.73E-08	7.51E+05	1.93E+00
Antimony	121.75	2.4E-02	1.00E+00			1.43E+01	4.50E+01				
Arsenic	74.92	7.7E-01	3.16E+01			1.43E+01	2.90E+01				
Barium	137.33	2.4E-02	1.00E+00			1.43E+01	4.10E+01				
Benzene	78.1	5.6E-03	2.28E-01	8.80E-02	9.80E-06	5.89E+01	8.84E-02	1.75E+03	7.30E-04	4.59E+03	5.06E+02
Benzidine	184.23	7.0E-11	2.88E-09	3.40E-02	1.50E-05	2.74E+03	4.11E+00	3.22E+02			
Benzo(a)anthracene	228	3.3E-06	1.37E-04	5.10E-02	9.00E-06	3.98E+05	5.97E+02	9.40E-03			
Benzo(a)pyrene	250	1.1E-06	4.63E-05	4.30E-02	9.00E-06	1.02E+06	1.53E+03	1.62E-03			
Benzo(b)fluoranthene	252.3	1.1E-04	4.55E-03	2.26E-02	5.56E-06	1.23E+06	1.85E+03	1.50E-03			
Benzo(k)fluoranthene	252.3	8.3E-07	3.40E-05	2.26E-02	5.56E-06	1.23E+06	1.85E+03	8.00E-04			
Beryllium	9.01	2.4E-02	1.00E+00			1.43E+01	7.90E+02				
α-BHC	290.85	1.1E-05	4.35E-04	1.42E-02	7.34E-06	1.23E+03	1.85E+00	2.00E+00			
β-BHC	290.85	7.4E-07	3.05E-05	1.42E-02	7.34E-06	1.26E+03	1.89E+00	2.40E-01			
γ-BHC	290.85	1.4E-05	5.74E-04	1.42E-02	7.34E-06	1.07E+03	1.61E+00	6.80E+00			
1,1-Biphenyl	150	2.9E-04	1.20E-02	4.00E-02	8.20E-06	7.80E+03	1.17E+01	7.50E+00	4.50E-07	1.85E+05	8.91E+01
Bis(2-chloroethyl) ether	140	1.8E-05	7.38E-04	6.92E-02	7.53E-06	7.60E+01	1.14E-01	1.72E+04	2.90E-06	7.29E+04	4.94E+03
Bis(2-chloroisopropyl) ether	170	1.1E-04	4.60E-03	6.30E-02	6.40E-06	6.17E+01	9.25E-02	1.70E+03	1.23E-05	3.53E+04	4.53E+02
Bis(2-ethylhexyl) phthalate	390.54	1.0E-07	4.18E-06	3.51E-02	3.66E-06	1.51E+07	2.27E+04	3.40E-01			7.70E+03
Bis(chloromethyl) ether	120	2.0E-04	8.20E-03	8.90E-02	9.40E-06	1.20E+00	1.80E-03	2.20E+04	4.55E-05	1.84E+04	3.87E+03
Boron	10.81	2.4E-02	1.00E+00			1.43E+01	3.00E+00				
Bromobenzene	157.02	3.7E-03	1.50E-01	7.30E-02	8.70E-06	2.20E+02	3.30E-01	4.70E+02	2.21E-04	8.36E+03	2.45E+02
Bromodichloromethane	164	1.6E-03	6.56E-02	2.98E-02	1.06E-05	1.00E+02	1.50E-01	6.74E+03	6.31E-05	1.56E+04	2.23E+03

Chemical	MW (g/mole)	H (atm-m^3/mole)	H' (dimensionless)	D_a (cm^2/s)	D_w (cm^2/s)	K_{oc} (cm^3/g)	K_d (cm^3/g)	S (mg/L-water)	D_A (cm^2/s)	VF (m^3/kg)	SAT (mg/kg)
Bromomethane	94.95	6.2E-03	2.56E-01	7.28E-02	1.21E-05	9.00E+00	1.35E-02	1.52E+04	9.03E-04	4.13E+03	3.31E+03
1,3-Butadiene	54	1.8E-01	7.30E+00	9.80E-02	1.10E-05	1.20E+02	1.80E-01	7.40E+02	6.24E-03	1.57E+03	9.10E+02
2-Butanone (MEK)	72	2.7E-05	1.10E-03	9.00E-02	9.80E-06	4.50E+00	6.75E-03	2.70E+05	7.91E-06	4.41E+04	4.87E+04
tert-Butyl methyl ether (MTBE)	88.2	5.9E-04	2.40E-02	8.00E-02	1.00E-05	6.00E+00	9.00E-03	1.50E+05	1.11E-04	1.18E+04	2.78E+04
n-Butylbenzene	130	1.3E-02	5.40E-01	7.50E-02	7.80E-06	2.80E+03	4.20E+00	1.40E+01	9.56E-05	1.27E+04	6.21E+01
sec-Butylbenzene	130	1.9E-02	7.70E-01	7.50E-02	7.80E-06	2.20E+03	3.30E+00	1.70E+01	1.70E-04	9.53E+03	6.06E+01
tert-Butylbenzene	130	1.3E-02	5.20E-01	7.50E-02	7.80E-06	2.20E+03	3.30E+00	3.00E+01	1.16E-04	1.15E+04	1.06E+02
Cadmium	112.41	2.4E-02	1.00E+00			1.43E+01	7.50E+01				
Carbon disulfide	76	2.9E-02	1.20E+00	1.04E-01	1.00E-05	4.60E+01	6.90E-02	1.19E+03	3.42E-03	2.12E+03	4.60E+02
Carbon tetrachloride	154	3.0E-02	1.25E+00	7.80E-02	8.80E-06	1.74E+02	2.61E-01	7.93E+02	1.76E-03	2.96E+03	4.63E+02
Chlordane	409.8	4.9E-05	1.99E-03	1.18E-02	4.37E-06	1.20E+05	1.80E+02	5.60E-02			
2-Chloroacetophenone	154.59	3.7E-02	1.50E+00	7.20E-02	6.80E-06	3.30E+02	4.95E-01	4.70E+02	1.34E-03	3.39E+03	3.99E+02
2-Chloro-1,3-butadiene	88	3.2E-02	1.30E+00	1.10E-01	1.10E-05	5.00E+01	7.50E-02	7.40E+02	3.75E-03	2.03E+03	2.99E+02
1-Chloro-1,1-difluoroethane	100.5	1.0E-01	4.10E+00	8.00E-02	1.10E-05	5.80E+01	8.70E-02	2.80E+02	4.67E-03	1.82E+03	2.11E+02
Chlorobenzene	113	3.7E-03	1.50E-01	7.30E-02	8.70E-06	2.19E+02	3.29E-01	4.72E+02	2.21E-04	8.34E+03	2.45E+02
1-Chlorobutane	92.57	3.2E-02	1.30E+00	1.10E-01	1.10E-05	5.00E+01	7.50E-02	7.40E+02	3.75E-03	2.03E+03	2.99E+02
Chlorodifluoromethane	86.47	1.0E-01	4.10E+00	8.00E-02	1.10E-05	5.80E+01	8.70E-02	2.80E+02	4.67E-03	1.82E+03	2.11E+02
Chloroethane	65	1.1E-02	4.50E-01	1.00E-01	1.20E-05	1.50E+01	2.25E-02	5.70E+03	1.90E-03	2.85E+03	1.42E+03
Chloroform	120	3.7E-03	1.50E-01	1.04E-01	1.00E-05	3.98E+01	5.97E-02	7.92E+03	6.53E-04	4.86E+03	1.99E+03
Chloromethane	51	2.4E-02	9.80E-01	1.09E-01	6.50E-06	3.50E+01	5.25E-02	8.20E+03	3.29E-03	2.16E+03	2.82E+03
β-Chloronaphthalene	160	3.2E-04	1.30E-02	3.50E-02	8.80E-06	1.60E+03	2.40E+00	1.20E+01	1.98E-06	8.81E+04	3.09E+01
o-Chloronitrobenzene	153.33	4.4E-05	1.80E-03	7.60E-02	8.60E-06	6.50E+01	9.75E-02	2.10E+03	6.54E-06	4.85E+04	5.69E+02
p-Chloronitrobenzene	153.33	5.1E-05	2.10E-03	7.60E-02	8.60E-06	6.50E+01	9.75E-02	2.10E+03	7.42E-06	4.56E+04	5.69E+02
2-Chlorophenol	130	3.9E-04	1.60E-02	5.01E-02	9.46E-06	4.00E+02	6.00E-01	2.20E+04	1.13E-05	3.69E+04	1.71E+04
2-Chloropropane	78.54	2.3E-03	9.40E-02	8.00E-02	1.00E-05	5.10E+01	7.65E-02	2.70E+03	3.03E-04	7.13E+03	7.05E+02
o-Chlorotoluene	172.57	3.4E-03	1.40E-01	7.20E-02	8.70E-06	1.60E+02	2.40E-01	4.70E+02	2.46E-04	7.91E+03	2.02E+02
Chromium III	52						1.80E+06				
Chromium VI	52						1.90E+01				
Chrysene	228.28	9.5E-05	3.88E-03	2.48E-02	6.21E-06	3.98E+05	5.97E+02	1.60E-03	2.10E-09	2.71E+06	9.55E-01
Cobalt	58.93	2.4E-02	1.00E+00			1.43E+01	4.50E+01				
Copper	63.55	2.4E-02	1.00E+00			1.43E+01	3.50E+01				
Crotonaldehyde	70.09	2.4E-01	1.00E+01	9.10E-02	1.00E-05	8.40E+02	1.26E+00	2.00E+01	3.67E-03	2.05E+03	5.27E+01

Chemical	MW (g/mole)	H (atm-m^3/mole)	H' (dimensionless)	D_a (cm^2/s)	D_w (cm^2/s)	K_{oc} (cm^3/g)	K_d (cm^3/g)	S (mg/L-water)	D_A (cm^2/s)	VF (m^3/kg)	SAT (mg/kg)
Cumene (isopropylbenzene)	120	1.2E+00	4.90E+01	7.50E-02	7.10E-06	2.20E+02	3.30E-01	6.10E+01	6.22E-03	1.57E+03	3.89E+02
Cyanide	27.03		5.44E-03			2.71E+00	9.90E+00				
Cyanogen	52	5.1E-03	2.10E-01	2.00E-01	1.40E-05	1.40E+00	2.10E-03	8.50E+03	2.20E-03	2.64E+03	1.71E+03
Cyanogen bromide	52	5.1E-03	2.10E-01	9.60E-02	1.00E-05	2.60E+01	3.90E-02	8.50E+03	8.93E-04	4.15E+03	2.02E+03
Cyanogen chloride	52	5.1E-03	2.10E-01	9.60E-02	1.00E-05	2.60E+01	3.90E-02	8.50E+03	8.93E-04	4.15E+03	2.02E+03
DDD	320	4.0E-06	1.64E-04	1.69E-02	4.76E-06	1.00E+06	1.50E+03	9.00E-02			
DDE	318	2.1E-05	8.61E-04	1.44E-02	5.87E-06	4.47E+06	6.71E+03	1.20E-01			
DDT	354.5	8.1E-06	3.32E-04	1.37E-02	4.95E-06	2.63E+06	3.95E+03	2.50E-02			
Dibenz(a,h)anthracene	278.3	1.5E-08	6.03E-07	2.02E-02	5.18E-06	3.80E+06	5.70E+03	2.49E-03			
Dibenzofuran	284.8	1.3E-05	5.33E-04	6.01E-02	1.00E-05	7.76E+03	1.16E+01	3.10E+00	6.20E-08	4.98E+05	3.66E+01
1,2-Dibromo-3-chloropropane	240	1.5E-04	6.00E-03	8.00E-02	8.00E-06	1.70E+02	2.55E-01	1.20E+03	1.24E-05	3.52E+04	5.15E+02
Dibromochloromethane	210	8.5E-04	3.50E-02	2.00E-02	1.00E-05	6.30E+01	9.45E-02	4.40E+03	2.84E-05	2.33E+04	1.20E+03
1,2-Dibromoethane	188	3.2E-04	1.30E-02	7.33E-02	8.06E-06	2.80E+01	4.20E-02	3.40E+03	4.75E-05	1.80E+04	7.37E+02
1,4-Dichloro-2-butene	130	2.7E-04	1.10E-02	7.30E-02	8.10E-06	4.80E+01	7.20E-02	2.80E+03	3.54E-05	2.09E+04	6.91E+02
1,2-Dichlorobenzene	147	1.9E-03	7.79E-02	6.90E-02	7.90E-06	3.80E+01	5.70E-02	1.56E+02	2.36E-04	8.07E+03	3.74E+01
1,3-Dichlorobenzene	147	1.9E-03	7.80E-02	6.90E-02	7.90E-06	3.80E+01	5.70E-02	1.56E+02	2.37E-04	8.07E+03	3.74E+01
1,4-Dichlorobenzene	147	2.4E-03	9.96E-02	6.90E-02	7.90E-06	6.16E+02	9.24E-01	7.38E+01	6.51E-05	1.54E+04	8.19E+01
3,3-Dichlorobenzidine	253.13	4.0E-09	1.64E-07	1.94E-02	6.74E-06	7.24E+02	1.09E+00	3.11E+00			
Dichlorodifluoromethane	120	1.0E-01	4.10E+00	8.00E-02	1.05E-05	5.80E+01	8.70E-02	2.80E+02	4.67E-03	1.82E+03	2.11E+02
1,1-Dichloroethane	99	5.6E-03	2.30E-01	7.42E-02	1.05E-05	5.30E+01	7.95E-02	5.06E+03	6.40E-04	4.90E+03	1.42E+03
1,2-Dichloroethane	99	9.8E-04	4.01E-02	1.04E-01	9.90E-06	3.80E+01	5.70E-02	8.52E+03	1.87E-04	9.07E+03	2.00E+03
cis-1,2-Dichloroethene	97	4.1E-03	1.67E-01	7.36E-02	1.13E-05	3.55E+01	5.33E-02	3.50E+03	5.25E-04	5.42E+03	8.63E+02
trans-1,2-Dichloroethene	97	9.4E-03	3.85E-01	7.07E-02	1.19E-05	3.80E+01	5.70E-02	6.30E+03	1.04E-03	3.85E+03	1.74E+03
1,1-Dichloroethene	97	2.7E-02	1.10E+00	9.00E-02	1.00E-05	6.50E+01	9.75E-02	2.30E+03	2.60E-03	2.43E+03	9.27E+02
2,4-Dichlorophenol	163	3.2E-06	1.30E-04	3.46E-02	8.77E-06	1.47E+02	2.21E-01	4.50E+03			
1,2-Dichloropropane	110	2.7E-03	1.10E-01	7.80E-02	8.70E-06	4.40E+01	6.60E-02	2.80E+03	3.58E-04	6.56E+03	7.07E+02
1,3-Dichloropropene	111	1.8E-02	7.26E-01	6.26E-02	1.00E-05	2.70E+01	4.05E-02	2.80E+03	1.60E-03	3.11E+03	8.43E+02
Dicyclopentadiene	130	1.1E-02	4.40E-01	6.70E-02	1.00E-05	5.70E+02	8.55E-01	1.80E+03	2.86E-04	7.34E+03	1.95E+03
Dieldrin	381	1.5E-05	6.19E-04	1.25E-02	4.74E-06	2.14E+04	3.21E+01	1.95E-01			
Diethyl phthalate	222.2	4.5E-07	1.85E-05	2.56E-02	6.35E-06	2.88E+02	4.32E-01	1.08E+03			
Dimethyl phthalate	194.19	4.1E-07	1.70E-05	5.68E-02	6.29E-06	3.71E+01	5.56E-02	4.00E+03			
Di-n-butyl phthalate	278.34	9.4E-10	3.85E-08	4.38E-02	7.86E-06	3.39E+04	5.09E+01	1.12E+01			

Chemical	MW (g/mole)	H (atm-m^3/mole)	H' (dimensionless)	D_a (cm^2/s)	D_w (cm^2/s)	K_{oc} (cm^3/g)	K_d (cm^3/g)	S (mg/L-water)	D_A (cm^2/s)	VF (m^3/kg)	SAT (mg/kg)
2,4-Dimethylphenol	122.16	2.0E-06	8.20E-05	5.84E-02	8.69E-06	2.09E+02	3.14E-01	7.87E+03			
4,6-Dinitro-o-cresol	198.14	1.4E-06	5.72E-05	2.93E-02	6.91E-06	6.02E+02	9.02E-01	1.98E+02			
2,4-Dinitrophenol	184.11	8.6E-08	3.52E-06	2.73E-02	9.06E-06	3.64E+02	5.46E-01	2.79E+03			
2,4-Dinitrotoluene	182.14	9.3E-08	3.80E-06	2.03E-01	7.06E-06	9.55E+01	1.43E-01	2.70E+02			
1,2-Diphenylhydrazine	184.24	4.6E-11	1.90E-09	3.17E-02	7.36E-06	3.48E+03	5.22E+00	2.21E+02			
Endosulfan	406.95	1.1E-05	4.59E-04	1.15E-02	4.55E-06	2.14E+03	3.21E+00	5.10E-01			
Endrin	381	7.5E-06	3.08E-04	1.25E-02	4.74E-06	1.23E+04	1.85E+01	2.50E-01			
Epichlorohydrin	93	3.2E-05	1.30E-03	8.80E-02	9.80E-06	3.50E+00	5.25E-03	6.00E+04	8.88E-06	4.17E+04	1.07E+04
Ethyl acetate	88	1.4E-04	5.70E-03	7.30E-02	9.70E-06	5.90E+01	8.85E-02	8.00E+04	1.81E-05	2.92E+04	2.10E+04
Ethyl acrylate	100.1	2.4E-01	9.80E+00	9.10E-02	8.60E-06	8.40E+02	1.26E+00	2.00E+01	3.63E-03	2.06E+03	5.22E+01
Ethyl chloride	65	1.1E-02	4.50E-01	1.00E-01	1.20E-05	1.50E+01	2.25E-02	5.70E+03	1.90E-03	2.85E+03	1.42E+03
Ethyl ether	74.12	1.3E-05	5.30E-04	7.00E-02	9.30E-06	1.40E+01	2.10E-02	1.00E+04	3.90E-06	6.29E+04	1.94E+03
Ethyl methacrylate	114.12	2.4E-01	1.00E+01	9.10E-02	8.60E-06	8.40E+02	1.26E+00	2.00E+01	3.67E-03	2.05E+03	5.27E+01
Ethylbenzene	106.2	7.9E-03	3.23E-01	7.50E-02	7.80E-06	3.63E+02	5.45E-01	1.69E+02	3.36E-04	6.77E+03	1.28E+02
Ethylene oxide	44	7.6E-05	3.10E-03	1.30E-01	1.50E-05	2.20E+00	3.30E-03	1.00E+06	2.72E-05	2.38E+04	1.77E+05
Fluoranthene	202.3	1.6E-05	6.60E-04	3.02E-02	6.35E-06	1.07E+05	1.61E+02	2.06E-01			
Fluorene	166.21	7.8E-05	3.20E-03	6.10E-02	7.88E-06	7.90E+03	1.19E+01	1.90E+00	1.96E-07	2.80E+05	2.28E+01
Fluoride	38	2.4E-02	1.00E+00			1.43E+01	1.50E+02	1.69E+00			
Furan	68	5.4E-03	2.20E-01	1.00E-01	1.20E-05	1.20E+01	1.80E-02	1.00E+04	1.06E-03	3.81E+03	2.18E+03
Heptachlor	373.5	1.1E-03	4.47E-02	1.12E-02	5.69E-06	1.41E+06	2.12E+03	1.80E-01			
Hexachlorobenzene	284.8	1.3E-03	5.41E-02	5.42E-02	5.91E-06	5.50E+04	8.25E+01	6.20E+00			
Hexachloro-1,3-butadiene	260.76	8.1E-03	3.34E-01	5.61E-02	6.16E-06	5.37E+04	8.06E+01	3.23E+00			
Hexachlorocyclopentadiene	272.75	2.7E-02	1.11E+00	1.61E-02	7.21E-06	2.00E+05	3.00E+02	1.80E+00			
Hexachloroethane	236.74	3.9E-03	1.59E-01	2.50E-03	6.80E-06	1.78E+03	2.67E+00	5.00E+01			
n-Hexane	86	1.2E-01	5.00E+00	2.00E-01	7.80E-06	8.90E+02	1.34E+00	1.80E+01	5.01E-03	1.75E+03	3.80E+01
HMX	296.2	1.0E-11	4.10E-10			1.85E+03	2.78E+00	2.56E+03			
Hydrogen cyanide	27	1.3E-04	5.30E-03	1.80E-01	1.80E-05	1.70E+01	2.55E-02	1.00E+06	5.36E-05	1.69E+04	1.99E+05
Indeno(1,2,3-c,d)pyrene	276.3	1.6E-06	6.56E-05	1.90E-02	5.66E-06	3.47E+06	5.21E+03	2.20E-05			
Iron	55.84	2.4E-02	1.00E+00			1.43E+01	2.50E+01				
Isobutanol	74	1.2E-05	4.90E-04	8.60E-02	9.30E-06	6.20E+01	9.30E-02	8.50E+04	3.04E-06	7.12E+04	2.26E+04
Isophorone	138.21	6.6E-06	2.72E-04	6.23E-02	6.76E-06	4.68E+01	7.02E-02	1.20E+04			
Lead	207.2	2.4E-02	1.00E+00			1.43E+01	9.00E+02				

Chemical	MW (g/mole)	H (atm-m^3/mole)	H' (dimensionless)	D_a (cm^2/s)	D_w (cm^2/s)	K_{oc} (cm^3/g)	K_d (cm^3/g)	S (mg/L-water)	D_A (cm^2/s)	VF (m^3/kg)	SAT (mg/kg)
lead (Tetraethyl-)	64.52										
Maleic hydrazide	110	6.6E-03	2.70E-01	9.00E-02	1.10E-05	4.20E+01	6.30E-02	6.00E+03	9.52E-04	4.02E+03	1.61E+03
Manganese	54.94	2.4E-02	1.00E+00			1.43E+01	6.50E+01				
Mercury (elemental)	200.59	2.4E-02	1.00E+00	3.07E-02	6.30E-06	1.43E+01	5.20E+01				
Mercury (methyl)	215.62	1.1E-02	4.67E-01			1.43E+01					
Methacrylonitrile	67.09	8.8E-05	3.60E-03	1.10E-01	1.30E-05	8.40E-01	1.26E-03	7.90E+04	2.66E-05	2.41E+04	1.38E+04
Methomyl	160	3.9E-02	1.60E+00	6.90E-02	1.00E-05	1.50E+01	2.25E-02	1.70E+05	3.03E-03	2.25E+03	6.59E+04
Methyl acetate	74.08	2.0E-05	8.40E-04	1.00E-01	1.00E-05	2.20E+00	3.30E-03	1.00E+06	7.22E-06	4.62E+04	1.77E+05
Methyl acrylate	86.09	2.4E-01	9.80E+00	9.10E-02	8.60E-06	8.40E+02	1.26E+00	6.00E+01	3.63E-03	2.06E+03	1.57E+02
Methyl isobutyl ketone	100	1.4E-04	5.70E-03	7.50E-02	7.80E-06	1.30E+02	1.95E-01	1.90E+04	1.30E-05	3.45E+04	7.01E+03
Methyl methacrylate	100	3.4E-04	1.40E-02	7.70E-02	8.60E-06	1.30E+01	1.95E-02	1.50E+04	5.98E-05	1.61E+04	2.92E+03
Methyl styrene (alpha)	118.18	2.3E-03	9.40E-02	7.10E-02	8.00E-06	3.60E+02	5.40E-01	3.00E+02	9.69E-05	1.26E+04	2.17E+02
Methyl styrene (mixture)	118.18	2.3E-03	9.40E-02	7.10E-02	8.00E-06	3.60E+02	5.40E-01	3.00E+02	9.69E-05	1.26E+04	2.17E+02
Methylcyclohexane	98	4.4E-01	1.80E+01	7.00E-02	9.00E-06	2.20E+03	3.30E+00	1.40E+01	2.37E-03	2.55E+03	7.89E+01
Methylene bromide	170	9.0E-04	3.70E-02	8.00E-02	8.00E-06	1.80E+02	2.70E-01	1.20E+04	6.99E-05	1.48E+04	5.37E+03
Methylene chloride	85	2.2E-03	9.00E-02	1.00E-01	1.20E-05	1.20E+01	1.80E-02	1.30E+04	4.69E-04	5.73E+03	2.63E+03
Molybdenum	95.94	2.4E-02	1.00E+00			1.43E+01	2.00E+01				
Naphthalene	128.16	4.8E-04	1.98E-02	5.90E-02	7.50E-06	2.00E+03	3.00E+00	3.10E+01	3.94E-06	6.25E+04	9.84E+01
Nickel	58.71	2.4E-02	1.00E+00			1.43E+01	6.50E+01				
Nitrate	101.1	2.4E-02	1.00E+00			1.43E+01					
Nitrite	46	2.0E-07	8.38E-06			2.37E+01	3.56E-02				
Nitrobenzene	120	2.4E-05	9.84E-04	7.60E-02	8.60E-06	6.46E+01	9.69E-02	2.10E+03	4.16E-06	6.09E+04	5.68E+02
Nitroglycerin	227.08	6.1E-03	2.50E-01			2.60E+02	3.90E-01	1.80E+03			
N-Nitrosodiethylamine	102.14	3.7E-06	1.50E-04	6.48E-02	9.13E-06	1.20E+03	1.80E+00	1.06E+05			
N-Nitrosodimethylamine	74.08	1.4E-01	5.90E+00	3.12E-02	6.35E-06	3.82E+01	5.73E-02	1.00E+06			
N-Nitrosodi-*n*-butylamine	158.2	3.2E-04	1.31E-02	5.80E-02	9.72E-06	2.60E+02	3.90E-01	1.27E+03	1.48E-05	3.23E+04	7.17E+02
N-Nitrosodiphenylamine	198.23	5.0E-06	2.05E-04	3.12E-02	6.35E-06	1.29E+03	1.94E+00	3.51E+01			7.40E+01
N-Nitrosopyrrolidine	100.2	4.9E-08	2.00E-06			1.59E+02	2.38E-01	1.00E+06			
m-Nitrotoluene	137.1	2.4E-05	9.80E-04	7.60E-02	8.60E-06	6.50E+01	9.75E-02	2.10E+03	4.14E-06	6.10E+04	5.69E+02
o-Nitrotoluene	137.13	2.4E-05	9.80E-04	7.60E-02	8.60E-06	6.50E+01	9.75E-02	2.10E+03	4.14E-06	6.10E+04	5.69E+02
p-Nitrotoluene	137.1	2.4E-05	9.80E-04	7.60E-02	8.60E-06	6.50E+01	9.75E-02	2.10E+03	4.14E-06	6.10E+04	5.69E+02
Pentachlorobenzene	250.32	7.1E-03	2.90E-01	5.70E-02	6.30E-06	2.00E+03	3.00E+00	8.31E+02			

Chemical	MW (g/mole)	H (atm-m^3/mole)	H' (dimensionless)	D_a (cm^2/s)	D_w (cm^2/s)	K_{oc} (cm^3/g)	K_d (cm^3/g)	S (mg/L-water)	D_A (cm^2/s)	VF (m^3/kg)	SAT (mg/kg)
Pentachlorophenol	266.34	2.4E-08	1.00E-06	5.60E-02	6.10E-06	5.92E+02	8.88E-01	1.95E+03			
Phenanthrene	178.2	2.3E-05	9.40E-04			1.40E+04	2.10E+01	1.15E+00			
Phenol	94	4.0E-07	1.63E-05	8.20E-02	9.10E-06	2.88E+01	4.32E-02	8.28E+04			
Polychlorinatedbiphenyls	(291.98 - 360.86)										
Aroclor 1016	variable	4.2E-02	1.73E+00	1.75E-02	8.00E-06	4.48E+04	6.72E+01	2.77E-01			
Aroclor 1221	variable	1.8E-08	7.40E-07	1.75E-02	8.00E-06	4.48E+04	6.72E+01	2.77E-01			
Aroclor 1232	variable	1.8E-08	7.40E-07	1.75E-02	8.00E-06	4.48E+04	6.72E+01	2.77E-01			
Aroclor 1242	variable	1.8E-08	7.40E-07	1.75E-02	8.00E-06	4.48E+04	6.72E+01	2.77E-01			
Aroclor 1248	variable	1.8E-08	7.40E-07	5.70E+03	6.00E-01	5.30E+05	7.95E+02	2.77E-01			
Aroclor 1254	variable	1.8E-08	7.40E-07	5.70E+03	6.00E-01	5.30E+05	7.95E+02	2.77E-01			
Aroclor 1260	variable	1.8E-08	7.40E-07	5.70E+03	6.00E-01	5.30E+05	7.95E+02	2.77E-01			
n-Propylbenzene	120.19	1.3E-02	5.40E-01	7.50E-02	7.80E-06	2.80E+03	4.20E+00	1.40E+01	9.56E-05	1.27E+04	6.21E+01
Propylene oxide	58	8.5E-05	3.50E-03	1.20E-01	1.30E-05	2.50E+01	3.75E-02	4.80E+05	2.33E-05	2.57E+04	1.01E+05
Pyrene	200	1.1E-05	4.51E-04	2.72E-02	7.24E-06	6.80E+04	1.02E+02	1.35E-01	4.07E-09	1.95E+06	1.38E+01
RDX	222.12	6.3E-08	2.60E-06			7.00E+01	1.05E-01	5.97E+01			
Selenium	78.96	9.7E-03	3.98E-01			1.43E+01	5.00E+00				
Silver	107.87	2.4E-02	1.00E+00			1.43E+01	8.30E+00				
Strontium	87.62	2.4E-02	1.00E+00			1.43E+01	3.50E+01				
Styrene	100	2.7E-03	1.10E-01	7.10E-02	8.00E-06	9.10E+01	1.37E-01	3.10E+02	2.54E-04	7.78E+03	1.00E+02
1,2,4,5-Tetrachlorobenzene	215.89	1.0E-03	4.10E-02	2.11E-02	8.76E-06	1.19E+03	1.78E+00	5.95E-01			
1,1,1,2-Tetrachloroethane	167.85	3.4E-04	1.41E-02	7.10E-02	7.90E-06	7.90E+01	1.19E-01	2.97E+03	3.68E-05	2.05E+04	8.72E+02
1,1,2,2-Tetrachloroethane	169.86	3.4E-04	1.40E-02	7.10E-02	7.90E-06	7.90E+01	1.19E-01	2.97E+03	3.65E-05	2.05E+04	8.72E+02
Tetrachloroethene	170	1.8E-02	7.54E-01	7.20E-02	8.20E-06	2.70E+02	4.05E-01	2.00E+02	8.54E-04	4.25E+03	1.34E+02
Thallium	204.37	2.4E-02	1.00E+00			1.43E+01	7.10E+01				
Toluene	92	6.6E-03	2.72E-01	8.70E-02	8.60E-06	1.82E+02	2.73E-01	5.26E+02	5.19E-04	5.45E+03	2.52E+02
Toxaphene	414	6.0E-06	2.46E-04	1.16E-02	4.34E-06	2.57E+05	3.86E+02	7.40E-01			
Tribromomethane	252.73	6.6E-04	2.70E-02	1.49E-02	1.03E-05	8.70E+01	6.92E+00	3.10E+03	6.51E-07	1.54E+05	2.20E+04
1,1,2-Trichloro-1,2,2-trifluoroethane	187.38	5.2E-01	2.14E+01	2.88E-02	8.07E-06	1.60E+02	2.40E-01	1.10E+03	2.23E-03	2.63E+03	3.28E+03
1,2,4-Trichlorobenzene	181	1.4E-03	5.82E-02	3.00E-02	8.23E-06	1.78E+03	2.67E+00	3.00E+02	6.53E-06	4.86E+04	8.55E+02
1,1,1-Trichloroethane	130	1.7E-02	7.05E-01	7.80E-02	8.80E-06	1.10E+02	1.65E-01	1.33E+03	1.37E-03	3.35E+03	5.63E+02
1,1,2-Trichloroethane	133	9.1E-04	3.74E-02	7.80E-02	8.80E-06	5.01E+01	7.52E-02	4.42E+03	1.22E-04	1.12E+04	1.12E+03

Chemical	MW (g/mole)	H (atm-m^3/mole)	H' (dimensionless)	D_a (cm^2/s)	D_w (cm^2/s)	K_{oc} (cm^3/g)	K_d (cm^3/g)	S (mg/L-water)	D_A (cm^2/s)	VF (m^3/kg)	SAT (mg/kg)
Trichloroethylene	131	1.0E-02	4.22E-01	7.90E-02	9.10E-06	9.40E+01	1.41E-01	1.10E+03	9.61E-04	4.00E+03	4.01E+02
Trichlorofluoromethane	140	9.8E-02	4.00E+00	8.70E-02	1.30E-05	1.60E+02	2.40E-01	1.10E+03	4.15E-03	1.93E+03	9.83E+02
2,4,5-Trichlorophenol	197.46	4.4E-06	1.80E-04	2.91E-02	7.03E-06	1.19E+03	1.78E+00	1.20E+03			
2,4,6-Trichlorophenol	197.46	7.8E-06	3.20E-04	3.18E-02	6.25E-06	1.19E+03	1.78E+00	8.00E+02			
1,1,2-Trichloropropane	147.43	2.9E-02	1.20E+00	4.00E-02	9.30E-06	5.10E+01	7.65E-02	2.70E+03	1.29E-03	3.45E+03	1.06E+03
1,2,3-Trichloropropane	147.43	2.7E-02	1.10E+00	7.10E-02	7.90E-06	5.10E+01	7.65E-02	2.70E+03	2.17E-03	2.67E+03	1.03E+03
1,2,3-Trichloropropene	145.42	2.7E-02	1.10E+00	7.10E-02	7.90E-06	5.10E+01	7.65E-02	2.70E+03	2.17E-03	2.67E+03	1.03E+03
Triethylamine	101.19	9.0E-05	3.70E-03	1.20E-01	1.30E-05	2.20E+00	3.30E-03	1.00E+06	2.92E-05	2.30E+04	1.77E+05
1,2,4-Trimethylbenzene	120	5.6E-03	2.30E-01	7.50E-02	7.10E-06	3.70E+03	5.55E+00	2.60E-01	3.14E-05	2.21E+04	1.50E+00
1,3,5-Trimethylbenzene	120	7.8E-03	3.20E-01	7.50E-02	7.10E-06	8.20E+02	1.23E+00	4.80E+01	1.75E-04	9.40E+03	6.92E+01
2,4,6-Trinitrotoluene	227.13	4.6E-07	1.90E-05	2.45E-02	6.36E-06	1.83E+03	2.75E+00	1.30E+02			
Vanadium	50.94	2.4E-02	1.00E+00			1.43E+01	1.00E+03				
Vinyl acetate	86	5.1E-04	2.10E-02	8.50E-02	9.20E-06	5.30E+00	7.95E-03	2.00E+04	1.04E-04	1.22E+04	3.68E+03
Vinyl bromide	106.95	6.3E-03	2.60E-01	1.00E-01	1.20E-05	1.30E+02	1.95E-01	1.80E+04	6.84E-04	4.75E+03	7.19E+03
Vinyl chloride	63	2.7E-02	1.11E+00	1.10E-01	1.20E-06	1.86E+01	2.79E-02	2.80E+03	3.87E-03	1.99E+03	9.36E+02
Vinyl chloride	63	2.7E-02	1.11E+00	1.10E-01	1.20E-06	1.86E+01	2.79E-02	2.80E+03	3.87E-03	1.99E+03	9.36E+02
m-Xylene	106	7.3E-03	3.01E-01	7.00E-02	7.80E-06	2.00E+02	3.00E-01	1.61E+02	4.34E-04	5.96E+03	8.20E+01
o-Xylene	106	5.2E-03	2.13E-01	8.70E-02	1.00E-05	2.40E+02	3.60E-01	1.78E+02	3.48E-04	6.65E+03	9.95E+01
Xylenes	106	7.3E-03	3.00E-01	7.00E-02	7.80E-06	2.00E+02	3.00E-01	1.61E+02	4.33E-04	5.96E+03	8.20E+01
Zinc	65.38	2.4E-02	1.00E+00			1.43E+01	6.20E+01				

Notes:
MW – Molecular weight
H' – Dimensionless Henry's Law Constant
D_w – Diffusivity in water
K_d – Soil-water partition coefficient
D_A – Apparent diffusivity (calculated for VOCs only)
SAT – Soil saturation limit (calculated for VOCs only)
H – Henry's Law Constant
D_a – Diffusivity in air
K_{oc} – Soil organic carbon partition coefficient
S - Solubility in water
VF – Volatilization factor (calculated for VOCs only)
VOC – Volatile organic compound

APPENDIX C

Table C-1: Human Health Benchmarks Used for Calculating SSLs

Chemical	CSF_o (mg/kg-day^{-1}	Reference	RfD_o (mg/kg-day)	Reference	CSF_i (mg/kg-day)$^{-1}$	Reference	RfD_i (mg/kg-day)	Reference	ABS
Acenaphthene			6.00E-02	IRIS			6.00E-02	route	0
Acetaldehyde					7.70E-03	IRIS	2.60E-03	IRIS	0
Acetone			9.00E-01	IRIS			9.00E-01	route	0
Acrylonitrile	5.40E-01	IRIS	1.00E-03	HEAST	2.40E-01	IRIS	5.71E-04	IRIS	0
Acetophenone			1.00E-01	IRIS			1.00E-01	route	0
Acrolein			5.00E-04	IRIS			5.71E-06	IRIS	0
Aldrin	1.72E+01	IRIS	3.00E-05	IRIS	1.72E+01	IRIS	3.00E-05	route	0.1
Aluminum			1.00E+00	NCEA			1.40E-03	NCEA	0
Anthracene			3.00E-01	IRIS			3.00E-01	route	0
Antimony			4.00E-04	IRIS					0
Arsenic	1.50E+00	IRIS	3.00E-04	IRIS	1.51E+01	IRIS			0.03
Barium			2.00E-01	IRIS			2.00E-01	route	0
Benzene	5.50E-02	IRIS	4.00E-03	IRIS	2.70E-02	IRIS	8.60E-03	IRIS	0
Benzidine	2.30E+02	IRIS	3.00E-03	IRIS	2.35E+02	IRIS	3.00E-03	route	0.1
Benzo(a)anthracene	7.30E-01	NCEA			3.10E-01	NCEA			0.13
Benzo(a)pyrene	7.30E+00	IRIS			3.10E+00	NCEA			0.13
Benzo(b)fluoranthene	7.30E-01	NCEA			3.10E-01	NCEA			0.13
Benzo(k)fluoranthene	7.30E-02	NCEA			3.10E-02	NCEA			0.13
Beryllium			2.00E-03	IRIS	8.40E+00	IRIS	5.71E-06	IRIS	0
α-BHC	6.30E+00	IRIS	5.00E-04	NCEA	6.30E+00	IRIS	5.00E-04	route	0.04
β-BHC	1.80E+00	IRIS	2.00E-04	NCEA	1.80E+00	IRIS	2.00E-04	route	0.04
γ-BHC	1.30E+00	HEAST	3.00E-04	IRIS	3.00E-04	route	3.00E-04	route	0.04
1,1-Biphenyl			5.00E-02	IRIS			5.00E-02	route	0

Chemical	CSF_o (mg/kg-day^{-1}	Reference	RfD_o (mg/kg-day)	Reference	CSF_i (mg/kg-day)$^{-1}$	Reference	RfD_i (mg/kg-day)	Reference	ABS
Bis(2-chloroethyl) ether	1.10E+00	IRIS			1.16E+00	IRIS			0
Bis(2-chloroisopropyl) ether	7.00E-02	HEAST	4.00E-02	IRIS	3.50E-02	HEAST	4.00E-02	route	0
Bis(2-ethylhexyl) phthalate	1.40E-02	IRIS	2.00E-02	IRIS	1.40E-02	route	2.00E-02	route	0.1
Bis(chloromethyl) ether	2.20E+02	IRIS			2.17E+02	IRIS			0
Boron			2.00E-01	IRIS			5.70E-03	HEAST	0
Bromobenzene			2.00E-02	NCEA			2.90E-03	NCEA	0
Bromodichloromethane	6.20E-02	IRIS	2.00E-02	IRIS	6.20E-02	route	2.00E-02	route	0
Bromomethane			1.40E-03	IRIS			1.43E-03	IRIS	0
1,3-Butadiene					1.05E-01	IRIS	5.71E-04	IRIS	0
2-Butanone (MEK)			6.00E-01	IRIS			1.43E+00	IRIS	0
tert-Butyl methyl ether (MTBE)	1.80E-03	Reg 6/prov	8.60E-01	route	1.80E-03	route	8.57E-01	IRIS	0
n-Butylbenzene			1.00E-02	NCEA			1.00E-02	route	0
sec-Butylbenzene			1.00E-02	NCEA			1.00E-02	route	0
tert-Butylbenzene			1.00E-02	NCEA			1.00E-02	route	0
Cadmium			5.00E-04	IRIS	6.30E+00	IRIS			0.001
Carbon disulfide			1.00E-01	IRIS			2.00E-01	IRIS	0
Carbon tetrachloride	1.30E-01	IRIS	7.00E-04	IRIS	5.25E-02	IRIS			0
Chlordane	3.50E-01	IRIS	5.00E-04	IRIS	3.50E-01	IRIS	2.00E-04	IRIS	0.04
2-Chloroacetophenone			8.60E-06	route			8.57E-06	IRIS	0
2-Chloro-1,3-butadiene			2.00E-02	HEAST			2.00E-03	HEAST	0
1-Chloro-1,1-difluoroethane			1.40E+01	route			1.43E+01	IRIS	0
Chlorobenzene			2.00E-02	iRIS			1.70E-02	NCEA	0
1-Chlorobutane			4.00E-02	Reg 6/prov			4.00E-02	route	0
Chlorodifluoromethane			4.10E+01	route			1.43E+01	IRIS	0
Chloroethane	2.90E-03	NCEA	4.00E-01	NCEA	2.90E-03	route	2.86E+00	IRIS	0
Chloroform			1.00E-02	IRIS	8.05E-02	IRIS	1.35E-02	NCEA	0

Chemical	CSF_o (mg/kg-day^{-1}	Reference	RfD_o (mg/kg-day)	Reference	CSF_i (mg/kg-day)$^{-1}$	Reference	RfD_i (mg/kg-day)	Reference	ABS
Chloromethane	1.30E-02	HEAST			6.30E-03	HEAST	2.57E-02	IRIS	0
β-Chloronaphthalene			8.00E-02	IRIS			8.00E-02	route	0
o-Chloronitrobenzene	9.70E-03	HEAST	1.00E-03	HEAST	9.70E-03	route	2.00E-05	HEAST	0
p-Chloronitrobenzene	6.70E-03	HEAST	1.00E-03	HEAST	6.70E-03	route	1.70E-04	HEAST	0
2-Chlorophenol			5.00E-03	IRIS			5.00E-03	route	0
2-Chloropropane			2.90E-02	route			2.90E-02	HEAST	0
o-Chlorotoluene			2.00E-02	IRIS			2.00E-02	route	0
Chromium III			1.50E+00	IRIS					0
Chromium VI			3.00E-03	IRIS	2.90E+02	IRIS	2.85E-05	IRIS	0
Chrysene	7.30E-03	NCEA			3.10E-03	NCEA			0.13
Cobalt			2.00E-02	NCEA	9.80E+00	NCEA	5.70E-06	NCEA	0
Copper			4.00E-02	HEAST					0
Crotonaldehyde	1.90E+00	HEAST			1.90E+00	route			0
Cumene (isopropylbenzene)			1.00E-01	IRIS			1.14E-01	IRIS	0
Cyanide			2.00E-02	IRIS					0.1
Cyanogen			4.00E-02	IRIS					0
Cyanogen bromide			9.00E-02	IRIS					0
Cyanogen chloride			5.00E-02	IRIS					0
DDD	2.40E-01	IRIS			2.40E-01	route			0.03
DDE	3.40E-01	IRIS			3.40E-01	route			0.03
DDT	3.40E-01	IRIS	5.00E-04	IRIS	3.40E-01	IRIS	5.00E-04	route	0.03
Dibenz(a,h)anthracene	7.30E+00	NCEA			3.10E+00	NCEA			0.13
Dibenzofuran			2.00E-03	NCEA			2.00E-03	route	0
1,2-Dibromo-3-chloropropane	1.40E+00	HEAST	5.70E-05	route	2.40E-03	HEAST	5.70E-05	IRIS	0
Dibromochloromethane	8.40E-02	IRIS	2.00E-02	IRIS	8.40E-02	route	2.00E-02	route	0
1,2-Dibromoethane	2.00E+00	IRIS	9.00E-03	iRIS	2.00E+00	IRIS	2.60E-03	IRIS	0

Chemical	CSF_o (mg/kg-day^{-1}	Reference	RfD_o (mg/kg-day)	Reference	CSF_i (mg/kg-day)$^{-1}$	Reference	RfD_i (mg/kg-day)	Reference	ABS
1,4-Dichloro-2-butene	9.30E+00	route			9.30E+00	HEAST			0
1,2-Dichlorobenzene			9.00E-02	IRIS			6.90E-03	NCEA	0
1,3-Dichlorobenzene			3.00E-03	NCEA			3.00E-03	NCEA	0
1,4-Dichlorobenzene	2.40E-02	HEAST	3.00E-02	NCEA	2.20E-02	NCEA	2.29E-01	IRIS	0
3,3-Dichlorobenzidine	4.50E-01	IRIS			4.50E-01	route			0.1
Dichlorodifluoromethane			2.00E-01	IRIS			5.71E-02	HEAST	0
1,1-Dichloroethane			2.00E-01	Reg 6/prov			2.00E-01	Reg 6/prov	0
1,2-Dichloroethane	9.10E-02	IRIS	2.00E-02	NCEA	9.10E-02	IRIS	1.40E-03	NCEA	0
cis-1,2-Dichloroethene			1.00E-02	HEAST			1.00E-02	route	0
trans-1,2-Dichloroethene			2.00E-02	IRIS			2.00E-02	route	0
1,1-Dichloroethene			5.00E-02	IRIS			5.70E-02	IRIS	0
2,4-Dichlorophenol			3.00E-03	IRIS			3.00E-03	route	0.1
1,2-Dichloropropane	6.80E-02	HEAST	1.10E-03	route	6.80E-02	route	1.10E-03	IRIS	0
1,3-Dichloropropene	1.00E-01	IRIS	3.00E-02	IRIS	1.40E-02	IRIS	5.71E-03	IRIS	0
Dicyclopentadiene			8.00E-03	Reg 6/prov			2.00E-03	Reg 6/prov	0
Dieldrin	1.60E+01	IRIS	5.00E-05	IRIS	1.61E+01	IRIS	5.00E-05	route	0.1
Diethyl phthalate			8.00E-01	IRIS			8.00E-01	route	0.1
Dimethyl phthalate			1.00E+01	HEAST			1.00E+01	route	0.1
Di-n-butyl phthalate			1.00E-01	IRIS			1.00E-01	route	0.1
2,4-Dimethylphenol			2.00E-02	IRIS			2.00E-02	route	0.1
4,6-Dinitro-o-cresol			1.00E-04	prov.			1.00E-04	route	0.1
2,4-Dinitrophenol			2.00E-03	IRIS			2.00E-03	route	0.1
2,4-Dinitrotoluene			2.00E-03	IRIS			2.00E-03	route	0.1
1,2-Diphenylhydrazine	8.00E-01	IRIS			7.70E-01	IRIS			0.1
Endosulfan			6.00E-03	IRIS			6.00E-03	route	0.1
Endrin			3.00E-04	IRIS			3.00E-04	route	0.1

Chemical	CSF_o (mg/kg-day^{-1}	Reference	RfD_o (mg/kg-day)	Reference	CSF_i (mg/kg-day)$^{-1}$	Reference	RfD_i (mg/kg-day)	Reference	ABS
Epichlorohydrin	9.90E-03	IRIS	2.00E-03	HEAST	4.20E-03	IRIS	2.86E-04	IRIS	0
Ethyl acetate			9.00E-01	IRIS			9.00E-01	route	0
Ethyl acrylate	4.80E-02	HEAST			4.80E-02	route			0
Ethyl chloride	2.90E-03	NCEA	4.00E-01	NCEA	2.90E-03	route	2.86E+00	IRIS	0
Ethyl ether			2.00E-01	IRIS			2.00E-01	route	0
Ethyl methacrylate			9.00E-02	HEAST			9.00E-02	route	0
Ethylbenzene			1.00E-01	IRIS			2.90E-01	IRIS	0
Ethylene oxide	1.00E+00	HEAST			3.50E-01	HEAST			0
Fluoranthene			4.00E-02	IRIS			4.00E-02	route	0.13
Fluorene			4.00E-02	IRIS			4.00E-02	route	0
Fluoride			6.00E-02	IRIS					0.1
Furan			1.00E-03	IRIS			1.00E-03	route	0
Heptachlor	4.50E+00	IRIS	5.00E-04	IRIS	4.55E+00	IRIS	5.00E-04	route	0.1
Hexachlorobenzene	1.60E+00	IRIS	8.00E-04	IRIS	1.61E+00	IRIS	8.00E-04	route	0.1
Hexachloro-1,3-butadiene	7.80E-02	IRIS	2.00E-04	HEAST	7.70E-02	IRIS	2.00E-04	route	0.1
Hexachlorocyclopentadiene			6.00E-03	IRIS			5.71E-05	IRIS	0.1
Hexachloroethane	1.40E-02	IRIS	1.00E-03	IRIS	1.40E-02	IRIS	1.00E-03	route	0.1
n-Hexane			1.10E+01	prov.			5.71E-02	IRIS	0
HMX			5.00E-02	IRIS			5.00E-02	route	0.1
Hydrogen cyanide			2.00E-02	IRIS			8.57E-04	IRIS	0
Indeno(1,2,3-c,d)pyrene	7.30E-01	NCEA			3.10E-01	NCEA			0.13
Iron			3.00E-01	NCEA					0
Isobutanol			3.00E-01	IRIS			3.00E-01	route	0
Isophorone	9.50E-04	IRIS	2.00E-01	IRIS	9.50E-04	route	2.00E-01	route	0.1
Lead									0
Lead (tetraethyl-)			1.00E-07	IRIS					0.1

Chemical	CSF_o (mg/kg-day^{-1}	Reference	RfD_o (mg/kg-day)	Reference	CSF_i (mg/kg-day)$^{-1}$	Reference	RfD_i (mg/kg-day)	Reference	ABS
Maleic hydrazide			5.00E-01	IRIS			5.00E-01	route	0
Manganese			4.70E-02	Reg 6			1.40E-05	IRIS	0
Mercury (elemental)							8.57E-05	IRIS	0
Mercury (methyl)			1.00E-04	IRIS					0.1
Methacrylonitrile			1.00E-04	IRIS			2.00E-04	HEAST	0
Methomyl			2.50E-02	IRIS			2.50E-02	route	0
Methyl acetate			1.00E+00	HEAST			1.00E+00	route	0
Methyl acrylate			3.00E-02	HEAST			3.00E-02	route	0
Methyl isobutyl ketone			8.00E-02	HEAST			8.57E-01	IRIS	0
Methyl methacrylate			1.40E+00	IRIS			2.00E-01	IRIS	0
Methyl styrene (alpha)			7.00E-02	HEAST			7.00E-02	route	0
Methyl styrene (mixture)			6.00E-03	HEAST			1.00E-02	HEAST	0
Methylcyclohexane			8.60E-01	route			8.60E-01	HEAST	0
Methylene bromide			1.00E-02	HEAST			1.00E-02	route	0
Methylene chloride	7.50E-03	IRIS	6.00E-02	IRIS	1.65E-03	IRIS	8.60E-01	HEAST	0
Molybdenum			5.00E-03	IRIS					0
Naphthalene			2.00E-02	IRIS			8.57E-04	IRIS	0
Nickel			2.00E-02	IRIS					0
Nitrate			1.60E+00	IRIS					0
Nitrite			1.00E-01	IRIS					0
Nitrobenzene			5.00E-04	IRIS			5.71E-04	HEAST	0
Nitroglycerin	1.40E-02	NCEA			1.40E-02	route			0.1
N-Nitrosodiethylamine	1.50E+02	IRIS			1.51E+02	IRIS			0.1
N-Nitrosodimethylamine	5.10E+01	IRIS	8.00E-06	prov.	4.90E+01	][	8.00E-06	route	0.1
N-Nitrosodi-*n*-butylamine	5.40E+00	IRIS			5.60E+00	IRIS			0.1
N-Nitrosodiphenylamine	4.90E-03	IRIS	2.00E-02	prov.	4.90E-03	route	2.00E-02	route	0.1

Chemical	CSF_o (mg/kg-day^{-1}	Reference	RfD_o (mg/kg-day)	Reference	CSF_i (mg/kg-day)$^{-1}$	Reference	RfD_i (mg/kg-day)	Reference	ABS
N-Nitrosopyrrolidine	2.10E+00	IRIS			2.14E+00	IRIS			0.1
m-Nitrotoluene			2.00E-02	HEAST			2.00E-02	route	0
o-Nitrotoluene	2.30E-01	prov.	1.00E-02	HEAST	2.30E-01	route	1.00E-02	route	0
p-Nitrotoluene	1.70E-02	prov.	1.00E-02	HEAST	1.70E-02	route	1.00E-02	route	0
Pentachlorobenzene			8.00E-04	IRIS			8.00E-04	route	0.1
Pentachlorophenol	1.20E-01	IRIS	3.00E-02	IRIS	1.20E-01	route	3.00E-02	route	0.25
Phenanthrene (pyrene surrogate)			3.00E-02	IRIS			3.00E-02	route	0.1
Phenol			3.00E-01	IRIS			3.00E-01	route	0.1
Polychlorinatedbiphenyls									
Aroclor 1016	7.00E-02	IRIS	7.00E-05	IRIS	7.00E-02	IRIS	7.00E-05	route	0.14
Aroclor 1221	2.00E+00	IRIS	2.00E-05	IRIS	2.00E+00	IRIS	2.00E-05	route	0.14
Aroclor 1232	2.00E+00	IRIS	2.00E-05	IRIS	2.00E+00	IRIS	2.00E-05	route	0.14
Aroclor 1242	2.00E+00	IRIS	2.00E-05	IRIS	2.00E+00	IRIS	2.00E-05	route	0.14
Aroclor 1248	2.00E+00	IRIS	2.00E-05	IRIS	2.00E+00	IRIS	2.00E-05	route	0.14
Aroclor 1254	2.00E+00	IRIS	2.00E-05	IRIS	2.00E+00	IRIS	2.00E-05	route	0.14
Aroclor 1260	2.00E+00	IRIS	2.00E-05	IRIS	2.00E+00	IRIS	2.00E-05	route	0.14
n-Propylbenzene			1.00E-02	NCEA			1.00E-02	route	0
Propylene oxide	2.40E-01	IRIS	8.60E-03	route	1.30E-02	IRIS	8.57E-03	IRIS	0
Pyrene			3.00E-02	IRIS			3.00E-02	route	0
RDX	1.10E-01	IRIS	3.00E-03	IRIS	1.10E-01	route	3.00E-03	route	0.1
Selenium			5.00E-03	IRIS					0
Silver			5.00E-03	IRIS					0
Strontium			6.00E-01	IRIS					0
Styrene			2.00E-01	IRIS			2.86E-01	IRIS	0
1,2,4,5-Tetrachlorobenzene			3.00E-04	IRIS			3.00E-04	route	0.1
1,1,1,2-Tetrachloroethane	2.60E-02	IRIS	3.00E-02	IRIS	2.59E-02	IRIS	3.00E-02	route	0

Chemical	CSF_o (mg/kg-day^{-1}	Reference	RfD_o (mg/kg-day)	Reference	CSF_i (mg/kg-day)$^{-1}$	Reference	RfD_i (mg/kg-day)	Reference	ABS
1,1,2,2-Tetrachloroethane	2.00E-01	IRIS	6.00E-02	NCEA	2.03E-01	IRIS	6.00E-02	route	0
Tetrachloroethylene	5.20E-02	NCEA	1.00E-02	IRIS	2.03E-02	NCEA	1.14E-01	NCEA	0
Thallium			6.60E-05	IRIS					0
Toluene			8.00E-02	IRIS			1.40E+00	IRIS	0
Toxaphene	1.10E+00	IRIS			1.12E+00	IRIS			0.1
Tribromomethane (Bromoform)	7.90E-03	IRIS	2.00E-02	IRIS	3.85E-03	IRIS	2.00E-02	route	0
1,1,2-Trichloro-1,2,2-trifluoroethane			3.00E+01	IRIS			8.57E+00	HEAST	0
1,2,4-Trichlorobenzene			1.00E-02	IRIS			1.00E-03	prov.	0
1,1,1-Trichloroethane			2.80E-01	NCEA			6.30E-01	NCEA	0
1,1,2-Trichloroethane	5.70E-02	IRIS	4.00E-03	IRIS	5.60E-02	IRIS	4.00E-03	route	0
Trichloroethene	4.0E-01	NCEA	3.00E-04	NCEA	4.0E-01	NCEA	1.00E-02	NCEA	0
Trichlorofluoromethane			3.00E-01	IRIS			2.00E-01	HEAST	0
2,4,5-Trichlorophenol			1.00E-01	IRIS			1.00E-01	route	0.1
2,4,6-Trichlorophenol	1.10E-02	IRIS	1.00E-04	NCEA	1.09E-02	IRIS	1.00E-04	route	0.1
1,1,2-Trichloropropane			5.00E-03	IRIS			5.00E-03	route	0
1,2,3-Trichloropropane	2.00E+00	NCEA	6.00E-03	IRIS	2.00E+00	route	1.40E-03	NCEA	0
1,2,3-Trichloropropene			1.00E-02	prov.			2.90E-04	prov.	0
Triethylamine			1.99E-03	route			1.99E-03	IRIS	0
1,2,4-Trimethylbenzene			5.00E-02	NCEA			1.70E-03	NCEA	0
1,3,5-Trimethylbenzene			5.00E-02	NCEA			1.70E-03	NCEA	0
2,4,6-Trinitrotoluene	3.00E-02	IRIS	5.00E-04	IRIS	3.00E-02	route	5.00E-04	route	0.1
Vanadium			1.00E-03	NCEA					0
Vinyl acetate			1.00E+00	HEAST			5.71E-02	IRIS	0
Vinyl bromide (Bromomethene)	1.10E-02	route	8.60E-04	HEAST	1.10E-01	HEAST	8.57E-04	IRIS	0
Vinyl chloride (Child)	1.40E+00	IRIS	3.00E-03	IRIS	3.00E-02	IRIS	2.80E-02	IRIS	0
Vinyl chloride (Adult)	7.20E-01	IRIS	3.00E-03	IRIS	1.54E-02	IRIS	2.85E-02	IRIS	0

Chemical	CSF_o (mg/kg-day^{-1}	Reference	RfD_o (mg/kg-day)	Reference	CSF_i (mg/kg-day)$^{-1}$	Reference	RfD_i (mg/kg-day)	Reference	ABS
m-Xylene			2.00E-01	IRIS			2.86E-02	IRIS	0.1
o-Xylene			2.00E-01	IRIS					0.1
Xylenes			2.00E-01	IRIS			2.86E-02	IRIS	0.1
Zinc			3.00E-01	IRIS					0

Notes:
CSFo – Oral cancer slope factor
CSFi – Inhalation cancer slope factor
RfDo – Oral Reference Dose
RfDi – Inhalation Reference Dose
r – Route-to-route extrapolation
ABS – Dermal absorption coefficient

IRIS – Integrated Risk Information System, USEPA 2006.
NCEA – National Center for Environmental Assessment, Office of Research and Development, USEPA 2003c.

VOLUME 2

TIER 1: SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

PHASE I
Scoping Assessment

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1. Introduction

The purpose of an ecological risk assessment is to evaluate the potential adverse effects that chemical contamination has on the plants and animals that make up ecosystems. The risk assessment process provides a way to develop, organize and present scientific information so that it is relevant to environmental decisions.

The New Mexico Environment Department Hazardous Waste Bureau (NMED) has developed a tiered procedure for the evaluation of ecological risk. This procedure is outlined in the *Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Risk Assessment* (GAERPC) (NMED, 2000). Briefly, the tiers of the procedure are organized as follows:

PHASE I: QUALITATIVE ASSESSMENT

- Tier I: Screening-Level Ecological Risk Assessment
- Scoping Assessment
- Screening Assessment

PHASE II: QUANTITATIVE ASSESSMENT

- Tier II: Site-Specific Ecological Risk Assessment

As discussed above and illustrated in Figure 1, the Scoping Assessment is the first phase of the Tier I Screening-Level Ecological Risk Assessment process as defined by the NMED GAERPC. This document provides specific procedures to assist the facility in conducting the first step (Scoping Assessment) of the Tier I, Screening-Level Ecological Risk Assessment process outlined in the GAERPC. The purpose of the Scoping Assessment is to gather information, which will be used to determine if there is "any reason to believe that ecological receptors and/or complete exposure pathways exist at or in the locality of the site" (NMED, 2000). The scoping assessment step also serves as the initial information-gathering phase for sites clearly in need of a more detailed assessment of potential ecological risk. This document outlines the methodology for conducting a Scoping Assessment, and includes a Site Assessment Checklist (Attachment A), which serves as tool for gathering information about the facility property and surrounding areas. Although the GAERPC provides a copy of the US EPA Checklist for Ecological Assessment/Sampling (US EPA, 1997), the attached Site Assessment Checklist provides an expanded, user-friendly template, which both guides the user as to what information to collect and furnishes an organized structure in which to enter the information.

After the Site Assessment Checklist has been completed, the assessor must use the collected information to generate a Scoping Assessment Report and Preliminary Conceptual Site Exposure Model (PCSEM). Guidance for performing these tasks is provided in this document, and in the GAERPC. The Scoping Assessment Report and PCSEM are subsequently used to address the first in a series of Technical Decision Points of the tiered GAERPC process. Technical Decision Points are questions which must be answered by the assessor after the completion of certain phases in the process. The resulting answer to the question determines the next step to be undertaken by the

facility. The first Technical Decision Point, as illustrated in Figure 1, is to decide: *Is Ecological Risk Suspected?*

If the answer to the first Technical Decision Point is "no" (that is, ecological risk is not suspected), the assessor may use the Exclusion Criteria Checklist and Decision Tree (Attachment B) to help confirm or deny that possibility. However, it is unlikely that any site containing potential ecological habitat or receptors will meet the Site Exclusion Criteria.

If ecological risk is suspected, the facility will usually be directed to proceed to the next phase of Tier I, which is a Screening Level Ecological Risk Assessment (SLERA). A SLERA is a simplified risk assessment that can be conducted with limited site-specific data by defining assumptions for parameters that lack site-specific data (US EPA, 1997). Values used for screening are consistently biased in the direction of overestimating risk to ensure that sites that might pose an ecological risk are properly identified. The completed Site Assessment Checklist is a valuable source of information needed for the completion of the SLERA. Instructions for performing a SLERA can be found in the GAERPC and in a number of EPA guidance documents (e.g., US EPA, 1997; US EPA, 1998).

2. Scoping Assessment

The Scoping Assessment serves as the initial information gathering and evaluation phase of the Tier I process. A Scoping Assessment consists of the following steps:

- Compile and Assess Basic Site Information (using Site Assessment Checklist)
- Conduct Site Visit
- Identify Preliminary Contaminants of Potential Ecological Concern
- Develop a Preliminary Conceptual Site Exposure Model
- Prepare a Scoping Assessment Report

The following subsections provide guidance for completing each step of the Scoping Assessment. For additional guidance, readers should refer to the GAERPC (NMED, 2000).

2.1 Compile and Assess Basic Site Information

The first step of the Scoping Assessment process is to compile and assess basic site information. Since the purpose of the Scoping Assessment is to determine if ecological habitats, receptors, and complete exposure pathways are likely to exist at the site, those items are the focus of the information gathering. The Site Assessment Checklist (Attachment A) should be used to complete this step. The questions in the Site Assessment Checklist should be addressed as completely as possible with the information available before conducting a site visit.

In many cases, a large portion of the Site Assessment Checklist can be completed using reference materials and general knowledge of the site. A thorough file search should be conducted to compile all potential reference materials. Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) and Facility Investigation (RFI) reports, inspection reports, RCRA Part B Permit

Applications, and facility maps can all be good sources of the information needed for the Site Assessment Checklist.

Habitats and receptors which may be present at the site can be identified by contacting local and regional natural resource agencies. Habitat types may be determined by reviewing land use and land cover maps (LULC), which are available via the Internet at http://www.nationalatlas.gov/scripts. Additional sources of general information for the identification of ecological receptors and habitats are listed in the introduction section of the Site Assessment Checklist (Attachment A).

After all available information has been compiled and entered into the Site Assessment Checklist, the assessor should review the checklist and identify data gaps. Plans should then be made to obtain the missing information by performing additional research and/or by observation and investigation during the site visit.

2.2 SITE VISIT

When performing a Scoping Assessment, at least one site visit should be conducted to directly assess ecological features and conditions. As discussed in the previous section, completion of the Site Assessment Checklist should have begun during the compilation of basic site information. The site visit allows for verification of the information obtained from the review of references and other information sources. The current land and surface water usage and characteristics at the site can be observed, as well as direct and indirect evidence of receptors. In addition to the site, areas adjacent to the site and all areas where ecological receptors are likely to contact site-related chemicals (i.e., all areas which may have been impacted by the release or migration of chemicals from the site) should be observed or visited and addressed in the Site Assessment Checklist. The focus of the habitat and receptor observations should be on a community level. That is, dominant plant and animal species and habitats (e.g., wetlands, wooded areas) should be identified during the site visit. Photographs should be taken during the site visit and attached to the Scoping Assessment Report. Photographs are particularly useful for documenting the nature, quality, and distribution of vegetation, other ecological features, potential exposure pathways, and any evidence of contamination or impact. While the focus of the survey is on the community level, the U.S. Fish and Wildlife Service and the New Mexico Natural Heritage Program should be contacted prior to the site visit. The intent is to determine if state listed and/or federal listed Threatened & Endangered (T&E) species or sensitive habitats may be present at the site, or if any other fish or wildlife species could occur in the area (as indicated in the Site Assessment Checklist, Section IIID). A trained biologist or ecologist should conduct the biota surveys to appropriately characterize major habitats and to determine whether T&E species are present or may potentially use the site. The site assessment should also include a general survey for T&E species and any sensitive habitats (e.g. wetlands, perennial waters, breeding areas), due to the fact that federal and state databases might not be complete.

Site visits should be conducted at times of the year when ecological features are most apparent (i.e., spring, summer, early fall). Visits during winter might not provide as much evidence of the presence or absence of receptors and potential exposure pathways.

In addition to observations of ecological features, the assessor should note any evidence of chemical releases (including visual and olfactory clues), drainage patterns, areas with apparent erosion, signs of

groundwater discharge at the surface (such as seeps or springs), and any natural or anthropogenic site disturbances.

2.3 IDENTIFY CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN

Contaminants of Potential Ecological Concern (COPECs) are chemicals which may pose a threat to individual species or biological communities. For the purposes of the Scoping Assessment, all chemicals known or suspected of being released at the site are considered COPECs. The identification of COPECs is usually accomplished by the review of historical information in which previous site activities and releases are identified, or by sampling data which confirm the presence of contaminants in environmental media at the site. If any non-chemical stressors such as mechanical disturbances or extreme temperature conditions are known to be present at the site, they too are to be considered in the assessment.

After the COPECs have been identified, they should be summarized and organized (such as in table or chart form) for presentation in the Scoping Assessment Report.

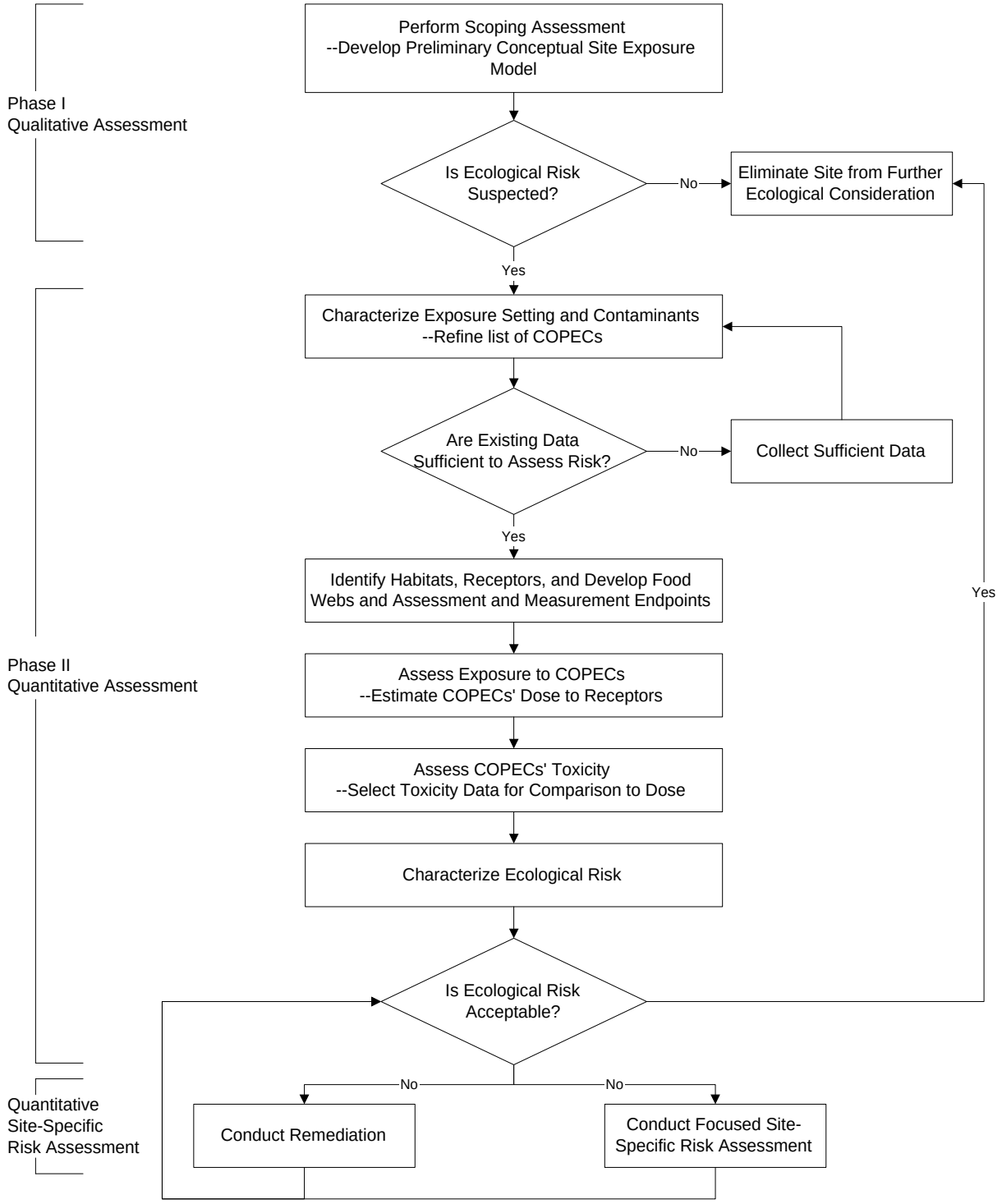
2.4 DEVELOPING THE PRELIMINARY CONCEPTUAL SITE EXPOSURE MODEL

A PCSEM provides a summary of potentially complete exposure pathways, along with potentially exposed receptor types. The PCSEM, in conjunction with the scoping report, is used to determine whether further ecological assessment (i.e., Screening-Level Assessment, Site-Specific Assessment) and/or interim measures are required.

A complete exposure pathway is defined as a pathway having all of the following attributes (US EPA, 1998; NMED, 2000):

- A source and mechanism for hazardous waste/constituent release to the environment
- An environmental transport medium or mechanism by which a receptor can come into contact with the hazardous waste/constituent
- A point of receptor contact with the contaminated media or via the food web, and
- An exposure route to the receptor.

If any of the above components are missing from the exposure pathway, it is not a complete pathway for the site. A discussion regarding all possible exposure pathways and the rationale/justification for eliminating any pathways should be included in the PCSEM narrative and in the Scoping Assessment Report.



Adapted from GAERPC (NMED 2000).

Figure 1. NMED Ecological Risk Assessment Process

The PCSEM is presented as both a narrative discussion and a diagram illustrating potential contaminant migration and exposure pathways to ecological receptors. A sample PCSEM diagram is presented in Figure 2. On the PCSEM diagram, the components of a complete exposure pathway are grouped into three main categories: sources, release mechanisms, and potential receptors. As a contaminant migrates and/or is transformed in the environment, sources and release mechanisms can be defined as primary, secondary, and tertiary.

For example, Figure 2 depicts releases from a landfill that migrate into soils, and reach nearby surface water and sediment via storm water runoff. In this situation, the release from the landfill is considered the primary release, with infiltration as the primary release mechanism. Soil becomes the secondary source, and storm water runoff is the secondary release mechanism to surface water and sediments, the tertiary source.

Subsequent ecological exposures to terrestrial and aquatic receptors will result from this release. The primary exposure routes to ecological receptors are direct contact, ingestion, and possibly inhalation. For example, plant roots will be in direct contact with contaminated sediments, and burrowing mammals will be exposed via dermal contact with soil and incidental ingestion of contaminated soil. In addition, exposures for birds and mammals will occur as they ingest prey items through the food web.

Although completing the Site Assessment Checklist will not provide the user with a ready made PCSEM, a majority of the components of the PCSEM can be found in the information provided by the Site Assessment Checklist. The information gathered for the completion of Section II of the Site Assessment Checklist, can be used to identify sources of releases. The results of Section III, Habitat Evaluation, can be used to both identify secondary and tertiary sources and to identify the types of receptors which may be exposed. The information gathered for completion of Section IV, Exposure Pathway Evaluation, will assist users in tracing the migration pathways of releases in the environment, thus helping to identify release mechanisms and sources.

Once all of the components of the conceptual model have been identified, complete exposure pathways and receptors that have the potential for exposure to site releases can be identified.

For further guidance on constructing a PCSEM, consult the GAERPC (NMED, 2000), and EPA's Office of Solid Waste and Emergency Response's *Soil Screening Guidance: User's Guide* (1996).

2.5 Assembling the Scoping Assessment Report

After completion of the previously described activities of the scoping assessment, the Scoping Assessment Report should be assembled to summarize the site information and present an evaluation of receptors and pathways at the site. The Scoping Assessment Report should be designed to support the decision made regarding the first Technical Decision Point (Is Ecological Risk Suspected?). The Scoping Assessment Report should, at a minimum, contain the following information:

- Existing Data Summary
- Site Visit Summary (including a completed Site Assessment Checklist)

- Evaluation of Receptors and Pathways
- Recommendations
- Attachments (e.g. photographs, field notes, telephone conversation logs with natural resource agencies)
- References/Data Sources

After completion, the Scoping Assessment Report and PCSEM should be submitted to NMED for review and approval. These documents will serve as a basis for decisions regarding future actions at the site.

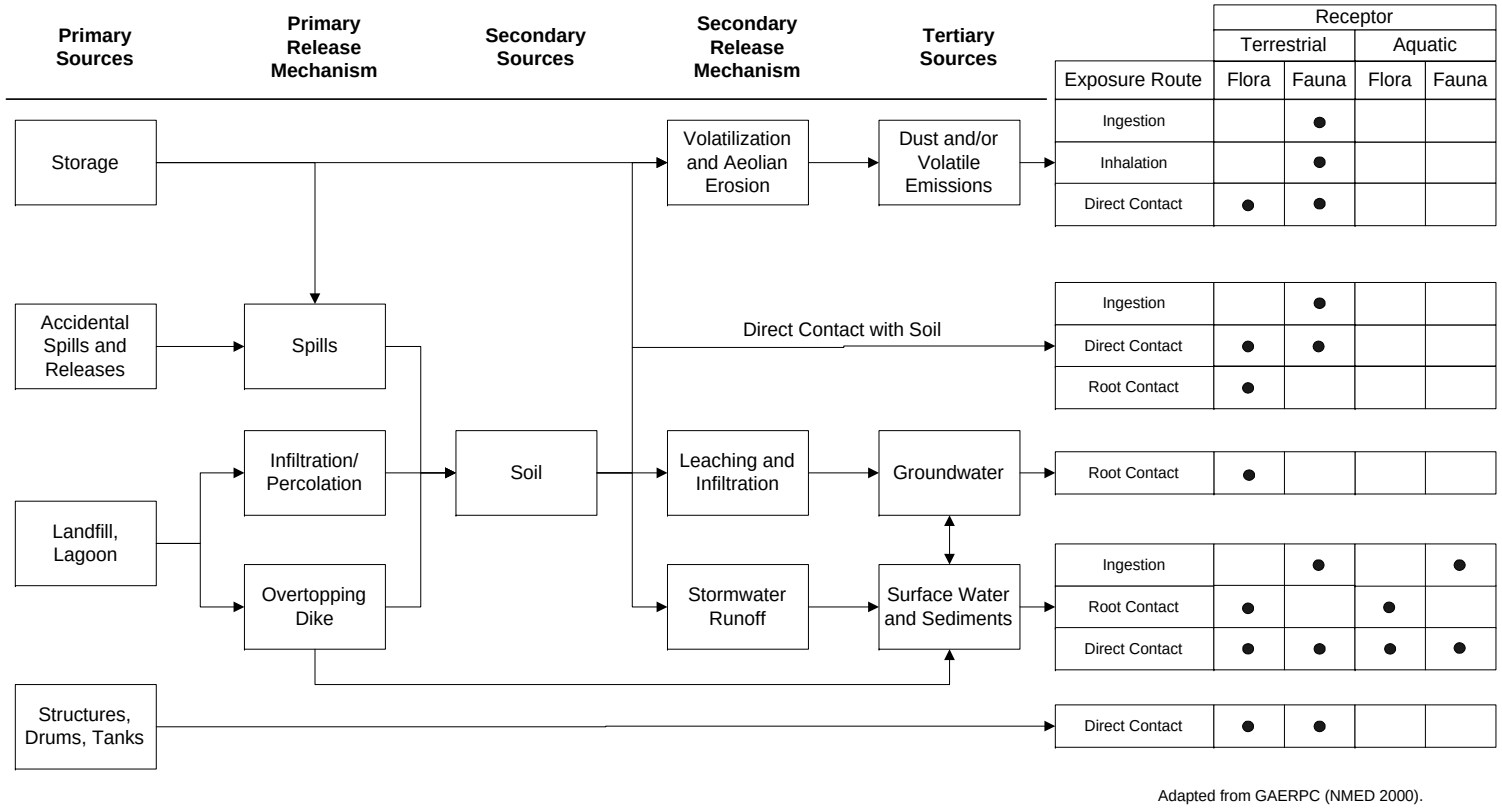


Figure 2. Example Preliminary Conceptual Site Exposure Model Diagram for a Hypothetical Site

3. Site Exclusion Criteria

If the assessor believes that the answer to the first Technical Decision Point (Is Ecological Risk Suspected?) is "no" based on the results of the PCSEM and Scoping Assessment Report, it should be determined whether the facility meets the NMED Site Exclusion Criteria.

Exclusion criteria are defined as those conditions at an affected property which eliminate the need for a SLERA. The three criteria are as follows:

- Affected property does not include viable ecological habitat.
- Affected property is not utilized by potential receptors.
- Complete or potentially complete exposure pathways do not exist due to affected property setting or conditions of affected property media.

The Exclusion Criteria Checklist and associated Decision Tree (Attachment B) can be used as a tool to help the user determine if an affected site meets the exclusion criteria. The checklist assists in making a conservative, qualitative determination of whether viable habitats, ecological receptors, and/or complete exposure pathways exist at or in the locality of the site where a release of hazardous waste/constituents has occurred. Thus, meeting the exclusion criteria means that the facility can answer "no" to the first Technical Decision Point.

If the affected property meets the Site Exclusion Criteria, based on the results of the checklist and decision tree, the facility must still submit a Scoping Assessment Report to NMED which documents the site conditions and justification for how the criteria have been met. Upon review and approval of the exclusion by the appropriate NMED Bureau, the facility will not be required to conduct any further evaluation of ecological risk. However, the exclusion is not permanent; a future change in circumstances may result in the affected property no longer meeting the exclusion criteria.

4. Technical Decision Point: Is Ecological Risk Suspected?

As discussed in the beginning of this document, the Scoping Assessment is the first phase of the GAERPC ecological risk assessment process (Figure 1). Following the submission of the Scoping Assessment Report and PCSEM, NMED will decide upon one of the following three recommendations for the site:

- No further ecological investigation at the site, or
- Continue the risk assessment process, and/or
- Undertake a removal or remedial action.

If the information presented in the Scoping Assessment Report supports the answer of "no" to the first Technical Decision Point, and the site meets the exclusion criteria, the site will likely be excused from further consideration of ecological risk. However, this is only true if it can be documented that a complete exposure pathway does not exist and will not exist in the future at the site based on current conditions. For those sites where valid pathways for potential exposure exist or are likely to exist in the future, further ecological risk assessment (usually in the form of a SLERA) will be

required. However, if the Scoping Assessment indicates that a detailed assessment is warranted, the facility would not be required to conduct a SLERA. Instead the facility would move directly to Tier II–Site-Specific Ecological Risk Assessment.

References

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NEW MEXICO ENVIRONMENT DEPARTMENT TPH SCREENING GUIDELINES
October 2006

In some instances, it may be practical to assess areas of soil contamination that are the result of releases of petroleum products such as jet fuel and diesel, using total petroleum hydrocarbon (TPH) analyses. TPH results may be used to delineate the extent of petroleum-related contamination at these sites and ascertain if the residual level of petroleum products in soil represents an unacceptable risk to future users of the site. Petroleum hydrocarbons represent complex mixtures of compounds, some of which are regulated constituents and some compounds that are not regulated. In addition, the amount and types of the constituent compounds in a petroleum hydrocarbon release differ widely depending on what type of product was spilled and how the spill has weathered. This variability makes it difficult to determine the toxicity of weathered petroleum products in soil solely from TPH results; however, these results can be used to approximate risk in some cases, depending upon the nature of the petroleum product, the release scenario, how well the site has been characterized, and anticipated potential future land uses. In some cases, site clean up cannot be based solely on results of TPH sampling. The New Mexico Environment Department (NMED) will make these determinations on a case by case basis. If NMED determines that additional data are necessary, these TPH guidelines must be used in conjunction with the screening guidelines for individual petroleum-related contaminants in Table 3 and other contaminants, as applicable.

The screening levels for each petroleum carbon range from the Massachusetts Department of Environmental Protection (MADEP) Volatile Petroleum Hydrocarbons/Extractable Petroleum Hydrocarbons (VPH/EPH) approach and the percent composition table below were used to generate screening levels corresponding to total TPH. Except for waste oil, the information in the compositional assumptions table was obtained from the Massachusetts Department of Environmental Protection guidance document *Implementation of the MADEP VPH/EPH Approach* (October 31, 2002). TPH toxicity was based only on the weighted sum of the toxicity of the hydrocarbon fractions listed in Table 1.

Table 1. TPH Compositional Assumptions in Soil

Petroleum Product	C11-C22 Aromatics	C9-C18 Aliphatics	C19-C36 Aliphatics
Diesel #2/ new crankcase oil	60%	40%	0%
#3 and #6 Fuel Oil	70%	30%	0%
Kerosene and jet fuel	30%	70%	0%
Mineral oil dielectric fluid	20%	40%	40%
Unknown oil[a]	100%	0%	0%
Waste Oil[b]	0%	0%	100%

[a] Sites with oil from unknown sources must be tested for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals, and polychlorinated biphenyls (PCBs) to determine if other potentially toxic constituents are present. The TPH guidelines in Table 2 are not designed to be protective of exposure to these constituents therefore they must be tested for, and compared to, their individual NMED soil screening guidelines.

[b] Compositional assumption for waste oil developed by NMED is based on review of chromatographs of several types of waste oil. Sites with waste oil must be tested for VOCs, SVOCs, metals, and PCBs to determine if other potentially toxic constituents are present. The TPH guidelines in Table 2 are not designed to be protective of exposure to these constituents therefore they must be tested for, and compared to, their individual NMED soil screening guidelines.

A TPH screening guideline was calculated for each of the types of petroleum product based on the assumed composition from Table 1 for petroleum products and the direct soil standards incorporating ceiling concentrations given in the MADEP VPH/EPH Excel spreadsheet for each of the carbon fractions. Groundwater concentrations are based on the weighted sum of the noncarcinogenic toxicity of the petroleum fractions.

Method 1 from the MADEP VPH/EPH document was applied, which represents generic cleanup standards for soil and groundwater. Method 1 applies if contamination exists in only soil and groundwater. The MADEP VPH/EPH further divides groundwater into standards. Standard GW-1 applies when groundwater may be used for drinking water purposes. GW-1 standards are based upon ingestion and use of groundwater as a potable water supply. The TPH screening guidelines for sites with potable groundwater are presented in Table 2a.

Table 2a. TPH Screening Guidelines for Potable Groundwater (GW-1)

TPH			Concentration in Groundwater (mg/L)
Petroleum Product	**Residential Direct Exposure (mg/kg)**	**Industrial Direct Exposure (mg/kg)**	
Diesel #2/crankcase oil	520	1120	1.72
#3 and #6 Fuel Oil	440	890	1.34
Kerosene and jet fuel	760	1810	2.86
Mineral oil dielectric fluid	1440	3040	3.64
Unknown oil [a]	200	200	0.2
Waste Oil [b]	2500	5000	Petroleum-Related Contaminants
Gasoline	Not applicable	Not applicable	Petroleum-Related Contaminants

[a] Sites with oil from unknown sources must be tested for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals, and polychlorinated biphenyls (PCBs) to determine if other potentially toxic constituents are present. The TPH guidelines in Table 2 are not designed to be protective of exposure to these constituents therefore they must be tested for, and compared to, their individual NMED soil screening guidelines.

[b] Compositional assumption for waste oil developed by NMED is based on review of chromatographs of several types of waste oil. Sites with waste oil must be tested for VOCs, SVOCs, metals, and PCBs to determine if other potentially toxic constituents are present. The TPH guidelines in Table 2 are not designed to be protective of exposure to these constituents therefore they must be tested for, and compared to, their individual NMED soil screening guidelines.

The second standard is GW-2, which is applicable for sites where the depth to groundwater is less than 15 feet from the ground surface <u>and</u> within 30 feet of an occupied structure. The structure may be either residential or industrial. GW-2 standards are based upon "inhalation exposures that could occur to occupants of the building impacted by volatile compounds, which partition from the groundwater" (MADEP 2001). The GW-2 screening guidelines ONLY apply for the evaluation of inhalation exposures. If potential ingestion or contact with contaminated soil and/or

groundwater could occur, then the screening guidelines provided in Table 2.a should be applied. Table 2.b lists the TPH screening guidelines for the inhalation scenario.

Table 2b. TPH Screening Guidelines – Vapor Migration and Inhalation of Groundwater (GW-2)

TPH			Concentration in Groundwater (mg/L)
Petroleum Product	**Residential Direct Exposure (mg/kg)**	**Industrial Direct Exposure (mg/kg)**	
Diesel #2/crankcase oil	880	2200	30.4
#3 and #6 Fuel Oil	860	2150	35.3
Kerosene and jet fuel	940	2350	15.7
Mineral oil dielectric fluid	1560	3400	10.4
Unknown oil[a]	800	2000	50.0
Waste Oil[b]	2500	5000	Petroleum-Related Contaminants
Gasoline	Not applicable	Not applicable	Petroleum-Related Contaminants

[a] Sites with oil from unknown sources must be tested for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals, and polychlorinated biphenyls (PCBs) to determine if other potentially toxic constituents are present. The TPH guidelines in Table 2 are not designed to be protective of exposure to these constituents therefore they must be tested for, and compared to, their individual NMED soil screening guidelines.

[b] Compositional assumption for waste oil developed by NMED is based on review of chromatographs of several types of waste oil. Sites with waste oil must be tested for VOCs, SVOCs, metals, and PCBs to determine if other potentially toxic constituents are present. The TPH guidelines in Table 2 are not designed to be protective of exposure to these constituents therefore they must be tested for, and compared to, their individual NMED soil screening guidelines.

Mineral oil based hydraulic fluids can be evaluated for petroleum fraction toxicity using the screening guidelines from Tables 2a and 2b specified for waste oil, because this type of hydraulic fluid is composed of approximately the same range of carbon fractions as waste oil. However, these hydraulic fluids often contain proprietary additives that may be significantly more toxic than the oil itself; these additives must be considered on a site- and product-specific basis (see ATSDR hydraulic fluids profile reference). **Use of alternate screening guideline values requires prior written approval from the New Mexico Environment Department.** TPH screening guidelines in Tables 2a and 2b must be used in conjunction with the screening levels for petroleum-related contaminants given in Table 3 because the TPH screening levels are NOT designed to be protective of exposure to these individual petroleum-related contaminants. Table 3 petroleum-related contaminants screening levels are based on the *NMED Technical Background Document for Development of Soil Screening Levels, Rev 4.0 (June 2006).*

The list of petroleum-related contaminants does not include polyaromatic hydrocarbons (PAHs) with individual screening levels that would exceed the total TPH screening levels (acenaphthene, anthracene, flouranthene, flourene, and pyrene). In addition, these TPH screening guidelines are based solely on human health, not ecological risk considerations, protection of surface water, or

potential indoor air impacts from soil vapors. Potential soil vapor impacts to structures or utilities are not addressed by these guidelines. Site-specific investigations for potential soil vapor impacts to structures or utilities must be done to assure that screenings are consistently protective of human health, welfare or use of the property. NMED believes that use of these screening guidelines will allow more efficient screenings of petroleum release sites at sites while protecting human health and the environment. Copies of the references cited below are available on the MADEP website at http://www.state.ma.us/dep/bwsc/vph_eph.htm and the NMED website at http://www.nmenv.state.nm.us/HWB/guidance.html.

Revised Table 3. Petroleum-Related Contaminants Screening Guidelines

Petroleum-Related Contaminants	Values for Direct Exposure to Soil		NMED DAF[a] 20 GW Protection (mg/kg in soil)	NMED DAF[b] 1 GW Protection (mg/kg in soil)
	NMED Residential SSL (mg/kg)	NMED Industrial SSL (mg/kg)		
Benzene	1.03E+01	2.58E+01	2.01E-02	1.00E-03
Toluene	2.52E+02	2.52E+02	2.17E+01	1.08E+00
Ethylbenzene	1.28E+02	1.28E+02	2.02E+01	1.01E+00
Xylenes[c]	8.20E+01	8.20E+01	2.06E+00	1.03E-01
Naphthalene	7.95E+01	3.00E+02	3.94E-01	1.97E-02
2-Methyl naphthalene[d]	5.00E+02	1.00E+03	---[e]	---[e]
Benzo(a)anthracene	6.21E+00	2.34E+01	1.09E+01	5.43E-01
Benzo(b)fluoranthene	6.21E+00	2.34E+01	3.35E+01	1.68E+00
Benzo(k)fluoranthene	6.21E+01	2.34E+02	3.35E+02	1.68E+01
Benzo(a)pyrene	6.21E-01	2.34E+00	2.78E+00	1.39E-01
Chrysene	6.15E+02	2.31E+03	3.48E+02	1.74E+01
Dibenz(a,h)anthracene	6.21E-01	2.34E+00	1.04E+01	5.18E-01
Indeno(1,2,3-c,d)pyrene	6.21E+00	2.34E+01	9.46E+01	4.73E+00

[a] DAF - Dilution Attenuation Factor

[b] For contaminated soil in contact with groundwater.

[c] Based upon total xylenes

[d] No NMED value available, value taken from Massachusetts Contingency Plan, 310 CMR 40.0985, 4/3/06.

[e] No NMED value available and leachability-based value for DAF =1 or 20 not established in the Massachusetts Contingency Plan, 310 CMR 40.0985, 4/3/06.

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North Wind, Inc. Site Specific Health and Safety Plan / Accident Prevention Plan for Final Closure of Solid Waste Management Units 70 and 71, Cannon Air Force Base, New Mexico

Prepared for:
U.S. Army Corps of Engineers, Omaha District
and
Cannon Air Force Base

Prepared by:
North Wind, Inc.

November 2008

NWI-5032-001

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APPENDICES

Appendix A–SSHP/APP Training Sign-off Sheet

Appendix B–Safety Walkthrough Checklist

ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygiene
ACM	asbestos containing material
AFB	Air Force Base
APP	Accident Prevention Plan
APR	air-purifying respirator
CFR	Code of Federal Regulations
CIH	Certified Industrial Hygienist
COR/PI	Contacting Officer Representative/Principal Investigator
CPR	cardio-pulmonary-resuscitation
dBA	decibel A-Weighted
EM	Engineer Manual
EMR	Experience Modification Rate
EPA	Environmental Protection Agency
ER	Engineer Regulation
FM/UL	Factory Mutual/Underwriters Laboratory
GFCI	Ground Fault Circuit Interrupter
HASP	Health and Safety Plan
HAZCOM	Hazard Communication
HEPA	high efficiency particulate air
HSD	Health and Safety Director
HSP	Health and Safety Procedure
HTRW	Hazardous, Toxic, and Radioactive Waste
LEL	lower explosive limit
LO/TO	lockout/tagout
LTA	lost time accident

MSDS	Materials Safety Data Sheet
MSHA	Mine Safety and Health Administration
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NMED	New Mexico Environment Department
North Wind	North Wind, Inc.
OSHA	Occupational Safety and Health Administration
PAPR	powered air-purifying respirator
PCB	polychlorinated biphenyl
PEL	permissible exposure limit
PID	photoionization detector
PM	Project Manager
PPE	Personal Protective Equipment
ppm	parts per million
QC	Quality Control
SI	site investigation
SS	Site Supervisor
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TPH-DRO	total petroleum hydrocarbon-diesel range organic
TPH-GRO	total petroleum hydrocarbon-gasoline range organic
USACE	U.S. Army Corps of Engineers
VOC	volatile organic compound
ZIP	Zero Incident Performance

North Wind, Inc. Site Specific Health and Safety Plan / Accident Prevention Plan for Final Closure of Solid Waste Management Units 70 and 71, Cannon Air Force Base, New Mexico

1. BACKGROUND INFORMATION

This North Wind, Inc. (North Wind) Site-Specific Health and Safety Plan/Accident Prevention Plan (SSHP/APP) establishes the scope and procedures that will be used to identify and minimize health and safety hazards to persons performing the final closure actions of Solid Waste Management Units (SWMUs) 70 and 71and at Cannon Air Force Base (AFB), New Mexico (see Figure 1). This document contains information about common work hazards and specific actions and equipment that may be used to protect workers. The intent of this document is to serve as a site safety, health, and accident prevention plan for known hazards and a contingency plan if new hazards are encountered or emergencies arise.

This SSHP/APP is prepared in accordance with the United States Army Corps of Engineers (USACE) Engineering Manual (EM)-385-1-1, Safety and Health Manual, Section 28, "Hazardous Waste Operations and Emergency Response" (USACE, 2003). Though a rigorous effort has been made to address the project and site-specific health and safety hazards personnel should be aware additional hazards, not addressed in this document, may be present and should be addressed accordingly by North Wind and Cannon AFB personnel. Additionally, general health and safety policies and guidance can be obtained from the *Cannon Basewide AFB Health and Safety Plan* (USACE, 2000). A copy of the Basewide Health and Safety Plan (HASP) will be readily available at the work site for all personnel.

1.1 Scope

The Omaha District of the USACE has tasked North Wind with performing a site investigation (SI) to determine contaminant concentration in soil surrounding four SWMUs. Soil borings will be performed and results of soil analysis will be reported to determine follow on actions. This project is being performed under contract No. W9128F-04-D-0017-0029.

This SSHP/APP governs all tasks associated with the SI activities. All tasks will be performed by North Wind personnel and Subcontractor personnel. Persons not normally assigned to work at the site, such as representatives of the State of New Mexico, Occupational Safety and Health Administration (OSHA), New Mexico Environmental Department (NMED), and USACE are not considered field team members.

Changes to this SSHP/APP may be required during field operations based on new hazards encountered or modification to required personal protective equipment (PPE). SSHP/APP changes may be implemented by the Site Supervisor (SS) with approval from the Health and Safety Director (HSD).

This document was written with the intent to provide applicable site-specific health and safety guidelines that are in accordance to USACE and OSHA regulations. Though effort has been made to address health and safety hazards that will or may be present on-site, additional hazardous conditions may be identified that are not addressed by this SSHP/APP. If additional hazardous conditions are identified they shall be reported immediately to the project or field manager to be addressed accordingly.

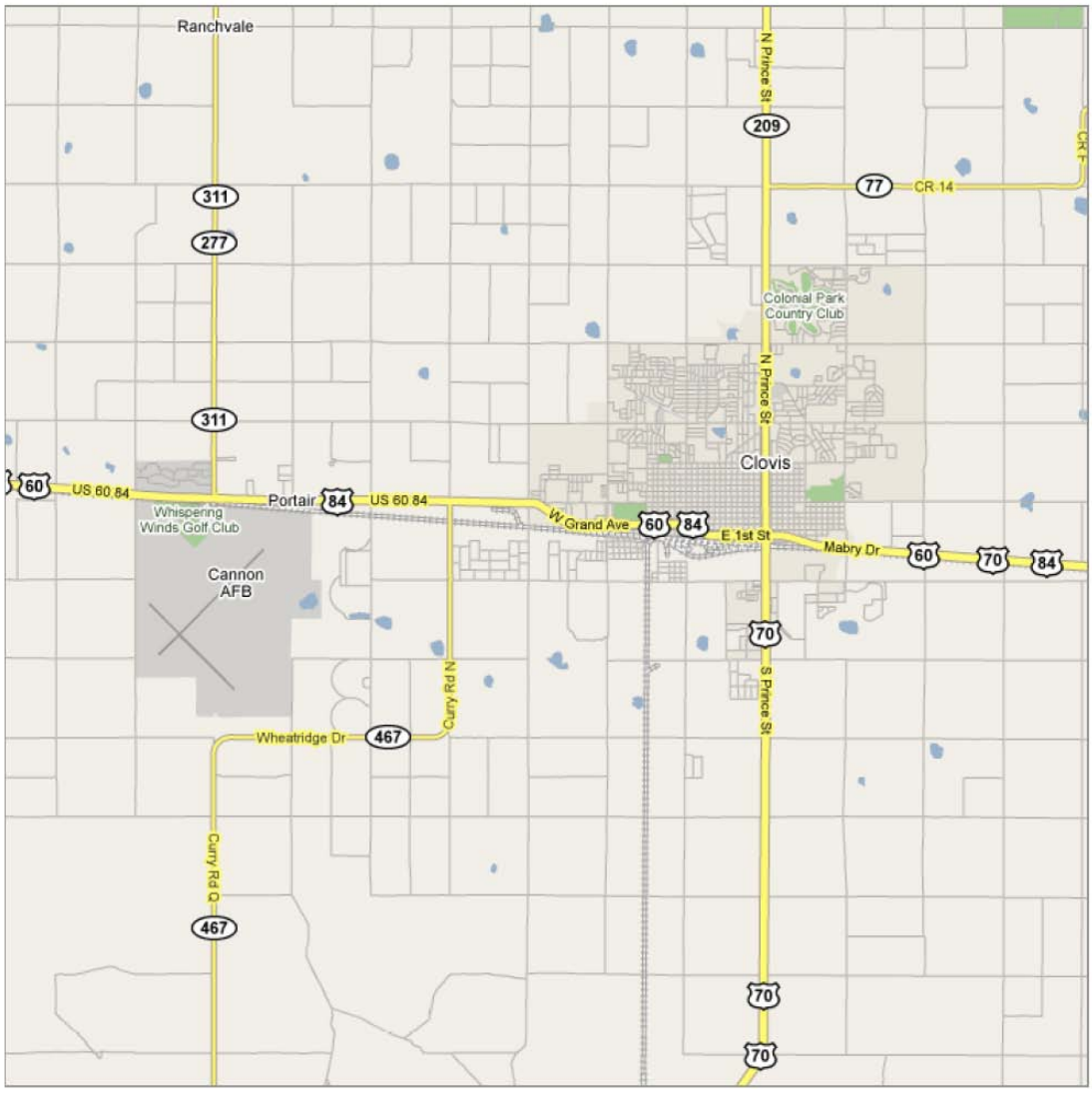

Figure 1. Location of Cannon AFB, New Mexico.

1.2 Site Information and Scope of Work

SWMUs 70 and 71are identified on Cannon's RCRA Permit decision letter dated February 27, 2006 as "requiring additional corrective action" before sites can be petitioned for corrective action complete. The goal of this objective is to achieve the requirement stated in the permit through assessment, data collection, data analysis and processing, concluding with NMED's administrative support for approving and granting each SWMU corrective action completed.

North Wind has been tasked to perform an SI and perform a total of 20 soil borings over the four sites, analyze the soil samples, and prepare a report with recommendations. Table 1 identifies areas of interest for the SI and the chemical contaminants of interest at each site.

Table 1. Sites and Contaminants of Interest at Cannon AFB.

Site Inspection Field Work Site	Contaminants of Interest
SWMU 70	TPH-DRO, TPH-GRO, VOCs, SVOCs, metals, pesticides/PCBs
SWMU 71	TPH-DRO, TPH-GRO, VOCs, SVOCs, metals, pesticides/PCBs

PCB = polychlorinated biphenyl
SVOC = semivolatile organic compound
TPH-DRO = total petroleum hydrocarbon-diesel range organic
TPH-GRO = total petroleum hydrocarbon-gasoline range organic
VOC = volatile organic compound

1.2.1 Soil Sampling

Subsurface soil will be investigated at each site as discussed in the following sections. North Wind field staff will accomplish all field work performed during this project.

1.2.1.1 Soil Investigation

Subsurface soil samples will be collected and analyzed to determine the nature and extent of any contamination at the Site. Soil samples will be collected in accordance with ENVP-008, *Soil Sampling* (North Wind 2006a).

A total of 10 soil borings are planned. Seven borings will be installed at SWMU-70 and three at SWMU-71. Two subsurface soil samples will be collected from each of the 10 borings. Soil obtained from direct push tooling will be collected from freshly opened tubes or sleeves. Samples to be analyzed for volatile organic compounds (VOCs) will be collected first followed by samples to be analyzed for less volatile parameters and finally metals. Samples will be collected and placed into appropriate containers using the sampling methods outlined below.

All personnel handling sampling equipment or opening sample containers will don a new pair of nitrile gloves prior to collecting each sample. Soil samples will be collected with decontaminated or unused disposable equipment. A photoionization detector (PID) will be use as a screening tool to measure the organic vapor concentrations during soil sampling activities. PID monitoring will be conducted according to procedure ENVP-019, *MiniRAE Photoionization Detector* (North Wind 2007a).

1.2.2 Demobilization

Equipment required for the SI will be demobilized from the site upon completion of these tasks.

1.2.3 Project Close Out

Descriptions of the sampling tasks discussed above are provided in the Work Plan.

1.3 Affected Personnel

All persons seeking admittance to the project site, including USACE personnel and their contractors, site visitors, subcontractor personnel, and governmental inspectors are subject to the provisions of this SSHP/APP. All personnel who require access to the work area will contact the SS for entry unless authorized to enter these areas for the duration of the contract period.

1.4 Additional Safety Information

North Wind has a declining Experience Modification Rate (EMR) that is currently at 0.72. All proactive safety and health practices as well as the North Wind safety culture will be instilled in all North Wind projects. Table 2 provides North Wind's safety statistics for 2007.

Table 2. North Wind 2007 Safety Information.

Hours Worked	Total Recordable Injuries	Total Recordable Illnesses	Recordable Injury Incidence Rate	Total Lost Time Injuries	Lost Time Injuries Incidence Rate	Days Away, Restricted or Transferred (DART)	Experience Modification Rate
482,524	2	2	0.82	1	0	0.41	0.72

2. NORTH WIND SAFETY AND HEALTH POLICY

North Wind safety and health policy is based on a sincere desire to eliminate personal injuries, occupational illnesses, environmental releases, damage to equipment and property, as well as to protect the general public.

Every employee and subcontractor of North Wind is charged with the overall responsibility of preventing incidents and eliminating conditions that can lead to occupational injuries and illnesses. It is the North Wind project manager's (PM's) responsibility to provide a safe work environment. Likewise, management can only give meaning to the Safety and Health Program if they take positive action to ensure that safety and health rules are adequate, enforced, and that effective training programs are employed.

North Wind recognizes that nearly all occupational injuries and illnesses are preventable, and that a high level of safety performance provides long-term beneficial returns including healthy employees and a productive work environment. Therefore, safety will not be compromised. It is fully accepted as an integral part of the North Wind organization and daily project activities. ***North Wind's goal is ZERO occupational illnesses, injuries or environmental releases – Zero Incident Performance (ZIP)*.**

This SSHP/APP adopts, by reference, the implementing procedures contained in the North Wind, Inc. *Corporate Environmental Health and Safety Program*, the USACE Safety and Health Requirements Manual, EM 385-1-1, and the USACE Safety and Occupational Health Requirements for Hazardous, Toxic, and Radioactive Waste (HTRW) Activities, Engineer Regulations (ER) 385-1-92 (USACE, 2007), as appropriate for the scope of work elements.

3. RESPONSIBILITIES AND LINES OF AUTHORITY

All personnel involved with this project will follow the health and safety requirements set forth in this SSHP/APP. Visitors will not be given entry to active work areas unless they meet all training requirements, are briefed on project site hazards and mitigation, and wear appropriate PPE. Evidence of training on SSHP/APP topics will be documented on a training acknowledgement form or equivalent. All other regulatory required training or USACE required training will be documented in accordance with the applicable regulatory or security requirements. Figure 2 shows the organizational structure including communication and authority for safety.

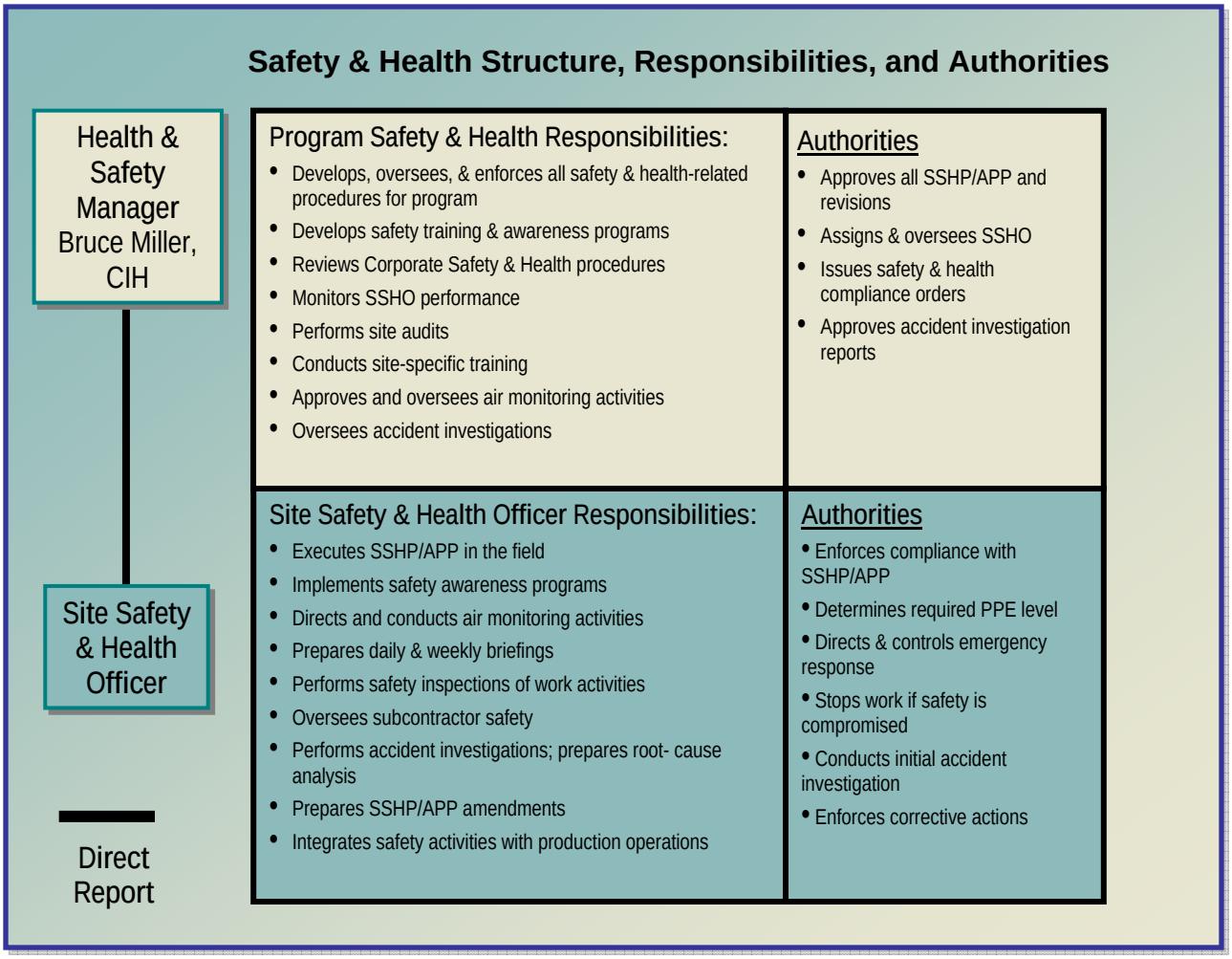

Figure 2. Safety and Health Structure, Responsibility, and Authority.

3.1 North Wind Program Manager

The North Wind Program Manager, Mr. Rusty Gilbert, is responsible to ensure USACE contractual requirements are met with respect to this scope of work. This includes all schedule, budget, and reporting requirements.

3.2 Project Manager

The North Wind PM, Mr. Tom Matzen, has overall responsibility to ensure the project meets all technical objectives in a safe manner. This includes ensuring that adequate staff and resources are available to implement the SSHP/APP.

3.3 Site Supervisor

The SS will be the person on site who has responsibility for ensuring all field activities are conducted in accordance with the Work Plan. The SS will also direct subcontract personnel and interface with the North Wind PM. The SS will also serve as the Site Safety and Health Officer (SSHO) for caretaker tasks

and in the role of competent person where qualified. The SS will monitor site activities to verify the SSHP/APP is being followed and perform the SSHO functions listed below for caretaker tasks. The SS oversees the safety of any visitors who enter the site and will serve as their escort if not trained to the SSHP/APP requirements. The SS maintains regular communication with the North Wind PM and reports to the North Wind HSD with all safety issues or concerns when serving in the capacity of the SSHO.

3.4 Site Safety and Health Officer

The SSHO will be responsible for implementation and enforcement of the health and safety aspects of this SSHP/APP. The SSHO will also implement and enforce applicable North Wind, Inc. Corporate Environmental Health and Safety Program implementing procedures at the project site. The SSHO will conduct the pre-job briefing and tailgate meetings, and will interface as required with the North Wind HSD and the North Wind PM to resolve safety related issues.

Health and safety related issues and concerns will be brought to the attention of the SS and documented in the SS field log book. Example entries may include daily safety meeting, training given, first aid administered, any incidents of a health and safety nature, inspections conducted, and emergency incidents or conditions.

3.5 Quality Control Specialist

The quality control (QC) specialist will conduct and document daily safety and occupational health inspections in the daily QC reports. For this project, the SSHO will also serve as the QC Specialist and meet all requirements for this position.

3.6 North Wind Health and Safety Manager

The North Wind HSD, Mr Bruce Miller, serves as the key resource for all health and safety issues and regulatory compliance as well as serving as the project Certified Industrial Hygienist (CIH). Responsibilities include review and approval of this SSHP/APP and all North Wind safety and health procedures, development and interpretation of regulatory required programs and procedures, determining medical surveillance requirements, investigating all incidents involving injuries or illnesses, and providing consultation for all field operations on matters related to safety and health. The SSHO will report all safety and health problems or issues to the North Wind HSD. Figure 3 provides an organization chart identifying personnel and their respective roles.

3.7 Site Workers and Visitor Safety Responsibility

All workers and site visitors have a personal responsibility to ensure they recognize site hazards and take appropriate action to minimize exposure to these hazards and report newly identified hazards. Personnel who enter active North Wind controlled work areas will receive a SSHP/APP briefing and shall wear all required PPE as directed by the SSHO. All personnel will follow the policies set forth in this SSHP/APP as well as any other site-specific safety documents that are developed and regulatory requirements. Visitors may be prohibited from entering certain North Wind controlled work areas of the site or during hazardous operations (i.e., during electrical disconnects). Casual visitors with no official business at the work site will not be allowed to enter the North Wind controlled work areas.

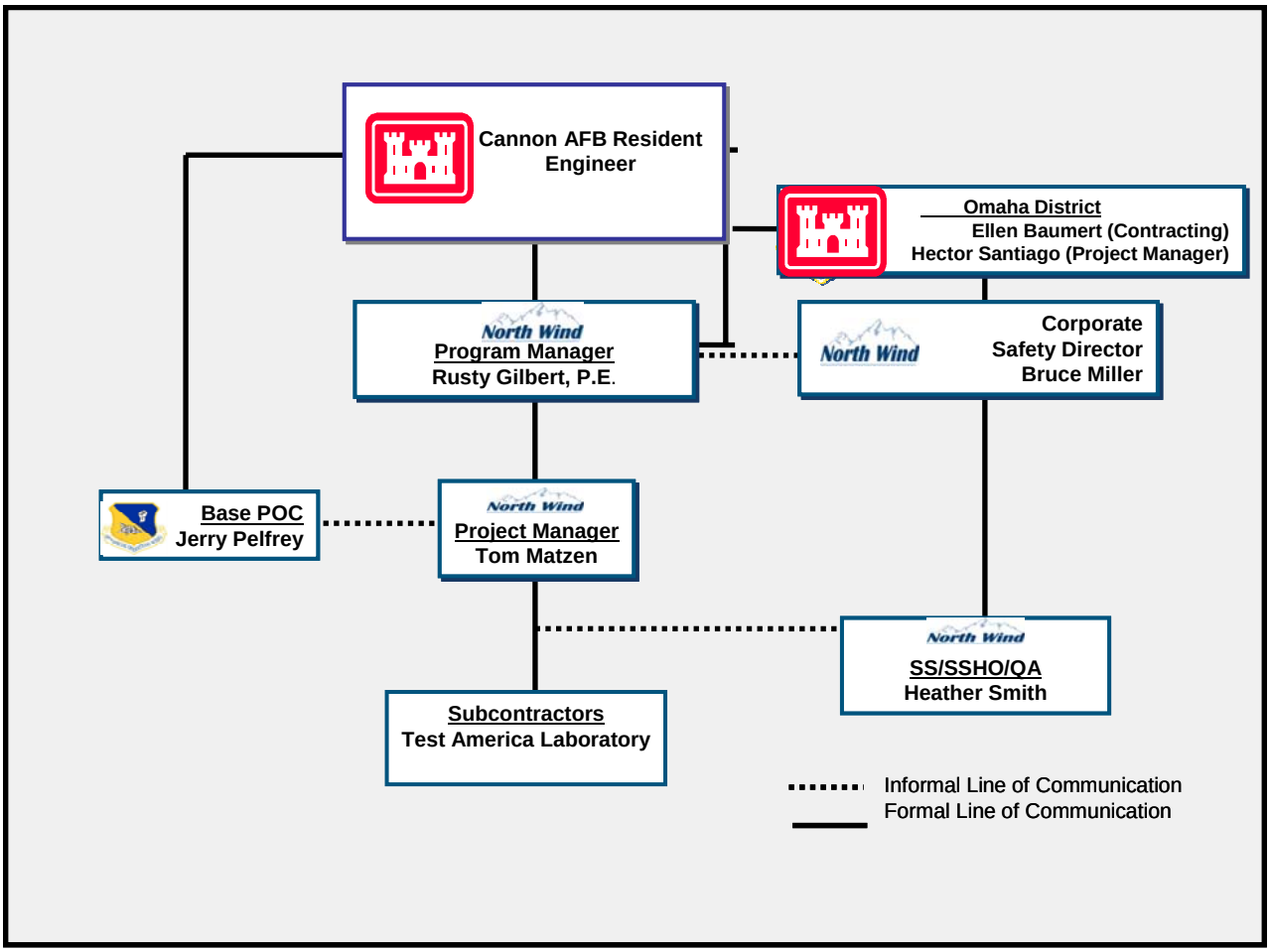

Figure 3. Organization chart for the soil borings task at Cannon AFB SWMUs 70 and 71.

4. SUBCONTRACTORS AND SUPPLIERS

All subcontractors will comply with the requirements established in this SSHP/APP. Subcontractors shall be fully contracted, licensed and insured, and shall follow all applicable OSHA, Environmental Protection Agency (EPA), and State of New Mexico regulatory requirements associated with their scope of services. Evidence of insurance and required licenses will be provided to the PM prior to starting subcontracted tasks. In addition, subcontractor workers and supervisors shall attend the required SSHP/APP training and tailgate safety briefings and meet all other applicable training requirements specified by the SSHO. Each subcontractor will designate a single representative with whom the SS will communicate. Each subcontractor has sole responsibility for their employees.

North Wind will observe subcontractors' safety performance to ensure compliance with this SSHP/APP. Individual subcontractors are responsible for observation of hazards and unsafe practices of their personnel and taking the appropriate corrective action to eliminate or mitigate all hazards. All unsafe acts, conditions, or incidents will immediately be brought to the attention of the North Wind SSHO, PM, and North Wind HSD. Health and safety related communications with North Wind and their subcontractors shall be conducted as follows:

- The SS will train all North Wind and subcontractor personnel on the provisions of this SSHP/APP and ensure each subcontract employee signs the Training Acknowledgement Form included in Appendix A prior to their beginning work. A copy of the SSHP/APP will be provided for subcontractor detailed review.

- Subcontractors shall brief their project team each morning, and/or prior to start up of major tasks (e.g., tailgate safety meeting) on the hazards, associated mitigation, and emergency actions related to their scope of services. A sign-up sheet to document daily safety briefings is attached at Appendix A.

- Immediately notify the North Wind SS of any injuries, illnesses or near misses at the project work site.

- Notify the SS of any government or regulatory representatives requesting access to the project site if a North Wind representative is not present.

- When apparent non-compliant or unsafe conditions or practices are observed, the SSHO or SS will halt subcontractor work as necessary in accordance with North Wind HSP-015, *Step Back and Stop Work Authority* (North Wind, 2007b) then notify the subcontractor representative and require corrective action be taken. The subcontractor is responsible for determining and implementing necessary controls and corrective actions. Following any stop work action, subcontractor work will only commence after providing a written corrective action to North Wind using HSF-015.1, *Stop Work Action Form* for approval. Authorization to restart work will be issued by the North Wind SS with concurrence from the PM. The HSD will be notified of all stop work actions taken.

- When hazard creating an apparent imminent danger is observed by any person on the work site, subcontractor personnel shall: 1) immediately stop work and place all equipment in a safe configuration, 2) remove all affected employees from the effected area, and 3) notify the North Wind SSHO or SS. Work will not commence until the hazard can be eliminated or mitigated to the satisfaction of the SSHO and HSD in accordance with North Wind HSP-015 and associated completed HSF-015.1. (The SS will immediately notify the PM and HSD). Also, notify the client PM. Emergency contacts are listed in Table 3 in Section 11 as appropriate based on the nature of the incident.

- If repeat non-compliant or unsafe conditions/acts are observed, additional actions will be taken including, but not limited to, removal of unsafe or non-complaint subcontractor employee from the project site as deemed appropriate by the North Wind SS or termination of the subcontract.

- Subcontractors and individual subcontractor personnel are responsible for ensuring the safety and compliance with all applicable OSHA requirements of all suppliers and venders who may enter the site to deliver materials or supplies. A SSHP/APP trained subcontract representative will escort all suppliers and vendors at all times when on site.

Where subcontractors fail to comply with SSHP/APP or other contractual requirements, their contract may be terminated by North Wind.

5. EMPLOYEE TRAINING AND INFORMATION

The SSHP/APP is designed to provide information necessary to assure that personnel are aware of the hazards associated with the tasks to be performed and the materials that they will be working with. All workers will be required to provide objective evidence of having met required training requirements as applicable to their tasks. A copy of training records, certificates, or cards shall be provided to the North Wind PM prior to initiating project tasks or at the initial SSHP/APP briefing.

5.1 Site-Specific Work Scope and Health and Safety Training

All workers and subcontractors assigned to the project who enter North Wind controlled work areas shall attend initial SSHP/APP training. Prior to entering the work areas, all personnel shall also participate in a daily safety briefing. Visitors will receive project training based on their access requirements to the specific facility area. Visitors requesting access to North Wind controlled areas must have a demonstrated need to access the area and meet all other applicable SSHP/APP, USACE EM 385-1-1 OSHA required training requirements and have objective evidence (training certificates or cards) before entry to controlled areas will be allowed.

5.2 SSHP/APP Briefing Content

The SSHP/APP briefing shall include a review of the SSHP/APP including activity hazard analysis, project-specific hazard communication information, review of applicable Material Safety Data Sheets (MSDS) for all chemicals brought on site, and emergency actions. Additionally, personnel will review PPE requirements and the proper use and limitation of Level D PPE, any specialized equipment, and applicable work control and safety procedures such as lockout/tagout (LO/TO) or confined space.

5.3 Attendance Documentation

All attendees of the SSHP/APP training shall sign a training acknowledgment form (Appendix A) verifying their attendance and acknowledgement that the information presented is understood and will be complied with. This briefing shall be held on or near the site during the mobilization phase of the project and before any work is started. Specialty subcontractors will be briefed prior to the start of their work tasks.

5.4 Daily Safety Briefings

Daily “tailgate” safety briefings shall be used to augment the SSHP/APP briefing and address site-specific concerns and any changes that arise during the course of the work. Prior to entering designated work areas, all personnel shall participate in a daily safety briefing.

Where separate project activities prohibit all personnel from attending a single safety briefing, each work group will conduct a briefing. Documentation of attendance of the tailgate safety briefing shall be maintained in the SS logbook. All personnel and subcontractors are encouraged to contribute suggestions during tailgate safety briefings on how to more effectively and safety complete project tasks based on ongoing lesson learned.

5.5 Equipment Operator Required Training and Qualifications

Documentation of the training and/or qualifications for equipment operators as required by 29 Code of Federal Regulations (CFR) 1926, *Safety and Health Regulations for Construction* shall be provided to the North Wind SS or PM as requested. Anticipated training certification or qualifications will be required as follows:

- Heavy equipment operator (training qualification).

Where subcontractors serve as OSHA-competent or qualified persons (29 CFR 1926.32, *Definitions*) for specialty work (i.e., excavation, fall protection, scaffolds or cranes), the Subcontractor competent or qualified person will provide objective evidence of training and qualifications to the SS prior to serving in

this capacity using North Wind Form HSF-102, *Competent Person Designation* (North Wind, 2007c). Subcontractors are responsible for compliance with all applicable OSHA, EPA, state, and federal requirements regardless if they are called out in this SSHP/APP or not.

5.6 Hazard Communication

To ensure 29 CFR 1910.1200, *Hazard Communication (HAZCOM)* requirements are met, the following training and information will be provided. General hazard communication training will be provided as part of the SSHP/APP briefing. This will include the requirement for all subcontractors to provide the North Wind SS with a copy of MSDSs for any chemical brought on site (prior to use), its intended use and potential to impact other project workers and activities, location of MSDS at the site, and PPE requirements for use of chemical products. Chemicals containing recognized carcinogens will not be brought on site or used without the approval of the North Wind HSD. Subcontractors are responsible for providing HAZCOM training to their personnel and to provide the North Wind SS with copies of objective evidence of HAZCOM training.

5.7 Other Regulatory Required Training

Project personnel will be trained to all applicable OSHA regulatory training requirements based on the project activities. This may include confined space entry (29 CFR 1910.146, *Permit-Required Confined Spaces*, 29 CFR 1926, Subpart M, *Fall Protection*, 29 CFR 1910.147, *The Control of Hazardous Energy (LO/TO)*, and associated North Wind Health and Safety Procedures (HSPs). Evidence of training will be provided to the North Wind SS prior to conducting these activities.

5.8 Subcontractors and All Site Visitors

All subcontractor personnel requiring unescorted access to North Wind controlled work areas shall be briefed on the SSHP/APP and relevant daily safety briefing topics. Subcontractors will sign the appropriate training SSHP/APP and other forms and wear a minimum of Level D PPE at all times.

Where subcontractors serve as OSHA competent or qualified person (29 CFR 1926.32) for specialty work (i.e., excavation, fall protection, scaffolds, cranes, or underground construction), the Subcontractor will complete a North Wind Form HSF-102 for each qualified person and provide objective evidence of training and qualifications to the North Wind PM prior to serving in this capacity. Subcontractors are responsible for compliance with all applicable USACE EM 385-1-1, OSHA, EPA, state, and federal requirements regardless if they are called out in this SSHP/APP or not.

Visitors will receive an abbreviated SSHP/APP briefing on the general hazards, associated controls and site requirements, PPE requirements, and emergency actions. PPE training may also be conducted for visitors required to wear hard hats and safety glasses. Visitors who have not met the requirements for unescorted access will be escorted (line of site) by the SS or designee at all times.

5.9 Emergency Response Training

Emergency Response Training requirements will include review of this SSHP/APP and training on all requirements listed in Section 11.2, “Emergency Response Plan.”

6. SAFETY AND HEALTH INSPECTIONS

Site inspections will be conducted throughout the project to verify compliance with the SSHP/APP. These inspections will be conducted by the SSHO for all field activities. Other inspections may be conducted by the QC Specialist as required by the Quality Assurance Plan. The SSHO and QC specialist shall provide a copy of their qualifications to the PM and HSD for approval. A standardized site safety inspection form will be used to document the inspection. The SS will also conduct a weekly inspection of the project site with the SSHO. Inspection records will be kept on file by the SS. In addition, personnel assigned as competent persons for specific activities such as excavation, LO/TO, or fall protection will be responsible for conducting and documenting inspections in accordance with the applicable regulatory requirement.

Identified safety and health issues and deficiencies, and the actions, timetable, and responsibility for correcting the deficiencies, shall be recorded in inspection reports and reported to the North Wind HSD for tracking purposes. Where deficiencies can be corrected on the spot, the SS and SSHO will take necessary actions to correct them. Pertinent information related to any deficiencies found shall be documented including the date, description of the deficiency, person responsible for correcting the deficiency, proposed deficiency resolution date and actual date resolved. Follow-up inspections to ensure correction of any identified deficiencies shall be conducted and documented in a like manner using the same inspection forms.

Objective evidence of the identified competent person's and qualified personnel's training records for these positions will be submitted to the PM prior to initiating project tasks on site. Copies of these training records will be available for review by USACE project personnel or Cannon AFB Environmental Restoration personnel.

No external inspections/certifications (e.g., USACE) have been identified for this project.

7. SAFETY AND HEALTH EXPECTATIONS, INCENTIVE PROGRAMS, AND COMPLIANCE

7.1 Safety and Health Goals

North Wind recognizes that nearly all occupational injuries and illnesses are preventable, and that a high level of safety performance provides long-term beneficial returns including healthy employees and a productive work environment. Therefore, safety will not be compromised. It is fully accepted as an integral part of the North Wind organization and daily project activities. North Wind's ZIP goal is the target for all projects.

It is the policy of North Wind to expect the highest degree of professionalism from its employees and subcontractors during the course of all projects. Starting at the hiring and subcontracting process, North Wind interviews prospective employees and subcontractors to assess their safety awareness and attitude. This includes review of subcontractor recordable injury and illness/lost workday incidence rates and EMRs.

7.2 Safety Incentives

The primary incentive for conducting all work in a safe and healthful manner is continued success of North Wind, which directly benefits every employee and subcontractor. Safety awards (jackets, gift certificates, spot bonuses) are occasionally given out to highlight exceptional safety awareness or actions.

North Wind has established an annual Safety Award for the project with the best safety record and most innovative proactive safety awareness training for employees and subcontractors. This award is presented to the winning PM during the annual North Wind Manager's Meeting by the President of North Wind.

7.3 Disciplinary Actions for Unsafe Acts

If an employee or subcontractor fails to follow North Wind health and safety requirements, then disciplinary actions (or contractual actions in the case of subcontractors) are taken. Actions will range from a written reprimand to termination. Subcontractors who fail to follow North Wind health and safety requirement are subject to removal from the project site or contract termination. Unsafe acts or environmental negligence will not be tolerated.

7.4 Accountability for Safety and Health

The *North Wind, Inc. Corporate Environmental Health and Safety Program*, describes how supervisors and PMs are held accountable for safety. The North Wind President is responsible for the overall North Wind health and safety program. The North Wind Program Manager has total accountability to the North Wind President to ensure North Wind projects are conducted in a safe and compliant manner. This policy is communicated to the assigned PMs, SSHO, and SSs who have the responsibility for implementing the Health and Safety Program and SSHP/APP requirements in the field.

All North Wind employees are responsible for their own safety and the safety of other individuals affected by their activities. These responsibilities include making a prompt report of any occupational injury, illness, spill/environmental release, or potential hazardous material exposure to the appropriate PM or SS. The North Wind PM is responsible for assuring that employees or subcontractors are not subject to discrimination or reprisal for responsible safety actions.

8. ACCIDENT REPORTING

All accidents no matter how minor will be reported to the SSHO and SS immediately. Depending on the nature of the event, additional notifications and reporting will be required as described below. The SS is responsible for collecting all information related to an accident on site in accordance with North Wind HSP-005, *Accident Reporting and Investigation* (North Wind, 2006b) including completion of North Wind HSF-005.1, *Incident Report Form*. The SS will take immediate actions to mitigate any accident or medical actions as described in Section 9. Except for rescue and emergency measures, the accident scene shall not be disturbed until it has been released by the investigating official.

The PM, Program Manager, North Wind HSD, and the Cannon AFB Environmental Restoration Manager (Mr. Gerald Pelfrey) will be notified within 1 hour of any accidents on site. Additionally, accidents that include any of the consequences listed below shall be immediately reported to the USACE PM and to the Cannon AFB Environmental Restoration Manager (Mr. Gerald Pelfrey). These accidents will be investigated in depth to identify all causes and to recommend hazard control measures and include:

- Fatal injury
- Permanent totally disabling injury
- Permanent partial disabling injury
- Three or more persons admitted to a hospital
- Property damage in an amount specified by USACE current accident reporting regulations.

9. MEDICAL SUPPORT AND SURVEILLANCE

9.1 Hearing Conservation

All personnel exposed to noise levels above 84 decibel A-Weighted (dBA) must have a baseline audiometric evaluation in accordance with 29 CFR 1926.52, *Occupational Noise Exposure*. Personnel shall receive hearing conservation awareness training concerning the hazards of noise and the procedures to properly use and maintain hearing protection. If any Subcontractor exposes his employees to noise levels above 84 dBA, the Subcontractor must establish a written hearing Conservation Program developed by a Competent Person as required by 29 CFR 1926.52. A copy of this program will be submitted to the North Wind PM for review and approval by the North Wind HSD.

9.2 Respiratory Protection

If respirators are required to be worn, then all requirements of 29 CFR 1910.134, *Respiratory Protection* will apply. North Wind personnel required to wear respiratory protection will meet all training and medical surveillance requirements of HSP-007, *Respiratory Protection* (North Wind, 2006c). Subcontractor personnel required to wear respirators will submit a copy of their respiratory protection plan or program to the North Wind PM for review and approval by the North Wind HSD prior to use of respirators at the site.

9.3 First-Aid/CPR

At least one person on site shall be First-Aid/Cardio-Pulmonary-Resuscitation (CPR) trained (American Red Cross course or equivalent) during all site active work periods. First aid will be provided on a voluntary basis and only within the level of training of the first aid provider on a voluntary basis. The names of the first-Aid/CPR trained personnel will be communicated to all project personnel during the SSHP/APP briefing and to all new personnel during their initial SSHP/APP briefing. Emergency medical treatment will be handled as described in Section 9.4.

9.4 Emergency Medical Treatment

In the event of a known or suspected injury or illness due to exposure to a hazardous substance, or physical agent, the worker(s) shall be evaluated by a first-aid/CPR trained worker and stabilized for transportation to the Eden Medical Center as required.

In the event a worker is injured or an illness is serious or requires emergency medical care beyond the capabilities of on-site first-aid/CPR trained personnel, the effected individual will be transported and treated at the Plains Regional Medical Center. **Directions to the Plains Regional Medical Center are provided in Table 5 and Figure 4 in Section 11.** If it is not safe to move the injured person, then they will be stabilized and treated for shock by a first aid/CPR trained worker until an ambulance arrives by contacting 911.

9.5 Medical Surveillance Requirements

Based on the nature of the work scope at Cannon AFB and activities to be performed, no OSHA 29 CFR 1910.1000, *Air Contaminants*, substance-specific medical surveillance requirements apply. Where use for certain PPE described below triggers OSHA medical surveillance, all applicable requirements will apply.

10. PERSONAL PROTECTIVE EQUIPMENT

All PPE for this project has been selected based on the hazards analysis for tasks to be conducted and materials that are anticipated to be encountered. Based on this analysis, the HSD has determined that Level D and modified Level D PPE will serve as the primary PPE for activities at the project sites. If additional hazards are encountered, action levels exceeded at the project site, or new task areas added, then the North Wind HSD will be contacted and hazards evaluated by the SSHO in accordance with North Wind, HSP-001, *Project Hazard Analysis* (North Wind, 2006d) to determine the appropriate level of PPE modifications. All such analysis documentation will be submitted by the SSHO to the North Wind HSD for approval and incorporation into this SSHP/APP.

Under no circumstances will PPE be modified without express approval from the HSD. If certain activities or conditions pose problems for workers using the assigned PPE, the HSD will be contacted to help resolve the problem. This SSHP/APP serves to meet 29 CFR 1910.132, *General Requirements* hazard assessment requirements for general tasks.

10.1 Required Personal Protective Equipment

Prior to use, all personnel will be trained on the proper use, maintenance and limitations of all PPE. Where specific OSHA standards such as Respiratory Protection govern required training, these will be required to be met. Other PPE (i.e., hard hats, safety glasses, and hearing protection training) will be provided during the initial SSHP/APP briefing.

10.1.1 Level D Personal Protective Clothing

The following constitutes Level D PPE for this task:

- Appropriate work clothes
- Hard hats (ANSI Z89.1, *Industrial Head Protection Standard*) (where overhead hazards exist)
- Sturdy leather boot above the ankles (safety toed boots for tank hoisting and rigging tasks – ANSI Z41-1991, *American National Standard for Personal Protection-Protective Footwear*)
- Safety glasses with side shields (ANSI Z87.1, *Occupational and Educational Personal Eye and Face Protection Devices*) and a face-shield for cutting tasks or where flying debris is anticipated
- Work gloves – leather for all material handling tasks (cut resistant for debris handling)
- High visibility/reflective vest
- Personal fall protection system for all tasks greater than 6 feet (where a protective guardrail system can not be established)
- Hearing protection where noise levels exceed 84 dBA
- Other PPE required for specific tasks (e.g., Tyvek coverall, cryogenic gloves, welding helmets, face shields, etc.).

10.1.2 Level C PPE

Level C respiratory protection is <u>*not*</u> *anticipated for this project.* This information is provided as a contingency only. If respiratory hazards requiring the use of Level C respiratory protection are identified, the North Wind HSD will be contacted for additional guidance.

Typical Level C PPE consists of (but not limited to) Level D ensemble with the addition of:

- Half-face or full-face air-purifying respirator (APR) with High Efficiency Particulate Air (HEPA) filter approved by the National Institute for Occupational Safety and Health (NIOSH)/Mine Safety and Health Administration (MSHA), such as a P100 respirator or powered air-purifying respirator (PAPR) equipped with HEPA filtered cartridges
- Tyvek hooded coveralls (or equivalent)
- Gloves – nitrile or latex inner, chemical resistant outer (nitrile or neoprene)
- Water-resistant overboots treaded to provide slip protection
- Hearing protection (as necessary).

10.2 Inspection of PPE

All PPE components must be inspected prior to use and when in use within work areas. Once PPE is donned, self-inspection will serve as the principle form of inspection. If at any time PPE should become damaged or unserviceable, an individual will inform others of the problem and proceed directly to the controlled work area exit point to doff and replace the equipment.

11. APP – APPLICABLE PLANS REQUIRED BY EM 385-1-1

The following items required by USACE EM 385-1-1, Attachment A, "Minimum Basic Outline for Accident Prevention Plan" are addressed below. Where required plans are not applicable they are so stated.

11.1 Layout Plans

Active work areas will be posted to prevent the public from entering work areas. All work areas, excavations, soil stockpiles, etc, will be cordoned off with construction ribbon.

11.2 Emergency Response Plan

11.2.1 Pre-Emergency Planning

Before starting site operations, the SS will implement emergency contingency planning actions that include:

- Identifying the location and route to emergency medical services
- Establishing site communications
- Designating emergency warning signal and evacuation routes

- Inventorying emergency equipment
- Communicating emergency procedures to personnel.

11.2.2 Personnel Roles, Lines of Authority

The SS takes the lead during site emergencies until off-site emergency responders arrive on-site. In cases of major emergencies, personnel will evacuate the site, contact local emergency responders, and rely on them to handle the emergency. Minor emergencies that are controllable on-site with emergency equipment located at the site will be addressed by on-site personnel with the approval of the SS.

11.2.3 Emergency Recognition and Prevention

The SS and subcontractor competent person will conduct an initial site safety briefing to review the requirements of the site safety plan with site personnel. This briefing will include discussions on the recognition, prevention, and control of emergencies anticipated on-site. Daily safety meetings will be held to emphasize emergency prevention and control measures.

11.2.4 Site Security and Control

Access to the site will be controlled by the SS until local emergency responders arrive. The SS will then relinquish site security/control to the authorized emergency response organization.

11.2.5 Site Communications

Site communications will provide means for both on-site and off-site communications. On-site communications will consist of verbal communications and line of sight observations. Off-site communications will be established to summon off-site emergency services and will consist of cellular telephones.

When reporting an emergency situation to off-site emergency responders, the following information must be provided:

- Name of person making the call
- Telephone number and location of person making the call
- Name of person(s) exposed or injured
- Description of exposure and emergency
- Actions taken
- Name and location of site contact for emergency, if other than caller.

Depending on the nature and severity of the event, the Cannon AFB Fire Department will arrive first and the Clovis response teams will arrive second.

Once a response team arrives, and regardless of the origin, on-site control of the event will be turned over to the responding Crew Chief, Incident Commander, or other person in charge.

Understand any injured person will be transported to Plains Regional Medical Center in Clovis. Cannon AFB has no hospital, only a clinic with limited capabilities. *Expect no treatment at the Cannon AFB Clinic.*

Table 3. Emergency contact information.

Contact	Phone
Fire, Local Police, Ambulance	911
Plains Regional Medical Center	(575) 769-2141
North Wind Program Manager – Rusty Gilbert	(210) 722-4074
North Wind PM – Tom Matzen	(785) 838-3141
North Wind HSD – Bruce Miller	(208) 520-4644
USACE PM – Mr. Hector Santiago	(402) 995-2738

11.2.6 Emergency 911 Calls

All cellular phone 911 calls are answered by CLOVIS Dispatch and land line 911 calls are answered by the local Fire Department Dispatch. The following information is important for a clear and timely emergency response:

1. When making a 911 cell phone call it is important to identify the location as "Cannon AFB."
2. Supply the dispatcher with requested information and the dispatcher will pass the information to Cannon AFB Fire Department.
3. Follow the Dispatchers instructions.

11.2.7 Emergency Equipment

The following emergency equipment will be located in the support area and will be immediately available for site emergencies:

- Portable fire extinguishers (minimum 20 lb-A/B/C)
- Industrial first aid kit
- Spill kit
- Portable eyewash station meeting ANSI Z-358.1-1998 requirements.

11.2.8 Emergency Alerting Procedures

A vehicle or air horn or verbal communication will be used to communicate emergency situations on-site. Any time an emergency signal is sounded on-site, site operations must temporarily cease and the emergency condition must be addressed. Table 4 lists horn signals to be used to warn personnel of specific emergency conditions and the need for a general site evacuation (if personnel are not within verbal communication distance).

Table 4. Horn signals used to warn personnel of specific emergency condictions.

Evacuation Alarm Description:		
Type of Alarm	**Number of Blasts**	**Response**
Warning	1 Blast	Prepare for emergency response–shut down ignition sources.
Emergency	2 Blasts	Initiate emergency response actions as directed by the SS
All Clear	Verbal Communication	Return to normal activities

11.2.9 Emergency Medical Treatment

In the event of a known or suspected injury or illness due to exposure to a hazardous substance, or physical or agent, the worker(s) shall be evaluated by a CPR first-aid trained worker and stabilized for transportation to a medical facility as required.

In the event of an employee injury or illness requiring emergency medical care beyond the capabilities of on-site CPR and first-aid trained personnel, the closest, capable medical facility shall be notified as defined below and the appropriate actions taken.

All personnel must be provided with concise, clear directions and transportation to local emergency medical treatment services. The name, location, and directions to the nearest hospital are available below:

Plains Regional Medical Center
2100 Martin Luther King, Jr. Blvd
Clovis, New Mexico 88101
General Phone (575)-769-2141

Table 5 provides driving directions from Cannon AFB to Plains Regional Medical Center. Figure 4 provides a map depicting these directions.

Table 5. Route to Plains Regional Medical Center:

Cannon Air Force Base, NM

	1. Head **northeast** on **Cannon AFB**	go 0.2 mi total 0.2 mi
	2. Turn **right** to stay on **Cannon AFB** About 3 mins	go 0.9 mi total 1.1 mi
	3. Turn **right** to stay on **Cannon AFB** About 3 mins	go 1.0 mi total 2.1 mi
	4. Continue on **N Perimeter Rd** About 1 min	go 0.4 mi total 2.6 mi
	5. Turn **right** at **N Torch Blvd** About 1 min	go 0.3 mi total 2.8 mi
60	6. Slight **right** to merge onto **US-60/US 60 84/US-84** About 5 mins	go 3.9 mi total 6.8 mi
	7. Turn **left** at **Curry Rd M/N Wheaton St** About 3 mins	go 1.0 mi total 7.8 mi
	8. Turn **right** at **W 21st St/Creek 11** Destination will be on the left About 3 mins	go 1.0 mi total 8.8 mi

2100 N Dr Martin Luther King Jr Blvd
Clovis, NM 88101

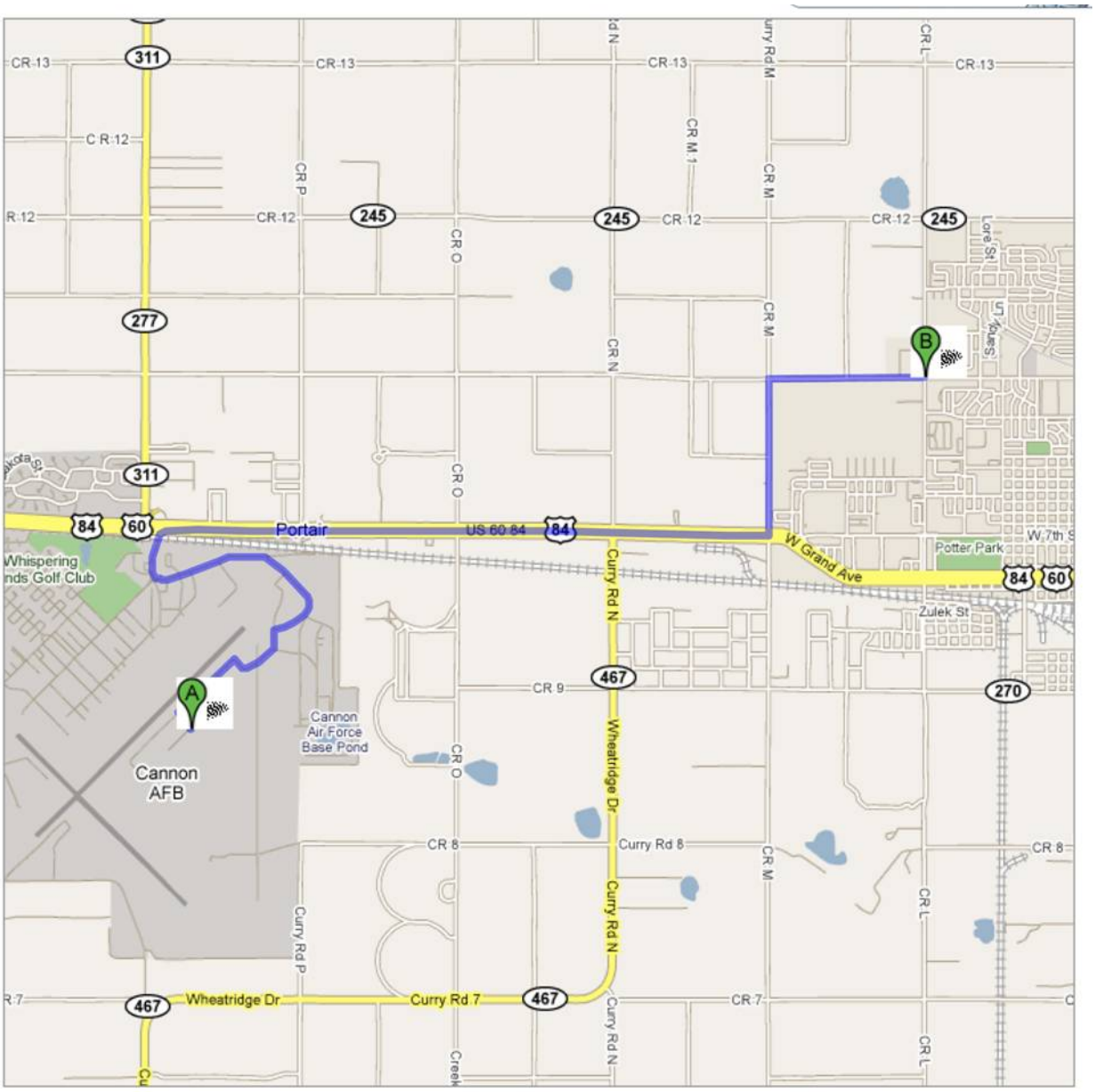

Figure 4. Driving route from Cannon AFB to Plains Regional Medical Center.

11.2.9.1 First Aid Procedures

First aid trained personnel shall only give first aid and stabilize an individual needing assistance. Life support techniques such as CPR and treatment of life threatening problems such as airway obstruction, and shock will be given top priority. At least one person trained in first aid/CPR shall be on-site during site operations. Professional medical assistance shall be obtained at the earliest possible opportunity.

11.2.9.2 Medical Emergency Actions

If actual or suspected serious injury occurs, perform the following steps:

1. Remove the exposed or injured person(s) from immediate danger.

2. Render first aid if necessary.

3. Obtain paramedic services or ambulance transport to local hospital. This procedure shall be followed even if there is no visible injury.

4. Evacuate other personnel in the work area to a safe distance until the SS determines that it is safe for work to resume. If there is any doubt regarding the condition of the area, work shall not commence until all hazard control issues are resolved.

11.2.10 Fire Emergency Actions

Portable fire extinguishers will be located in all work site vehicles and on each piece of mobile heavy construction equipment. The following procedures apply to fire emergencies on-site:

- Attempt to extinguish the fire through use of shovels and by discharging the contents of portable fire extinguishers in the area.

- If unable to extinguish the fire, sound the general site evacuation alarm and evacuate the site. If off-site fire emergency responders are required, notify using the 911 emergency exchange and provide detailed information on the fire emergency conditions.

- The SS will interface with the fire department upon arrival and provide technical assistance.

11.2.11 Fire, Explosion, Unknown Container Puncture

11.2.11.1 Evacuation Alarm

Either fire or explosion shall require a general evacuation alarm. All personnel will evacuate to a pre-designated rally point. Once all personnel are accounted for by the SS containment measures will be implemented.

11.2.11.2 Unidentified Containers

When an unidentified container of any sort is encountered in any activity, the Contracting Officer Representative/Principal Investigator (COR/PI) shall be notified by the Program Manager. If the container is still intact, the SS (in consultation with the Program Manager and COR/PI) shall determine the course to be followed for safe removal and disposal. If the container has been punctured or is leaking for any reason, the evacuation alarm shall be sounded immediately.

11.2.12 Emergencies/Releases/Spills in Adjacent Areas Not Under North Wind Control

The SS shall assess adjacent operations for potential hazards. Where the potential for personal exposure to uncontrolled hazardous releases from operations not under the control of North Wind exists, the SS in consultation with the North Wind HSD shall determine the potential risk, obtain hazard communication information, inform employees and provide for necessary control measures or additional contingency planning.

11.2.13 General Site Evacuation

A general site evacuation will be ordered in the event of a fire, explosion, spill or toxic vapor release where on-site personnel are unable to control the emergency condition. The SS, or designee, will collect a list of names or signatures at the off-site assembly area to account for site-specific project personnel. The daily tail-gate safety briefing sign-in sheet will be used to verify that all project personnel are accounted for. The assembly point location(s) will be chosen, identified, and described to all field personnel at each morning tail-gate safety meeting.

11.2.13.1 Safe Distance and Places of Refuge

The on-site assembly point will be located where site personnel are accounted for and emergency services are contacted. The SS will evaluate the emergency situation based on the hazards posed to site personnel remaining at the on-site assembly point, and then determine the need and location of further off-site evacuation and assembly points.

11.2.13.2 Evacuation Routes and Procedures

Evacuation routes will be designated such that direct evacuation occurs in an upwind direction. In cases of uncontrollable emergencies such as fire, explosion, or toxic vapor release, a site evacuation shall be implemented as follows:

1. Sound the emergency warning signal or verbally communicate the emergency
2. Stop work activities and evacuate the work area in an upwind direction
3. Assemble in safe area and account for personnel
4. Contact off-site emergency response services
5. Evacuate the areas as deemed appropriate.

11.2.14 Response Follow-up

The SS must complete HSF-005.1 for site emergencies within 24 hours of the incident. Incidents involving potential Lost Time Accident (LTA) injuries, recordable injuries or illnesses, property damage or emergencies causing general site evacuations must be reported immediately to North Wind Human Resources. The SS in conjunction with the HSD will identify the cause(s) of the incident and take action to prevent occurrence.

Emergency recovery operations will be conducting where required and incorporate requirements of EM 385-1-1, Appendix B, “Emergency Recovery Operations,” as applicable to the nature of the event.

11.3 Hazard Communication Program

The Hazard Communication program will be established for this project in accordance with North Wind HSP-002, *Hazard Communication* (North Wind, 2006e). Chemicals (e.g., fuels, lubricants, and cleaners) will be used in support of project activities. Project personnel will be required to have an MSDS for all chemicals used in accordance 29 CFR 1910.1200. All chemicals entering the project must be entered into and tracked on a chemical inventory form.

11.4 Lead Abatement Plan

Not applicable.

11.5 Respiratory Protection Program

Although not anticipated, Level C PPE may be required where exposure to petroleum products exceed airborne action levels. If action levels are exceeded, then air-purifying respirator will be required. All requirements of 29 CFR 1910.134, *Respiratory Protection* and North Wind HSP-007 will be complied with where respirators are used.

11.6 Health Hazard Control Program

Numerous potential physical, chemical and environmental hazards may be encountered during the performance of the work. This hazard assessment section documents the anticipated hazards associated with each project task and the controls and mitigative actions that are required to eliminate (where feasible) or minimize these hazards.

All personnel entering the project site need to understand the hazards and hazard mitigation associated with these issues. If new hazards are identified during the course of project activities, they will be evaluated and mitigated to prevent worker exposure or injury. All safety and health concerns will be brought to the attention of the subcontractor competent person and North Wind SS/SSHO.

11.6.1 General Safe Work Practices

The following are general safe work practices that shall be followed at the site to minimize potential exposure of personnel to hazardous situations:

- If appropriate, the work area(s) shall be delineated with rope, ribbon, cones or equivalent materials to prevent non-project personnel from entering the work area. Appropriate caution and warning signs will be posted based on the nature of the activities and hazards in accordance with the applicable 29 CFR 1926 and USACE EM 385-1-1 requirements based on the task(s) being conducted.

- Eating, drinking, chewing gum or tobacco, smoking, or any practice that presents the possibility of hand to mouth transfer and ingestion of chemical hazards is prohibited in North Wind controlled work areas.

- A clean area for breaks, eating, and smoking shall be established. Unless otherwise prohibited, smoking, fluid intake, and the use of rest room facilities shall be permitted in this area. A smoking receptacle shall be located in the break area.

- Excellent housekeeping shall be maintained at all times. All debris shall be collected in appropriately marked containers and all work areas kept free of such material.

- An industrial first aid kit shall be located on the project site or in the North Wind SS project vehicle at all times.

- Portable eyewash bottles shall be located in controlled work areas where there is a potential for chemical or debris eye hazards. Where required for chemical usage (i.e., battery maintenance), an eye wash station meeting the requirements of ANSI Z358.1-1998.

- At least one project vehicle or designated area at each controlled work site and each piece of heavy equipment will be equipped with a fire extinguisher.

- Personnel shall inform the SS of any symptoms of heat or cold stress experienced.

- Whenever flammable liquids are used, transferred, or handled, grounding and bonding shall be used to prevent a build up of static electricity and the resulting production of a spark. All equipment shall be shut down and allowed to cool prior to refueling.

- All PPE shall be worn as prescribed in this SSHP/APP and the applicable MSDS.

Table 6 presents activity hazards analysis for the major activities associated with this project. Sections 11.6.2, 11.6.3, and 11.6.4 provide physical, chemical, and environmental hazards (respectively) that may be encountered.

11.6.2 Physical Hazards

The subcontract competent person and North Wind SS/SSHO will observe the general work practices site personnel and subcontractors and enforce SSHP/APP requirements to minimize physical hazards associated with each task. Personal protective equipment such as hard hats (where overhead hazards exist), safety glasses, and heavy leather work boots are required in all active work areas at the site. Site-specific hazards and all necessary precautions will be discussed at the daily safety meeting.

Physical hazards may be encountered throughout the all phases of the project. The following sections describe some of the anticipated hazards and associated controls and mitigation to minimize accidents and injuries.

11.6.2.1 Slips, Trips, and Falls

- Clear walkways/work areas of equipment, tools, standing water/ice, and debris.

- Mark, identify, or barricade other obstructions.

- Maintain good housekeeping practices.

- Wear protective footwear with adequate tread for outdoor/indoor conditions.

- Maintain at least 3-point contact when ascending/descending ladders, scaffolding, and heavy equipment. Do not carry tools and equipment when ascending/descending ladders.

- Cover all floor and working surface openings to prevent falling into them.

- Route cords and lines around walkways, stairs, and entrances and exits to eliminate tripping hazards.

- Keep elevated walkways and platforms clear of potential tripping hazards at all times.

Table 6. Project Activity Hazard Analysis – Site Inspection and Soil Characterization.

Task	Work Activities	Potential Safety/ Health Hazard	Controls (See Applicable Section)	Equipment	Inspections	Required Training
Mobilization and Demobilization	• Mobilize / demobilize necessary equipment and materials • Set up work zones • Cleanup site • Remove and dispose of generated waste	• Back/muscle strains • Slips/trips/falls • Moving vehicles • Injury from hand or power tools • Struck by or against equipment • Pinch points	• Material Handling and Back Strain (Section 11.6.2.6) • Slips, Trips, and Falls (Section 11.6.2.1) • Heavy Equipment Operations (Section 11.6.2.18) • Powered and Hand Tools (Section 11.6.2.9) ***PPE: Level D***	• Vehicles • Hand tools	• Pre-operational equipment inspection • Hand and power tools	• Review SSHP • Qualified equipment operator (as applicable) • Review of Cannon AFB regulations

Table 6. (continued).

Task	Work Activities	Potential Safety/ Health Hazard	Controls (See Applicable Section)	Equipment	Inspections	Required Training
Soil Boring	• Geoprobe direct push • Compressed gases • Methanol (or other solvent)	• Back/muscle strains • Slips/trips/falls • Heavy equipment operation • Class IV Laser • Petroleum hydrocarbon exposure • Skin/eye hazards	• Material Handling and Back Strain (Section 11.6.2.6) • Slips, Trips, and Falls (Section 11.6.2.1) • Heavy Equipment Operations (Section 11.6.2.18) • Petroleum Fuel Products (Section 11.6.3.3) ***Other:*** • Establish control zones • Wear nitrile gloves when cleaning boring rods ***PPE: Level D with safety glasses or goggles, and hearing protection (if needed).***	• Geoprobe • Hand tools	• Check cylinder storage (upright, secure) • Operate per training and manufacturer's instructions • PID used for screening of soil and background VOC exposure levels.	• Qualified equipment operator • Read and be familiar with MSDS for any chemicals used. • Review of Cannon AFB regulations

Table 6. (continued).

Task	Work Activities	Potential Safety/ Health Hazard	Controls (See Applicable Section)	Equipment	Inspections	Required Training
Grouting / Asphalt Patch Boreholes	• Mixing, pumping, pouring grout • Cold asphalt	• Back/muscle strains • Slips/trips/falls • Struck by or against equipment • Injury from tools • Noise • Particulate hazard from mixing grout • Pinch points and eye/head injuries • Sharps.	• Material Handling and Back Strain (Section 11.6.2.6) • Slips, Trips, and Falls (Section 11.6.2.1) • Heavy Equipment Operations (Section 11.6.2.18) • Petroleum Fuel Products (Section 11.6.3.3) • Noise (Section 11.6.2.5) • Sharp Objects (Section 11.6.2.3) ***Other:*** • Don proper PPE: leather gloves, safety glasses, hardhat. ***PPE: Level D, plus hearing protection (as applicable)***	• Geoprobe hydraulic grout pump	• Hand and power tools	• Review SSHP • Review of Cannon AFB regulations

Table 6. (continued).

Task	Work Activities	Potential Safety/ Health Hazard	Controls (See Applicable Section)	Equipment	Inspections	Required Training
Collect Soil Samples	• Sample collection	• Back/muscle strains • Slips/trips/falls • TPH exposure • Potential laceration while cutting acetate liner	• Material Handling and Back Strain (Section 11.6.2.6) • Slips, Trips, and Falls (Section 11.6.2.1) • Petroleum Fuel Products (Section 11.6.3.3) • Sharp Objects (Section 11.6.2.3) ***PPE: Level D***	• Hand sampling tools	• Inspect general area for loose soils, cobbles, debris, etc.	• Review SSHP • Review of Cannon AFB regulations

Table 6. (continued).

Task	Work Activities	Potential Safety/ Health Hazard	Controls (See Applicable Section)	Equipment	Inspections	Required Training
General	• Varied	• Adverse weather • Slip, trips, falls • Electrical hazards • Material handling • Noise • Heat or cold stress • Heavy equipment operations • Flammable / combustible materials • Handling sharp items	• Inclement Weather (Section 11.6.4.2) • Slips, Trips, and Falls (Section 11.6.2.1) • Electrical Hazards (Section 11.6.2.8) • Material Handling and Back Strain (Section 11.6.2.6) • Noise (Section 11.6.2.5) • Heat/Cold Stress (Section 11.6.4.1) • Heavy Equipment Operation (Section 11.6.2.18) • Flammable / Combustible Materials (Section 11.2.10) • Sharp Objects (Section 11.6.2.3) ***PPE: Level D***	• As determined applicable	• General inspection prior to use	• Review SSHP • Review of Cannon AFB regulations

11.6.2.2 Caught-Between, Struck By/Against, and Heavy Equipment

- Review and understand hand signals before acting in signalman capacity for hoisting and rigging tasks.
- No one will be permitted within equipment work areas or swing radius during operations or walk in front of moving equipment unless acting as a signalman or spotter for the operator.
- Make eye contact and establish visual communication with operators through hand signals (i.e., signaling to stop the equipment) before approaching equipment.
- All heavy equipment shall be equipped with a backup signal.
- Use a spotter for all vehicle and aerial platform backing near roadways and moving under power lines, excavations, or near structures or other equipment.
- Use established equipment travel routes or lanes.
- Place all equipment buckets or tines (forklifts) on the ground surface when not in use or when exiting the operating position.
- Use proper body position and never place yourself or body part between a wall or other solid surface that creates a pinch or crushing hazard.

11.6.2.3 Sharp Objects

- Wear leather gloves for all material handling, rigging, and hand tool tasks.
- Wear cut resistant (i.e., Kevlar) work gloves when the possibility of lacerations or other injury may be caused by sharp edges or objects.
- Maintain all hand and power tools in a safe condition.
- Ensure all equipment guards are in place prior to use.
- Retract or close blades when cutting tools (knives or box cutters) are not in use.
- Use all tools for their intended use only.

11.6.2.4 Caught Between Moving Parts

- Identify and understand parts of equipment that may cause crushing, pinching, rotating, or similar motions.
- Proper body position awareness near pinching and crushing hazards.
- Inspect all equipment prior to use.
- Ensure guards are in place to protect from these parts of equipment during operation.
- Provide and use proper work gloves when the possibility of pinching, or other injury may be caused by handling heavy equipment or objects.

- Maintain all equipment in a safe condition.
- Do not wear rings or loose clothing that could be snagged or caught around rotating or other equipment.
- Stay out of the arm swing radius of equipment.
- Use mechanical lifting and materials handling equipment whenever possible.

11.6.2.5 High Noise Levels

- Use hearing protection when exposed to excessive noise levels (greater than 84 dBA).

11.6.2.6 Handling Heavy Objects

- Use mechanical means for lifting whenever possible (i.e., forklift, liftgate, loader, etc.).
- Observe proper lifting techniques.
- Obey sensible lifting limits (50 pounds maximum per person manual lifting or 1/3 a person's body weight, whichever is less or if the object is unbalanced or awkward to carry). If a worker has a medical lifting restriction, communicate this to the supervisor and do not exceed the restriction.
- Ensure workers have a proper grip and stable walking surface when transporting materials by hand (inspect the walking surface before proceeding with materials).
- Store all materials in a safe configuration to prevent rolling, tipping or falling.

11.6.2.7 Combustible and Flammable Materials/Liquids

- Store flammable liquids in Factory Mutual/Underwriters Laboratory (FM/UL)-approved containers in well ventilated areas. FM/UL-approved flammable liquid containers, labeled with the content, will be used to store fuel.
- All fuel containers will be stored at least 15 meters (50 feet) from any facilities and ignition sources, or stored inside an approved flammable storage cabinet.
- ABC fire extinguishers will be located in each field vehicle and on each piece of heavy equipment, inside the containment area and active demolition areas.
- Store flammable liquids in UL containers in well ventilated areas.
- Post "NO SMOKING" signs in refueling areas and on fuel storage tanks.
- Clear combustible materials such as tall dry grasses from vehicle and equipment parking areas.
- Clear all areas of combustible materials prior to initiating hot work and have an extinguisher/fire watch in the area during the hot work.
- Avoid parking vehicles in area of tall dry grass or other potentially combustible material.
- Where required for hot work, inert or otherwise place potential flammable or combustible tanks or vessels in a safe condition (less than 10 percent of the lower explosive limit [LEL]).

11.6.2.8 Electrical and Stored Energy Hazards

Electrical equipment and tools, as well as overhead lines and existing electrical conduit, breakers, leads, and receptacles may pose shock or electrocution hazards to personnel. Safety-related work practices will be employed to prevent electric shock or other injuries resulting from direct or indirect electrical contact. Ground-fault protected electrical circuits and receptacles in combination with safety-related work practices will be employed to prevent electric shock or other injuries resulting from direct or indirect electrical contact. Before conducting demolition work and wall penetrations, hazardous energy of the affected system or area will be brought to a zero energy state through the use of isolation methods in accordance with 29 CFR 1910.147 and North Wind HSP-012, *Control of Hazardous Energy* (North Wind, 2006f).

NOTE: *Only qualified personnel are permitted to work on unprotected energized electrical systems.*

If work on energized systems is necessary, these practices will conform to the requirements in Parts I through III of the National Fire Protection Association (NFPA) 70E, *Standard for Electrical Safety in the Workplace*. Additionally, all effected electric, gas, water, steam, sewer, and other service lines will be identified then shut off, capped, or otherwise placed in a safe zero energy state before conducting disconnect tasks or surface penetrations that could effect these system.

11.6.2.9 Powered and Hand Tools

- All portable equipment and tools will be properly maintained and used according to the manufacturer's specifications by qualified individuals.
- All tools will be inspected by the user prior to use to ensure they are in good working condition, guards are in place, and cords are in good condition.
- Replace worn or damaged blades, bits, or other tool attachments before use.
- Any tool found to be damaged will be tagged and taken out of service.
- All electric tools used outdoors will have a ground-fault circuit interrupter (GFCI) protection inline.
- Loose or frayed clothing, loose long hair, and dangling jewelry shall not be worn while working with any power tool.

11.6.2.10 Hoisting and Rigging Equipment

- The operator shall comply with the manufacturer's specifications and limitations applicable to the operation of the crane.
- Hoisting and rigging equipment will show evidence of a current inspection (e.g. tag) and be inspected by qualified personnel before use.
- Belts, gears, shafts, or other reciprocating, rotating, or other moving parts or equipment shall be guarded if such parts are exposed to contact by employees, or, otherwise create a hazard.
- The operator or designated person for mobile cranes or boom trucks will perform a visual inspection each day or before use (if the crane has not been in regular service) of items such as, but not limited to, the following:

- All control mechanisms for maladjustment that would interfere with proper operation
- Crane hooks and latches for deformation, cracks, and wear
- Hydraulic systems for proper oil level
- Lines, tanks, valves, pumps, and other parts of air or hydraulic systems for leakage
- Hoist ropes for kinking, crushing, birdcaging, and corrosion
- All anti-two-block, two-block warning, and two-block damage prevention systems for proper operation.

- The area around the lift (including the swing radius) will be isolated.
- The operator shall respond to signals from the person who is directing the lift or an appointed signal person. When a signal person is not used in the crane operation, the operator shall ensure he/she has full view of the load and the load travel paths at all times the load is rigged to the crane.
- Except for critical lifts, when these duties will be carried out by the lift supervisor, the rigger shall ensure that:
  - The crane is level and, where necessary, blocked
  - The load is well secured and balanced in the sling or lifting device before it is lifted more than a few inches
  - The lift and swing path is clear of obstructions and adequate clearance is maintained from electrical sources
  - All persons are clear of the swing radius of the counterweight.
- Other applicable requirements of USACE EM 385-1-1, Section 16, “Machinery and Mechanized Equipment” will be followed with respect to hoisting and rigging operations.

11.6.2.11 Elevated Work Areas

Personnel may during the course of the project be required to work on elevated equipment or at heights above 1.8 meters (6 feet). Unprotected or leading edge work in areas that will not allow for complete guardrail systems will require a fall protection hazard analysis to be prepared. Additionally, the following requirements will apply:

- Personnel shall be aware of, and follow all requirements established by the competent person for the use and limitation of fall protection systems.
- Personal fall arrest systems shall be inspected prior to each use. Personnel shall not use damaged fall protection systems at any time, or for any reason.
- Personnel shall remain within the guardrail system when provided. Leaning over or stepping across a guardrail system is not permitted.

- Materials to construct guardrail systems may be required to provide fall protection on unprotected walking or working surfaces.

- Full body harnesses and lanyards may be required for fall protection if adequate guardrail systems are not in place.

- Horizontal, vertical, and self-retracting lifelines, winches, descent devices, anchorage points, and other fall protection equipment may be required depending on the configuration of the walking or working surface and the availability of adequate anchorage points.

- Ropes, wire, or chains, and supporting stanchions shall be required when a warning-line system or controlled-access zone is used for fall protection.

- Toe boards, screens, or canopies may be required to prevent objects from falling from elevated surfaces.

- Specific fall protection systems shall be constructed and used in accordance with the requirements of North Wind HSP-014, *Fall Protection* (North Wind, 2006g), 29 CFR 1926, Subpart M, and EM 385-1-1, Section 21, "Safe Access and Fall Protection."

11.6.2.12 Confined Spaces

The SSHO will be responsible for identifying any potential confined spaces (not already identified and posted by the facility) and for conducting an evaluation to determine if the work to be conducted inside this confined space would change it to a permit-required space. All permit-required confined space entries will be made in coordination with the North Wind HSD and in accordance with North Wind HSP-010, *Confined Spaces* (North Wind, 2006h). These requirements include elimination of all hazards from outside the space (where feasible), isolating hazardous energy sources (LO/TO), and conducting atmospheric monitoring prior to entry.

11.6.2.13 Scaffolding

Scaffolding is not required for this project.

11.6.2.14 Aerial Lifts

Aerial platform operations are not required for this project.

11.6.2.15 Hot Work

- A North Wind HSF-104, *Welding, Cutting, and Other Hot Work Area Permit,* (North Wind, 2007d) or equivalent tenant facility or subcontractor required hot work permit will be completed prior to initiating any welding, cutting, or grinding.

- Signs shall be posted to designate welding, cutting, and other hot work areas, and to indicate that eye protection shall be worn.

- Combustibles shall be protected from ignition.

- A fire watch will be assigned during the hot work.

- Fire extinguishing equipment shall be readily available.

- No welding, cutting, or other hot work shall be performed on used drums, barrels, tanks, or other containers until they have been cleaned so that there are no flammable materials present or any substances such as greases, tars, acids, or other materials, which when subject to heat, might produce flammable or toxic vapors.

- When working on drums, barrels, tanks, or other containers any pipe lines or connections to the vessel shall be disconnected or blanked.

- All equipment used for welding, cutting, and other hot work shall be in good condition before starting work.

- Other requirements of NFPA 51B, "Fire Prevention in Use of Cutting and Welding Processes," National Fire Protection Association shall be followed.

- PPE for welding, cutting, and grinding tasks will be selected in accordance with 29 CFR 1926, Subpart J, *Welding and Cutting*.

11.6.2.16 Compressed Gases

If compressed gas cylinders are used on site, all cylinders will be used, stored, handled, and labeled in accordance with 29 CFR 1910.101, *Compressed Gases* and NFPA 55, *Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders*. Additionally, the North Wind HSD should be consulted about any compressed gas cylinder storage, transport, and usage issues including compatibility of gases.

11.6.2.17 Excavations

All excavation activities will be conducted and monitored in accordance with 29 CFR 1926, Subpart P, *Excavations*, North Wind HSP-011, *Excavations* (North Wind, 2006i), and USACE EM 385-1-1, Section 25, "Excavations." The following are some key elements from these requirements:

- Employees exposed to public vehicular traffic will be provided with and will wear warning vests or other suitable garments marked with or made of reflecting or high-visibility material.

- A barricade, hand or mechanical signals, or stop logs (or equivalent) warning system shall be established for mobile equipment operated adjacent to the excavation, or when such equipment is required to approach the edge of the excavation, and the operator does not have a clear and direct view of the edge of the excavation. If possible, the grade should be away from the excavation.

- No personnel shall be permitted underneath loads handled by lifting or digging equipment. Personnel shall stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded to provide adequate protection for the operator.

- Daily inspections of excavations, areas adjacent to the excavations, and protective systems will be made by a competent person for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions. An inspection will be conducted by the competent person before the start of work and as needed throughout the shift. Inspections also will be made after every rainstorm or other hazard-increasing occurrence. Inspection activities shall be documented. Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres or other hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.

- Sidewalks, pavements, and appurtenant structure shall not be undermined unless a support system or another method of protection is provided to protect employees from the possible collapse of such structures.

- Atmospheric testing of the excavation will be conducted as deemed appropriate by the excavation competent person to ensure that a hazardous atmosphere does not exist prior to any personnel entering the excavation. Work situations that may create a hazardous atmosphere during the course of work shall also be evaluated. This sampling shall include the following in the order they appear: 1) Oxygen (19.5-23.5 percent), 2) LEL (less than 10 percent), and 3) toxic materials (subject to percent of permissible exposure limit [PEL], etc. as identified by the SSHO). The project health and safety manager will be contacted where hazardous atmosphere are identified to provide additional guidance on atmospheric testing.

11.6.2.18 Heavy Equipment Operation

The hazards associated with the operation of heavy equipment and industrial vehicles (e.g., vacuum trucks, end dumps, haul trucks, etc.) include injury to personnel, equipment damage, and/or property damage. All heavy equipment will be operated in the manner in which it was intended and according to manufacturer's instructions. Only authorized personnel will be allowed near operating heavy equipment and industrial vehicles, and they should maintain visual communication with the operator. Work-site activities shall comply with the requirements in EM 385-1-1, Section 16.

Before any machinery is placed in use, it shall be inspected and tested by a qualified operator and determined to be in safe operating condition in accordance with the manufacturer's recommendations. The North Wind Field Manager (or designee) shall be responsible for documenting the inspection. Whenever machinery is found to be unsafe, the equipment shall be taken out of service and its use prohibited until the unsafe condition has been corrected.

11.6.3 Chemical Hazards

11.6.3.1 Ethylene Glycol

Ethylene glycol may be encountered because of its use as a coolant in equipment. Handling of ethylene glycol shall be per manufacturer's instructions. Ethylene glycol is a skin and eye irritant. Proper PPE shall be worn when handling ethylene glycol.

11.6.3.2 Asbestos

Where asbestos containing materials (ACM) are encountered (based on facility drawings or as labeled), every effort will be made to prevent disturbing them and creating an airborne hazard. If friable or damaged ACM is identified, it will be reported to the North Wind SSHO and the USACE COR with the location and condition of the materials. No attempt to patch or repair damaged ACM will be made by North Wind personnel or subcontractors.

11.6.3.3 Petroleum Fuel Products

Gasoline and diesel fuels contain toxic substances that can enter the environment and cause adverse health effects in workers. Some of these substances, such as benzene, toluene and xylenes, are found in crude oil and occur naturally in fuels and their vapors. Personnel will minimize direct contact with these constituents at all times. Where contact cannot be avoided, PPE will be worn to prevent direct skin contact and respiratory protection as required based on real-time monitoring. A photoionization device with a 10.6 electron volt (eV) lamp will be used to measure VOCs in the breathing zone.

11.6.3.4 Exposure Standards

Exposure, through inhalation, ingestion, skin absorption, or physical contact, to any chemical, biological, or physical agent in excess of the acceptable limits specified in the 2007 American Conference of Governmental Industrial Hygienist (ACGIH), *Threshold Limit Values and Biological Exposure Indices*, or by OSHA, whichever is more stringent, shall be prohibited. In case of conflicts between ACGIH and other standards or regulations referenced in this manual, the more stringent shall prevail. Due to the complexity of diesel and gasoline constituents, an action level of 5 parts per million (ppm) in the breathing zone will be established.

11.6.4 Environmental Hazards

Environmental factors such as weather, wild animals, insects, and irritant plants pose a hazard when performing outdoor work. The subcontractor competent person and SS/SSHO and all workers should take all necessary measures to identify and mitigate these hazards should they arise. Biological hazards, including but not limited to animal encounters, rodents, poison plants, bees, and mosquitoes may pose a risk at the project site.

11.6.4.1 Heat Stress/Cold Stress

Working in the required protective clothing in confined areas can cause problems with heat stress unless proper precautions are taken. Serious medical difficulties can arise from over-stressing the body when personnel are initially introduced to the heat without gradual acclimatization and/or work without adequate frequent, short rest periods. Workers will be informed of the serious dangers of the body being overstressed and how to monitor themselves and their fellow workers for symptoms of heat exhaustion and heat stroke. When a worker recognizes symptoms in himself or a fellow worker, the SSHO will be notified immediately. The worker will be escorted out of the work area to the decontamination area (if necessary) where the protective clothing can be removed. The worker should be encouraged to drink fluids (water), and a period of rest should be provided. Depending on the severity of the worker's condition, he/she may need to be artificially cooled off by applying water externally and rapid fanning and further medical attention provided.

Exposure to low temperatures can be encountered if the conditions are right. Relatively cool ambient temperatures and wet or windy conditions increase the potential for cold injury to personnel. The ACGIH Thermal Stress guidelines will be followed and provide the cold stress work and warm-up schedule.

11.6.4.2 Inclement Weather Conditions

Inclement or adverse weather conditions that may pose a threat to persons, equipment or property at the site (for example, sustained strong winds 25 miles per hour or greater) electrical storms, heavy precipitation, or tornadoes) will be evaluated by the SSHO and subcontractor competent person with input from the other site personnel. Project tasks will be halted if it is deemed that such weather hazards will create additional risk to personnel conducting project tasks. In the event of thunderstorm, tornado, or other severe weather warning, North Wind and subcontractors will secure the site and equipment and follow all official evacuation orders. In the event of a tornado, shelter shall be taken in a nearby facility building.

11.6.4.3 Lightning Protection

When conditions conducive to lightning activity exist within 10 miles of the site, notification will be made to the SS and all work at the site will cease and the site workers will proceed to a safe area. Normal activities may resume when approved by the SS after a minimum of 30 minutes from the last observed lightning or thunder.

11.7 Asbestos Abatement Plan

No asbestos abatement activities have been identified for this project. If damaged or friable ACM is encountered it will not be disturbed and notifications will be made as described in Section 11.6.3.2.

11.8 Abrasive blasting

No abrasive blasting activities have been identified for this project.

11.9 Confined Space

No confined space activities have been identified for this project.

11.10 Hazardous Energy Control Plan

Hazardous energy control (LO/TO), if required, will be conducted as described in Section 11.6.2.8.

11.11 Critical Lift Procedures

No critical lift plan is required.

11.12 Contingency Plan for Severe Weather

This project does not involve any floating plants or marina activities mandating these requirements.

11.13 Access and Haul Road Plan

This project does not involve the construction of any access or haul roads. Existing roadways will be utilized for all activities.

11.14 Demolition Plan (Engineering and Asbestos Surveys)

No demolition activities are being conducted during this project.

11.15 Emergency Rescue (Tunneling)

No tunneling activities will be conducted during this project.

11.16 Underground Construction Fire Prevention and Protection Plan

No underground construction is being conducted during this project.

11.17 Compressed Air Plan

Work with compressed air is not being conducted during this project.

11.18 Formwork and Shoring Erection and Removal Plans

No concrete and masonry construction or steel erection is being conducted during this project.

11.19 Jacking Plan (Lift) Slab Plans

No concrete and masonry construction or steel erection is being conducted during this project.

11.20 Safety and Health Plan and SSHP

This SSHP/APP document meets the requirements of a SSHP according to 385-1-1 and 29 CFR 1910.120, HAZWOPER Standard.

11.21 Blasting Plan

No blasting will be conducted during this project.

11.22 Diving Plan

No diving will be conducted during this project.

11.23 Plan for Prevention of Alcohol and Drug Abuse

The North Wind Drug and Alcohol Policy is as follows:

> North Wind is committed to providing the safest practical work environment for its employees. Accordingly, it is the policy of North Wind to maintain a drug and alcohol free workplace. North Wind will not hire and or retain employees who use, possess or sell illegal substances. Additionally, North Wind will not tolerate abuse of legal substances that adversely affect work safety, productivity or an employee's overall performance.
>
> Any employee reporting to work under the influence of alcohol or drugs will be asked to leave immediately. Under these circumstances, assistance will be provided to make sure that the employee arrives home safely. Any employee who reports to work under the influence of alcohol or drugs may have his/her employment terminated immediately.
>
> North Wind will take all reasonable and necessary steps to make sure this policy is followed. Such action may include, but is not limited to, the right to inspect or search all Company property on North Wind premises. If the Company has reason to suspect that an employee is coming to work under the influence of illegal drugs or controlled substances, the employee may be asked to undergo testing for the presence of alcohol, drugs, or controlled substances in their systems. Refusal to cooperate under the above circumstances will be considered insubordination and cause for disciplinary action up to and including termination. Employees who use or possess illegal drugs or controlled substances on Company property, client project sites or while on Company business will be subject to disciplinary action, which may include immediate termination. Any illegal substance found in the workplace will be confiscated and turned over to the appropriate law enforcement agency.
>
> Subcontractors of North Wind are subject to these same provisions through the contractual conditions.

11.24 Fall Protection Plan

Walking and working surfaces will be maintained as described in Section 11.6.2.1. Currently, no specific tasks associated with this scope of work have been identified that will require elevated work. If elevated work tasks are identified, they will be conducted as described in Section 11.6.2.11 above.

11.25 Steel Erection Plan

No steel erection is being conducted during this project.

11.26 Night Operations Lighting Plan

No night operations are anticipated during this project.

11.27 Site Sanitation Plan

Before any eating, smoking, or drinking in the clean area(s), personnel will wash hands. If public facilities are not readily available, potable water and soap (or sanitizing solution) will also be available at the sites to wash hands and face upon exiting the work area. Personnel should make every attempt to minimize waste through judicious use of consumable materials. All site personnel are expected to make good housekeeping a priority at the job site. A portable toilet will be provided at the project site.

11.28 Fire Prevention Plan

The primary sources for a fire would be any petroleum constituents including diesel fuel and gas. Potential ignition sources include sparks, static discharge during pumping operations, or heated materials associated with boring activities. No hot work activities are anticipated during this project.

NOTE: *At least one representative from each contractor and subcontractor must attend a PRECONSTRUCTION BRIEFING where a member of the Cannon AFB Fire Department will discuss important on base Fire Department expectations.*

11.28.1 Fire Prevention

- All temporary heating equipment will be of approved type and its use will be in a safe and workmanlike manner.
- Flammable liquids will be stored only in OSHA approved containers.
- If required, oxygen-acetylene units will be used and stored in a safe and workmanlike manner in accordance with EM 385-1-1, Section 20.D, “Compressed Gas Cylinders.”
- Flameproof tarpaulins and enclosures will be provided for welding and burning operations when necessary.
- No smoking areas will be established in accordance with EM 385-1-1 and will be properly identified and enforced.
- No burning will be permitted at the project site.

11.28.2 Fire Protection

- Portable fire extinguishers shall be provided and maintained in accordance with EM 358-1-1, Section 9.E, "First Response Fire Protection." At a minimum, one 20-pound ABC fire extinguisher will be present at the work site at all times.

- All heavy equipment will be furnished with properly sized fire extinguishers.

- Compatible fire extinguishing equipment shall be provided in the immediate vicinity of the welding or torch operation whenever combustible material is exposed.

- The emergency phone number for additional fire resources is 911.

12. CONTRACTOR INFORMATION

All applicable sections of USACE EM 385-1-1 will be met by North Wind, and onsite subcontractor personnel, by adhering to the requirements outlined in this SSHP and North Wind health and safety procedures. All contractors and subcontractors must adhere to the Cannon AFB regulations. A copy of the Cannon AFB regulation must be obtained from the base contracting office and reviewed prior to commencing activities.

12.1 Excavation

All excavation activities associated with boring activities will be conducted as described in Section 11.6.2.17, "Excavations."

12.2 Medical and First-Aid

All medical and first aid requirements are described in Section 9, "Medical Support and Surveillance."

12.3 Sanitation

Project sanitation procedures for this project area described in Section 11.27, "Site Sanitation Plan."

12.4 PPE

PPE requirements are describe in Section 10, "Personal Protective Equipment."

12.5 Fire Prevention

Fire prevention requirements are described in Section 11.28, "Fire Prevention Plan."

12.6 Machinery and Mechanized Equipment

Hazards and mitigation associated with machinery and mechanized equipment anticipated to be used is described in Sections 11.6.2.10, "Hoisting and Rigging Equipment" and 11.6.2.18, "Heavy Equipment Operation."

12.7 Electrical Safety

Electrical hazards and safety are described in Section 11.6.2.8, “Electrical and Stored Energy Hazards.”

12.8 Public Safety Requirements

Not applicable.

12.9 Occupational Exposure Requirements

Occupation exposure to physical, chemical, and environmental hazards are described in Section 11.6, “Health Hazard Control Program”

13. RECORDKEEPING

13.1 General

Record keeping shall, at a minimum, be consistent with OSHA regulations in all respects. The following permanent records shall be maintained in the North Wind office:

- Accident Reports (HSF-005.1) submitted to North Wind Human Resources and a copy kept by the Program Manager
- Training documentation documenting training requirement compliance for all on site personnel
- First-Aid/CPR Certification for all certified personnel
- Record of all inspections and corrective actions conducted by the contractor
- Subcontractor certifications or training documentation related to equipment operator qualifications
- Waste disposal records.

14. REFERENCES

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29 CFR 1910.120, Title 29, "Labor," Part 1910, "Occupational Safety and Health Standards," Subpart H, "Hazardous Materials," Section 1910.120, "Hazardous Waste Operations and Emergency Response," *Code of Federal Regulations,* Office of the Federal Register.

29 CFR 1910.132, Title 29, "Labor," Part 1910, "Occupational Safety and Health Standards," Subpart I, "Personal Protective Equipment," Section 1910.132, "General Requirements," *Code of Federal Regulations,* Office of the Federal Register.

29 CFR 1910.134, Title 29, "Labor," Part 1910, "Occupational Safety and Health Standards," Subpart I, "Personal Protective Equipment," Section 1910.134, "Respiratory Protection," *Code of Federal Regulations,* Office of the Federal Register.

29 CFR 1910.146, Title 29, "Labor" Part 1910, "Occupational Safety and Health Standards," Subpart J, "General Environmental Controls," Section 1910.146, "Permit-Required Confined Spaces," *Code of Federal Regulations,* Office of the Federal Register.

29 CFR 1910.147, Title 29, "Labor" Part 1910, "Occupation Safety and Health Standards," Subpart J, "General Environmental Controls," Section 1910.147, "The Control of Hazardous Energy (Lockout/Tagout)," *Code of Federal Regulations,* Office of the Federal Register.

29 CFR 1910.1000, Title 29, "Labor" Part 1910, "Occupational Safety and Health Standards," Subpart Z, "Toxic and Hazardous Substances," Section 1910.1000, "Air Contaminants," *Code of Federal Regulations,* Office of the Federal Register.

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29 CFR 1926.32, Title 29, "Labor," Part 1926, "Safety and Health Regulations for Construction," Subpart C, "General Safety and Health Provisions," Section 1926.32, "Definitions," *Code of Federal Regulations,* Office of the Federal Register.

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29 CFR 1926, Subpart M, Title 29, "Labor," Part 1926, "Safety and Health Regulations for Construction," Subpart M, "Fall Protection," *Code of Federal Regulations,* Office of the Federal Register.

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ANSI, 1999, *Personal Protection-Protective Footwear,* ANSI Z41-1999, American National Standards Institute, August 16, 1999.

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NFPA 55, *Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders,* National Fire Protection Association, 2005 Edition.

NFPA 70E, *Standard for Electrical Safety in the Workplace,* National Fire Protection Association, 2004 Edition.

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North Wind, 2006b. *Accident Reporting and Investigation,* North Wind, Inc., HSP-005. August 28, 2006. Revision 1, North Wind, Inc.

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Appendix A

SSHP/APP Training Sign-Off Sheet

SSHP/APP Training Sheet

Jobsite: _____

By signing below, I acknowledge that I have received SSHP/APP training and understand the potential hazards and responsibilities at the work site. I further agree to abide by all SSHP/APP requirements.

Printed Name	**Signature**	**Date**

Appendix B

Safety Walkthrough Checklist

Date: **Area Inspected:** **Person(s) Conducting Inspection:**

Directions: Check appropriate column with an "X" indicating the inspection results for each item. State corrective action taken for any item(s) marked deficient and report item(s) to the NWI Project Manager or Site Superintendent; use bottom of form if necessary. Deficiencies must have a corrective action taken.

NOTE: *If a work activity or condition poses an immediate threat to safety or health,* ***stop work*** *and contact project North Wind SS, PM and HSM.*

Place completed checklist in project file (as appropriate).

Inspection Item	Not Required or Not in Use	Adequate	Deficient	Comments	Corrective Action Taken (only required for items marked as deficient)
GENERAL SITE CONDITIONS					
Site free of debris	☐	☐	☐		
Field trailer clean	☐	☐	☐		
Working/walking surfaces	☐	☐	☐		
Trailer stairs/ladder	☐	☐	☐		
Roadway marked	☐	☐	☐		
Ropes/barriers	☐	☐	☐		
Fencing intact	☐	☐	☐		
Road gate signs	☐	☐	☐		
Construction/Project Signs	☐	☐	☐		
Personnel badges	☐	☐	☐		
Water available and eating area established	☐	☐	☐		

Inspection Item	Not Required or Not in Use	Adequate	Deficient	Comments	Corrective Action Taken (only required for items marked as deficient)
Gates secured	☐	☐	☐		
Sanitary Facilities					
PPE USAGE					
Hard hats	☐	☐	☐		
Safety glasses	☐	☐	☐		
Safety boots (where required)	☐	☐	☐		
Hearing protection (if >84 dBA)	☐	☐	☐		
Gloves (material handling)	☐	☐	☐		
Reflective safety vest	☐	☐	☐		
Cold weather gear available (as required)	☐	☐	☐		
Fall Protection	☐	☐	☐		
Extra PPE for visitors	☐	☐	☐		
HASP REQUIRED ITEMS					
Fire extinguishers	☐	☐	☐		
First aid kit	☐	☐	☐		
Radios	☐	☐	☐		
HAZ spill kit	☐	☐	☐		
Eye wash station or bottles	☐	☐	☐		
Wind sock	☐	☐	☐		
DOCUMENTATION					

Inspection Item	Not Required or Not in Use	Adequate	Deficient	Comments	Corrective Action Taken (only required for items marked as deficient)
HASP copy available	☐	☐	☐		
MSDS binder	☐	☐	☐		
Training records	☐	☐	☐		
Fitness for duty forms	☐	☐	☐		
Site badges	☐	☐	☐		
ELECTRICAL ITEMS					
Extension cord condition/current inspection	☐	☐	☐		
GFCI use (all outside cords/equipment)	☐	☐	☐		
Tool/cord condition/current inspection	☐	☐	☐		
VEHICLE MOVEMENT, HEAVY EQUIPMENT USAGE, HOISTING AND RIGGING					
Qualified equipment operators	☐	☐	☐		
Backup alarms on equipment/industrial vehicles	☐	☐	☐		
Hoisting/rigging equipment inspections current	☐	☐	☐		

Inspection Item	Not Required or Not in Use	Adequate	Deficient	Comments	Corrective Action Taken (only required for items marked as deficient)
No unattended running equipment/vehicles	☐	☐	☐		
Fire extinguisher on equipment	☐	☐	☐		
Parked equipment tires chalked	☐	☐	☐		
Daily inspection of heavy equipment	☐	☐	☐		
Flashing yellow lights on heavy equipment	☐	☐	☐		
MISCELLANEOUS (add miscellaneous items as deemed appropriate)					
Flammable storage cabinet	☐	☐	☐		
All chemicals labeled	☐	☐	☐		
Fire extinguishers have current inspection	☐	☐	☐		
Combustible materials properly managed (e.g., not discarded, well housekept)	☐	☐	☐		

Inspection Item	Not Required or Not in Use	Adequate	Deficient	Comments	Corrective Action Taken (only required for items marked as deficient)
CONTINUATION SHEET					

Draft Final
Quality Assurance Project Plan for Final Closure of Solid Waste Management Units-70 and -71, Cannon Air Force Base, New Mexico

QAPP-05032-001

Prepared for:

U. S. Army Corps of Engineers
Omaha District

Contract No. W9128F-04-D-0017-0029

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ACRONYMS

ADR	Automated Data Review
AFB	Air Force Base
ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing Material
CASRN	Chemical Abstract Service Registry Number
CFR	Code of Federal Regulations
COC	Chain of Custody
DI	deionized
DoD	Department of Defense
DQCR	Data Quality Control Report
DQO	data quality objective
EDD	electronic data deliverable
EICP	Extracted Ion Current Profile
EPA	Environmental Protection Agency
FSP	Field Sampling Plan
FTL	Field Team Leader
GC	gas chromatography
GC/MS	gas chromatography/mass spectroscopy
GPS	Global Positioning System
GRO	gasoline range organic
HPLC	high performance liquid chromatography
LCL	lower control limit
LCS	laboratory control sample
LD	laboratory duplicate
LDC	Laboratory Data Consultant

LRL	laboratory reporting limit
MB	method blank
MDL	method detection limit
MQL	method quantitation limit
MS/MSD	matrix spike/matrix spike duplicate
NELAP	National Environmental Laboratory Accreditation Program
NIST	National Institute of Standards and Technology
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PID	photoionization detector
PM	Project Manager
ppmv	parts per million, volume per volume
PQL	practical quantitation limit
QAPP	Quality Assurance Project Plan
QC	quality control
QCSM	Quality Control Site Manager
QCSR	Quality Control Summary Report
QL	quantitation limit
QSM	Quality System Manual
RF	response factor
RL	reporting limit
RPD	relative percent difference
RT	retention time
SAP	Sampling and Analysis Plan
SDG	Sample Delivery Group
SIM	selected ion monitoring

SOP	standard operating procedure
SOW	Scope of Work
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
SSL	soil screening level
TAL	Test America Laboratory
SVOC	semivolatile organic compounds
SWMU	Solid Waste Management Unit
UCL	upper control limit
USACE	U.S. Army Corps of Engineers
VOC	volatile organic compound

Draft Final
Quality Assurance Project Plan for Final Closure of Solid Waste Management Units-70 and -71 Cannon Air Force Base, New Mexico

1. INTRODUCTION

This Quality Assurance Project Plan (QAPP) presents the organization, objectives, functional activities, and specific quality control (QC) activities for collection and management of soil samples data collected as part of this site inspection. The analytical methods to be used are listed in Table C-1. The fixed laboratory method detection limits, reporting limits, and QC acceptance limits for each of the methods are provided in Tables C-2 through C-7. This QAPP should be referenced to guide and assure the acquisition of quality data during the site inspection of Solid Waste Management Units (SWMUs)-70 and -71 at Cannon Air Force Base (AFB), New Mexico.

The process described in North Wind procedure QAP-183, *Quality Grading*, has been completed, and this project was determined to be Quality Level 1. This QAPP has been developed in accordance with QAP-012, *Development of Project Quality Plans (PQPs) and Quality Assurance Project Plans (QAPPs)*.

Table C-1. Sample Extraction and Analysis Methods for SWMUs-70 and -71.

Contaminant of Interest	Subsurface Soil	Soil Vapor	Groundwater/ Surface Water
TPH-DRO (diesel) (C_{10} to C_{28} hydrocarbons)	SW3550C/8015BM (modified for diesel range)	NA	NA
TPH-GRO (gasoline) (C_6 to C_{10} hydrocarbons)	SW5035/8015D, Cal-LUFT (modified for gasoline range)	NA	NA
VOCs	SW5035/8260C	NA	NA
TVPH and BTEX	NA	EPA-TO-3	NA
Metals	SW846 method 6010C	NA	NA
PAH (SVOCs)	SW3550C/8270D-SIM (modified for selected ion monitoring [SIM])	NA	NA
Pesticides	SW3550C/8081A	NA	NA
PCBs	SW3550C/8082A	NA	NA

Table C-2. Reporting Limits, Detection Limits, and Quality Control Criteria for Volatile Organic Compounds (Method 8260C).

Analyte	CASRN	ParLabel	Solid Matrix					
			Units	RL	MDL	LCL, %	UCL, %	RPD
Acetone	67-64-1	ACE	ug/Kg	20	5.38	20	160	30
Benzene	71-43-2	BZ	ug/Kg	5	0.47	75	125	30
2-Butanone (MEK)	78-93-3	MEK	ug/Kg	20	1.83	30	160	30
n-Butylbenzene	104-51-8	BTBZN	ug/Kg	5	0.56	65	140	30
sec-Butylbenzene	135-98-8	BTBZS	ug/Kg	5	0.77	65	130	30
tert-Butylbenzene	98-06-6	BTBZT	ug/Kg	5	0.5	65	130	30
Carbon tetrachloride	56-23-5	CTCL	ug/Kg	5	0.63	65	135	30
Chlorobenzene	108-90-7	CLBZ	ug/Kg	5	0.54	75	125	30
Chloroform	67-66-3	TCLME	ug/Kg	10	0.29	70	125	30
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	DBCP	ug/Kg	10	0.60	40	135	30
1,2-Dibromoethane (EDB)	106-93-4	EDB	ug/Kg	5	0.52	70	125	30
1,2-Dichlorobenzene	95-50-1	DCBZ12	ug/Kg	5	0.45	75	120	30
1,3-Dichlorobenzene	541-73-1	DCBZ13	ug/Kg	5	0.48	70	125	30
1,4-Dichlorobenzene	106-46-7	DCBZ14	ug/Kg	5	0.78	70	125	30
1,1-Dichloroethane	75-34-3	DCA11	ug/Kg	5	0.21	75	125	30
1,2-Dichloroethane	107-06-2	DCA12	ug/Kg	5	0.70	70	135	30
cis-1,2-Dichloroethene	156-59-2	DCE12C	ug/Kg	2.5	0.56	65	125	30
trans-1,2-Dichloroethene	156-60-5	DCE12T	ug/Kg	2.5	0.39	65	135	30
1,1-Dichloroethene	75-35-4	DCE11	ug/Kg	5	0.59	65	135	30
Ethylbenzene	100-41-4	EBZ	ug/Kg	5	0.67	75	125	30
2-Hexanone	591-78-6	HXO2	ug/Kg	20	4.89	45	145	30
Isopropylbenzene	98-82-8	IPBZ	ug/Kg	5	0.59	75	130	30

Table C-2. (continued).

Analyte	CASRN	ParLabel	Solid Matrix					
			Units	RL	MDL	LCL, %	UCL, %	RPD
p-Isopropyltoluene	99-87-6	CYMP	ug/Kg	5	0.49	75	135	30
Methylene chloride	75-09-2	MTLNCL	ug/Kg	5	0.75	55	140	30
4-Methyl-2-pentanone	108-10-1	MIBK	ug/Kg	20	4.36	45	145	30
Methyl tert-butyl ether	1634-04-4	MTBE	ug/Kg	20	0.34	67	119	30
Naphthalene	91-20-3	NAPH	ug/Kg	5	0.63	40	125	30
n-Propylbenzene	103-65-1	PBZN	ug/Kg	5	0.58	65	135	30
Styrene	100-42-5	STY	ug/Kg	5	0.63	75	125	30
Tetrachloroethene	127-18-4	PCE	ug/Kg	5	0.59	65	140	30
Toluene	108-88-3	BZME	ug/Kg	5	0.69	70	125	30
Trichloroethene	79-01-6	TCE	ug/Kg	5	0.23	75	125	30
1,2,4-Trimethylbenzene	95-63-6	TMB124	ug/Kg	5	0.58	65	135	30
1,3,5-Trimethylbenzene	108-67-8	TMB135	ug/Kg	5	0.57	65	135	30
Vinyl chloride	75-01-4	VC	ug/Kg	5	1.34	60	125	30
m-Xylene & p-Xylene	1330-20-7	XYLMP	ug/Kg	3.2	1.04	80	125	30
o-Xylene	95-47-6	XYLO	ug/Kg	2.5	0.61	75	125	30
4-Bromofluorobenzene (surr)	460-00-4	BR4FBZ				85	120	0
1,2-Dichloroethane-d4 (surr)	17060-07-0	DCA12D4				61	129	0
Toluene-d8 (surr)	2037-26-5	BZMED8				85	115	0
Dibromofluoromethane (surr)	1868-53-7	DBFM				71	126	0

LCL = lower control limit
MDL = method detection limit
RL = reporting limit
RPD = relative percent difference
UCL = upper control limit

Table C-3. Reporting Limits, Detection Limits, and Quality Control Criteria for TVPH/BTEX (Method EPA-TO-3).

Analyte	MDL (ppmv)	RL (ppmv)	MDL (µg/M^3)	RL (µg/M^3)
Benzene	0.010	0.020	0.03	0.06
Toluene	0.010	0.020	0.04	0.08
Ethylbenzene	0.0040	0.020	0.02	0.09
m,p-Xylene	0.0080	0.020	0.03	0.09
o-Xylene	0.0080	0.020	0.03	0.09
Xylenes, total	0.0080	0.020	0.03	0.09
Methyl tert-butyl ether (MTBE)	0.015	0.030	0.05	0.11
TPH as Gasoline	0.30	1.0	1.23	4.09

MDL = Method detection limit.
ppmv = parts per million, by volume
RL = Reporting limit.
TPH = Total petroleum hydrocarbons
µg/M^3 = micrograms per cubic meter

Table C-4. Reporting Limits, Detection Limits, and Quality Control Criteria for Total Metals (Method 6010C).

			Solid Matrix					
Analyte	CASRN	ParLabel	Units	RL	MDL	LCL, %	UCL, %	RPD
Antimony	7440-36-0	SB	µg/Kg	200	14.012	82	110	20
Arsenic	7440-38-2	AS	µg/Kg	600	50.636	83	111	20
Barium	7440-39-3	BA	µg/Kg	250	70.476	86	120	20
Beryllium	7440-41-7	BE	µg/Kg	100	22.465	70	136	20
Cadmium	7440-43-9	CD	µg/Kg	100	9.376	85	109	20
Chromium	7440-47-3	CR	µg/Kg	600	75.991	87	121	20
Cobalt	7440-48-4	CO	µg/Kg	100	6.628	91	113	20
Copper	7440-50-8	CU	µg/Kg	2,500	71.069	87	125	20
Lead	7439-92-1	PB	µg/Kg	400	18.194	81	125	20
Manganese	7439-96-5	MN	µg/Kg	1,000	32,993	86	120	20
Molybdenum	7439-98-7	MO	µg/Kg	200	17.629	80	120	20
Nickel	7440-02-0	NI	µg/Kg	350	25.305	90	113	20
Selenium	7782-49-2	SE	µg/Kg	500	133.025	78	108	20
Silver	7440-22-4	AG	µg/Kg	100	20.301	83	113	20
Thallium	7440-28-0	TL	µg/Kg	100	3.514	84	124	20
Tin			µg/Kg	2,500	66.256	80	120	20
Uranium			µg/Kg	100	1.573	85	123	20
Vanadium	7440-62-2	V	µg/Kg	500	38.516	88	114	20
Zinc	7440-66-6	ZN	µg/Kg	2,500	315.767	85	119	20

Table C-5. Reporting Limits, Detection Limits, and Quality Control Criteria for Gasoline Range Organics (Method 8015D, Cal-LUFT).

Analyte	CASRN	ParLabel	Solid Matrix					
			Units	RL	MDL	LCL, %	UCL, %	RPD
GROs (C_7 - C_{12} range)	GRO	GRO	mg/Kg	1.2	0.325	85	153	20
a,a,a-Trifluorotoluene (surr)	98-56-6	AAATFBZME				77	130	0

Notes:
CASRN = Chemical Abstract Service Registry Number
GRO = gasoline range organic
LCL = Lower control limit
MDL = Method detection limit
ParLabel = Parameter label
RL = Reporting limit
RPD = Relative percent difference
UCL = Upper control limit

Table C-6. Reporting Limits, Detection Limits, and Quality Control Criteria for Diesel Range Organics (Method 8015BM).

Analyte	CASRN	ParLabel	Solid Matrix					
			Units	RL	MDL	LCL, %	UCL, %	RPD
Diesel Range Organics (C_{10} - C_{28} range)	DRO	DRO	mg/Kg	4.0	678	53	115	23
o-Terphenyl (surr)	84-15-1	PHENO				49	115	0

Notes:
CASRN = Chemical Abstract Service Registry Number
LCL = Lower control limit
MDL = Method detection limit
ParLabel = Parameter label
RL = Reporting limit
RPD = Relative percent difference
UCL = Upper control limit

Table C-7. Reporting Limits, Detection Limits, and Quality Control Criteria for Polynuclear Aromatic Hydrocarbons (Method 8270D-SIM).

Analyte	CASRN	ParLabel	Solid Matrix					
			Units	RL	MDL	LCL, %	UCL, %	RPD
Acenaphthene	83-32-9	ACNP	µg/Kg	330	10.3	45	110	30
Acenaphthylene	208-96-8	ACNPY	µg/Kg	330	17	45	105	30
Anthracene	120-12-7	ANTH	µg/Kg	330	17	55	105	30
Benzo(a)anthracene	56-55-3	BZAA	µg/Kg	330	20	50	110	30
Benzo(b)fluoranthene	205-99-2	BZBF	µg/Kg	330	26.2	45	115	30
Benzo(k)fluoranthene	207-08-9	BZKF	µg/Kg	330	40	45	125	30
Benzo(ghi)perylene	191-24-2	BZGHIP	µg/Kg	330	16	40	215	30
Benzo(a)pyrene	50-32-8	BZAP	µg/Kg	330	20	50	110	30
Chrysene	218-01-9	CHRYSENE	µg/Kg	330	27	55	110	30
Dibenz(a,h)anthracene	53-70-3	DBAHA	µg/Kg	330	19	40	125	30
Fluoranthene	206-44-0	FLA	µg/Kg	330	36	55	115	30
Fluorene	86-73-7	FL	µg/Kg	330	18	50	110	30
Indeno(1,2,3-cd)pyrene	193-39-5	INP123	µg/Kg	330	22	40	120	30
Naphthalene	91-20-3	NAPH	µg/Kg	330	31	40	105	30
Phenanthrene	85-01-8	PHAN	µg/Kg	330	17	50	110	30
Pyrene	129-00-0	PYR	µg/Kg	400	12.1	45	215	30
2-Fluorobiphenyl (surr)	321-60-8	PHEN2F				45	105	0
Nitrobenzene-d5 (surr)	4165-60-0	NO2BZD5				35	100	0
Terphenyl-d14 (surr)	1718-51-0	PHEND14				30	125	0

2. DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are qualitative and quantitative statements that specify the objectives of the project, define the types of decisions that will be made, identify the intended use of the data and design a data collection program that addresses the quantity and quality of data required to support the project objectives. The DQOs are based on the DQO process defined in EPA QA/G-4 EPA/240/B-06/001, February 2006. The DQO process identifies the overall objective of data needs and follows a documented process through to the sampling strategy. The purpose of using the DQO process is to ensure that the sampling data meet the needs of the project and the usability of the data is directly linked to the objectives.

The SWMUs-70 and -71 soil sampling project objectives include the following:

1. Verify that all contaminant concentrations remaining in the soil are below State of New Mexico soil screening levels (SSLs), and

2. Determine the potential need for further action.

SWMU-70 is an oil/water separator with associated leach field. SWMU-71 is a JP-4 fuel recovery tank.

Table C-8 presents the DQOs for the site inspection field work areas. Information from previous reports was evaluated to define the problem statements and the constituents of concern for the areas. The table also presents the conceptual contaminant transport processes, media of concern, and the number of samples that will satisfy the project objectives.

The media and contaminants of concern, and the number of samples for site inspection were provided by U.S. Army Corps of Engineers (USACE) in the Scope of Work (SOW) (USACE 2008). The DQO process presented in Table C-8 indicates that the scope is justifiable.

Laboratory detection limits for the analyses specified are expected to be in the range of low µg/kg to low mg/kg range for soils samples. The fixed laboratory detection limits and data quality acceptance ranges are presented in Tables C-2 thru C-7.

A critical element of decision-making is the threshold concentrations below which an action may not be required. These threshold concentrations are designed to be protective of the most susceptible human and ecological receptors, whether or not applicable to the site. The threshold concentrations minimize the possibility of false negatives (i.e., unsupported elimination of an area for further consideration). In other words, the site concentrations below the thresholds can be assumed to be safe, but the concentrations above the thresholds do not necessarily indicate unacceptable risk. Tables C-9 and C-10 present the human health and ecological risk screening criteria, or the threshold concentrations. Also presented in the tables is a comparison of the method detection limits (MDLs) with the criteria. Except for a few chlorinated VOCs, the MDLs are low enough to make the site decisions. Alternate analytical methods are not available for the VOCs with criteria lower than the MDLs.

The objectives for this sampling effort do not include background sampling for metals in soil. The site inspection performance standard for lead is 400 mg/kg (Table C-4).

Table C-8. Data Quality Objectives for the Work Areas.

Step 1 **State the Problem**	**Step 2** **Identify the Goal of the Study**	**Step 3** **Identify Information Inputs**	**Step 4** **Define the Boundaries of the Study**	**Step 5** **Develop the Analytical Approach**	**Step 6** **Specify Performance or Acceptance Criteria**	**Step 7** **Develop the Plan for Obtaining Data**
The problem that necessitates the study	How data will be used in meeting the objectives and solving the problem	Data and information needed to answer study questions	Target population, spatial and temporal limits	Parameters of Interest	Performance and acceptance criteria	Sampling and Analysis Plan
SWMU-70 – Oil/Water Separator No. 326 with associated Leach Field						
This oil/water separator is considered an area of interest because of the possibility of petroleum product contaminated soil. The system consisted of an oil/water separator and associated leach field that received wash-down water generated during JP-4 fuel truck maintenance. A bioventing system has been in operation at SWMU-70 for some time.	1) Identify releases that exceed NMED soil screening levels for residential exposure. 2) Identify the need for potential removal action for contaminated soil.	Analytical data are needed for comparison with NMED Soil Screening Levels in order to determine if the bio-venting system has been successful in reducing TPH concentration in soil. Media of concern include subsurface soil.	Future residential exposure to soil media in the study area is considered plausible.	TPH-DRO, TPH-GRO, VOCs, TVPH and BTEX, semivolatile organic compounds (SVOCs), metals, and pesticides/polychlorinated biphenyls (PCBs).	Subsurface Soil: If soil analyses indicate that subsurface soil contains contaminant concentrations that exceed the NMED SSLs (NMED 2006a) or the NMED TPH Screening Guidelines (NMED 2006b) (Attached as Appendix A) the data will be further evaluated to determine "hot spots", the effectiveness of the bio-venting system, or areas that may require a removal action, or to determine the need for further investigation.	Soil Gas: Collect soil gas samples from five depths from three monitoring locations using Summa® canisters to determine the need for subsurface soil sampling. 15 samples. Subsurface Soil: Advance 7 soil borings using DPT to a depth of 10 feet in the former location of the oil-water separator and leach field. Collect 2 soil samples per boring based on PID headspace screening or odor or visual indications of contamination. If no contamination is evident, collect samples at 5 feet and 20 feet depth at each location for off-site laboratory analysis (total 14 samples).
SWMU-71 – Former JP-4 Fuel Recovery Tank No. 390						
This area of the former JP-4 fuel recovery tank is considered an area of interest because of the possibility of petroleum product contaminated soil. The system consisted of a 2000-gallon underground JP-4 fuel storage tanks at Facility 390. The tank stored JP-4 that had escaped through pressure relief valves in the piping attached to the bulk fuel storage tanks.	1) Identify releases that exceed NMED soil screening levels for residential exposure. 2) Identify the need for potential removal action for contaminated soil.	Analytical data are needed for comparison with NMED Soil Screening Levels in order to determine if all contaminated soil that may have been present was removed when the old storage tank was replaced with storage tank system.	Future residential exposure to soil media in the study area is considered plausible.	TPH-DRO, TPH-GRO, VOCs, SVOCs, metals, and pesticides/PCBs.	Subsurface Soil: If soil analyses indicate that subsurface soil contains contaminant concentrations that exceed the NMED SSLs (NMED 2006a) or the NMED TPH Screening Guidelines (NMED 2006b) (Attached as Appendix A) the data will be further evaluated to determine areas that may require a removal action, or to determine the need for further investigation.	Subsurface Soil: Advance 3 soil borings using DPT to a depth of 10 feet in the former location of the JP-4 storage tank (adjacent to the location of the new storage tank). Collect 2 soil samples per boring based on PID headspace screening or odor or visual indications of contamination. If contamination is not evident, collect samples at 10 feet and 20 feet depth at each location for off-site laboratory analysis (total 6 samples).

Table C-9. Preliminary Human Health Protection Criteria.

Analytical Method	Analyte	CASRN	ParLabel	CASRN_alt	Soil		
					Protection of Groundwater Criteria (GPL, mg/kg)	Residential Exposure (RBSL, mg/kg)	Solid MDL OK?
8260C	Acetone	67-64-1	ACE	67-64-1	1.91E+01	2.81E+04	Yes
8260C	Benzene	71-43-2	BZ	71-43-2	2.01E-02	1.03E+01	Yes
8260C	Bromobenzene	108-86-1	BRBZ	108-86-1	2.14E-1	3.70E+01	Yes
8260C	Bromochloromethane	74-97-5	BRCLME	74-97-5			
8260C	Bromodichloromethane	75-27-4	BDCME	75-27-4	1.18E-02	1.44E+01	Yes
8260C	Bromoform	75-25-2	TBME	75-25-2			
8260C	Bromomethane	74-83-9	BRME	74-83-9	3.74E-02	8.51E+00	Yes
8260C	2-Butanone (MEK)	78-93-3	MEK	78-93-3	2.55E+01	3.18E+04	Yes
8260C	n-Butylbenzene	104-51-8	BTBZN	104-51-8	5.40E+00	6.21E+02	Yes
8260C	sec-Butylbenzene	135-98-8	BTBZS	135-98-8	4.33E+00	6.06E+01	
8260C	tert-Butylbenzene	98-06-6	BTBZT	98-06-6	4.30E+00	1.06E+02	Yes
8260C	Carbon disulfide	75-15-0	CDS	75-15-0	7.89E+00	4.60E+02	Yes
8260C	Carbon tetrachloride	56-23-5	CTCL	56-23-5	1.95E-02	3.47E+00	Yes
8260C	Chlorobenzene	108-90-7	CLBZ	108-90-7	1.10E+00	1.94E+02	Yes
8260C	Dibromochloromethane	124-48-1	DBCME	124-48-1	7.16E-03	1.48E+01	Yes
8260C	Chloroethane	75-00-3	CLEA	75-00-3	1.88E-01	6.33E+01	Yes
8260C	Chloroform	67-66-3	TCLME	67-66-3	8.25E-03	4.00E+00	Yes
8260C	Chloromethane	74-87-3	CLME	74-87-3	1.00E-01	2.18E+01	Yes
8260C	2-Chlorotoluene	95-49-8	CLBZME2	95-49-8			
8260C	4-Chlorotoluene	106-43-4	CLBZME4	106-43-4			
8260C	1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	DBCP	96-12-8	2.98E-03	1.84E+00	Yes
8260C	1,2-Dibromoethane (EDB)	106-93-4	EDB	106-93-4	2.40E-04	5.04E-01	No

Table C-9. (continued).

Analytical Method	Analyte	CASRN	ParLabel	CASRN_alt	Soil		
					Protection of Groundwater Criteria (GPL, mg/kg)	Residential Exposure (RBSL, mg/kg)	Solid MDL OK?
8260C	Dibromomethane	74-95-3	DBMA	74-95-3			Yes
8260C	1,2-Dichlorobenzene	95-50-1	DCBZ12	95-50-1	2.37E-01	3.74E+01	Yes
8260C	1,3-Dichlorobenzene	541-73-1	DCBZ13	541-73-1	8.73E-02	3.26E+01	Yes
8260C	1,4-Dichlorobenzene	106-46-7	DCBZ14	106-46-7	1.10E-01	3.95E+01	Yes
8260C	Dichlorodifluoromethane	75-71-8	FC12	75-71-8	5.72E+00	1.61E+02	Yes
8260C	1,1-Dichloroethane	75-34-3	DCA11	75-34-3	6.79E+00	1.40E+03	Yes
8260C	1,2-Dichloroethane	107-06-2	DCA12	107-06-2	5.71E-03	6.04E+00	Yes
8260C	cis-1,2-Dichloroethene	156-59-2	DCE12C	156-59-2	2.99E-01	7.65E+01	Yes
8260C	trans-1,2-Dichloroethene	156-60-5	DCE12T	156-60-5	6.67E-01	1.12E+02	Yes
8260C	1,1-Dichloroethene	75-35-4	DCE11	75-35-4	2.68E+00	2.06E+02	Yes
8260C	1,2-Dichloropropane	78-87-5	DCPA12	78-87-5	8.19E-03	6.00E+00	Yes
8260C	1,3-Dichloropropane	142-28-9	DCPA13	142-28-9	2.31E-02	1.20E+01	Yes
8260C	2,2-Dichloropropane	594-20-7	DCPA22	594-20-7			
8260C	cis-1,3-Dichloropropene	10061-01-5	DCP13C	10061-01-5			
8260C	trans-1,3-Dichloropropene	10061-02-6	DCP13T	10061-02-6			
8260C	1,1-Dichloropropene	563-58-6	DCP11	563-58-6			
8260C	Ethylbenzene	100-41-4	EBZ	100-41-4	2.02E+01	1.28E+02	Yes
8260C	Hexachlorobutadiene	87-68-3	HCBU	87-68-3			
8260C	2-Hexanone	591-78-6	HXO2	591-78-6			
8260C	Isopropylbenzene	98-82-8	IPBZ	98-82-8			
8260C	p-Isopropyltoluene	99-87-6	CYMP	99-87-6			
8260C	Methylene chloride	75-09-2	MTLNCL	75-09-2	1.70E-01	1.82E+02	Yes
8260C	4-Methyl-2-pentanone	108-10-1	MIBK	108-10-1			
8260C	Methyl tert-butyl ether	1634-04-4	MTBE	1634-04-4		3.88E+02	Yes

Table C-9. (continued).

Analytical Method	Analyte	CASRN	ParLabel	CASRN_alt	Soil		
					Protection of Groundwater Criteria (GPL, mg/kg)	Residential Exposure (RBSL, mg/kg)	Solid MDL OK?
8260C	Naphthalene	91-20-3	NAPH	91-20-3	3.94E-01	7.95E+01	Yes
8260C	n-Propylbenzene	103-65-1	PBZN	103-65-1			
8260C	Styrene	100-42-5	STY	100-42-5	1.05E+01	1.00E+02	Yes
8260C	1,1,1,2-Tetrachloroethane	630-20-6	TC1112	630-20-6	2.50E-02	4.32E+01	Yes
8260C	1,1,2,2-Tetrachloroethane	79-34-5	PCA	79-34-5	3.21E-03	5.55E+00	Yes
8260C	Tetrachloroethene	127-18-4	PCE	127-18-4	5.74E-02	1.25E+01	Yes
8260C	Toluene	108-88-3	BZME	108-88-3	2.17E+01	2.52E+02	Yes
8260C	1,2,3-Trichlorobenzene	87-61-6	TCB123	87-61-6			
8260C	1,2,4-Trichlorobenzene	120-82-1	TCB124	120-82-1	5.00E+00	6.22E+01	Yes
8260C	1,1,1-Trichloroethane	71-55-6	TCA111	71-55-6	2.65E+01	5.63E+02	Yes
8260C	1,1,2-Trichloroethane	79-00-5	TCA112	79-00-5	9.95E-03	1.19E+01	Yes
8260C	Trichloroethene	79-01-6	TCE	79-01-6	2.00E-03	6.38E-01	Yes
8260C	Trichlorofluoromethane	75-69-4	FC11	75-69-4	2.23E+01	5.88E+02	Yes
8260C	1,2,3-Trichloropropane	96-18-4	TCPR123	96-18-4	2.35E-01	2.53E-01	Yes
8260C	1,2,4-Trimethylbenzene	95-63-6	TMB124	95-63-6	1.42E+00	5.80E+01	Yes
8260C	1,3,5-Trimethylbenzene	108-67-8	TMB135	108-67-8	3.55E-01	2.48E+01	Yes
8260C	Vinyl chloride	75-01-4	VC	75-01-4	2.80E-03	2.25E-00	Yes
8260C	m-Xylene	1330-20-7	XYLM	179601-23-1	2.06E+00	8.20E+01	Yes
8260C	o-Xylene	95-47-6	XYLO	95-47-6	8.14E+01	9.95E+01	
6010C	Aluminum	7429-90-5	AL	7429-90-5	1.10E+06	7.78E+04	Yes
6010C	Antimony	7440-36-0	SB	7440-36-0	1.32E+01	3.13E+01	Yes
6010C	Arsenic	7440-38-2	AS	7440-38-2	2.90E-01	3.90E+00	Yes

Table C-9. (continued).

Analytical Method	Analyte	CASRN	ParLabel	CASRN_alt	Soil		
					Protection of Groundwater Criteria (GPL, mg/kg)	Residential Exposure (RBSL, mg/kg)	Solid MDL OK?
6010C	Barium	7440-39-3	BA	7440-39-3	6.03E+03	1.56E+04	Yes
6010C	Beryllium	7440-41-7	BE	7440-41-7	1.15E+03	1.56E+02	Yes
6010C	Cadmium	7440-43-9	CD	7440-43-9	2.75E+01	3.90E+01	Yes
6010C	Calcium	7440-70-2	CA	7440-70-2			
6010C	Chromium	7440-47-3	CR	7440-47-3	1.97E+09	1.00E+05	
6010C	Cobalt	7440-48-4	CO	7440-48-4	6.61E+02	1.52E+03	Yes
6010C	Copper	7440-50-8	CU	7440-50-8	1.03E+03	3.13E+03	Yes
6010C	Iron	7439-89-6	FE	7439-89-6	5.54E+03	2.35E+04	Yes
6010C	Lead	7439-92-1	PB	7439-92-1		4.00E+02	Yes
6010C	Magnesium	7439-95-4	MG	7439-95-4			
6010C	Manganese	7439-96-5	MN	7439-96-5	2.24E+03	3.59E+03	Yes
6010C	Molybdenum	7439-98-7	MO	7439-98-7	7.40E+01	3.91E+02	Yes
6010C	Nickel	7440-02-0	NI	7440-02-0	9.53E+02	1.56E+03	Yes
6010C	Potassium	7440-09-7	K	7440-09-7			
6010C	Selenium	7782-49-2	SE	7782-49-2	1.90E+01	3.91E+02	Yes
6010C	Silver	7440-22-4	AG	7440-22-4	3.13E+01	3.91E+02	Yes
6010C	Sodium	7440-23-5	NA	7440-23-5			
6010C	Thallium	7440-28-0	TL	7440-28-0	3.43E+00	5.16E+00	Yes
6010C	Vanadium	7440-62-2	V	7440-62-2	7.30E+02	7.82E+01	Yes
6010C	Zinc	7440-66-6	ZN	7440-66-6	1.36E+04	2.35E+04	Yes
8015BM	Gasoline Range Organics (C_7 - C_{12} range)	GRO	GRO	GRO			
8015BM	Diesel Range Organics (C_{10} - C_{24} range)	DRO	DRO	DRO		520	
8015BM	Heating Oil (C_{14} - C_{20} range)	HOIL	HOIL	HOIL			

Table C-9. (continued).

Analytical Method	Analyte	CASRN	ParLabel	CASRN_alt	Soil		
					Protection of Groundwater Criteria (GPL, mg/kg)	Residential Exposure (RBSL, mg/kg)	Solid MDL OK?
8270D-SIM	Acenaphthene	83-32-9	ACNP	83-32-9	5.49E+01	3.73E+03	Yes
8270D-SIM	Acenaphthylene	208-96-8	ACNPY	208-96-8			
8270D-SIM	Anthracene	120-12-7	ANTH	120-12-7	1.62E+03	2.20E+04	Yes
8270D-SIM	Benzo(a)anthracene	56-55-3	BZAA	56-55-3	1.09E+01	6.21E+00	Yes
8270D-SIM	Benzo(b)fluoranthene	205-99-2	BZBF	205-99-2	3.35E+01	6.21E+00	Yes
8270D-SIM	Benzo(k)fluoranthene	207-08-9	BZKF	207-08-9	3.35E+02	6.21E+01	Yes
8270D-SIM	Benzo(ghi)perylene	191-24-2	BZGHIP	191-24-2			
8270D-SIM	Benzo(a)pyrene	50-32-8	BZAP	50-32-8	2.78E+00	6.21E-01	Yes
8270D-SIM	Chrysene	218-01-9	CHRYSENE	218-01-9	3.48E+02	6.15E+02	Yes
8270D-SIM	Dibenz(a,h)anthracene	53-70-3	DBAHA	53-70-3	1.04E+01	6.21E-01	Yes
8270D_SIM	Fluoranthene	206-44-0	FLA	206-44-0	4.69E+03	2.29E+03	Yes
8270D-SIM	Fluorene	86-73-7	FL	86-73-7	5.85E+01	2.66E+03	Yes
8270D_SIM	Indeno(1,2,3-cd)pyrene	193-39-5	INP123	193-39-5	9.46E+01	6.21E+00	Yes
8270D_SIM	Naphthalene	91-20-3	NAPH	91-20-3	3.94E-01	7.95E+01	Yes
8270D-SIM	Phenanthrene	85-01-8	PHAN	85-01-8	4.64E+02	1.83E+03	
8270-SIMD	Pyrene	129-00-0	PYR	129-00-0	3.73E+03	2.29E+03	Yes
8081A	Aldrin				2.84E+00	2.84E-01	
8081A	a-BHC				4.25E-03	9.02E-01	
8081A	b-BHC				1.52E-02	3.16E+00	
8081A	g-BHC				1.82E-02	4.37E+00	
8081A	Bromobenzene				2.14E-01	3.70E+01	
8081A	Bromodichloromethane				1.18E-02	1.44E+01	
8081A	Chlordane				6.83E+00	1.62E+01	
8081A	DDD				8.30E+01	2.44E+01	
8081A	DDE				2.62E+02	1.72E+01	

Table C-9. (continued).

Analytical Method	Analyte	CASRN	ParLabel	CASRN_alt	Soil		
					Protection of Groundwater Criteria (GPL, mg/kg)	Residential Exposure (RBSL, mg/kg)	Solid MDL OK?
8081A	DDT				1.54E+02	1.72E+01	
8081A	Dieldrin				2.68E-02	3.04E-01	
8081A	Endosulfan				1.48E+01	3.67E+02	
8081A	Endrin				4.08E+00	1.83E+01	
8081A	Heptachlor				6.24E+00	1.08E+00	
8081A	Hexachlorobenzene				6.86E-01	3.04E+00	
8082	Aroclor 1016				3.45E+00	3.93E+00	
8082	Aroclor 1221				4.47E-01	1.12E+00	
8082	Aroclor 1232				4.47E-01	1.12E+00	
8082	Aroclor 1242				4.47E-01	1.12E+00	
8082	Aroclor 1248				5.28E+00	1.12E+00	
8082	Aroclor 1254				5.28E+00	1.12E+00	
8082	Aroclor 1260				5.28E+00	1.12E+00	

Table C-10. Preliminary Ecological Screening Criteria.

Analytical Method	Analyte	CASRN	CASRN_alt	Soil ESL (mg/kg)	Sediment ESL (mg/kg)	Solid MDL OK?
8260C	Acetone	67-64-1	67-64-1	2.50E+00	9.90E-03	**No**
8260C	Benzene	71-43-2	71-43-2	5.00E-02	5.70E-02	Yes
8260C	Bromobenzene	108-86-1	108-86-1			
8260C	Bromochloromethane	74-97-5	74-97-5			
8260C	Bromodichloromethane	75-27-4	75-27-4	5.40E-01		Yes
8260C	Bromoform	75-25-2	75-25-2	1.59E+01	4.92E-01	Yes
8260C	Bromomethane	74-83-9	74-83-9	2.35E-01	1.37E-03	**No**
8260C	2-Butanone (MEK)	78-93-3	78-93-3	8.96E+01	4.24E-02	Yes
8260C	n-Butylbenzene	104-51-8	104-51-8			
8260C	sec-Butylbenzene	135-98-8	135-98-8			
8260C	tert-Butylbenzene	98-06-6	98-06-6			
8260C	Carbon disulfide	75-15-0	75-15-0	9.41E-02	2.39E-02	Yes
8260C	Carbon tetrachloride	56-23-5	56-23-5	2.98E+00	1.20E+00	Yes
8260C	Chlorobenzene	108-90-7	108-90-7	5.00E-02	2.91E-01	Yes
8260C	Dibromochloromethane	124-48-1	124-48-1	2.05E+00	1.11E+00	Yes
8260C	Chloroethane	75-00-3	75-00-3			
8260C	Chloroform	67-66-3	67-66-3	1.00E-03	1.21E-01	**No**
8260C	Chloromethane	74-87-3	74-87-3	1.04E+01		Yes
8260C	2-Chlorotoluene	95-49-8	95-49-8			
8260C	4-Chlorotoluene	106-43-4	106-43-4			
8260C	1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	96-12-8	3.52E-02		Yes
8260C	1,2-Dibromoethane (EDB)	106-93-4	106-93-4	1.23E+00		Yes
8260C	Dibromomethane	74-95-3	74-95-3	6.50E+01		Yes
8260C	1,2-Dichlorobenzene	95-50-1	95-50-1	1.00E-02	2.94E-01	Yes
8260C	1,3-Dichlorobenzene	541-73-1	541-73-1	3.77E+01	1.32E+00	Yes
8260C	1,4-Dichlorobenzene	106-46-7	106-46-7	1.00E-02	3.18E-01	Yes
8260C	Dichlorodifluoromethane	75-71-8	75-71-8	3.95E+01		Yes
8260C	1,1-Dichloroethane	75-34-3	75-34-3	2.01E+01	5.75E-04	**No**

Table C-10. (continued).

Analytical Method	Analyte	CASRN	CASRN_alt	Soil ESL (mg/kg)	Sediment ESL (mg/kg)	Solid MDL OK?
8260C	1,2-Dichloroethane	107-06-2	107-06-2	4.00E-01	2.60E-01	Yes
8260C	cis-1,2-Dichloroethene	156-59-2	156-59-2			
8260C	trans-1,2-Dichloroethene	156-60-5	156-60-5	7.84E-01	6.54E-01	Yes
8260C	1,1-Dichloroethene	75-35-4	75-35-4	8.28E+00	1.94E-02	Yes
8260C	1,2-Dichloropropane	78-87-5	78-87-5	3.27E+01	3.33E-01	Yes
8260C	1,3-Dichloropropane	142-28-9	142-28-9			
8260C	2,2-Dichloropropane	594-20-7	594-20-7			
8260C	cis-1,3-Dichloropropene	10061-01-5	10061-01-5	3.98E-01		Yes
8260C	trans-1,3-Dichloropropene	10061-02-6	10061-02-6	3.98E-01		Yes
8260C	1,1-Dichloropropene	563-58-6	563-58-6			
8260C	Ethylbenzene	100-41-4	100-41-4	5.00E-02	1.75E-01	Yes
8260C	Hexachlorobutadiene	87-68-3	87-68-3	3.98E-02	2.65E-02	Yes
8260C	2-Hexanone	591-78-6	591-78-6	1.26E+01	5.82E-02	Yes
8260C	Isopropylbenzene	98-82-8	98-82-8			
8260C	p-Isopropyltoluene	99-87-6	99-87-6			
8260C	Methylene chloride	75-09-2	75-09-2	2.00E+00	1.59E-01	Yes
8260C	4-Methyl-2-pentanone	108-10-1	108-10-1	4.43E+02	2.51E-02	Yes
8260C	Methyl tert-butyl ether	1634-04-4	1634-04-4			
8260C	Naphthalene	91-20-3	91-20-3	9.94E-02	1.76E-01	Yes
8260C	n-Propylbenzene	103-65-1	103-65-1			
8260C	Styrene	100-42-5	100-42-5	1.00E-01	2.54E-01	Yes
8260C	1,1,1,2-Tetrachloroethane	630-20-6	630-20-6	2.25E+02		Yes
8260C	1,1,2,2-Tetrachloroethane	79-34-5	79-34-5	1.27E-01	8.50E-01	Yes
8260C	Tetrachloroethene	127-18-4	127-18-4	1.00E-02	5.30E-01	Yes
8260C	Toluene	108-88-3	108-88-3	5.00E-02	6.70E-01	Yes
8260C	1,2,3-Trichlorobenzene	87-61-6	87-61-6	1.00E-02		Yes
8260C	1,2,4-Trichlorobenzene	120-82-1	120-82-1	1.00E-02	5.06E+00	Yes
8260C	1,1,1-Trichloroethane	71-55-6	71-55-6	2.98E+01	1.70E-01	Yes

Table C-10. (continued).

Analytical Method	Analyte	CASRN	CASRN_alt	Soil ESL (mg/kg)	Sediment ESL (mg/kg)	Solid MDL OK?
8260C	1,1,2-Trichloroethane	79-00-5	79-00-5	2.86E+01	5.18E-01	Yes
8260C	Trichloroethene	79-01-6	79-01-6	1.00E-03	1.12E-01	**No**
8260C	Trichlorofluoromethane	75-69-4	75-69-4	1.64E+01		Yes
8260C	1,2,3-Trichloropropane	96-18-4	96-18-4	3.36E+00		Yes
8260C	1,2,4-Trimethylbenzene	95-63-6	95-63-6			
8260C	1,3,5-Trimethylbenzene	108-67-8	108-67-8			
8260C	Vinyl chloride	75-01-4	75-01-4	1.00E-02	2.02E-01	Yes
8260C	m-Xylene & p-Xylene	1330-20-7	179601-23-1			
8260C	o-Xylene	95-47-6	95-47-6			
6010C	Aluminum	7429-90-5	AL	5.00E+01		Yes
6010C	Antimony	7440-36-0	SB	1.42E-01	2.00E+00	**No**
6010C	Arsenic	7440-38-2	AS	5.70E+00	5.90E+00	Yes
6010C	Barium	7440-39-3	BA	1.04E+00		**No**
6010C	Beryllium	7440-41-7	BE	1.06E+00		Yes
6010C	Cadmium	7440-43-9	CD	2.22E-03	5.96E-01	**No**
6010C	Calcium	7440-70-2	CA			
6010C	Chromium	7440-47-3	CR	4.00E-01	3.73E+01	**No**
6010C	Cobalt	7440-48-4	CO	1.40E-01	5.00E+01	**No**
6010C	Copper	7440-50-8	CU	5.40E+00	1.87E+01	Yes
6010C	Iron	7439-89-6	FE	2.00E+02	2.00E+04	Yes
6010C	Lead	7439-92-1	PB	5.37E-02	3.02E+01	**No**
6010C	Magnesium	7439-95-4	MG			
6010C	Manganese	7439-96-5	MN	1.00E+02	4.60E+02	Yes
6010C	Molybdenum	7439-98-7	MO	2.00E+00		Yes
6010C	Nickel	7440-02-0	NI	1.36E+01	1.59E+01	Yes
6010C	Potassium	7440-09-7	K			
6010C	Selenium	7782-49-2	SE	2.76E-02		**No**
6010C	Silver	7440-22-4	AG	2.00E+00	5.00E-01	**No**

Table C-10. (continued).

Analytical Method	Analyte	CASRN	CASRN_alt	Soil ESL (mg/kg)	Sediment ESL (mg/kg)	Solid MDL OK?
6010C	Sodium	7440-23-5	NA			
6010C	Thallium	7440-28-0	TL	5.69E-02		**No**
6010C	Vanadium	7440-62-2	V	1.59E+00		Yes
6010C	Zinc	7440-66-6	ZN	6.62E+00	1.21E+02	Yes
8015D, Cal_LUFT	Gasoline Range Organics (C_7 - C_{12} range)	GRO	GRO			
8015DD	Diesel Range Organics (C_{10} - C_{24} range)	DRO	DRO			
8015DR	Heating Oil (C_{14} - C_{20} range)	HOIL	HOIL			
8270CSIM	Acenaphthene	83-32-9	ACNP	2.00E+01	6.71E-03	Yes
8270CSIM	Acenaphthylene	208-96-8	ACNPY	6.82E+02	5.87E-03	Yes
8270CSIM	Anthracene	120-12-7	ANTH	1.00E-01	5.72E-02	Yes
8270CSIM	Benzo(a)anthracene	56-55-3	BZAA	5.21E+00	3.17E-02	Yes
8270CSIM	Benzo(b)fluoranthene	205-99-2	BZBF	5.98E+01	1.04E+01	Yes
8270CSIM	Benzo(k)fluoranthene	207-08-9	BZKF	1.48E+02	2.40E-01	Yes
8270CSIM	Benzo(ghi)perylene	191-24-2	BZGHIP	1.19E+02	1.70E-01	Yes
8270CSIM	Benzo(a)pyrene	50-32-8	BZAP	1.00E-01	3.19E-02	Yes
8270CSIM	Chrysene	218-01-9	CHRYSENE	4.73E+00	5.71E-02	Yes
8270CSIM	Dibenz(a,h)anthracene	53-70-3	DBAHA	1.84E+01	3.30E-02	Yes
8270CSIM	Fluoranthene	206-44-0	FLA	1.00E-01	1.11E-01	Yes
8270CSIM	Fluorene	86-73-7	FL	3.00E+01	7.74E-02	Yes
8270CSIM	Indeno(1,2,3-cd)pyrene	193-39-5	INP123	1.09E+02	2.00E-01	Yes
8270CSIM	Naphthalene	91-20-3	NAPH	9.94E-02	1.76E-01	Yes
8270CSIM	Phenanthrene	85-01-8	PHAN	1.00E-01	4.19E-02	Yes
8270CSIM	Pyrene	129-00-0	PYR	1.00E-01	5.30E-02	Yes

2.1 Screening Level Data

Screening data are often generated by rapid, less precise methods of analysis or with less rigorous sample preparation. Screening data provide analyte identification and quantification, although quantification may be relatively imprecise and not always definitive. Screening level data are often used for health and safety monitoring, preliminary comparison to applicable or relevant and appropriate requirements (ARARs), or initial site characterization to locate areas for subsequent laboratory based analyses.

The analysis of headspace for soil samples (by photoionization detector [PID]) and the measurement of pH, specific conductance, temperature, turbidity, and dissolved oxygen performed in the field on water samples are considered screening level data. Screening data will be used to direct fieldwork and monitor stabilization of groundwater conditions during sampling. Without documented and standardized procedures that demonstrate method performance within known QC criteria, these methods cannot be considered definitive.

2.2 Definitive Data

Definitive data are needed to support the assessment of carcinogenic and non-carcinogenic risks to human receptors as well as ecological receptors. The Environmental Protection Agency (EPA) defines definitive data as data generated using rigorous analytical methods with satisfactory QC requirements, such as approved EPA reference methods. Data are analyte-specific, with confirmation of analyte identity and concentration. Methods produce tangible raw data (e.g., chromatograms, spectra, and digital values) in the form of paper printouts and computer-generated electronic files. Data may be generated at the site or at an off-site location, as long as the QC requirements are satisfied. The data generated at an off-site environmental laboratory will be considered definitive.

2.3 Method Specific Data Quality Indicators

Precision, accuracy, representativeness, completeness, and comparability goals for this project are defined below. These data quality parameters are expressed as goals due to uncertainties regarding field conditions and the complexity of the sample matrices at the site. The ability of the laboratory to extract and quantify the target analytes is dependent on the matrix complexity. The variability of field conditions (i.e., soil type and contaminant deposition) will also affect the data representativeness and comparability. The data quality indicator acceptance criteria for the fixed laboratory methods are provided in Tables C-2 to C-7.

2.3.1 Precision

Precision is a measure of the degree of mutual agreement among data that have been collected the same way under prescribed conditions. Precision is assessed by replicate measurements of known standards and analysis of duplicate field samples. Precision is expressed as relative percent difference (RPD) between duplicate samples.

Field: Field-sampling precision will be assessed through comparisons of field duplicate sample analytical results. Sampling and Analysis Plan (SAP) tables, included as Appendix A of the Work Plan, show the field duplicate samples that will be collected. The field duplicates will be taken from the areas of highest potential contamination.

2.3.2 Accuracy

Accuracy is the measure of the closeness of an observed value to the accepted reference or true value. Accuracy is expressed as percent recovery for each analyte of the spike samples (matrix spike/matrix spike duplicates [MS/MSDs], laboratory control samples [LCSs], surrogates, etc.).

$$\% R = \frac{(SpikeAmount - SampleAmount)}{SpikeConcentrationAdded} \times 100$$

%R: Percent Recovery.

2.3.3 Representativeness

Field: Representativeness is dependent upon the proper design of the sampling program. Representativeness will be satisfied by ensuring that the Field Sampling Plan (FSP) is followed, proper sampling techniques are used, proper sample handling and documentation procedures are followed, and proper analytical procedures are followed in the field (North Wind procedures will be used, where applicable). Proper documentation will establish that protocols have been followed and sample identification and integrity are assured. Additionally, representativeness requires that the sample is adequately preserved and is not biased by field-induced contamination during sample collection, handling, and shipment. Therefore, representativeness will be assessed by analyzing field blanks, trip blanks, laboratory checks of pH for preserved water samples and the temperature of the samples as received at the laboratory. Samples will be maintained at a temperature of 4°C ± 2°C.

Field blank samples will be collected as stated in the FSP (see Section 3 of the Work Plan). Field blank samples are prepared at a specified sampling location by exposing certified analyte free water to ambient field conditions. Trip blanks will accompany all sample shipments that contain water samples for VOC analysis. Trip blanks provide an indication of contamination attributable to sample collection, handling and shipment. Trip blanks will be prepared in the laboratory from organic-free water provided by the laboratory and will be analyzed for all VOC analytes of concern.

The objective is for trip blanks and laboratory method blanks to contain no detectable project analytes above the analytical laboratory reporting limits (LRL) and for all samples to be the proper pH and temperature when received at the laboratory. However, it is recognized that common contaminants arising from field sampling equipment, decontamination solutions and laboratory operations may be detected, including: acetone, methylene chloride, toluene, 2-butanone, and the common phthalates. A limit for laboratory corrective will be set at one-half the RL for all analytes, except common laboratory contaminants. The common laboratory contaminants may not exceed the RL. Concentrations above these limits detected in laboratory blanks will require the initiation of a laboratory corrective action, and reanalysis of samples associated with the noncompliant blanks if the analyte in question was also detected in the field samples.

Laboratory: Representativeness expresses the degree to which data accurately and precisely represents the characteristics of a population of samples, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness is a measure of how closely the measured results reflect the actual concentration or distribution of the chemical compounds in the sample. Analytical data should represent the sample analyzed. Representativeness of the analytical results with respect to the medium sampled can be assessed by comparing the results for field duplicate samples collected from a site. To ensure representativeness in the laboratory, the samples will be prepared and analyzed together as much as possible so that the laboratory QC is applicable to this project's samples and laboratory variables are minimized.

2.3.4 Completeness

Field: Completeness of field activities will be measured as the amount of field measurements (pH, conductivity, temperature, headspace analysis, etc.) that comply with field standard operating procedures (SOPs) for calibration and precision objectives compared to all of the field measurements attempted. The field data completeness objective for this site inspection is 95%.

Field sample collection completeness will be measured as the total number of field samples of sufficient volume collected for laboratory analysis compared to the total number of samples planned for collection in the FSP and Table C-11 of this QAPP.

Laboratory: Completeness is defined as the amount of valid data obtained from the laboratory compared with the amount of data that would be expected under normal conditions. Completeness is presented in Table C-11 as the percent of data that are valid, or not rejected. Data are considered valid if they are unqualified detections or non-detections, if they are qualified as estimated (J), or qualified as estimated at the reporting limit (UJ). For chemical analyses, the completeness of laboratory analytical data will be 95% or better. The goal for meeting the holding times is 100%.

Table C-11. Sampling and Analysis Completeness Goals, SWMUs-70 and -71.

Analyte	Matrix	Completeness (%)
Field Data Collection	Solid	95
Field Sample Collection	Solid	100
Holding Time for all analytes	Solid	100
FPXRF Field Measurements	Soil	95
All Fixed Laboratory Measurements	Solid	95

The percent completeness for each set of samples can be calculated as follows:

Completeness = [valid data obtained / total data planned] x 100.

2.3.5 Comparability

Field: Comparability of data obtained during this investigation is dependent upon the proper design of the sampling program and will be satisfied by ensuring the FSP is followed and proper sampling and handling techniques are used. The intent is that field data will be directly comparable to data obtained during subsequent phases of the project.

Laboratory: Comparability is an expression of the confidence with which one data set can be compared with another. Comparability of analytical data will be achieved through the use of accepted and documented analytical methods. The data will be reported in units consistent with Federal and State regulations, methods, and guidelines. Reporting limits (RLs) for all analytes will be recorded on all laboratory data report sheets for all samples within the sample set. Comparability between databases will be achieved by using standardized sampling and analysis methods and data formats.

2.3.6 Sensitivity

Sensitivity broadly describes the method detection/quantitation/RLs established to meet the project-specific DQOs. The sample RL is the lowest concentration of an analyte that can be reported by the laboratory without qualifying the result as estimated, such as applying "J-flags". The RLs are a function of the sample characteristics, method quantitation and laboratory performance.

MDLs are determined by the laboratory by performing annual MDL studies according to 40 Code of Federal Regulations (CFR) 136, subpart B. The MDLs and quantitation limits (QLs) are then defined based on the variability observed within the MDL sample measurements (3-sigma, and 10-sigma, respectively). The method quantitation limit (MQL) is considered the level at which the laboratory can reliably quantitate the concentration of an analyte to a known accuracy, and will typically represent the concentration of the low standard of the initial calibration curve. The RL can be equal to the Method Quantitation Limit, but often are above since the MDL studies are performed using clean matrices (spiked deionized [DI] water) and represent a best-case sensitivity; whereas, environmental samples are naturally more complex and may include error and/or bias. RL and/or practical quantitation limits (PQLs) are provided in Section 5 of this QAPP. For this project, data reported below the RL will be reported as estimated. Factors that may result in elevated RL are:

- High concentrations of target or nontarget analytes may require that the sample extract be diluted to avoid saturation of the detector or to quantify the analyte concentration within the calibration range of the instrument. Consequently, RLs are elevated in proportion to the dilution factor.

- Matrix interferences may require that the sample be diluted to reduce or eliminate the interference. Consequently, the RL are elevated in proportion to the dilution factor.

- The physical characteristics of the matrix do not permit concentration to the required final extract volume during sample preparation resulting in an elevation in RLs.

- Matrix interference may introduce bias and cause the RL to be elevated.

3. SAMPLE RECEIPT, HANDLING, AND CUSTODY

The generation of useable data includes the proper handling of samples at the time of collection, observing documented preservation requirements, maintaining complete documentation, and observing custody protocols. The analytical protocols for sample containers, preservation, holding times, and required sample volumes are summarized in Table C-12 for soil and sediment samples.

Table C-12. Sample Containers, Preservation, and Holding Times, and Soil and Soil Gas Samples at the SWMUs-70 and -71.

Method Number and Analysis	**TPH DRO (8015BM)**	**TPH GRO (8015BM)**	**TVPH and BTEX (TO-3)**	**VOCs (8260C)**	**SVOCs (8270D-SIM)**	**Metals (6010C)**	**Pesticides/ PCB(8081 A/8082)**
Matrix	Soil	Soil	Soil Gas	Soil	Soil	Soil	Soil
Preservatives	Chill to 4°C ± 2°C	Chill to 4°C ± 2°C	NA	Chill to 4°C ± 2°C	Chill to 4°C ± 2°C		Chill to 4°C ± 2°C
Analytical Holding Time	14 days	14 days	30 days	14 days	14 days to extraction 40 days to analysis	6 months	14 days
Sample Volume/ Sample Container	2 × 8 ounce glass jar	3 × 5 gram en core sampler	1 liter SUMMA canister	3 × 5 gram en core sampler	1 × 8 ounce glass jar	1 × 8 ounce glass jar	1 x 8 ounce glass jar

3.1 Field Operations

Sample custody is critical to ensuring the integrity of field sampling and laboratory analysis. In the field, all sample labeling, packing, transportation, and Chain of Custody (COC) procedures will follow the Requirements for the Preparation of Sampling and Analysis Plans (USACE 2001). A sample is under a person's custody if it is in their actual possession. A sample in a designated and secure area is under the custody of the person responsible for the security of that area. Each person involved with sample handling will be trained in COC procedures prior to the implementation of the field program at the site.

Sample custody documentation is initiated in the field as each sample is collected. The sampling team assumes custody of the samples as soon as they are collected. A sample label is attached to each sample jar immediately after it is filled to uniquely identify the sample. The sample information is also recorded in the field logbook at the time of collection. Details regarding sample custody documentation are provided in the FSP and in the SOPs. To reduce the chance for error, the number of field personnel handling the samples will be minimized.

Samples will be maintained in strict custody and held cool on ice or in a refrigerator to maintain the 4˚C ± 2˚C. The samples will be shipped to the laboratory on the day of sample collection by an overnight courier.

During sample collection or at the end of each day and prior to shipping or storage, COC forms will be completed for all samples. The information on the sample labels will be rechecked and verified against field logbook entries and the COC forms. Any necessary changes to COC forms, sample container labels, or the field logbook will be made by striking out the error with one line and reentering the correct information. The new entries will be initialed and dated.

Samples for laboratory QC procedures (MS/MSDs) will be designated as such on the COC form. The laboratory will decide how to batch samples within the constraint of a maximum of 20 samples per batch. Samples that arrive over a period of several days may be combined in a Sample Delivery Group (SDG), provided the samples are processed together and holding times are not jeopardized.

All field activities must be documented. Laboratory receipt of samples, proper storage and preservation, holding times, and extraction of samples (if necessary) must also be documented.

3.2 Shipping Operations

All samples will be accompanied by COC forms during shipment. The sampler provides the first signature on the COC form when relinquishing custody to the shipping company or laboratory courier. When samples are shipped, the sample containers will be securely packed inside the shipping coolers and placed on ice, as specified in the FSP. The original COC forms will be enclosed in a plastic bag and taped to the inside lid of the cooler. The cooler will be taped closed by wrapping fiber tape completely around it. “This End Up” labels and “Fragile” labels, as well as any other required shipping labels, will be attached to the cooler and the cooler will be sealed with two custody seals on adjacent sides of the lid. Packaging will conform to applicable U.S. Department of Transportation regulations.

Field personnel will be responsible for sample custody and appropriate sample storage prior to shipment, as well as for packing and shipping samples in a manner that allows the laboratory sufficient time to meet holding time requirements. Field personnel will contact the laboratory to notify them of each sample shipment.

3.3 Laboratory Operations

The laboratory will verify receipt of each sample shipment and will contact the Project Chemist or designee to provide notification that all samples were received and to relay any concerns or observations regarding sample integrity or documentation. The laboratory will also be responsible for ensuring that laboratory COC forms and tracking records are completed upon receipt of the samples and maintained through all stages of laboratory analysis. Storage information must be maintained until disposal of the samples. The sample tracking records must show the date of sample extraction or preparation and the date of instrument analysis for each analytical procedure. These records will be used to determine compliance with holding time requirements. The laboratory will maintain daily temperature logs for all refrigerators and freezers that contain samples for this project. These logs will be stored at the laboratory and copies will be made available to the USACE, as requested. The laboratory will notify the Project Chemist or designee if storage temperatures deviate from those specified in the associated method.

3.4 Inspection of Sample Receipt Condition

The laboratory will log the essential parameters of sample receipt. These log-in sheets will be included as part of the laboratory report. Information recorded in the log-in sheets will include, at a minimum, the following:

- Identification of samples received, including all location and sample identification numbers,
- Date and time of sample collection,
- Condition of the containers upon receipt, including cooler temperature and temperature of the sample blank,

- Types of containers and verification of preservatives (if applicable),
- Analyses requested,
- Laboratory project number, and
- Sample custodian's signature and date.

In addition, the laboratory will notify the Project Manager (PM) or the Field Team Leader (FTL) as soon as possible if the conditions of any submitted samples are not acceptable to the extent that re-sampling would be required (e.g., if sample containers were received broken).

4. PROJECT ORGANIZATION OVERVIEW

The project organization is designed to provide a line of functional responsibility and authority, and be supported by a management control structure defined in Section 1.3 of the Work Plan. This control structure provides for effective quality assurance of data collection and can identify concerns or corrections as work progresses. North Wind will provide project management, perform the field investigations, review and evaluate the data, prepare Data Quality Control Reports (DQCRs) and prepare a draft, draft final, and final site inspection report.

4.1 Quality Assurance Responsibilities

The Project Chemist, along with the Laboratory Director, will ensure appropriate analysis and data collection are performed as per the DQOs. The data quality evaluation findings will be incorporated into the Quality Control Summary Report (QCSR) provided as an attachment to the site inspection report. The DQCRs will be provided to the USACE to track field work compliance. The COCs, Cooler Receipt forms, and appropriate laboratory QC forms will be examined to assure project requirements have been fulfilled. The FTL will perform oversight of all fieldwork. The Project Chemist or designee will perform data verification on 100% of the data, and validate all of the data by media. All personnel involved in this project will adhere to the COC and field documentation protocols and will perform all activities in accordance with the FSP and Site Safety and Health Plan (SSHP). The laboratory will perform the sample analyses and will provide a preliminary review of the data and assign qualifiers based on review of QC data. QA, field, laboratory, and management responsibilities of key project personnel are defined below.

4.1.1 Project Manager

The Project Manager will provide day-to-day supervision and ensure that the scope is executed according to all planning documents to ensure quality data. Any quality assurance issues that may arise will be addressed as necessary to preserve the integrity of the data. Other duties of the Project Manager include:

- Serving as the primary point of contact to the USACE for all aspects of task order execution;
- Ensuring routine compliance with the project work plans;
- Verifying training and qualifications of personnel conducting quality-affecting work;
- Responding and correcting quality problems and deviations;
- Directing staff to prepare deliverables and execute field work;
- Coordinating, managing, and overseeing all subcontractors involved in each project;
- Negotiating subcontract agreements and approving subcontractor invoices;
- Reviewing and approving all task order submittals; and
- Ensuring compliance with all applicable federal, state, and local regulations.

4.1.2 Project Chemist

The Project Chemist has primary responsibility for ongoing surveillance of project activities to help ensure conformance with this QAPP and evaluating the effectiveness of its requirements. The Project Chemist determines appropriate procedures, including strict QC and decisions about data acquisition in accordance with "Chemical Data Quality Management for Hazardous Waste Remedial Activities" (USACE 1998). The Project Chemist and the other members of the project team coordinate and implement the fieldwork to ensure that data collected will support the intent of the sampling effort.

The Project Chemist will be the primary technical point of contact with the laboratory QA officers and other laboratory personnel on data quality issues and will be responsible for coordination of analytical requirements with the laboratory. Additionally, the Project Chemist will be responsible for the initial data review of all sample results from the analytical laboratories. Finally, the Project Chemist will be responsible for coordinating 100% data review, the preparation of the draft and final QCSR, and preparation of specific portions of the draft, draft final, and final site inspection report.

4.1.3 Field Team Leader/Site Safety and Health Officer

The FTL/Site Safety and Health Officer (SSHO) are responsible for all site activities. In this role, the FTL may be required to adjust the field program to accommodate site-specific needs. When it becomes necessary to modify the field program, the FTL will notify the PM of the anticipated change, document the change, and implement the necessary changes after approval from the PM. Significant field changes may include: deleting a sampling location, moving a sample location, substituting different field equipment for that stated in the FSP or making any changes in the SSHP.

The FTL is responsible for the day-to-day field data collection and sampling activities of the various resource specialists under his/her supervision. Specific FTL responsibilities include:

- Day-to-day coordination of technical issues in specific areas of expertise;
- Implementing the FSP;
- Coordinating and managing field staff during drilling, well installation and sampling;
- Implementing QC measures for technical data provided by the field staff, including field measurement data;
- Adhering to work schedules provided by the PM;
- Identifying problems at the field team level, resolving difficulties in consultation with the PM and USACE representatives, implementing and documenting corrective action procedures and providing communication between field sampling team, the PM and the laboratory;
- Participating in preparation of the draft and final reports;
- Providing input related to schedule and quality issues; and,
- Ensuring that the field team writes completes logbooks, safety and health documentation and any other documentation for the project, maintaining copies of these documents at the site and submitting documents to the PM on a weekly basis (if no problems occur at the site) or on a daily basis (if problems occur at the site) until the problems have been corrected.

The FTL will be responsible for the coordination of all personnel at the site and for providing technical assistance when required. The FTL or designee will be present whenever sampling occurs and ensure completion of a Daily Activity Field log, which will describe activities conducted on site, include a log of all communications, identify personnel entering and leaving the site and note general observations regarding site activities.

4.1.4 Field Team Members

A Quality Control Site Manager (QCSM) and an operator will be responsible for sampling of the soil, sediment, and surface water. The Field Team Members will complete boring logs, DQCRs, field logbook entries, and assuring the availability and maintenance of the necessary shipping/packing materials, sample containers and sampling equipment. All field team members will be experienced professionals who possess the degree of specialization and technical competence required to effectively and efficiently perform the required work. All field personnel will adhere to COC and field documentation protocols and will perform field activities in accordance with the FSP and SSHP.

4.1.5 Laboratory Responsibilities

All samples for laboratory analysis will be sent to:

Test America Laboratories (TAL, formerly the Severn Trent Laboratory [STL]))
Denver Colorado

The laboratory will perform all analytical procedures requested in accordance with Department of Defense (DoD) Quality System Manual (QSM) Version 3 (DoD, January 2006). TAL maintains a rigorous QA/QC program that follows the criteria established by the National Environmental Laboratory Accreditation Program (NELAP), USACE, and the DoD QSM that includes EPA approved analytical procedures, sample handling and preservation techniques. TAL holds a current NELAP certification in the State of California.

4.2 Training

Personnel performing work under this project will be trained to quality assurance implementing procedures, as prescribed by the Responsible Manager. Documentation of this quality assurance training will be in accordance with North Wind procedure QAP-021, *Indoctrination and Training*. Project-specific training will be conducted, and will be documented, in a manner that provides a traceable record for the project files.

5. PERFORMANCE/SYSTEM AUDITS

Internal audits of field activities (sampling and measurements) may be conducted. The audits will include examinations of field sampling and measurement records, field instrument operating and calibration records, sample collection, handling and packaging in compliance with the established procedures, maintenance of QC procedures, COC, field and sample documentation, safety procedures, etc. These audits will occur at the onset of the project to verify that all established procedures are followed. Follow-up audits will be conducted to correct deficiencies identified, and to verify that QC procedures are maintained throughout the sampling effort. The audits will include reviews of field measurement records, instrumentation calibration records, as well as field and sample documentation. Any internal audits conducted will be documented by memorandum and may be included in the site inspection report. No formal performance or system audits of the laboratory are planned under this project. TAL will maintain USACE certifications/approval throughout the duration of the project.

Independent assessments may be conducted and documented in accordance with QAP-181, Independent Assessments (Audits).

5.1 Inspection of Supplies

Supplies and consumables are required for sample collection and laboratory activities. During sample collection, the most critical supplies affecting data quality are those used for decontamination of the sampling equipment. Supplies of appropriate, documented purity will be used for sample collection and decontamination. Acceptance for all supplies will require an intact seal upon receipt, maintenance at appropriate temperature, and use only prior to the expiration date. This method of documentation allows any contamination problem to be traced to its source and will enable identification of related samples that may have been affected. Acceptance requirements will include a basic inspection of all containers received and rejection of unacceptable supplies. Documentation of inspections and certifications of equipment and supplies will be maintained in project files. Receipt inspections for quality-affecting items will be conducted and documented according to QAP-071, Quality Procurement Controls.

5.2 Nonconformance/Corrective Actions

During the field investigation, the field team will be responsible for completing a DQCR. This report will include a description of any problems encountered and any corrective actions taken. These reports will be compiled and sent daily to the PM. Work may be stopped by the PM if corrective actions for significant problems are not effective and the problem remains unresolved.

Corrective action will be initiated when potential or existing field or laboratory conditions are identified that may adversely affect data quantity, or quality as defined in previous tables, for each method. Events that may lead to corrective action include the following:

- Violation of established analytical controls;
- Performance, system, or QA audits;
- Laboratory/field comparison studies;
- Violation of shipping requirements; and
- Violation of holding times.

Corrective action may take several forms, but the following steps generally are included:

- Check the calculations;
- Check the instrument for proper setup;
- Re-extract and/or reanalyze the control item, as appropriate; and
- Resample.

The Project Manager, Project Chemist, field team members, and laboratory quality manager may be involved in the corrective action. The corrective action may be immediate or long term. An immediate corrective action may be recalculating, reanalyzing, or repeating sample collection. Long-term corrective actions may be identified through performance evaluation samples, standards, control charts, or other devices.

Problems requiring corrective action in the field must be reported accordance with North Wind's Control of Nonconforming Items (QAP-10-151). Problems requiring corrective action in the laboratory are documented by the use of a laboratory corrective action report. Corrective actions that warrant data as unusable will be provided to the Project Chemist within 24 hours so re-collection can be evaluated immediately. The QA manager or any other laboratory member can initiate the corrective action request in the event QC results exceed acceptability limits, or upon identification of some other laboratory problem. Corrective actions can include reanalysis of the sample or samples affected, resampling and analysis, or a change in procedures, depending upon the severity of the problem.

Corrective actions, if necessary, are to be completed once. If acceptance criteria were not met and a corrective action was not successful or the corrective action was not performed, the appropriate flagging criteria will be applied.

Nonconforming items identified by North Wind personnel or subcontractors on this project will be identified, segregated (if possible), documented, dispositioned, and approved for use in accordance with the client's requirements. A copy of the client's Nonconformance Report form will be sent to the North Wind Quality Assurance Manager for information and trending. If the client does not require nonconformances to be documented in a specific manner, North Wind procedure QAP-151, *Control of Nonconforming Items,* will be used.

System or process control deficiencies (e.g., not following procedure, lack of training of project personnel, etc.) will be identified, documented, and corrected in accordance with the process described in North Wind procedure QAP-161, *Corrective Action Management System.* The North Wind corrective action process includes the following: identification, documentation, cause determination, correction of the immediate problem, correction to preclude recurrence, and verification of effective implementation prior to closure.

5.3 Field Quality Control Samples

During the field activities for this project, QC samples will be collected/generated to assess the quality of the data resulting from the field sampling program and the analytical laboratory procedures. QC samples sent to the laboratory for analysis will consist of blanks and field duplicate samples.

5.3.1 Trip Blank Samples

Trip blanks will be used to assess the potential for VOC contamination of water samples due to contaminant migration during sample collection and handling, shipment and storage procedures. One VOC trip blank, consisting of deionized distilled ultra pure water, will be included with each shipment of aqueous VOC samples. Trip blanks will be analyzed for all VOC analytes of concern. The objective is for the trip blanks to contain no detectable analytes above the analytical reporting limits and for all samples to be properly preserved when received at the laboratory. Trip blanks will be kept with the aqueous field samples for VOCs analysis and shipped with them to the laboratory for analysis.

5.3.2 Field Blank Samples

Field blanks will be used to determine if contaminants at the site are affecting the sample integrity. A field blank is prepared by pouring analyte free water into the sample containers at the sampling location.

5.3.3 Field Duplicate Samples

Field duplicate samples will be analyzed to assess the quality of the data resulting from the field sampling program. Field duplicate samples will be analyzed to provide an indication of precision with respect to sample collection procedures and analytical reproducibility, but also provide an indication of the variability of the contaminant and matrices under investigation. Field duplicates are samples taken in the field at the same time and in the same manner as the original sample for verifying reproducibility in the sampling technique. The general level of the QC effort will be one field duplicate for every 10 primary samples. Three times the standard volume of sample is required at locations where QC and MS/MSD samples are collected.

Field duplicates (D1 and D2) are compared using the following RPD calculation:

$$\text{RPD} = \frac{|(D1 - D2)|}{1/2(D1 + D2)} \text{ x } 100$$

where:

D1 is the measured concentration of the first sample aliquot

D2 is the measured concentration of the second sample aliquot.

5.4 Field Instruments and Analysis

The field equipment for this project includes multi-parameter probe (for measurement of temperature, pH, conductivity, oxidation reduction potential and dissolved oxygen), and PID instrument. Specific preventive maintenance procedures recommended by the manufacturer will be followed for field equipment.

Critical spare parts such as pH probes, electrodes, and batteries will be kept on-site to minimize instrument down time. Backup instruments and equipment will be available on-site or within one-day shipment to avoid delaying field activities.

5.4.1 Calibration Procedures and Frequency for Field Test Equipment

Instruments and equipment used to obtain, generate, or measure environmental data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specifications. Field instruments may include a pH meter, thermometer, specific conductivity meter, turbidity meter, water level indicator, and PID.

The pH meter will be calibrated with standard buffer solutions prior to a field event. In the field, the meter will be calibrated daily with two buffers bracketing the field range, before use each day. Thereafter, the meter will be checked against two buffers as deemed necessary by the FTL. Fresh traceable buffer solutions will be used. Calibration procedures and frequency will be recorded in a field logbook, along with the lot numbers of the buffers.

The specific conductivity meter will have its conductivity cells cleaned and checked against known conductivity standards prior to a field sampling event. In the field, the instrument will be checked daily with traceable standards. The PID will be calibrated daily with a gas standard of known concentration [typically 100 parts per million, volume per volume (ppmv) isobutylene].

5.4.2 Field Data Reduction

Field measurements will be made by the field team members. The recorded field data will be noted in the site inspection report using standard reporting units. The following standard reporting units will be used during all phases of the project:

- PID readings will be reported to 0.2 ppmv;
- pH will be reported to 0.1 standard unit;
- Specific conductance will be reported to two significant figures below 100 micromhos per centimeter (umhos/cm) and three significant figures above 100 umhos/cm;
- Temperature will be reported to the nearest 0.5°C; and
- Water levels measured in wells will be reported to the nearest 0.01 foot.

The location of all sample locations will be determined with the use of a Global Positioning System (GPS). Raw data from field measurements and sample collection activities will be appropriately recorded in the field logbook. As the data are used in project reports, they will be reduced and summarized, and the method of reduction will be documented in the report.

5.4.3 Field Data and Reporting

Field data will be validated and reported using the procedures, as described below:

Completeness of field records. The check of field record completeness will ensure that all requirements for field activities in the FSP have been fulfilled, complete records exist for each field activity, and that the procedures specified in this QAPP (or approved as field change requests) were implemented. Field documentation will ensure sample integrity and provide sufficient technical information to recreate each field event. The results of the completeness check will be documented and environmental data affected by incomplete records will be identified in the technical report.

Identification of valid samples. The identification of valid samples involves interpretation and evaluation of the field records to detect problems affecting the representativeness of environmental samples. Photographs may show the presence or absence of obvious sources of potential contamination, such as operating combustion engines during sampling. Judgments of sample validity will be documented in the technical report, and environmental data associated with poor or incorrect fieldwork will be identified.

Correlation of data. The results of field tests obtained from similar areas will be correlated. The findings of these correlations will be documented and the significance of anomalous data will be discussed in the technical report.

Identification of anomalous field test data. Anomalous field data will be identified and explained to the extent possible.

Accuracy and precision of field data and measurements. The assessment of the quality of field measurements will be based on instrument calibration records and a review of any field corrective actions. The accuracy and precision of field measurements will be discussed. Field record review is an on-going process. The FTL will be responsible for ensuring that proper documentation is recorded during sampling activity.

5.5 Laboratory Analysis

Table C-1 lists the recommended analytical methods to be utilized for the analysis of all samples. The analytical requirements for these methods are summarized in the following subsections.

5.5.1 Calibration Methods

Analytical instruments will be calibrated in accordance with the analytical methods. All analytes reported will be present in the initial and continuing calibration verification standards, and these calibrations must meet the acceptance criteria specified in the method protocols. Records of standard preparation and instrument calibration will be maintained. Records will unambiguously trace the preparation of standards and their use in calibration and quantitation of sample results. Calibration standards will be traceable to National Institute of Standards and Technology (NIST)-standard reference materials. Analyte concentrations are determined with either calibration curves or response factors (RFs). For gas chromatography (GC) and gas chromatography/mass spectroscopy (GC/MS) methods, when using RFs to determine analyte concentrations, the average RF from the initial five-point calibration will be used. The continuing calibration will not be used to update the RFs from the initial five-point calibration.

Laboratory calibration procedures and frequency will be performed in accordance with EPA methods and as described in the laboratory SOPs. Documentation of initial and continuing calibration will be kept in bound notebooks. Equipment calibration will be verified daily or prior to use, and re-calibration performed if necessary. If the instrument undergoes major maintenance, initial calibration procedures must be performed.

5.5.2 Laboratory Quality Control

Internal QC checks for each parameter are laboratory specific and will conform to the DoD QSM Version 3 limits. Specific analytes included in each analyte group and their LRL, MDL and QC Limits will also conform to the QSM and will be included in the laboratory report. Descriptions of internal QC checks are provided below.

5.5.2.1 Holding Time

Holding time is calculated from the date and time of sample collection to the time of sample preparation and/or analysis. The goal is for all sample analyses, including dilutions and second column confirmation, to meet the required holding time. Tables C-9 and C-10 define the applicable analytical holding times and sample containers. If holding times are exceeded, the Project Chemist will be notified by the laboratory, and if deemed necessary by the Project Chemist, samples will be recollected.

5.5.2.2 Analytical Batches

Analytical batches will be comprised of a maximum of 20 project samples of similar matrix prepared and analyzed together during the same timeframe using the same reagents, etc. Each analytical batch will be assigned an analytical batch identification number that allows a reviewer to determine the association between field samples and QC samples. Each analytical batch of samples analyzed in the laboratory will include the following QC samples:

- Method blanks,
- Laboratory control sample,
- MS/MSDs,
- Surrogate spikes (organic methods only, analyze for each sample),
- Laboratory duplicate (LD).

Additional sample volume will be collected in the field for samples designated for MS/MSD analysis at the laboratory.

5.5.2.3 Method Blank Samples

Method blanks (MBs) are designed to detect contamination due to the laboratory instrumentation, reagents, and environment. Method blanks verify that interferences caused by contaminants in solvents, reagents, glassware, or in other sample processing hardware are known and minimized. The method blank will be American Society for Testing Material (ASTM) Type II water (or equivalent) for water samples. The laboratory will apply a B flag to results when the method blank exceeds the MDL, analysts will only take a corrective action if the blank result exceeds half of the RL (or up to the RL for common laboratory contaminants).

5.5.2.4 Laboratory Control Samples

LCSs are prepared in an interference-free matrix similar to that of the field samples and which have been spiked with known concentrations of all target analytes. The LCS is prepared and analyzed with each batch of field samples. The percent recovery of the analytes in the LCS provides an indication of method performance under optimal conditions, and whether the analytical method is within established control limits. If the control limits are exceeded, appropriate corrective actions will be taken in accordance with the laboratory's procedures.

5.5.2.5 Matrix Spike/Matrix Spike Duplicate Samples

MS recoveries and RPDs will be reported for the all samples. All sample results will be designated as corresponding to a particular MS/MSD pair. The report will indicate what field sample was spiked. MS/MSDs will be performed on project samples. The control limits for the MS/MSDs and RPD criteria will be included in the analytical data package.

5.5.2.6 Surrogate Standards for Organic Analysis

Surrogates are analyzed to assess the ability of the method to successfully recover these specific nontarget analytes from an actual matrix. Surrogates are organic compounds that are similar to the analytes of interest in chemical behavior but are not normally found in environmental samples. Surrogates are identified with the determinative methods. These compounds should be spiked into all samples and accompanying QC samples requiring GC, liquid chromatography, or GC/MS analysis prior to any sample manipulation. As a result, the surrogates are used in much the same way that matrix spikes are used, but cannot replace the function of the matrix spike. The results of the surrogates are evaluated, in conjunction with other QC information, to determine the effect of the matrix on the bias of the individual sample determinations. Sample results will not be corrected for surrogate excursions. The surrogate percent recovery is a measure of the effectiveness of the preparation and analysis methods on the field samples. The surrogate recovery must fall within the accuracy limits established in the QSM. Any sample with a surrogate recovery that exceeds the QC limits must be re-prepared and re-analyzed in accordance with the laboratory's LQMM, with both sets of data reported unless otherwise approved by the USACE Project Chemist. In some instances, the judgment of the QA Officer will also be used as the basis for alternate corrective actions.

5.5.2.7 Internal Standards

An internal standard compound (the peak of which is well separated but near the target analyte) is introduced into each sample and standard prior to analyses. Internal standards ensure that GC/MS sensitivity and response are stable during each analysis for VOCs. If the Extracted Ion Current Profile (EICP) area for any of the internal standards in the calibration verification standard changes by a factor of two (-50% to +100%) from that the mid-point standard level of the most recent initial calibration sequence, the mass spectrometer must be inspected for malfunctions and corrections must be made, as appropriate. The same must be done if the retention time for any internal standard changes by more than 30 seconds from the mid-point standard level of the most recent initial calibration sequence. As corrections are made, reanalysis of samples analyzed while the system was malfunctioning is required.

5.5.2.8 Retention Times

Retention time (RT) is the amount of time required for a target compound to elute from the chromatographic column and into the instrument detector to record a signal response. RT windows are established to determine the allowable deviation from the true expected RT for any one compound. A peak response within this RT window will constitute a positive detection for that compound. RT windows are a requirement of all GC and high performance liquid chromatography (HPLC) methods. RT windows are accomplished through replicate analyses of a standard over multiple days. The calculation of RT windows is described in the SW846 Method SW8000C, March 2003, Section 7.6. Corrective action is required when the CCV target analyte RT windows are outside of control.

5.5.2.9 Control Limits

The acceptance criteria for the control limits associated with all methods will follow guidance established in the SW-846 methods, and the laboratory's historical data. The laboratory control limits for LCS, and surrogate spikes are defined in the laboratory SOW. The laboratory reviews and evaluates QC data through the use of method specific control charts. At least 20 measurements are required before control limits can be established. Warning limits are set at two standard deviations. Control limits are defined as three standard deviations.

5.6 Laboratory Procedures

Nonconformance is defined as any event which is beyond the limits established for laboratory performance, such as data which fall outside accepted bounds for accuracy and precision due to improper equipment calibration, maintenance operation, or improper data verification. Any activity in the laboratory, which affects data quality, can result in a nonconformance.

Nonconformances associated with the statistical analysis and review of data are straightforward to identify. The Project Chemist will be responsible for the assessment of QC sample information. The PM or LTO will be notified of non-conformances that affect data quality to the degree that re-sampling may be necessary.

Any quality assurance issues that relate to the final data results will be included in the narrative that is included with the data package. Issues that should be covered are:

1. Responses to the findings of any internal or external systems or performance laboratory audits;

2. Any laboratory or sample conditions that necessitate a departure from the methods or procedures specified in this QAPP; and

3. Any missed holding times or problems with laboratory QC acceptance criteria and the associated corrective actions taken.

Corrective actions will be designed to correct the associated problems and to minimize the possibility of their recurrence. Examples of corrective actions include modifying nonconforming procedures; tagging, repairing or replacing deficient equipment; training or replacing unqualified personnel; re-analyzing affected samples; marking rejected data; and, re-issuing affected reports.

6. LABORATORY DATA REDUCTION AND VERIFICATION

Upon completion of an analysis, the analyst will calculate the final sample results and associated QC results from the raw data. Additionally, for organic analyses, the analyst will review the scans of each sample and standard on the instrument terminal. The analyst will check for recovery of surrogate compounds, sample response within the linear range of the calibration curve and the integration of peaks in the chromatogram. Peaks that appear suspect may require re-integration by the analyst.

6.1 Laboratory Data Validation and Reporting

The laboratory will hold, and make available upon request, all project raw data for a minimum period of 10 years after the samples have been analyzed. This QC discussion will not prevent notification of such problems when timely notice can reduce the loss or potential loss of quality, time, effort, or expense. Appropriate steps will be taken to correct any QC concerns as they are identified.

Reporting of analytical results for this project will include environmental and QC sample analysis data in hard-copy format. The laboratory data package deliverable will include:

Case Narrative:

- A table(s) summarizing samples received, providing a correlation between field sample numbers and laboratory sample numbers, and identifying which analytical test methods were performed;
- A description of extractions or analyses that are performed out of holding times;
- A definition of all data qualifiers or flags used;
- Identification of deviations of any calibration standards or QC sample results from appropriate acceptance limits and a discussion of the associated corrective action taken by the laboratory;
- Appropriate notation of any other factors that could affect the sample result; and
- Identification of numerical results outside of quantitation limits.

Analytical Results:

- Project name and site location,
- Field sample ID number as written on custody form,
- Laboratory sample ID number,
- Matrix (soil, water, oil, etc.),
- Date and time sample analyzed,
- Method numbers for all preparation and analysis procedures,
- Method reporting limits and method detection limits,

- Any data qualifiers assigned,
- Units, and
- Dilution factors.

Sample Management Records:

- Chain-of-custody records.

QC Information:

- Matrix spike percent recovery;
- RPD of required duplicates;
- LCS percent recoveries;
- Surrogate percent recoveries (organics);
- Method blank results;
- QC acceptance criteria MS, LCS, surrogates, etc.; and
- Spike Concentration for MS, LCS, surrogates, etc.

6.2 Electronic Data Deliverable

In addition to hard copy data, a SEDD 2a electronic data deliverable (EDD) will be required for this site inspection. The turnaround time for the hard copy deliverables will be established in the laboratory scope of services documentation. The EDD for groundwater will be provided within three weeks of the receipt of the last water or soil sample by the laboratory. The EDD will contain the same information as described for the hard copy deliverable. It will consist of three separate, comma-delimited ASCII text files or Excel CSV files as required by the Automated Data Review (ADR) software developed by Laboratory Data Consultants (LDC), Carlsbad, CA. The EDD will: (1) use a common syntax for terms used to describe diverse laboratory activities and report analytical data; and (2) will provide sufficient input parameters to allow users to link analytical data to underlying laboratory activities, provide full traceability for data, and a means for reporting complex analytical relationships. The laboratory will parse the EDD and run the EDD through the compliance checker portion of the ADR software to resolve any non-conformances with the project library. The Project Chemist will ensure a project library to support the EDD is submitted to the laboratory prior to sample receipt.

6.3 Analytical Data Package Reporting

The data will be submitted to USACE in both hard copy and on disk as EDDs compatible with LDC ADR software. In addition, the laboratory will address all non-conformances with the project library. For each analytical method run, the laboratory will report the analytes for each sample as a detected concentration or as less than the specific limits of quantitation. The data will be reported in units consistent with both federal and state regulations, methods and guidelines. Sample-specific LRLs and MDLs for the analytes will be recorded on the laboratory data report. Each analytical method run will be clearly identified as

belonging to a specific analytical batch and will be reported with dates of collection, preparation and analysis; the laboratory also will report dilution factors for each sample. A complete set of QC results will be reported for each analytical batch. A turnaround time, will be stipulated in the laboratory SOW.

6.4 Data Validation

The Project Chemist will use the ADR software developed by LDC to validate laboratory data. The data validation will be performed on 100% of the data by an automated review process. ADR validates data and assigns validation flags based on the "National Functional Guidelines for Low Concentration Organic Data Review" (EPA 2001) and the "National Functional Guidelines for Inorganic Data Review" (EPA 2004). The parameters and validation qualifiers used in the ADR conform to the QSM QC limits.

The ADR evaluates the following criteria:

- Sample extraction and analysis holding times,
- Surrogate recoveries,
- Blank contamination (laboratory, field, trip and preparation),
- MS/MSD recoveries and precision,
- LCS recoveries, and
- Duplicate precision (laboratory and field.

The Project Chemist will review the ADR outputs and perform a professional assessment of the accuracy of the ADR qualifiers, and usability of the data based on the issues raised by the software and their impact on intended use of the data. The results of the data QC evaluation and usability will be discussed in the QCSR. Data validation qualifiers used for risk assessment are shown in Table C-13.

Table C-13. Data Validation Qualifiers used in Risk Assessment and Definitions.

U	The analyte was analyzed for, but was not detected up to the method detection limit, and was not quantifiable to the reporting limit.
J	The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
R	The data are unusable. The sample results are rejected due to serious deficiencies in meeting QC criteria. The analyte may or may not be present in the sample.
UJ	The analyte was not detected above the adjusted RL. However, the reported adjusted RL is approximate and may be inaccurate or imprecise.
Qualifiers from EPA, 2004; 2001.	

Reviews of field records, the laboratory data report (which includes the data with laboratory qualification); and the data validation. Environmental data that are not sufficient to meet DQOs because they were generated through poor field or laboratory practices will be rejected. Only valid data that meet the project DQOs will be used for this project. The following evaluation and validation considerations will be used to determine the usability of the data for this project:

Evaluate field duplicate and replicate results. Field duplicate/replicate results that meet project precision goals indicate reproducible sampling technique and precise laboratory analysis. Field duplicate/replicate results not within control limits may indicate a heterogeneous sample medium, poor sampling technique, or a lack of analytical precision. If laboratory duplicates are within projection goals, but field duplicates are not, then the problem may be associated with the field sampling activities or the matrix itself. If homogenized samples show poor precision, the imprecision is probably in the laboratory analytical process.

Evaluate field and laboratory blank results. A variety of blanks will be assessed to determine potential sources of contamination and the impact of any contamination on the analytical results. Examples of any field sources capable of contaminating field blanks and samples include combustion engine exhaust, container cleaning solvents, pollution from offsite sources, drilling fluids or source water used during monitoring well installation. Method blank results are used to detect laboratory contamination from reagents, instruments, ambient sources within the laboratory, or sample handling. The presence of a contaminant in a blank requires corrective action to eliminate the source of contamination and re-establish analytical control. Contamination proven to be a constant, low-level systematic error will be noted in the technical report, and its impact on the results discussed. Under no circumstances will the results for environmental samples be "corrected" for blank contamination.

Evaluate sample matrix effects. Assessment of the sample matrix can help to define the sources of anomalous data. The matrix can cause either a high or low bias to the results of environmental samples. High analytical results can be caused by natural background material in the sample. Potential matrix effects will be identified through the evaluation of matrix spike and matrix spike duplicate samples and surrogates. The impacts of matrix interferences on results will be described in the technical report.

Interpret and integrate environmental data to formulate conclusions and recommendations. The duplicate results, blank results, and potential interference effects will be considered in evaluating the data, as well as an evaluation of the LCS to determine method performance. These considerations will be utilized when the project chemist prepares the QCSR.

6.5 Chemical Data Quality Review Report

The North Wind Project Chemist or designee will generate a QCSR report, in accordance with the guidance provided in the DoD QSM, Appendix B. The ADR qualification will be verified manually from the hard-copy QC summary forms, as applicable.

6.6 Document Control and Records Management

This QAPP, and any implementing procedures required for the project, will be controlled in accordance with North Wind procedure QAP-061, *Document Control.* QAP-061 describes the processes North Wind uses to prepare, review, approve, issue, and revise procedures and documents. Deliverables will be reviewed and approved in accordance with QAP-014, *Review of Deliverables.*

Records (i.e., any document that provides objective evidence of North Wind performance on a project) will be controlled by the Responsible Manager while in-process, and will be turned over to the North Wind Records Management Custodian for archiving at the end of the project, or once per year at a minimum. The North Wind Records Management Custodian will maintain the project records in accordance with QAP-171, *Records Control.*

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Draft Final
Spill Prevention and Reporting Plan for Final Closure at Solid Waste Management Units-70 and -71, Cannon Air Force Base, New Mexico

Prepared for:

U. S. Army Corps of Engineers
Omaha District

Contract No. W9128F-04-D-0017-0029

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ACRONYMS

AFB	Air Force Base
BMP	best management practice
CFR	Code of Federal Regulations
MSDS	material safety data sheet
North Wind	North Wind, Inc.
NRC	National Response Center
OES	Office of Emergency Services
PPE	personal protective equipment
SS	Site Superintendent
SWMU	Solid Waste Management Unit
USACE	U. S. Army Corps of Engineers

Draft Final
Spill Prevention and Reporting Plan for Final Closure at Solid Waste Management Units-70 and -71, Cannon Air Force Base, New Mexico

1. SPILL CONTROL

This Spill Prevention and Reporting Plan provides general spill prevention and response instructions to North Wind, Inc. (North Wind) personnel and subcontractors who are working at a job site where oil products and/or other hazardous substances may be present. This procedure covers spills from minor drips up to large spills.

1.1 Responsibilities

The North Wind Site Superintendent (SS) is responsible for ensuring that site activities are carried out in accordance with this Plan. The SS will conduct pre-job briefings to ensure personnel are aware of construction hazards, preventive measures, and response measures should a spill occur. Operations that involve the use and/or transfer of petroleum products or other hazardous substances will be designed to minimize spill potential and health risk to personnel. Spill control equipment and personal protective equipment (PPE) necessary to handle, at a minimum, minor spills will be in place prior to commencement of work activities that involve the use or transfer of oil, fuel, or other hazardous substances.

The SS will immediately notify the contracting officer, the local fire department, and North Wind Project Manager, as required.

1.2 Spill Control and Containment

Spill control and containment procedures will be instituted prior to conducting site operations. Site operations will be performed in such a manner to prevent the occurrence of spills through proper planning and managing of resources in completing site operations.

1.2.1 Responsibilities

The SS will be responsible for implementing and supervising the containment and cleanup of any spills.

1.2.2 Training Requirements

All site personnel will be required to read and understand the Spill Prevention and Reporting Plan. Aspects of the Plan applicable to any given day's work will be discussed during the daily tailgate briefing prior to starting work each day. Any potential environmental issues will be discussed at that time.

The training log, showing formal and informal training of various personnel, is shown in Attachment 1. The training shall include a project briefing on the requirements of this Plan. On-site training will be conducted on an on-going basis. The on-site training shall cover all aspects of the project, including inspection results. Personnel attending tailgate training will document attendance in the training log.

Informal training will include tailgate site briefings to address the following topics:

- Erosion control best management practices (BMPs) (if used).
- Sediment control BMPs (if used).
- Non-storm water BMPs.
- Waste management and materials pollution control BMPs.

1.2.3 Spill Control Equipment and Materials

On projects or tasks where the potential for chemical spills exists, spill control equipment and materials will be stored at the site. The equipment and materials will be used in the event of a spill resulting from material handling or liquid transfers performed during site operations. The following equipment and materials will be available onsite:

- Shovels,
- A broom,
- 6-mil polyurethane (1 roll),
- Spill adsorbent media,
- Containers for holding spilled substances and contaminated materials (55-gallon drums), and
- PPE, as specified in the Site Specific Health and Safety Plan.

1.2.4 Spill Containment Materials Suppliers

Local suppliers will be used to provide the above spill control equipment.

1.2.5 Spill Potential

The activities being implemented at the Solid Waste Management Unit (SWMU) project site involve collecting and analyzing samples. Medium to heavy construction equipment will be used to include an excavator, a frontloader, and transport trucks. The work will involve the use of equipment that contains fuels, hydraulic fluids, coolants, and lubricants. It is possible that normal operations of equipment will result in minor leaks of these fluids. Material safety data sheets (MSDSs) for fuels and lubricants are included in Attachment 2.

1.2.6 Spill Prevention

Equipment used will be maintained in good working order and will be inspected for leaks at the beginning of each day. All vehicle and equipment fueling will be closely supervised by the operator to prevent overflows. Drip pans or pads will be used as required.

1.2.7 Small Container Spill Response

Should a small container spill occur during handling, spill control equipment (i.e., absorbent material, etc.) will be used to contain and clean up the spillage. Personnel are required to retrieve overturned containers immediately to minimize spillage and take immediate action to contain the spill.

1.2.8 Miscellaneous Small Spills

Oil is used as a lubricant for material handling equipment that will be located onsite during construction activities. A portable diesel fuel tank mounted in pickup trucks will be used to fuel equipment onsite, as needed. The possibility exists that spilled oil or diesel fuel could contaminate soil or water. This potential is lessened by training operators and technicians demonstrating good housekeeping practices, providing constant oversight of refueling activities, providing spill control materials, and limiting the amount of oil present in the work area. Should oil, fuel, etc. be spilled on the ground in a quantity that presents a visible stain, personnel will shovel the stained soil into a properly labeled waste container for proper disposal.

2. SPILL RESPONSE AND REPORTING

Employees will take necessary corrective actions to stop spills and will notify their immediate supervisor or designated personnel as soon as possible. The supervisor is responsible for notifying government agencies and/or response organizations, if necessary.

2.1 Discovery of a Spill

Upon discovery of a spill of a hazardous substance, employees will take prompt corrective actions to stop the spill (if on-going) and control the spread of the spilled substance. The Construction Superintendent shall be notified immediately prior to any corrective action. PPE will be donned (as necessary) prior to taking any corrective action. No employee will undertake corrective actions to stop a spill unless adequately trained regarding the proper handling of the particular substance and the dangers associated with that substance. The employee will request assistance as necessary.

2.2 Reporting

North Wind will make spill notifications to the United States Army Corps of Engineers (USACE) Project Manager, Mr. Hector Santiago (402) 995-2738, immediately upon discovery. Spills (i.e., releases) of hazardous substances to the environment that exceed the reportable quantities in 40 Code of Federal Regulations (CFR) 302, "Designation, Reportable Quantities, and Notification," will be reported immediately to the designated agencies listed in 40 CFR 302 (the National Response Center (NRC) at (800) 424-8802). Spill reporting requirements are included in Attachment 3.

The 24-hour spill reporting number for Cannon Air Force Base (AFB) is 911 from any land-line phone on base, or the Cannon AFB fire department at (575)784-2576 (non emergency), or the Cannon AFB police department at (575) 784-4111.

Mr. Jerry Pelfrey (575) 784-6391 should be notified with in 24 hours of the event.

Spills of gasoline, fuels, etc. are excluded from the federal definition of a hazardous substance (40 CFR 300.5).

2.3 Emergency Spill Response Procedure

If the spill causes an immediate threat to human life, health, or the environment, it is classified as an emergency.

The following steps should be followed for emergency spills only:

1. Evacuate and deny entry to all personnel in the immediate area.

2. Call 911 (local fire department), the USACE Project Manager (Hector Santiago - USACE), as appropriate, using a land-line phone or mobile phone and provide the following information:

    a. Your name and call back number,

    b. Exact location of spill,

    c. Injuries involved,

d. Type of substance involved,

e. Amount of substance involved, and

f. Stay on line and answer all questions asked by the dispatcher.

3. Assign someone to direct emergency personnel to the spill site.

4. Do not attempt to rescue downed personnel unless you are trained to do so.

5. Fill out a Spill Incident Report (Attachment 4) completely and accurately and submit to the USACE Omaha District Project Manager within 24 hours.

3. APPLICABLE STANDARDS AND REGULATIONS

Following is a list of applicable standards and regulations for this Spill Prevention Plan:

- 19 CCR, Chapter 4.5, “Hazardous Materials, Accidental Release Prevention (CalARP) Program“
- 40 CFR, Part 110, “Discharge of Oil,”
- 40 CFR, Part 302, “Reportable Quantity Listings,”
- 40 CFR, Part 370, “Hazardous Chemical Release Reporting: Community Right to Know,” and
- 40 CFR, Part 372, “Toxic Chemical Release Reporting: Community Right to Know.”

4. REFERENCES

40 CFR 110, Title 40, "Protection of the Environment," Part 110, "Discharge of Oil," *Code of Federal Regulations,* Office of the Federal Register.

40 CFR 300.5, Title 40, "Protection of the Environment," Part 300.5, "Designation, Reportable Quantities, and Notification," *Code of Federal Regulations,* Office of the Federal Register.

40 CFR 302, Title 40, "Protection of the Environment," Part 302, "Reportable Quantity Listings," *Code of Federal Regulations,* Office of the Federal Register.

40 CFR 370, Title 40, "Protection of the Environment," Part 370, "Hazardous Chemical Release Reporting: Community Right to Know," *Code of Federal Regulations,* Office of the Federal Register.

40 CFR 372, Title 40, "Protection of the Environment," Part 372, "Toxic Chemical Release Reporting: Community Right to Know," *Code of Federal Regulations,* Office of the Federal Register.

Attachment 1
Spill Control Plan Training Log

Trained Personnel Log

Spill Control and Reporting Training Log

Project Name: Final Closure for SWMUs-70 and -71, Cannon AFB, New Mexico

Storm Water Management Topic:

- ❑ Temporary Soil Stabilization
- ❑ Temporary Sediment Control
- ❑ Non-storm water management
- ❑ Waste Management and Materials Pollution Control

Specific Training Objective: _____

Location: _____ Date: _____

Instructor: _____ Telephone: _____

Course Length (hours): _____

Attendee Roster (attach additional forms if necessary)

Name	Company	Phone

Name	Company	Phone

COMMENTS:

Attachment 2
Material Safety Data Sheets

MSDS	Material Safety Data Sheet for #2 Diesel

Definition of terms

1. Chemical Product

MSDS Number: U7770

MSDS Date: 01-31-99

Product Name: #2 Diesel Fuel

24 Hour Emergency Phone: (210) 979-8346
Transportation Emergencies: Call Chemtrec at 1-800-424-9300
MSDS Assistance: (210) 592-4593

Distributors Name and Address:

T.W. Brown Oil Co., Inc.
1857 Knoll Drive
Ventura, California 93003

Chemical Name:#2 Diesel Fuel **Cas Number:** 68476-34-6

Synonyms/Common Names: This Material Safety Data Sheet applies to the following product descriptions for Hazard Communication purposes only. Technical specifications vary greatly depending on the product, and are not reflected in this document. Consult specification sheets for technical information.

California Air Resources Board (Carb) Diesel Fuel- On-road, Off-Road, Tax Exempt blends
Premium Diesel Fuel- Low-Sulfur, High-sulfur, On-Road, Off-Road, Tax Exempt blends
#2 Distillate- Low-Sulfur, High-sulfur, On-Road, Off-Road, Tax Exempt blends
#2 Diesel Fuel- Low-Sulfur, High-sulfur, On-Road, Off-Road, Tax Exempt blends
#2 Fuel Oil- Low-Sulfur, High-sulfur, On-Road, Off-Road, Tax Exempt blends

2. Composition, Information On Ingredients

Product Use: This product is intended for use as a fuel in engines and heaters designed for diesel fuels, and for use in engineered processes. Use in other applications may result in higher exposures and require additional controls, such as local exhaust ventilation and personal protective equipment.

Description: #2 Diesel is a complex mixture of hydrocarbons from a variety of chemical processes blended to meet standardized product specifications. Composition varies greatly and includes C9 to C20 hydrocarbons with a boiling range of about 325-675 degrees F. The following is a non-exhaustive list of common components, typical percentage ranges in product, and occupational exposure limits for each.

Component or Material Name	%	CAS Number	ACGIH Limits TLV -- STEL -- Units	OSHA Exposure Limits PEL -- STEL -- C/P -- Units
Cat cracked distillate, light	0-100	64741-59-9	100 -- NA -- mg/m3	N/A -- N/A -- N/A -- N/A
Hydrotreated distillate, middle	0-100	64742-46-7	100 -- NA -- mg/m3	N/A -- N/A -- N/A -- N/A
Hydrotreated distillate, light	0-100	64742-47-8	100 -- NA -- mg/m3	N/A -- N/A -- N/A -- N/A
Gas oil, light	0-100	64741-44-2	100 -- NA -- mg/m3	N/A -- N/A -- N/A -- N/A

3. Hazards Identification

Health Hazard Data:

1. The major effect of exposure to this product is giddiness, headache, central nervous system depression; possible irritation of eyes, nose, and lungs; and dermal irritation. Signs of kidney and liver damage may be delayed. Pulmonary irritation secondary to exhalation of solvent.

2. NIOSH recommends that whole diesel engine exhaust be regarded as a potential occupational carcinogen. Follow OSHA and NSHA rules where diesel engine exhaust fumes may be generated.

3. A life time skin painting study by the American Petroleum Institute has shown that similar naphtha products with a boiling range of 350-700 degrees F usually produce skin tumors and/ or skin cancers in laboratory mice. Only a weak to moderate response occurred. The effect to humans has not been determined.

4. Positive results at 2.0 ml/kg and 6.0 ml/kg noted in mutagenesis studies via in-vivo bone marrow cytogenetics assay in rats.

5. Kerosene is classified as a severe skin irritant. Mutation data has been reported for kerosene products. Hydrotreated kerosene is listed as being probably carcinogenic to humans with limited evidence in humans and sufficient evidence in experimental animals.

Hazards of Combustion Products: Carbon monoxide and carbon dioxide can be found in the combustion products of this product and other forms of hydrocarbon combustion. Carbon monoxide in moderate concentrations can cause symptoms of headache, nausea, vomiting, increased cardiac output, and confusion. Exposure to higher concentrations of carbon monoxide can cause loss of consciousness, heart damage, brain damage, and/or death. Exposure to high concentrations of carbon dioxide can cause simple asphyxiation by displacing available oxygen. Combustion of this and other similar materials should only be carried out in well ventilated areas.

MSDS	Material Safety Data Sheet for Gasoline

Definition of terms

1. Chemical Product

MSDS Number: U4080

MSDS Date: 01-1-99

Product Name: Gasoline

24 Hour Emergency Phone: (210) 979-8346
Transportation Emergencies: Call Chemtrec at 1-800-424-9300
MSDS Assistance: (210) 592-4593

Distributors Name and Address:

T.W. Brown Oil Co., Inc.
1857 Knoll Drive
Ventura, California 93003

Chemical Name: Gasoline **Cas Number:** 8006-61-9

Synonyms/Common Names: This Material Safety Data Sheet applies to the following product descriptions for Hazard Communication purposes only. Technical specifications vary greatly depending on the product, and are not reflected in this document. Consult specification sheets for technical information.

Unleaded Gasoline Blendstocks/Subgrades- all types, grades, octanes, and vapor pressures.
California Air Resources Board (Carb) Gasoline- all grades, octanes, vapor pressures, and oxygenate blends.
Reformulated Gasoline (RFG)-all grades, octanes, vapor pressures, and oxygenate blends.
California Reformulated Gasoline (CARFG)-all grades, octanes, vapor pressures, and oxygenate blends.
Conventional Gasoline-all grades, octanes, vapor pressures, and oxygenate blends.

2. Composition, Information On Ingredients

Product Use: This product is intended for use as a fuel in engines or for use in engineered processes. Use in other applications may result in higher exposures and require additional controls, such as local exhaust ventilation and personal protective equipment.

Description: Reformulated gasoline is a complex mixture of hydrocarbons from a variety of chemical processes blended to meet standardized product specifications. Composition varies greatly and includes C? to C? hydrocarbons with a boiling range of about 80-473 degrees F. The following is a non-exhaustive list of common components, typical percentage ranges in product, and occupational exposure limits for each. Functional and performance additives may also be present at concentrations below reporting thresholds.

Component or Material Name	%	CAS Number	ACGIH Limits TLV -- STEL -- Units	OSHA Exposure Limits PEL -- STEL -- C/P -- Units
Gasoline	90-100	Mixture	300--500--ppm	NA--NA--NA -- ----
Butane	<9	106-97-8	800--NA--ppm	NA--NA--NA -- ----
Pentane	<6	109-66-0	600--750--ppm	1000--NA--NA--ppm
n-Hexane	<4	110-54-3	50--NA--ppm	500--NA--NA--ppm
Hexan(other isomers)	<8	NA	500--1,000--ppm	NA--NA--NA-- ----
Benzene	1.2 - 4.9	7-4-2	0.5--2.5--ppm	1--5--NA--ppm
N-heptane	<2	14-82-5	400--500--ppm	500--NA--NA--ppm
Ethylbenzene	<2	100-41-4	100--125--ppm	100--NA--NA--ppm
Xylene (o,m,p, - isomers)	<11	1330-20-7	100--150--ppm	100--NA--NA--ppm
Cyclohexane	<2	110-82-7	300--NA--ppm	300--NA--NA--ppm
Trimethylbenzene	<4	25551-13-7	25--NA--ppm	NA-NA-NA- ----
Methyl-t-butyl ether (MTBE)	0-15	1634-04-4	40--NA--ppm	NA-NA-NA- ----
Toluene	<12	108-88-3	50-NA-ppm	200-300/500-NA-ppm
Ethyl-t-butyl ether (ETBE)	0-7	637-92-3	N/A-NA-ppm	NA-NA-NA- ----
t-amyl-methyl-ether	0-5	994-05-8	N/A-NA-ppm	NA-NA-NA- ----
Ethanol	0-11	64-17-5	1,000-NA-ppm	1,000-NA-NA-ppm

C=Ceiling concentration not to be exceeded at any time. P= Peak concentration for a single 10 minute exposure per day.

3. Hazards Identification

Health Hazard Data:

1. The major effect of exposure to this product is central nervous system depression and polyneuropathy.

2. Studies have shown that repeated exposure of laboratory animals to high concentrations of whole gasoline vapors at 67,262 and 2056 ppm has caused kidney damage and cancer of the kidney in rats and liver cancer in mice.

3. LARC has listed gasoline as possibly carcinogenic (2B) to humans with limited evidence in humans in the absence of sufficient evidence in experimental animals. NIOSH lists gasoline as a carcinogen with no further classification.

4. N-heptane and cyclohexane cause narcosis and irritation of eyes and mucous membranes. Cyclohexane has been reported to cause liver and kidney changes in rabbits. N-heptane has been reported to cause polyneuritis following prolonged exposure.

5. ACGIH lists benzene a human carcinogen with and assigned TLV of 0.5 ppm 8 hour TWA and a STEL of 2.5 ppm; IARC, NTP $ OSHA show sufficient evidence for classifying Benzene as a human carcinogen, see 29 CGR 1910.1028 for current PEL of 1 ppm and specific actions to take. Studies have shown that benzene can induce leukemia at concentrations as low as 1 ppm. Significant elevations of chromosomal aberrations have been corroborated among workers exposed to levels at mean concentrations less than 10 ppm. Based on risk assessment studies by Rinsky, an individual inhaling 1 ppm of benzene for 40 years, the odds of benzene-induced leukemic death were 1.7 times higher than those of unexposed workers.

6. MTBE is a mild irritant to the eye with an LC50 of 85 mg/m3 on 4 hr. exposure and an LD50 ~4 ml/Kg (RATS). An increase in anesthesia with increasing concentration (250,500 & 1000 ppm) was observed during a 90 day Test exposure. ACGIH has listed MTBE as an animal carcinogen (A3) based on tests in experimental animals at relatively high dose levels, by routes of administration, at sites, of histologic types, or by mechanisms not considered relevant to worker exposure. Available evidence suggests that MTBE is not likely to cause cancer in humans except under uncommon or unlikely routes of levels of exposure.

7. Trimethylbenzene (pseudocumene (1,2,4,) & mesitylene (1,2,5,)) has a PEL and TLV of 25 ppm 8 hr. TWA; the isomers may cause nervousness, tension, and anxiety and asthmatic bronchitis.

8. n-Hexane has been shown to cause polyneuropathy (peripheral nerve damage) after repeated and prolonged exposure, other hexanes show narcotic effects at 1000 ppm and are not metabolized like n-hexane.

9. Toluene can cause impairment of coordination and momentary loss of memory (200-500 ppm); Palpations, extreme weakness and pronounced loss of coordination (500-1500). The 100 ppm 8 hr. TWA and the 150 ppm STEL provides adequate protection.

10. The toxicological effects of ETBE and TAME have not been thoroughly investigated. ETBE and TAME are expected to be an inhalation hazard and a severe eye and moderate skin irritant.

Hazards of Combustion Products: Carbon monoxide and carbon dioxide can be found in the combustion products of this product and other forms of hydrocarbon combustion. Carbon monoxide in moderate concentrations can cause symptoms of headache, nausea, vomiting, increased cardiac output, and confusion. Exposure to higher concentrations of carbon monoxide can cause loss of consciousness, heart damage, brain damage, and/or death. Exposure to high concentrations of carbon dioxide can cause simple asphyxiation by displacing available oxygen. Combustion of this and other similar materials should only be carried out in well ventilated areas.

MATERIAL SAFETY DATA SHEET
Review Date: 04/06/2005

SECTION 1 PRODUCT AND COMPANY IDENTIFICATION

PRODUCT: SHELL® FM Hydraulic Oil 32

MSDS NUMBER: 400898E - 0
PRODUCT CODE(S): 65547, 6554700001, 6554700055

MANUFACTURER ADDRESS: SOPUS Products, P.O. Box 4427, Houston, TX. 77210-4427

TELEPHONE NUMBERS
Spill Information: (877) 242-7400
Health Information: (877) 504-9351
MSDS Assistance Number: (877) 276-7285

SECTION 2 PRODUCT/INGREDIENTS

CAS#	CONCENTRATION	INGREDIENTS
		Hydraulic Oil
8042-47-5	95 - 98.99 %weight	White Mineral Oil
Proprietary	1 - 4.99 %weight	Copolymer additive

This product is acceptable as a lubricant with incidental food contact (H1) for use in and around food processing areas.

SECTION 3 HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW
Appearance & Odor: Clear liquid. Mild odor.
Health Hazards: No known immediate health hazards. High-pressure injection under the skin may cause serious damage.
Physical Hazards: No known physical hazards.
NFPA Rating (Health, Fire, Reactivity): 0, 1, 0
Hazard Rating: Least - 0 Slight - 1 Moderate - 2 High - 3 Extreme - 4

Inhalation:
Inhalation of vapors (generated at high temperatures only) or oil mist may cause mild irritation of the nose, throat, and respiratory tract.

Eye Irritation:
Lubricating oils are generally considered no more than minimally irritating to the eyes.

Skin Contact:
May cause slight irritation of the skin. If irritation occurs, a temporary burning sensation and minor redness and/or swelling may result. Release of the material during high-pressure applications may result in injection under the skin causing possible extensive tissue damage which is difficult to heal. Other adverse effects not expected from brief skin contact.

Ingestion:
Lubricating oils are generally no more than slightly toxic if swallowed.

Signs and Symptoms:
Irritation as noted above. Local necrosis is evidenced by delayed onset of pain and tissue damage a few hours following injection.

Aggravated Medical Conditions:
Pre-existing eye, skin and respiratory disorders may be aggravated by exposure to this product.

For additional health information, refer to section 11.

SECTION 4 FIRST AID MEASURES

Inhalation:
If the victim has difficulty breathing or tightness of the chest, is dizzy, vomiting or unresponsive, give 100% oxygen with rescue breathing or CPR as required and transport to the nearest medical facility.

Skin:
Remove contaminated clothing and shoes and wipe excess from skin. Flush skin with water, then wash with soap and water. If irritation occurs, get medical attention. Do not reuse clothing until cleaned. If material is injected under the skin, transport to the nearest medical facility for additional treatment. If redness, swelling, pain and/or blisters occur, transport to the nearest medical facility for additional treatment.

Eye:
Flush with water. If irritation occurs, get medical attention.

Ingestion:
Do not induce vomiting. In general, no treatment is necessary unless large quantities of product are ingested. However, get medical attention. Have victim rinse mouth out with water, then drink sips of water to remove taste from mouth. If vomiting occurs spontaneously, keep head below hips to prevent aspiration.

Note to Physician:
In general, emesis induction is unnecessary in high viscosity, low volatility products such as oils and greases.

SECTION 5 FIRE FIGHTING MEASURES

Flash Point [Method]: 380 ºF -415 ºF/193.33 ºC -212.78 ºC [Cleveland Open Cup]

Extinguishing Media:
This material is non-flammable. Material will float and can be re-ignited on surface of water. Use water fog, 'alcohol foam', dry chemical or carbon dioxide (CO2) to extinguish flames. Do not use a direct stream of water.

Fire Fighting Instructions:
Do not enter confined fire space without full bunker gear (helmet with face shield, bunker coats, gloves and rubber boots), including a positive pressure, NIOSH approved, self-contained breathing apparatus. This material is non-flammable.

Unusual Fire Hazards:
Material may ignite when preheated.

SECTION 6 ACCIDENTAL RELEASE MEASURES

Protective Measures:
May burn although not readily ignitable.

Wear appropriate personal protective equipment when cleaning up spills. Refer to Section 8.

Spill Management:
FOR LARGE SPILLS: Remove with vacuum truck or pump to storage/salvage vessels.

FOR SMALL SPILLS: Soak up residue with an absorbent such as clay, sand or other suitable material. Place in non-leaking container and seal tightly for proper disposal.

Reporting:
CERCLA: Product is covered by EPA's Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) petroleum exclusion. Releases to air, land, or water are not reportable under CERCLA (Superfund).

CWA: This product is an oil as defined under Section 311 of EPA's Clean Water Act (CWA). Spills into or leading to surface waters that cause a sheen must be reported to the National Response Center, 1-800-424-8802.

SECTION 7 HANDLING AND STORAGE

Precautionary Measures:
Wash with soap and water before eating, drinking, smoking, applying cosmetics,
or using toilet. Launder contaminated clothing before reuse. Properly dispose of contaminated leather articles such as shoes or belts that cannot be decontaminated. Avoid heat, open flames, including pilot lights, and strong oxidizing agents. Use explosion-proof ventilation to prevent vapor accumulation. Ground all handling equipment to prevent sparking.

Storage:
Do not store in open or unlabeled containers. Store in a cool, dry place with adequate ventilation. Keep away from open flames and high temperatures.

Container Warnings:
Keep containers closed when not in use. Containers, even those that have been emptied, can contain explosive vapors. Do not cut, drill, grind, weld or perform similar operations on or near containers.

SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

Oil Mist, Mineral ACGIH TLV TWA: 5 mg/m3 STEL: 10 mg/m3
Oil Mist, Mineral OSHA PEL - 1989(revoked) TWA: 5 mg/m3

EXPOSURE CONTROLS
Provide adequate ventilation to control airborne concentrations below the exposure guidelines/limits.

PERSONAL PROTECTION
Personal protective equipment (PPE) selections vary based on potential exposure conditions such as handling practices, concentration and ventilation.
Information on the selection of eye, skin and respiratory protection for use with this material is provided below.

Eye Protection:
Chemical Goggles, or Safety glasses with side shields

Skin Protection:
Use protective clothing which is chemically resistant to this material. Selection of protective clothing depends on potential exposure conditions and may include gloves, boots, suits and other items. The selection(s) should take into account such factors as job task, type of exposure and durability requirements.

Published literature, test data and/or glove and clothing manufacturers indicate the best protection is provided by:
Neoprene, or Nitrile Rubber
Respiratory Protection:
If engineering controls do not maintain airborne concentrations to a level which is adequate to protect worker health, an approved respirator must be worn. Respirator selection, use and maintenance should be in accordance with the requirements of the OSHA Respiratory Protection Standard, 29 CFR 1910.134.

Types of respirator(s) to be considered in the selection process include:
For Mist: Air Purifying, R or P style NIOSH approved respirator.
For Vapors: Air Purifying, R or P style prefilter & organic cartridge, NIOSH approved respirator. Self-contained breathing apparatus for use in environments with unknown concentrations or emergency situations.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

Appearance & Odor: Clear liquid. Mild odor.
Substance Chemical Family: Lubricants
Appearance: Clear liquid.

Flash Point: 380 ºF - 415 ºF [Cleveland Open Cup]

Odor: Mild odor.

Pour Point: 20 ºF

Specific Gravity: 0.86

Viscosity: 32 cSt - 68 cSt @ 40 ºC

SECTION 10 REACTIVITY AND STABILITY

Stability:
Material is stable under normal conditions.

Conditions to Avoid:
Avoid heat and open flames.

Materials to Avoid:
Avoid contact with strong oxidizing agents.

Hazardous Decomposition Products:

Thermal decomposition products are highly dependent on combustion conditions. A complex mixture of airborne solids, liquids and gases will evolve when this material undergoes pyrolysis or combustion. Aldehydes, Carbon Monoxide, Carbon Dioxide, Ketones and other unidentified organic compounds may be formed upon combustion.

SECTION 11 TOXICOLOGICAL INFORMATION

Acute Toxicity
Dermal LD50 >5.0 mg/kg(Rabbit) OSHA: Non-Toxic Based on components(s)
Oral LD50 >2000 ml/kg(Rat) OSHA: Non-Toxic Based on components(s)
Carcinogenicity Classification
Hydraulic Oil
NTP: No IARC: Not Reviewed ACGIH: No OSHA: No

SECTION 12 ECOLOGICAL INFORMATION

Environmental Impact Summary:
There is no ecological data available for this product. However, this product is an oil. It is persistent and does not readily biodegrade. However, it does not bioaccumulate.

SECTION 13 DISPOSAL CONSIDERATIONS

RCRA Information:

Under RCRA, it is the responsibility of the user of the material to determine,
at the time of the disposal, whether the material meets RCRA criteria for hazardous waste. This is because material uses, transformations, mixtures, processes, etc. may affect the classification. Refer to the latest EPA, state and local regulations regarding proper disposal.

SECTION 14 TRANSPORT INFORMATION

US Department of Transportation Classification
This material is not subject to DOT regulations under 49 CFR Parts 171-180.

Oil: This product is an oil under 49CFR (DOT) Part 130. If shipped by rail or highway in a tank with a capacity of 3500 gallons or more, it is subject to these requirements. Mixtures or solutions containing 10% or more of this product may also be subject to this rule.

International Air Transport Association
Not regulated under IATA rules.

International Maritime Organization Classification
Not regulated under International Maritime Organization rules.

SECTION 15 REGULATORY INFORMATION

FEDERAL REGULATORY STATUS

OSHA Classification:
Product is hazardous according to the OSHA Hazard Communication Standard, 29 CFR 1910.1200, because it carries the occupational exposure limit for mineral oil mist.

Ozone Depleting Substances (40 CFR 82 Clean Air Act):
This material does not contain nor was it directly manufactured with any Class I or Class II ozone depleting substances.

Superfund Amendment & Reauthorization Act (SARA) Title III:
There are no components in this product on the SARA 302 list.

SARA Hazard Categories (311/312):
Immediate Health: NO Delayed Health: NO Fire: NO Pressure: NO
Reactivity: NO

SARA Toxic Release Inventory (TRI) (313):

There are no components in this product on the SARA 313 list.

Toxic Substances Control Act (TSCA) Status:
All component(s) of this material is(are) listed on the EPA/TSCA Inventory of Chemical Substances.

Other Chemical Inventories:
Component(s) of this material is (are) listed on the Australian AICS, Canadian DSL, Chinese Inventory, European EINECS, Korean Inventory, Philippines PICCS,

State Regulation
This material is not regulated by California Prop 65, New Jersey Right-to-Know Chemical List or Pennsylvania Right-To-Know Chemical List. However for details on your regulation requirements you should contact the appropriate agency in your state.

SECTION 16 OTHER INFORMATION

Revision#: 0
Review Date: 04/06/2005
Revision Date: 10/09/2001
Revisions since last change (discussion): This Material Safety Data Sheet (MSDS) has been created to fully comply with the guidance contained in the ANSI MSDS standard (ANSI Z400.1-2003). We encourage you to take the opportunity to read the MSDS and review the information contained therein.

SECTION 17 LABEL INFORMATION

READ AND UNDERSTAND MATERIAL SAFETY DATA SHEET BEFORE HANDLING OR DISPOSING OF
PRODUCT. THIS LABEL COMPLIES WITH THE REQUIREMENTS OF THE OSHA HAZARD COMMUNICATION STANDARD (29 CFR 1910.1200) FOR USE IN THE WORKPLACE. THIS LABEL IS NOT INTENDED TO BE USED WITH PACKAGING INTENDED FOR SALE TO CONSUMERS AND MAY NOT CONFORM WITH THE REQUIREMENTS OF THE CONSUMER PRODUCT SAFETY ACT OR OTHER RELATED REGULATORY REQUIREMENTS.

PRODUCT CODE(S): 65547, 6554700001, 6554700055

SHELL® FM Hydraulic Oil 32

ATTENTION!

PROLONGED OR REPEATED SKIN CONTACT MAY CAUSE OIL ACNE OR DERMATITIS.
HIGH-PRESSURE INJECTION UNDER SKIN MAY CAUSE SERIOUS DAMAGE.

Precautionary Measures:
Avoid prolonged or repeated contact with eyes, skin and clothing. Avoid breathing of vapors, fumes, or mist. Use only with adequate ventilation. Wash thoroughly after handling.

FIRST AID
Inhalation: If the victim has difficulty breathing or tightness of the chest, is dizzy, vomiting or unresponsive, give 100% oxygen with rescue breathing or CPR as required and transport to the nearest medical facility.
Skin Contact: Remove contaminated clothing and shoes and wipe excess from skin. Flush skin with water, then wash with soap and water. If irritation occurs, get medical attention. Do not reuse clothing until cleaned. If material is injected under the skin, transport to the nearest medical facility for additional treatment. If redness, swelling, pain and/or blisters occur, transport to the nearest medical facility for additional treatment.
Eye Contact: Flush with water. If irritation occurs, get medical attention.
Ingestion: Do not induce vomiting. In general, no treatment is necessary unless large quantities of product are ingested. However, get medical attention. If vomiting occurs spontaneously, keep head below hips to prevent aspiration. Have victim rinse mouth out with water, then drink sips of water to remove taste from mouth.

FIRE

In case of fire, Use water fog, 'alcohol foam', dry chemical or carbon dioxide (CO_2) to extinguish flames. Do not use a direct stream of water. Material will float and can be re-ignited on surface of water.
SPILL OR LEAK
Dike and contain spill.
FOR LARGE SPILLS: Remove with vacuum truck or pump to storage/salvage vessels.

FOR SMALL SPILLS: Soak up residue with an absorbent such as clay, sand or other suitable material. Place in non-leaking container and seal tightly for proper disposal.

CONTAINS: White Mineral Oil, 8042-47-5; Copolymer additive, Proprietary

NFPA Rating (Health, Fire, Reactivity): 0, 1, 0

TRANSPORTATION

US Department of Transportation Classification
This material is not subject to DOT regulations under 49 CFR Parts 171-180.

Oil: This product is an oil under 49CFR (DOT) Part 130. If shipped by rail or highway in a tank with a capacity of 3500 gallons or more, it is subject to these requirements. Mixtures or solutions containing 10% or more of this product may also be subject to this rule.

CAUTION: Misuse of empty containers can be hazardous. Empty containers can be hazardous if used to store toxic, flammable, or reactive materials. Cutting or welding of empty containers might cause fire, explosion or toxic fumes from residues. Do not pressurize or expose to open flames or heat. Keep container closed and drum bungs in place.

Name and Address
SOPUS Products
P.O. Box 4427
Houston, TX 77210-4427

ADMINISTRATIVE INFORMATION
MANUFACTURER ADDRESS: SOPUS Products, P.O. Box 4427, Houston, TX. 77210-4427

THE INFORMATION CONTAINED IN THIS DATA SHEET IS BASED ON THE DATA AVAILABLE TO US AT THIS TIME, AND IS BELIEVED TO BE ACCURATE BASED UPON THAT : IT IS PROVIDED INDEPENDENTLY OF ANY SALE OF THE PRODUCT, FOR PURPOSE OF HAZARD COMMUNICATION. IT IS NOT INTENDED TO CONSTITUTE PRODUCT PERFORMANCE INFORMATION, AND NO EXPRESS OR IMPLIED WARRANTY OF ANY KIND IS MADE WITH RESPECT TO THE PRODUCT, UNDERLYING DATA OR THE INFORMATION CONTAINED HEREIN. YOU ARE URGED TO OBTAIN DATA SHEETS FOR ALL PRODUCTS YOU BUY, PROCESS, USE OR DISTRIBUTE, AND ARE ENCOURAGED TO ADVISE THOSE WHO MAY COME IN CONTACT WITH SUCH PRODUCTS OF THE INFORMATION CONTAINED HEREIN.

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44144-30003-100R-04/06/2005

Material Safety Data Sheet - 20W 50 Motor Oil

Product Identification

EDP Number: 182133

Product Name: 20W 50 Motor Oil

DOT Hazard: Not Hazardous, Flammable

DOT Ship. Name: Motor Oil and Lubricant

Physical Data

Boil Point	Freeze Point	Gravity	Vapor Pressure	Vapor Density	Evap Rate	% Volatile	Solubility
432 F	N/A	N/A	<0.01	N/A	N/A	N/A	Neg.

Odor and Appearance: Clear, bright light brown liquid with petroleum odor

Ingredients

Material Name	Percentage	TLV	Hazard	CAS Number
Base Lubricants Oils Mixture	75-85	No Limit	Irritant, Flammable	
Detergent/Inhibitor System Mixture	5-15	No Limit	Irritant	
Viscosity Index Mixture	5-15	No Limit	Irritant	
Pour Point Depressant Mixture	<1	No Limit	None	
Antifoam Additive Mixture	<1	No Limit	None	

Fire and Explosion Hazard Data

Flash Point	LEL	UEL
432 F	N/A	N/A

Extinguishing Media: Foam, Carbon Dioxide and Dry Chemicals

Unusual Fire & Explosion Hazards: Water may be ineffective but can be used to cool containers exposed to heat or flame. Caution should be exercised when using water or foam as frothing may occur, especially if sprayed into containers of hot, burning liquid.

Health Hazard Data

Acute Effects	N/A
Swallowing	This product is relatively non-toxic by ingestion but may cause abdominal cramps and diarrhea.
Inhalation	Prolonged and repeated exposure to oil mist poses a risk of pulmonary disease such as chronic lung inflammation. This condition is usually asymptomatic as a result of repeated small aspirations. Shortness of breath and cough are the most common symptoms.
Skin Contact	Minimally irritating upon contact. Prolonged exposure may result in contact dermatitis.
Eye Contact	Minimal irritation upon direct contact.
Chronic Effects	None Known.
Other Hazards	None.

Emergency First Aid Procedures

Swallowing	Do not induce vomiting. Seek medical attention immediately
Inhalation	Remove to fresh air. If not breathing begin CPR. If symptoms persist, seek medical attention immediately.
Skin Contact	Wash effected area immediately with soap and water. Remove contaminated clothing and wash before re-use. Seek medical attention immediately if skin disorder develops.
Eye Contact	Flush eye with large amounts of water for 15 minutes, lifting upper and lower lids periodically. Seek medical attention immediately if eye irritation persists.
Primary	N/A
Note to Physician	This product contains Zinc at a wt of 2.5%. This product is considered none hazardous in its blended form. All ingredients of this product are listed on the Toxic Substance Control Act Inventory.

Reactivity Data

Stability	Stable
Conditions to Avoid	Heat sources, open flames, sparks and strong oxidizing agents such as peroxides, chlorine and strong acids.
Materials to Avoid	Strong oxidizing agents such as peroxides, chlorine and strong acids.
Hazardous Decom Prod	Decomposition and combustion may cause dense smoke, carbon dioxide and carbon monoxide and other oxides.
Hazardous Polymerization	No
Additional Cond to Avoid	Sources of heat, open flames, sparks and strong oxidizing agents.

Spill or Leak Procedures

Steps if spilled	Ventilate the area. Remove any sources of ignition. Dyke to contain the spill. Absorb with inert material such as clay, sand or commercial absorbents. Keep away from sewers and natural waterways.
Waste Disposal Method	Dispose of in accordance with all local, state and federal regulations. Keep this product out of sewers and waterways.

Special Protection Information

Respiratory Protection	Not needed if used in consumer quantities. If bulk handling, use NIOSH approved respirator or mask to prevent over exposure. Use self-contained breathing apparatus for entry to confined spaces, poorly ventilated areas and for large spill clean up sites.
Ventilation	Use with appropriate general ventilation
Impervious Gloves	Neoprene Gloves
Other PPE	None if used as a consumer. If bulk handling, use neoprene gloves and apron. If handling hot, use insulated protective clothing.

Special Precautions

Storage & Handling Precautions	Store in closed, properly marked containers away from heat source, open flames, sparks or strong oxidizing agents.
Other Precautions	Wearing contact lenses while bulk handling is not advisable. Keep away from children and animals.

HMIS Ratings

Health	1
Flammability	2
Reactivity	1
Personal Protective Equipment	D

Prepared By:	JOEL POCHRON TECHNICAL DIRECTOR MALCO PRODUCTS, INC. 36I FAIRVIEW AVE P O BOX 892 BARBERTON OHIO 44203 330-753-0361 OR 800-253-2526 These numbers are available days, nights, weekends and holidays.
Last Updated	10/14/04

THE INFORMATION CONTAINED HEREIN IS BASED ON DATA CONSIDERED ACCURATE. HOWEVER, NO WARRANTY IS EXPRESSED OR IMPLIED REGARDING THE ACCURACY OF THIS DATA OR THE RESULTS TO BE OBTAINED FROM THE USE THEREOF. VENDOR ASSUMES NO RESPONSIBILITY FOR INJURY TO VENDEE OR THIRD PERSONS PROXIMATELY CAUSED BY THE MATERIALS IF REASONABLE SAFETY PROCEDURES ARE NOT ADHERED TO AS STIPULATED IN THE DATA SHEET. ADDITIONALLY, VENDOR ASSUMES NO RESPONSIBILITY FOR INJURY TO VENDEE OR THIRD PERSONS PROXIMATELY CAUSED BY ABNORMAL USE OF THE MATERIAL, EVEN IF REASONABLE SAFETY PROCEDURES ARE FOLLOWED. FURTHERMORE, VENDEE ASSUMES THE RISK IN HIS USE OF THE MATERIAL.

MSDS Number: **E5125** * * * * * *Effective Date:* ***03/15/04*** * * * * * *Supersedes:* ***11/02/01***

MSDS **Material Safety Data Sheet**

24 Hour Emergency Telephone: 908-859-2151
CHEMTREC: 1-800-424-9300

National Response in Canada
CANUTEC: 613-996-6666

Outside U.S. and Canada
Chemtrec: 703-527-3887

NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

From: **Mallinckrodt Baker, Inc.**
222 Red School Lane
Phillipsburg, NJ 08865

Mallinckrodt CHEMICALS J.T.Baker

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

ETHYLENE GLYCOL

1. Product Identification

Synonyms: 1,2-Ethanediol; glycol; 1,2-Dihydroxyethane; Ethylene Alcohol; Ethylene Dihydrate
CAS No.: 107-21-1
Molecular Weight: 62.07
Chemical Formula: CH2OHCH2OH
Product Codes:
J.T. Baker: 5387, 5845, 9140, 9298, 9300, 9346, 9356, L715
Mallinckrodt: 5001, 5037

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Ethylene Glycol	107-21-1	99 - 100%	Yes

3. Hazards Identification

Emergency Overview

WARNING! HARMFUL OR FATAL IF SWALLOWED. HARMFUL IF INHALED OR ABSORBED THROUGH SKIN. MAY CAUSE ALLERGIC SKIN REACTION. MAY CAUSE IRRITATION TO SKIN, EYES, AND RESPIRATORY TRACT. AFFECTS CENTRAL NERVOUS SYSTEM.

SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 2 - Moderate (Life)
Flammability Rating: 1 - Slight
Reactivity Rating: 1 - Slight
Contact Rating: 3 - Severe (Life)
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES
Storage Color Code: Green (General Storage)

Potential Health Effects

Inhalation:
Vapor inhalation is generally not a problem unless heated or misted. Exposure to vapors over an extended time period has caused throat irritation and headache. May cause nausea, vomiting, dizziness and drowsiness. Pulmonary edema and central nervous system depression may also develop. When heated or misted, has produced rapid, involuntary eye movement and coma.
Ingestion:
Initial symptoms in massive dosage parallel alcohol intoxication, progressing to CNS depression, vomiting, headache, rapid respiratory and heart rate, lowered blood pressure, stupor, collapse, and unconsciousness with convulsions. Death from respiratory arrest or cardiovascular collapse may follow. Lethal dose in humans: 100 ml (3-4 ounces).
Skin Contact:
Minor skin irritation and penetration may occur.
Eye Contact:
Splashes may cause irritation, pain, eye damage.
Chronic Exposure:
Repeated small exposures by any route can cause severe kidney problems. Brain damage may also occur. Skin allergy can develop. May damage the developing fetus.
Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders, eye problems, or impaired liver, kidney, or respiratory function may be more susceptible to the effects of this substance.

---

4. First Aid Measures

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.
Ingestion:
Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention.
Skin Contact:
Remove any contaminated clothing. Wash skin with soap and water for at least 15 minutes. Get medical attention if irritation develops or persists.
Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

Note to Physician:
Give sodium bicarbonate intravenously to treat acidosis. Urinalysis may show low specific gravity, proteinuria, pyuria, cylindruria, hematuria, calcium oxide, and hippuric acid crystals. Ethanol can be used in antidotal treatment but monitor blood glucose when administering ethanol because it can cause hypoglycemia. Consider infusion of a diuretic such as mannitol to help prevent or control brain edema and hemodialysis to remove ethylene glycol from circulation.

---

5. Fire Fighting Measures

Fire:
Flash point: 111C (232F) CC
Auto ignition temperature: 398C (748F)
Flammable limits in air % by volume:
lel: 3.2; uel: 15.3
Slight to moderate fire hazard when exposed to heat or flame.
Explosion:
Above flash point, vapor-air mixtures are explosive within flammable limits noted above. Containers may explode when involved in a fire.
Fire Extinguishing Media:
Dry chemical, foam or carbon dioxide. Water or foam may cause frothing. Water spray may be used to extinguish surrounding fire and cool exposed containers. Water spray will also reduce fume and irritant gases.
Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode. Toxic gases and vapors may be released if involved in a fire.

---

6. Accidental Release Measures

Ventilate area of leak or spill. Remove all sources of ignition. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Use non-sparking tools and equipment. Collect liquid in an appropriate container or absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer! US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Separate from acids and oxidizing materials. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
-OSHA Permissible Exposure Limit (PEL):
50 ppm Ceiling

-ACGIH Threshold Limit Value (TLV):
50 ppm Ceiling (vapor)
Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.
Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded, a half-face respirator with an organic vapor cartridge and particulate filter (NIOSH type P95 or R95 filter) may be worn for up to ten times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. A full-face piece respirator with an organic vapor cartridge and particulate filter (NIOSH P100 or R100 filter) may be worn up to 50 times the exposure limit, or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. Please note that N series filters are not recommended for this material. For emergencies or instances where the exposure levels are not known, use a full-face piece positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.
Skin Protection:
Wear protective gloves and clean body-covering clothing.
Eye Protection:
Use chemical safety goggles. Maintain eye wash fountain and quick-drench facilities in work area.

9. Physical and Chemical Properties

Appearance:
Clear oily liquid.
Odor:
Odorless.
Solubility:
Miscible in water.
Specific Gravity:
1.1 @20C/4C
pH:
No information found.
% Volatiles by volume @ 21C (70F):
100
Boiling Point:
197.6C (388F)
Melting Point:
-13C (9F)
Vapor Density (Air=1):
2.14
Vapor Pressure (mm Hg):
0.06 @ 20C (68F)
Evaporation Rate (BuAc=1):
No information found.

---

10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage.
Hazardous Decomposition Products:
Carbon dioxide and carbon monoxide may form when heated to decomposition. May produce acrid smoke and irritating fumes when heated to decomposition.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Strong oxidizing agents. Reacts violently with chlorosulfonic acid, oleum, sulfuric acid, perchloric acid. Causes ignition at room temperature with chromium trioxide, potassium permanganate and sodium peroxide; causes ignition at 212F(100C) with ammonium dichromate, silver chlorate, sodium chloride and uranyl nitrate.
Conditions to Avoid:
Heat, flames, ignition sources, water (absorbs readily) and incompatibles.

---

11. Toxicological Information

Toxicological Data:
Oral rat LD50: 4700 mg/kg; skin rabbit LD50: 9530 mg/kg.
Irritation - skin rabbit: 555mg(open), mild; eye rabbit: 500mg/24H, mild.
Investigated as a tumorigen, mutagen, reproductive effecter.
Reproductive Toxicity:
Has shown teratogenic effects in laboratory animals.

```
--------\Cancer Lists\-----------------------------------------------------
                     ---NTP Carcinogen---
Ingredient                Known  Anticipated  IARC Category
------------------------------------  -----  -----------  -------------
Ethylene Glycol (107-21-1)       No     No      None
```

12. Ecological Information

Environmental Fate:
When released into the soil, this material is expected to readily biodegrade. When released into the soil, this material is expected to leach into groundwater. When released into the soil, this material is not expected to evaporate significantly. When released into water, this material is expected to readily biodegrade. When released into the water, this material is expected to have a half-life between 1 and 10 days. This material is not expected to significantly bioaccumulate. This material has a log octanol-water partition coefficient of less than 3.0. When released into water, this material is not expected to evaporate significantly. When released into the air, this material is expected to be readily degraded by reaction with photochemically produced hydroxyl radicals. When released into the air, this material is expected to have a half-life between 1 and 10 days.
Environmental Toxicity:
The LC50/96-hour values for fish are over 100 mg/l.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Not regulated.

15. Regulatory Information

```
 --------\Chemical Inventory Status - Part 1\--------------------------------
-
 Ingredient                    TSCA EC  Japan Australia
 ---------------------------------------------- ---- --- ----- ---------
 Ethylene Glycol (107-21-1)            Yes  Yes  Yes  Yes

 --------\Chemical Inventory Status - Part 2\--------------------------------
-
                              --Canada--
 Ingredient                    Korea DSL  NDSL Phil.
 ---------------------------------------------- ----- ---  ---- -----
 Ethylene Glycol (107-21-1)            Yes  Yes  No   Yes

 --------\Federal, State & International Regulations - Part 1\---------------
-
                       -SARA 302-  ------SARA 313------
 Ingredient                 RQ  TPQ   List Chemical Catg.
 ---------------------------------------- ---  -----  ---- --------------
 Ethylene Glycol (107-21-1)         No  No   Yes    No

 --------\Federal, State & International Regulations - Part 2\---------------
-
                            -RCRA-  -TSCA-
 Ingredient                 CERCLA   261.33   8(d)
 ---------------------------------------- ------   ------  ------
 Ethylene Glycol (107-21-1)         5000    No     No


Chemical Weapons Convention: No   TSCA 12(b): No   CDTA: No
SARA 311/312: Acute: Yes   Chronic: Yes Fire: No Pressure: No
Reactivity: No     (Pure / Liquid)
```

Australian Hazchem Code: None allocated.
Poison Schedule: None allocated.
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

16. Other Information

NFPA Ratings: Health: **1** Flammability: **1** Reactivity: **0**
Label Hazard Warning:
WARNING! HARMFUL OR FATAL IF SWALLOWED. HARMFUL IF INHALED OR ABSORBED THROUGH SKIN. MAY CAUSE ALLERGIC SKIN REACTION. MAY CAUSE IRRITATION TO SKIN, EYES, AND RESPIRATORY TRACT. AFFECTS CENTRAL NERVOUS SYSTEM.
Label Precautions:
Do not breathe vapor or mist.
Use only with adequate ventilation.
Keep container closed.
Avoid contact with eyes, skin and clothing.
Wash thoroughly after handling.
Label First Aid:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes. Call a physician if irritation develops or persists. If swallowed, give water or milk to drink and induce vomiting. Never give anything by mouth to an unconscious person. In all cases call a physician.
Product Use:
Laboratory Reagent.
Revision Information:
MSDS Section(s) changed since last revision of document include: 3.
Disclaimer:
****

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****

Prepared by: Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

Attachment 3
Spill Reporting Requirements

Hazardous Waste/Material/Substance/Used Oil						
Regulation	**When Required**	**Information Required**	**Notify Whom**	**Oral Notice Time**	**Phone Numbers**	**Written Notice Time**
19 CCR Ch. 4.5	Petroleum products spill of 5 gal or more (except for gasoline which is 1 gal) Any other hazardous substance not immediately cleaned up	Name, address, and telephone number of person reporting, location of spill, company name and location, material spilled, estimated quantity, source of spill, cause of spill, name of water body involved or nearest body of water, action taken for containment and cleanup.	CA OES	Immediately	1-800-852-7550	
40 CFR 302.6	Discharge of a hazardous substance in quantities greater than the reportable quantity over 24 hours	Not specified	NRC	Immediately	1-800-424-8802	
40 CFR 110	If oil or hazardous substance release: (1) causes a sheen; or (2) violates water quality standards: or (3) causes sludge or emulsion to be deposited below water level	Not specified	NRC	Immediately	1-800-424-8802	
NRC = National Response Center OES = Office of Emergency Services						

Attachment 4
Spill Incident Report Form

Notification of Pollution Event

1. INSTALLATION:	2. COMMANDER:	3. DISCOVERY DATE & TIME:

4. PERSON REPORTING (NAME/PHONE):	5. SEVERITY: ( ) MINOR ( ) MEDIUM ( ) MAJOR

6. TYPE & AMOUNT OF MATERIAL SPILLED:

7. LOCATION OF SPILL (FACILITY/EQUIPMENT INVOLVED):

8. CAUSE:

9. PERSONNEL INJURIES/PROPERTY LOSS:

10. DURATION/MAGNITUDE OF POLLUTION PRODUCED/RELEASED:

a.	SOURCE OF RELEASE BEEN STOPPED?	( ) Yes ( ) No	
b.	RELEASED MATERIAL BEEN RETAINED?	( ) Yes ( ) No	
c.	REACH ENVIRONMENTA (CHECK ALL THAT APPLY)?	( ) Navigable waters ( ) Ground water ( ) Land surface (soil)	( ) Surface water ( ) Drinking water supply ( ) Ambient air
d.	NAME OF RECEIVING WATER:		
e.	PASS THE INSTALLATION BOURNDARY?	( ) Yes ( ) No	
f.	NPDES PERMIT POINTS INVOLVED?	( ) Yes ( ) No	
g.	SAMPLE BEING TAKEN FOR LEGAL RECORD?	( ) Yes ( ) No	

11. DAMAGE/IMPACT ON SURROUNDINGS (GROUND WATER, WILDLIFE, ETC.):

12. REMEDIAL ACTION TAKEN:

13. REMEDIAL ACTION PLANNED:	14. DATE OF REMEDIAL ACTION COMPLETION:

15. NOTIFICATIONS:			
a. NRC	( ) Yes ( ) No	DATE/TIME:	POC NAME:
b. ACO STAFF	( ) Yes ( ) No	DATE/TIME:	POC NAME:
c. STATE	( ) Yes ( ) No	DATE/TIME:	POC NAME:
d. LEPC	( ) Yes ( ) No	DATE/TIME:	POC NAME:
e. EPA	( ) Yes ( ) No	DATE/TIME:	POC NAME:

16. NRC INCIDENT NUMBER:	17. REACTION BY NEWS MEDIA/PUBLIC:
18. DOLLAR VALUE OF MATERIAL SPILLED:	19. TOTAL COST OF CLEANUP ACTIVITIES: (Est/Actual):

20. WHAT STEPS ARE BEING TAKEN TO PREVENT FUTURE OCCURRENCES OF THIS TYPE AND DATE FORMAL REPORT IS DUE (TO WHAT AGENCY)?

21. FORWARD REPORT TO: Hector Santiago at USACE Omaha

Email: hector.l.santiago@usace.army.mil

ENVP-002

Sample Handling, Packaging and Shipping

Revision 1

August 28, 2006

Approved:

Doug Jorgensen *(See letter number NW-2006-156)*	08/28/06
Line Manager	Date

REVISION HISTORY

Revision No.	Effective Date	Sections Affected	Description
0	04/07/06	All	Baseline Document
1	08/28/06	All	Revised document numbers for corporate plans, policies, procedures, and forms, and corrected references to these documents, to reflect the number changes per Letter NW-2006-156. Also made minor formatting changes (i.e., moved definitions and acronyms to the front of the document and changed page numbers) per QAP-061_Rev 2.

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DEFINITIONS

Chain of Custody Form — A form used to record the transfer of sample custody.

Custody — A sample is considered in custody if it:

A. is in one's possession,

B. is in one's view after being in possession,

C. was in possession and is now locked up,

D. is secured (such as, sealed with tamper-indicating devices) by the responsible individual so that no tampering can occur,

E. is in a designated secured area.

Sample — Any physical evidence collected from an environmental measuring or monitoring activity. Evidence is anything offered at the time of a legal proceeding as a means of ascertaining the truth. In investigations involving hazardous wastes, physical and documentary evidence is collected to determine if the site poses a potential threat to human health or the environment and if the site complies with applicable regulations.

ACRONYMS

C	Celsius
COC	Chain of Custody
DOT	Department of Transportation
ENVP	Environmental Procedure
FTL	Field Team Leader
QAP	Quality Assurance Procedure
QAPjP	Quality Assurance Project Plans
SAP	Sampling and Analysis Plans

1. PURPOSE

This procedure establishes methods for proper handling, packaging, and shipping of samples to ensure sample integrity and validity, personal safety, and compliance with applicable regulations.

2. SCOPE

This procedure is applicable to North Wind, Inc. (NWI) projects that specifically reference this procedure in the Project Execution Plan (PEP), Project Work Plan, or Sampling and Analysis Plan (SAP).

This procedure provides instructions for packaging, handling, and shipping samples collected, as directed by North Wind project documents (such as sampling and analysis plans (SAPs), field sampling plans, quality assurance project plans (QAPjP), or other documents). This procedure applies and remains applicable from the time of sample collection until custody of the sample is transferred to the appropriate destination. Guidance for shipping samples that are considered "environmental samples" and "dangerous goods" is provided in Appendix A and B of this procedure.

3. RESPONSIBILITIES

3.1 Field Team Leader

- Directs and ensures proper sample handling, packaging, and shipping.
- Performs duties of field personnel, as applicable.

3.2 Field Personnel

- Performs sample handling, packaging, and shipping tasks identified in this procedure.
- Identifies and follows appropriate shipping classification (based on DOT regulations).

4. SAMPLE HANDLING, PACKAGING, AND SHIPPING

4.1 Documentation

4.1.1 Follow ENVP-021, Chain of Custody (COC) Documentation, for COC form documentation instructions during sample handling, packaging, and shipping.

4.1.2 Maintain all COC forms, records, labels, and documents neatly.

4.1.3 Use indelible ink to record all information.

4.2 Sample Handling

4.2.1 Properly store labeled samples in the custody of the assigned field personnel at all times.

4.2.2 Refer to the project-specific health and safety plan for the proper personal protective equipment required for handling samples.

4.2.3 Inspect sample bottles and associated documentation to ensure the bottles meet the criteria for quality specified in the project documentation.

4.2.4 If samples are temperature sensitive, ensure storage of sample at appropriate temperature.

4.2.5 Arrange for shipping all samples as soon as required after collection to ensure all holding times are met.

4.3 Sample Packaging

4.3.1 Gather the following tools and equipment, which may include, but are not limited to, samples with appropriate labels, field logbook, sample packing and shipping materials that (as applicable to the sample matrix, container type, and analysis) may include:

- hard, plastic-lined metal or plastic cooler or shipping container
- sealable, plastic bags
- absorbent, cushioning material
- tape
- bubble wrap
- foam vial holders
- blue ice packs or double-bagged ice
- indelible ink pen
- trip blanks
- Department of Transportation (DOT) material hazard labels
- clear and regular plastic strapping tape
- plastic garbage bags
- address/return address labels

- “this side up” labels
- “fragile” labels
- scissors or pocket knife

4.3.2 Remove any existing labels from the cooler or shipping container that are not applicable for the current shipment.

4.3.3 Inspect sample bottles for cleanliness or damage. Samples can be packaged if the sample containers are clean, not cracked or broken, and the lids and seals are present and undamaged. Clear tape may be placed over the sample labels, if necessary, to prevent damage. If any problems are detected, notify the Field Team Leader (FTL), dispose of the sample material and container in an appropriate manner, and properly document the occurrence.

4.3.4 Package samples into a cooler or shipping container. Ensure the samples do not leak, spill, or vaporize. The following steps provide a guideline of sample packing:

- Obtain a hard, plastic-lined metal or plastic cooler.
- Tape the inside and outside of the cooler drain with duct/strapping tape.
- Line the cooler with a large plastic bag, or place individual samples in sealable, plastic bags.
- Place a layer of absorbent cushioning material in the bottom of the liner bag, if applicable.
- Place the sample container into a plastic sealable bag. The individual containers can be wrapped with bubble wrap or plastic bags for protection prior to placement in the cooler for shipment.
- Squeeze as much air as possible from the bag before sealing.
- Ensure the container is upright and surrounded with an absorbent cushioning material to prevent contact with other samples, tipping over, breaking, or spilling.
- Fill in around the containers with additional absorbent cushioning material.
- Ensure the cooler contains enough absorbent material to absorb all the sample material contained in the cooler in case of an accident.
- Pull the ends of the liner bag together and twist.

- Tape the top of the liner bag down.
- If sample temperature must be maintained at 4°C, place blue ice packs or double-bagged wet ice around the sides and top of the liner bag or inside the bag and in between samples.

4.3.5 Confirm that all information from the sample labels in the cooler matches the COC forms (see def.) exactly. Ensure the following information accompanies the sample:

- collector's name, mailing address, and telephone number
- laboratory's name, mailing address, and telephone number
- quantity of sample
- date of shipment
- description of sample.

4.3.6 Sign and record the current date and time on the completed corresponding COC form "relinquished by" block.

4.3.7 Remove the back copy of the COC form or make a photocopy of the form for project files.

4.3.8 Place the remaining forms in a large transparent sealable bag and place inside the cooler or shipping container.

4.3.9 Close the lid and latch.

4.3.10 Make a few wraps around the cooler using fiberglass or strapping tape to ensure the lid will remain closed.

4.3.11 Place a complete address label on the lid of the cooler including the name, address, and phone number of the receiving laboratory and a laboratory contact.

4.4 Sample Shipment

4.4.1 Deliver non-hazardous coolers or shipping containers directly to the selected commercial air cargo transporter, rail, or truck for delivery to appropriate location.

4.4.2 If shipping hazardous materials, follow appropriate DOT regulations. Make appropriate arrangements for shipment of hazardous materials.

4.4.3 Notify the laboratory in advance that samples are being shipped to ensure a laboratory custodian will be available for receipt.

5. RECORDS

The Project Manager shall maintain the following records in accordance with QAP-171, Records Control:

- Case-specific written procedures used during the shipment of dangerous goods as presented in a controlled document or project logbook;
- Chain-of-custody form(s) for the shipped samples; and,
- Airbill or other package tracking information provided by the courier.

6. REFERENCES

ENVP-021, Chain of Custody Documentation

QAP-171, Records Control

APPENDIX A, Guidance for Shipping Environmental Samples

Guidance for the shipment of environmental laboratory samples by personnel is provided in a memorandum dated March 6, 1981, subject "Final National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Laboratory Samples." By this memorandum, the shipment of the following unpreserved samples is not regulated:

- Drinking water
- Treated effluent
- Biological specimens
- Sediment
- Water treatment plant sludge
- POTW sludge

In addition, the shipment of the following preserved samples is not regulated, provided the amount of preservative used does not exceed the amounts found in 40 CFR 136.3:

- Drinking water
- Ambient water
- Treated effluent
- Biological specimens
- Sediment
- Wastewater treatment plant sludge
- Water treatment plant sludge

It is the shippers' (individual signing the airway bill) responsibility to ensure that proper amounts of preservative are used. The amounts of preservative used in each container may be checked using the sampling teams field notes and/or chain-of-custody information.

Samples determined by the project leader to be in these categories are to be shipped using the following protocol, which is modified from a procedure developed jointly between US-EPA, OSHA, and DOT in the "Final National Guidance Package for Compliance

with Department of Transportation Regulations in the Shipment of Environmental Laboratory Samples."

Untreated wastewater and sludge from POTW's are considered to be "diagnostic specimens" (not environmental laboratory samples). However, because they are not considered to be etiologic agents (infectious) they are not restricted and may be shipped using the procedures outlined below.

APPENDIX B, Guidance for Shipping Dangerous Goods

Samples collected during field investigations or in response to a hazardous materials incident must be classified prior to shipment, as either environmental or hazardous materials samples. In general, environmental samples include drinking water, most groundwater and ambient surface water, soil, sediment, treated municipal and industrial wastewater effluent, biological specimens, or any samples not expected to be contaminated with high levels of hazardous materials.

Samples collected from process wastewater streams, drums, bulk storage tanks, soil, sediment, or water samples from areas suspected of being highly contaminated may require shipment as dangerous goods. Regulations for packing, marking, labeling, and shipping of dangerous goods by air transport are promulgated by the International Air Transport Authority (IATA), which is equivalent to United Nations International Civil Aviation Organization (UN/ICAO). Transportation of hazardous materials (dangerous goods) by EPA personnel is covered by EPA Order 1000. 18.

The Project Leader is responsible for determining if samples collected during a specific field investigation meet the definitions for dangerous goods. If a sample is collected of a material that is listed in the Dangerous Goods List, Section 4.2, IATA, then that sample must be identified, packaged, marked, labeled, and shipped according to the instructions given for that material. If the composition of the collected sample(s) is unknown, and the project leader knows or suspects that it is a regulated material (dangerous goods), the sample may not be offered for air transport. If the composition and properties of the waste sample or highly contaminated soil, sediment, or water sample are unknown, or only partially known, the sample may not be offered for air transport.

In addition, the shipment of pre-preserved sample containers or bottles of preservatives (e.g., NaOH pellets, HCL, etc.) which are designated as dangerous goods by IATA is regulated. Shipment of nitric acid is forbidden on all aircraft. Dangerous goods must not be offered for air transport without contacting the Division dangerous goods shipment designee.

The Project Leader is responsible for the identification of sample packaging and shipping procedures on a case-by-case basis when dangerous goods must be shipped. If the materials to be shipped are identified as dangerous goods, then

- the Field Team Leader must identify specific shipping requirements and procedures to be carried out on a case-by-case basis in accordance with applicable shipping regulations.

- The Field Personnel must pack dangerous goods according to case-specific procedures provided by the project leader.

References for Appendix A and B

Dangerous goods Regulations, International Air Transport Authority (IATA). Current Edition which changes annually.

EPA Order 1000.18, February 16, 1979.

"Final Regulation Package for Compliance with DOT Regulations in the Shipment of Environmental Laboratory Samples," Memo from David Weitzman, Work Group Chairman, Office of Occupational Health and Safety (PM-273), US-EPA, April 13, 1981.

40 CFR 136.3. July 1, 2001. See Table 11, Footnote 3

ENVP-006

Groundwater Sampling

Revision 3

December 8, 2006

Approved:

Doug Jorgensen *Original signature on file*	12/05/06
Line Manager	Date

REVISION HISTORY

Revision No.	Effective Date	Sections Affected	Description
0	5/24/06	All	Baseline Document
1	08/28/06	All	Revised document numbers for corporate plans, policies, procedures, and forms, and corrected references to these documents, to reflect the number changes per Letter NW-2006-156. Also made minor formatting changes (i.e., moved definitions and acronyms to the front of the document and changed page numbers) per QAP-061_Rev 2.
2	09/25/06	4, References, Appendix A	Revised to provide detailed technical direction, add one reference, and add acronyms.
3	12/08/06	All	Revised to clarify technical directions and add definitions. Add example calculation in appendix.

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DEFINITIONS

High-Yield Formation	A formation that provides groundwater to a well in sufficient quantity that the well is not pumped dry at flowrates used during purging and sampling operations.
Low-Flow Sampling Approach	An approach for purging a well and sampling groundwater that utilizes groundwater extraction rates that are so low that mobilization of colloids and larger particles in the vicinity of the well is minimized.
Low-Yield Formation	A formation that provides groundwater to a well in such low quantity that the well is pumped dry at flowrates used during purging and sampling operations.
Purge Water	Water extracted from a well during purging.
Purging	Removal of water from a well prior to sample collection in order that the sample consists of water recently drawn from the formation.
Standing Water Volume	Volume of water in well under static conditions.

ACRONYMS

C	degrees Celsius
CFR	Code of Federal Regulations
DI	Distilled or Deionized
DO	Dissolved Oxygen
Eh	Redox Potential
ENVP	Environmental Procedure
EPA	Environmental Protection Agency
ft	foot or feet
gal	gallon
HSP	Health and Safety Plan
L	Liter
m	meter

mg	milligram
min	minute
mV	millivolt
NWI	North Wind, Inc.
ORP	Oxidation Reduction Potential
PEP	Project Execution Plan
PQP	Project Quality Plan
QAP	Quality Assurance Procedure
SAP	Sampling and Analysis Plan
SOW	Statement of Work
VOC	Volatile Constituents

1. PURPOSE

The purpose of this Procedure is to set guidelines for the collection of a sample representative of groundwater residing in the geologic formation of interest. The purpose of this procedure is to provide a process to support the reduction of the potential bias caused by the sampling equipment used to obtain the sample.

2. SCOPE

This procedure is applicable to North Wind, Inc. (NWI) projects that specifically reference this procedure in the Project Execution Plan (PEP), Project Work Plan, or Project Quality Plan (PQP).

This procedure is intended to provide general guidance on sampling of groundwater wells, this guideline is primarily concerned with the collection of water samples from the saturated zone of the subsurface. Every effort must be made to ensure that the sample is representative of the particular zone of water being sampled. This procedure is designed to be used in conjunction with analyses for the most common types of groundwater contaminants (e.g., volatile and semivolatile organic compounds, pesticides, metals, biological parameters). This is a standard (i.e., typically applicable) operating procedure which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedure employed should be documented and associated with the final report.

3. RESPONSIBILITIES

3.1 Project Manager

- Meet customer's expectations and serve as a primary point of contact with the customer.
- Ensures that the sampler has been trained and that the training has been documented.
- Ensure that the sampler has access to necessary equipment to complete groundwater sampling.
- Ensures that the sampler follows protocol and procedures for completing groundwater sampling task(s).

3.2 Sampling Personnel

- Ensures appropriate preparation and planning is completed prior to groundwater sampling activities to reduce delays in start-up or progress task.
- Ensures all materials and equipment are available for sampling task.

- Communicates on a routine basis with the Project Manager on status of task, any additional needs to complete task, and on any issues related to properly completing task.

- Follows all procedures and project plans to adequately complete groundwater sampling task.

- Ensures all documentation of groundwater sampling activity in logbook is complete and legible.

4. GROUNDWATER SAMPLING

The following outlines standard groundwater sampling procedures and processes that should be used for any groundwater sampling task. The approach for acquiring groundwater samples can vary widely from sampling site to sampling site. This procedure should be used as a general reference to guide filed personnel when preparing for and performing groundwater sampling.

Groundwater sampling typically includes three phases: preparation, well purging, and sample collection. Activities conducted in each phase are described in this section. Three approaches for purging and sampling are described here: purging and sampling a low-yielding formation; purging and sampling a high-yielding formation using a high-flow approach; and purging and sampling a high-yielding formation using a low-flow approach.

4.1 Preparation

Proper sampling preparation and organization is critical to ensure no delays in starting sampling operations and to ensure all materials and equipment have been obtained. Perform the following steps during preparation for groundwater sampling:

4.1.1 Coordinate sampling activities with appropriate NWI/subcontractor personnel, the client, regulatory agency, analytical laboratory, and shipping services.

4.1.2 Obtain the following documentation tools, equipment, and supplies, as appropriate, for sampling. Verify that all equipment functions properly before deployment to the field. For example, calibrate equipment per QAP-121, Control of Measuring and Test Equipment and document calibration in field logbooks per ENVP-003, Field Logbooks.

- Work control documents
  - Health and Safety Plan (HSP)
  - Sampling and Analysis Plan (SAP)

- Site Map
- Well completion logs
- Keys for gates, buildings, and well caps
- Communication equipment that will work at the site, such as a cell-phone, two-way radio, or satellite phone
- Logbook
- Pen with waterproof black ink
- Field data sheets
- Chain of custody records and seals
- Calculator
- Water level indicator, with space batteries
- Oil-water interface probe, if appropriate
- Engineer's rule
- Steel brush
- Sharp knife (locking blade)
- Tool box (to include at least: screwdrivers, pliers, hacksaw, hammer, flashlight, adjustable wrench)
- Plastic trash bags
- Appropriate Health and Safety Equipment and personal protective equipment, as specified in the health and safety plan
- Leather work gloves
- Fire extinguisher
- 5-gallon pail
- Plastic sheeting
- Sample containers and sample labels

- Preservatives as specified in the SAP
- Shipping containers (e.g., ice boxes) for transporting/shipping samples to analytical laboratory
- Packing materials (e.g., absorbent material such as vermiculite)
- Ice or gel cold packs (e.g., Blue Ice)
- Ziploc plastic bags
- Containers for water produced during purging and sampling
- Equipment decontamination materials:
  - Decontamination solutions identified in project work control documents
  - Tap water
  - Non phosphate soap
  - Several brushes
  - Pails or tubs
  - Aluminum foil
  - Garden sprayer
  - Distilled or deionized (DI) water
  - Containers for solid and liquid decontamination wastes
- Bailers with retrieval line, or other sampler/sampling pump, and ancillary equipment
- Control box for sampler/pump (if necessary)
- Spare parts and maintenance supplies for field serviceable components of sampling equipment
- Operator's manual for sampling equipment
- If electric power is needed, generator (110, 120, or 240 volt) with fuel, oil, and extension cord, or 12 volt battery if inaccessible to field vehicle
- Absorbent wipes

- Nitrile or latex gloves
- Multi-parameter water quality instrument capable of measuring temperature, pH, and conductivity as a minimum. Other parameters, such as oxidation/reduction potential specifications in the work planning documents.
- Operator's manual for water quality instrument
- Calibration supplies for the water quality instrument
- Spare parts and maintenance supplies for field-serviceable components (batteries, fuses, electrode components and filling solutions, etc.) for water quality instruments

NOTE: *Decontaminate or pre-clean equipment, and ensure that it is in working order. Starting sampling operations with decontaminated tools is crucial to ensure quality and reliability of sampling results. Refer to Sample Equipment Decontamination procedure (ENVP-014).*

4.1.3 Final Preparation

4.1.3.1 Ensure that appropriate sample bottles (as described in SAP) have been, labeled and pre-loaded with preservatives (if required by SAP).

4.1.3.2 Confirm that equipment has been decontaminated prior to use.

4.1.3.3 Perform a general site survey prior to site entry.

4.1.3.4 Mobilize to the appropriate wellhead. (Start at the least contaminated well, if known).

4.1.3.5 Don personal protective equipment, as required by the Health and Safety Plan. As a minimum, wear clean, waterproof gloves (e.g., latex or nitrile) to prevent skin oils, dust particles, or other contaminants from contaminating samples and to protect personnel. Change gloves between wells or discrete sampling zones. Leather work gloves can be worn over waterproof gloves at the discretion of field personnel, and will be worn when required by the HSP. Leather work gloves will not be worn while filling or handling sample containers.

4.2 Well Purging

Select sampling equipment so that disturbance of the actual concentration of the chemical constituents of interest is minimized. The collection methods required for individual investigations will be as defined in the governing data collection plans. Use bailers, low-volume suction pumps, or submersible pumps to remove water from the well. Manage

purge water in accordance with the Field Sampling Plan or Project Waste Management Plan.

Separate approaches are used for wells completed in low-yield and high-yield formations. A low-yield formation is operationally defined as one in which wells are easily pumped or bailed dry during routine purging and sampling. A high-yield formation is operationally defined as one in which wells are not easily pumped or bailed dry during routine purging and sampling.

The following outlines standard procedures, processes, and considerations for purging wells prior to groundwater sampling.

4.2.1 Purging Low-Yield Formations

4.2.1.1 Lay plastic sheeting around the well to minimize likelihood of contaminating equipment by contact with soil adjacent to the well.

4.2.1.2 Measure the depth to water from a reference point (typically a permanent mark at the top of casing). Record the measured depth and describe the reference mark in the field notes. If there is a layer of free product (i.e. organic liquid) floating at the water surface, then the top and bottom of the layer can be measured with a specialized interface meter, if required by the project field sampling plan. Operate the interface meter in accordance with manufacturer's instructions.

4.2.1.3 When purging a low-yield well (a well that is incapable of yielding three casing volumes), purge the well dry once. Purging can be performed using a bailer, pump, or other system as specified in the project specific work plan.

4.2.1.4 Record purge water volume in field log book. The purge volume can be measured using a 5-gallon bucket.

4.2.1.5 Manage purge water in accordance with applicable work control documents (e.g. field sampling plan, waste management plan).

4.2.1.6 As soon as the well recovers sufficiently to provide ample water for sample collection, collect and bottle samples in the order of the parameters' volatilization sensitivity or per sample collection priority (i.e. collect samples for volatile organic compound analysis and dissolved gas analysis first, then dissolved iron, semi-volatile organic compounds, metals, other organics, and other inorganics; a different sample collection order specified by the SAP would supersede the general order provided here). Sampling procedures are described in Section 4.3.

4.2.1.7 Secure the well.

4.2.1.8 Decontaminate equipment.

4.2.1.9 Manage water produced during sampling, decontamination waste, and any other waste generated in accordance with work control documents.

4.2.1.10 Demobilize from the well site.

4.2.2 Purging High-Yield Formations Using High-Flow Approach

4.2.2.1 Lay plastic sheeting around the well to minimize likelihood of contaminating equipment by contact with soil adjacent to the well.

4.2.2.2 Measure the depth to water from a reference point (typically a permanent mark at the top of casing). Record the measured depth and describe the reference mark in the field notes. If there is a layer of free product (i.e. organic liquid) floating at the water surface, then the top and bottom of the layer can be measured with a specialized interface meter, if required by the project field sampling plan. Operate the interface meter in accordance with manufacturer's instructions.

4.2.2.3 Measure total depth of well (at least twice to confirm measurement) and record in site logbook or on field data sheet.

4.2.2.4 Calculate the volume of standing water in a well using the following generalized equation

$$V = (0.163)\ r2(h1 - h2)$$

where

V = volume of standing water in well, in gallons

r = inside radius of well casing, in inches

h1 = depth of the well from the top of the casing, in feet

h2 = depth to water from the top of the casing, in feet

The factor 0.163 includes both units conversion factors and the value of pi.

An example calculation and the derivation of the conversion factor are presented in Appendix A.

4.2.2.5 If the well is not equipped with a permanent pump, then install a pump such that the pump intake is at the depth specified in project work control documents. If

project documents do not specify this depth, then place the pump intake at mid-depth of the screened interval.

4.2.2.6 Operate the pump to purge standing water in the casing so that formation water replaces the stagnant water in the well and filter pack. In contrast to the low flow approach described in Section 4.2.3, the allowable maximum flowrate is not specified, and any convenient flowrate can be used.

NOTE: *Typically three to five times the calculated volume of water in the well is removed in an effort to obtain a representative sample from the aquifer. The actual number of volumes to be removed may also be specified in governing data collection plans. The water standing in a well prior to sampling may not be representative of in-situ groundwater quality.*

4.2.2.7 In some cases, work control documents may specify that purging is accomplished by removing a specified volume of water, such as 3 times the volume of water standing in a well. In other cases, work control documents may require that purging be continued until water quality parameters have stabilized. In this case, measure water quality parameters using a multi-parameter water quality instrument according to the manufacturer's instructions. The instrument must be maintained and calibrated per manufacturer's instructions, and the maintenance and calibration activities must be recorded in project documents.

4.2.2.8 Continue well purging until the stagnant water volume has been removed and/or certain indicator parameters (such as pH, specific conductance, and temperature) have stabilized.

NOTE: *Stabilization of the indicator parameters is satisfied when successive readings meet the criteria in Table 4-1.*

Table 4-1 Purge parameter stabilization criteria

Parameter	Stabilization Criterion (Maximum difference in three values measured at an interval of 3 to 5 minutes)
pH	+/- 0.1 standard units
Conductivity	+/- 3%
Redox Potential/Oxidation Reduction Potential/ORP	+/- 10 mV
Dissolved Oxygen/DO	+/- 10% for DO > 1 mg/L +/- 0.1 mg/L for DO < 1 mg/L
Turbidity	+/- 10%
Temperature	+/- 0.5 C

4.2.2.9 Record flowrate and purge water volume in field logbook.

4.2.2.10 Immediately after purging has been completed, collect samples according to sample collection procedures described in Section 4.3.

4.2.2.11 Secure the well.

4.2.2.12 Decontaminate equipment.

4.2.2.13 Manage water produced during purging and sampling in accordance with work control documents.

4.2.2.14 Manage decontamination waste and any other wastes generated during purging and sampling in accordance with work control documents.

4.2.2.15 Demobilize from the well site.

4.2.3 Purging High-Yield Formations Using the Low-Flow Approach

The procedure for purging and sampling using the low-flow approach is based on Environmental Protection Agency (EPA) recommendations (Puls and Barcelona, 1996).

The overall approach is to extract groundwater at a low flowrate such that water that is representative of the formation adjacent to the well screen is extracted, while minimizing mobilization of colloidal particles or other fine-grained soil particles in the formation or that have accumulated in the bottom of the well. The approach includes a maximum flowrate limitation that is proportional to well screen length, and a maximum drawdown limitation that does not depend on well screen length (Table 4-2).

Table 4-2, Low-flow purging and sampling flowrate and drawdown limitations

Well Screen Length (ft)	Maximum Flowrate (L/min)	Maximum Flowrate (gal/min)	Maximum Drawdown (m)	Maximum Drawdown (ft)
<5	1	0.25	0.1	0.3
5	1	0.25	0.1	0.3
10	2	0.50	0.1	0.3
15	3	0.75	0.1	0.3
20	4	1.0	0.1	0.3
>20	1 per 5 ft length of screen	0.25 per 5 ft length of screen	0.1	0.3

4.2.3.1 Based on the well completion log, determine the well screen length. Look up the maximum allowable flowrate based on well screen length in Table 4-1.

4.2.3.2 Based on the well completion log, calculate the depth from the top of the well to the center of the well screen.

4.2.3.3 Don personal protective equipment as required by the site-specific health and safety plan.

4.2.3.4 Lay plastic sheeting on the ground around the well head to minimize the potential spread of contamination from soil to purging and sampling equipment.

4.2.3.5 Measure the depth from a permanent reference mark at the top of the well to the water level in the well, using a water level tape or equivalent. Record the measured depth and a description of the reference mark in the filed notes. If floating organic liquids are a concern, their presence can be determined using an oil/water interface probe, if required by the project field sampling plan. Operate the interface meter in accordance with manufacturer's instructions.

NOTE: *To minimize mixing water inside the well and distributing sediment in the bottom of the well, avoid lowering equipment into the well to the extent practical. If the total depth of the well must be measured, it is recommended that this measurement be made after purging and sampling has been completed.*

4.2.3.6 Make sure that the purging / sampling pump and tubing has been decontaminated prior to use at each well. The pump must be capable of pumping at a flowrate of 0.1 to 1 L/minute, without exposing the water being pumped to air or to materials that are incompatible with the analytes being sampled. Lower the purging / sampling pump into the well so that the pump intake is located at or slightly above the midpoint of the well screen, or at other depth specified in the SAP. Record the installation details in the field notes. The pump should be lowered slowly into the well so as to minimize mixing water in the well and re-suspending sediment that may have accumulated in the bottom of the well. If possible, install the pump well in advance of when purging will be performed to allow time for the effects of installation to subside. For wells that will be sampled repeatedly, it is recommended that purging / sampling pumps be installed permanently.

4.2.3.7 Calibrate a multi-parameter water quality monitoring instrument according to the manufacturer's procedures. Document the calibration in the field notes.

NOTE: *Calibration can be performed ahead of time, if the manufacturer's recommendations indicate that the interval between calibrations is long enough to allow it.*

4.2.3.8 Install a flow-through cell for the water quality instrument sonde in the effluent line of the purging/sampling pump.

4.2.3.9 Purge water from the well at a flowrate of approximately not exceeding the maximum flowrate calculated in Step 4.2.3.1. Periodically measure the depth to water and calculated drawdown as the difference between the depth to water

under pumping conditions and the depth to water under static conditions (which was measured in Step 4.2.3.5. If the drawdown is greater than 0.1 m or 0.3 ft., then reduce the pumping rate until the drawdown stabilizes at less than 0.1 m or 0.3 ft.

4.2.3.10 Continue purging until the purge parameters have stabilized. The purge parameters are, at minimum, pH, conductivity, and either redox potential (also known as oxidation – reduction potential, or ORP) or dissolved oxygen (DO). Ideally, the following parameters will be measured: pH, redox potential/ ORP, conductivity, dissolved oxygen, temperature, and turbidity.

4.2.3.11 At a 3- to 5-minute interval, observe the values of purge parameters and record them on the purging record lag sheet. Continue purging until all parameters have stabilized.

4.2.3.12 Purging stabilization has been achieved when all parameters are stable as defined in Table 4-1.

4.2.3.13 Temperature and pH typically stabilize quickly, turbidity typically stabilizes the most slowly, and other parameters are in between. Stabilization times can be minimized by (a) maximizing the time between installing the pump and beginning purging, and (b) minimizing the amount of disturbance of water in the well due to installing / removing / moving equipment in the well.

4.2.3.14 Immediately after purge parameters have stabilized, collect groundwater samples according to the procedure described in Section 4.3.2. The flow-through cell should be removed, bypassed, or samples collected from a sampling port upstream of the flow-through cell.

4.3 Sample Collection

Samples are collected either after a well in a low-yielding formation has recovered enough that it contains sufficient volume to fill the required sample containers, or after completing purging of a well in a high-yielding formation. Groundwater samples are typically collected using a bailer or similar device that is lowered into the well, filled, and retrieved from the well, or using a specialized sampling pump. Wells in low-yielding formations are typically sampled using a bailer or similar devices, or a specialized sampling pump that operates at a low flowrate. Wells in high-yielding formations are typically sampled using a specialized sampling pump. A common practice is to use the same pump for purging and sampling; this approach is required while using the low-flow purging and sampling technique.

The Sampling and Analysis Plan provides authoritative information on requirements for sample containers, filtration, preservation, labeling, and collection of quality assurance

samples. It will also indicate any special requirements for a particular type of sample, such as that headspace is not allowed in samples to be analyzed for volatile constituents.

NOTE: *Sample preservation is required for many of the chemical constituents and physiochemical parameters that are not chemically stable but are measured or evaluated in a groundwater sampling program. Methods of sample preservation are generally intended to retard biological action, retard hydrolysis, and reduce sorption effects. Preservation methods usually include pH control, chemical addition, refrigeration, and protection from light.*

Samples shall be handled in accordance with ENVP-002, Sample Handling, Packaging, and Shipping.

4.3.1 Sample Collection with a Bailer or Similar Sampler

4.3.1.1 Don personal protective equipment per requirements of the health and safety plan.

4.3.1.2 Lay plastic sheeting on the ground around the well head to minimize the potential spread of contamination from soil to purging and sampling equipment.

4.3.1.3 Wear clean, waterproof gloves to prevent skin oils, dust particles, or other contaminants from contaminating the sample and to protect personnel. Change gloves between wells or discrete sampling zones.

4.3.1.4 Prepare sample bottles and labels in accordance with SAP. Record the following information both on the sample labels and in the field logbook: date and time of sample collection, sample number, sampler's initials. In the logbook, also record the location from which each sample was collected.

4.3.1.5 Prepare the bailer/sampler for sample collection by installing a sample bottle (if required), positioning valves or other mechanisms, as appropriate for the device being used.

4.3.1.6 Attach the bailer/sampler to a cord, rope, or cable. Secure the other end to a fixed point so that the equipment cannot be lost in the well.

4.3.1.7 Lower the bailer/sampler to the desired sampling depth. Take care to minimize contact of the bailer/sampler with the casing, to the extent possible, and lower it gently into the water without splashing. The appropriate sampling depth may be specified in work control documents. In lieu of specific requirements, lower the bailer/sampler so that the point where water enters the bailer/sampler is located at the mid-depth of the screened interval. Consult the well completion log to determine the depth of the screened interval from the top of casing. Record the sampling depth in the field logbook.

4.3.1.8 If required by the bailer/sampler being used, perform any operations necessary to initiate sample collection (per manufacturer's directions). Note that many bailer/sampler designs fill automatically without a separate operation being performed. Allow sufficient time for the bailer/sampler to fill.

4.3.1.9 Retrieve the bailer/sampler from the well. To the extent practical, avoid contact with the casing in order to minimize dislodging rust or foreign objects that could contaminate the sample.

4.3.1.10 After the bailer/sampler has been retrieved from the well, transfer water from it into sample containers. The method for accomplishing this is specific to the type of bailer/sampler required. For samples to be analyzed for volatile constituents (VOCs), dissolved gases), take care to minimize contact between water and the atmosphere. Refer to the Field Sampling Plan and/or SAP for direction on the sample container material and volume, preservation requirements, and requirements for quality assurance samples such as duplicates and blacks. As soon as a sample container is filled, tightly cap it and place it in an ice chest or other shipping container.

4.3.1.11 Repeat the process of collecting water samples from the well and transferring it into sample containers until all required sample containers have been filled.

4.3.1.12 Prepare field blanks, equipment blanks, trip blanks, duplicates, and other quality assurance samples in accordance with the SAP.

4.3.1.13 Record sample information in the field logbook and chain of custody documents.

4.3.1.14 Secure the well.

4.3.1.15 Decontaminate equipment.

4.3.1.16 Manage solid and liquid decontamination wastes, and any other waste generated, in accordance with work control documents.

4.3.1.17 Demobilize from the well.

4.3.1.18 Prepare samples for shipment to analytical laboratory.

4.3.2 Sample Collection Using Pumps

Specific details of sampling depend on the type of pump or sampler used. The general procedure is described here. Operate a pump or sampler in accordance with manufacturer's directions. Sampling is typically performed immediately after purging has been completed. The same general procedure applies to sampling after purging using either the high-flow or low-flow approach.

4.3.2.1 Don personal protective equipment per requirements of the health and safety plan.

4.3.2.2 Lay plastic sheeting on the ground around the well head to minimize the potential spread of contamination from soil to purging and sampling equipment.

4.3.2.3 Wear clean, waterproof gloves to prevent skin oils, dust particles, or other contaminants from contaminating the sample and to protect personnel. Change gloves between wells or discrete sampling zones.

4.3.2.4 Prepare sample bottles and labels in accordance with the SAP. Record the following information both on the sample labels and in the field logbook: date and time of sample collection, sample number, sampler's initials. In the logbook, also record the location from which each sample was collected.

4.3.2.5 After completing the prescribed purging, establish an appropriate flow (typically tens to hundreds of milliliters per minute) of groundwater from the sample port into a bucket. The bucket is used to contain excess water for subsequent disposal per the project waste management plan. If purging was performed using the high-flow approach, then any convenient flowrate can be used during sampling. It may be beneficial to reduce the flowrate during sampling to minimize sample aeration, bubble formation, or turbulent filling of sample containers. Typically a flowrate of about 0.5L/min is convenient.

4.3.2.6 If purging was performed using the low-flow approach, then the flowrate used during sampling must be the same as or lower than the flowrate used during purging, with an exception described below. It may be beneficial to reduce the flowrate during sampling to minimize sample aeration, bubble formation, or turbulent filling of sample containers. If the purging flowrate was less than

4.3.2.7 Place the sample bottles under the flowing water stream to collect samples. Ensure that the sample port does not enter or touch the sample bottle.

NOTE: *If water flow must be interrupted during sample collection, reestablish flow before placing the sample bottle under the port for more sample collection.*

4.3.2.8 Fill sample containers in accordance with the SAP. Refer to the SAP for instructions regarding sample containers, sample identifiers, requirements for filtration, preservation, storage, and shipment.

4.3.2.9 Prepare field blanks, equipment blanks, trip blanks, duplicates, and other quality assurance samples in accordance with the SAP.

4.3.2.10 Record sample collection details in the field notes. Prepare sample chain-of-custody forms per the SAP.

4.3.2.11 Secure the well.

4.3.2.12 Unless a dedicated purging/sampling pump is used, remove the pump from the well, decontaminate the pump, and either decontaminate or replace the tubing.

4.3.2.13 Manage solid and liquid decontamination wastes, water produced during purging and sampling, and any other waste generated, in accordance with work control documents.

4.3.2.14 Demobilize from the well.

4.3.2.15 Prepare samples for shipment to analytical laboratory.

5. RECORDS

The Project Manager shall maintain the following records in accordance with QAP-171, Records Control:

- All sampling activities shall be recorded in the appropriate sample logbooks and in the Field Team Leader's logbook. Chain-of-custody records will be documented in accordance with ENVP-021, Chain of Custody Documentation for all samples shipped or transferred to other laboratories for analysis.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to field activities. Equipment must be decontaminated in accordance with ENVP-014, Sampling Equipment Decontamination prior to initial use in the field and before each subsequent use at a different sampling location.

- All information that was generated during the course of the groundwater sampling are to be recorded in the project file. At a minimum, the project file for groundwater sampling projects shall contain:

  – Project authorization form and supporting documentation (e.g., contract releases, Statement of Work (SOW), schedule, etc.)

  – Correspondence

  – Quality Assurance documentation including Sampling and Analysis Plans, laboratory results, calculations and methodology of interpreting results.

  – Project deliverables and supporting notes, calculations, logbooks, and work plans, etc.

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ENVP-002, Sample Handling, Packaging, and Shipping

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ENVP-021, Chain of Custody

QAP-171, Records Control

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APPENDIX A, Example Calculation

This appendix provides an example of the calculation of the volume of standing water in a well (Step 4.2.2.4).

Calculate the volume of standing water in a well using the following generalized equation:

$$V = (0.163)\, r^2\, (h_1 - h_2)$$

where

V = volume of standing water in well, in gallons

r = inside radius of well casing in inches
(note that the radius is half of the inside diameter of the well casing)

h_1 = depth of the well from the top of the casing, in feet

h_2 = depth to water from the top of the casing in feet

The dimensions are illustrated on Figure A-1.

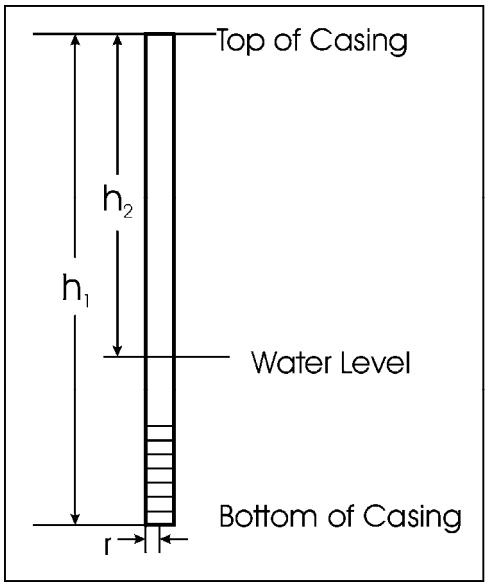

Figure A-1 Dimensions used in calculation of standing water volume

In this example, assume that the dimensions have the following values:

Depth from top of casing to bottom of well h_1	22.4 ft
Depth from top of casing to water surface h_2	10.8 ft
Inside diameter of casing	3.94 in
Inside radius of casing = diameter/2, r	1.97 in

$$V = (0.163)\, r^2\, (h_1 - h_2)$$

$$= (0.163)\, (1.97 \text{ in})^2\, (22.4 - 10.8 \text{ ft})$$

$$= 7.3 \text{ gallons}$$

For background information, the conversion factor 0.163 was calculated as follows:

$$V = \pi\, r^2 \text{ Length of water column}$$

$$= \pi\, (r \text{ in})^2\, (h_1 - h_2) \text{ ft}$$

$$= \pi\, [r^2 \text{in}^2 \text{ x } (1 \text{ ft}/12 \text{ in})^2]\, [(h_1 - h_2)\text{ft}]\, 7.48 \text{ gallons / ft}^3$$

$$= r^2 \text{in}^2\, (h_1 - h_2)\text{ft x } (\pi \text{ x } 1 \text{ ft}/144 \text{ in}^2 \text{ x } 7.48 \text{ gallons / ft}^3)$$

$$= r^2 \text{ in}^2\, (h_1 - h_2) \text{ ft x } 0.163 \text{ gallons/in}^2 \text{ ft}$$

Substituting values from above yields

$$V = \pi\, (1.97 \text{ in})^2\, (22.4 - 10.8\text{ft})\, (1 \text{ ft}/12 \text{ in})^2\, (7.48 \text{ gallons / ft}^3)$$

$$= 7.3 \text{ gallons}$$

ENVP-008

Soil Sampling

Revision 3

August 28, 2006

Approved:

Doug Jorgensen (See letter number NW-2006-156)	08/28/06
Line Manager	Date

REVISION HISTORY

Revision No.	Effective Date	Sections Affected	Description
0	02/06/06	All	Baseline Document
1	03/08/06	4.2.6	Added Use of EnCore™ samplers for VOCs
2	03/13/06	Title	Changed title from “ER” to “ENV”
3	08/28/06	All	Revised document numbers for corporate plans, policies, procedures, and forms, and corrected references to these documents, to reflect the number changes per Letter NW-2006-156. Also made minor formatting changes (i.e., moved definitions and acronyms to the front of the document and changed page numbers) per QAP-061_Rev 2.

DEFINITIONS

None

ACRONYMS

ENVP	Environmental Procedure
EPA	Environmental Protection Agency
NWI	North Wind, Inc.
OSHA	Occupational Safety and Health Administration

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ACRONYMS 3

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1. PURPOSE

The purpose of this procedure is to describe the procedures for the collection of representative soil samples. These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the actual procedures used should be documented and described in an appropriate site report.

2. SCOPE

This procedure provides instructions for North Wind Inc. (NWI) personnel for collection of soil samples. Sample quantities, containers, preservatives, handling procedures, and any specific sampling protocol for select analytes will be addressed in site-specific sampling and analysis plans.

3. RESPONSIBILITIES

3.1 Project Manager

- Meet customer's expectations and serve as a primary point of contact with the customer.
- Ensures sampling technician(s) have access to necessary equipment to complete soil sampling task(s).
- Ensures sampling technician(s) follow protocol and procedures for completing sampling task(s).

3.2 Sampling Technician(s)

- Ensures appropriate preparation and planning is completed prior to sampling activities to reduce delays in start-up or progress of task.
- Ensures all materials and equipment are available for sampling task.
- Communicates on a routine basis with project manager on status of task, any additional needs to complete task, and on any issues related to properly completing task.
- Follows all procedures, plans and protocols to complete sampling task adequately.
- Ensures all documentation of soil sampling activity is complete and legible.

4. PROCEDURE/PROCESS

The following outlines standard soil sampling procedures and processes that should be used for any soil sampling task. Soil sampling tasks and methods of acquiring soil samples vary widely from sampling site to sampling site. This procedure should be used as a general reference to guide field personnel when preparing for and performing soil sampling.

4.1 Preparation

Proper sampling preparation and organization is critical to ensure no delays in starting sampling operations and to ensure all materials and equipment have been obtained. Starting sampling operations with decontaminated tools is crucial to ensure quality and reliability of sampling results.

The following steps should be considered during preparation of soil sampling:

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies required.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or pre-clean equipment, and ensure that it is in working order.

4. Prepare schedules and coordinate with staff, client, and regulatory agencies, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site specific Health and Safety Plan or Task Hazard Analysis.

6. Use stakes, flagging, or buoys to identify and mark all sampling locations. Specific site factors, including extent and nature of contaminants, should be considered when selecting sample location. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All subsurface sample locations should be utility-cleared by the property owner or the client prior to soil sampling; and utility clearance should always be confirmed before beginning work.

4.2 Sample Collection

4.2.1 Surface Soil Samples

Collection of samples from near-surface soil can be accomplished with tools such as spades, shovels, trowels, and scoops. Surface material is removed to the required depth and a stainless steel or plastic scoop is then used to collect the sample. This method can be used in most soil types but is limited to sampling at or near the ground surface.

Accurate, representative samples can be collected with this procedure depending on the care and precision demonstrated by the sample team member. A flat, pointed mason trowel to cut a block of the desired soil is helpful when undisturbed profiles are required. Tools plated with chrome or other materials should not be used. Plating is particularly common with garden implements such as potting trowels.

The following procedure is used to collect surface soil samples:

1. Carefully remove the top layer of soil or debris to the desired sample depth with a pre-cleaned spade.

2. Using a pre-cleaned, stainless steel scoop, plastic spoon, or trowel, remove and discard a thin layer of soil from the area that came in contact with the spade.

3. If volatile organic analysis is to be performed, transfer the sample directly into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval or location into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

4.2.2 Sampling at Depth with Augers and Thin Wall Tube Samplers

This system consists of an auger, or a thin-wall tube sampler, a series of extensions, and a "T" handle. The auger is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger. If a core sample is to be collected, the auger tip is then replaced with a thin wall tube sampler. The system is then lowered down the borehole, and driven into the soil to the completion depth. The system is withdrawn and the core is collected from the thin wall tube sampler. Several types of augers are available; these include bucket type, continuous flight (screw), and post-hole augers. Bucket type augers are better for direct sample recovery because they provide a large volume of sample in a short time. When continuous flight augers are used, the sample can be collected directly from the flights. The continuous flight augers are satisfactory when a composite of the complete soil column is desired. Post-hole augers have limited utility for sample collection as they are designed to cut through fibrous, rooted, swampy soil and cannot be used below a depth of approximately three feet.

The following procedure is used for collecting soil samples with the auger:

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

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

3. Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods. It also facilitates refilling the hole, and avoids possible contamination of the surrounding area.

4. After reaching the desired depth, slowly and carefully remove the auger from the hole. When sampling directly from the auger, collect the sample after the auger is removed from the hole and proceed to Step 10.

5. Remove auger tip from the extension rods and replace with a pre-cleaned thin wall tube sampler. Install the proper cutting tip.

6. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the soil. Do not scrape the borehole sides. Avoid hammering the rods as the vibrations may cause the boring walls to collapse.

7. Remove the tube sampler, and unscrew the drill rods.

8. Remove the cutting tip and the core from the device.

9. Discard the top of the core (approximately 1 inch), as this possibly represents material collected before penetration of the layer of concern. Place the remaining core into the appropriate labeled sample container. Sample homogenization is not required.

10. If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

11. If another sample is to be collected in the same hole, but at a greater depth, reattach the auger bit to the drill and assembly, and follow steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.

12. Abandon the hole according to applicable state regulations. Generally, shallow holes can simply be backfilled with the removed soil material.

4.2.3 Sampling with a Trier

The system consists of a trier, and a "T" handle. The auger is driven into the soil to be sampled and used to extract a core sample from the appropriate depth.

The following procedure is used to collect soil samples with a sampling trier:

1. Insert the trier into the material to be sampled at a 0° to 45° angle from horizontal. This orientation minimizes the spillage of sample.

2. Rotate the trier once or twice to cut a core of material.

3. Slowly withdraw the trier, making sure that the slot is facing upward.

4. If volatile organic analyses are required, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

4.2.4 Sampling at Depth with a Split Spoon (Barrel) Sampler

Split spoon sampling is generally used to collect undisturbed soil cores from boreholes. A series of consecutive cores may be extracted with a split spoon sampler to give a complete soil column profile, or the borehole may be advanced to a specific depth for sampling. When split spoon sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D1586-98, “Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils”.

The following procedures are used for collecting soil samples with a split spoon:

1. Assemble the sampler by aligning both sides of barrel and then screwing the drive shoe on the bottom and the head piece on top.

2. Place the sampler in a perpendicular position on the sample material.

3. Using a well ring, drive the tube. Do not drive past the bottom of the head piece or compression of the sample will result.

4. Record in the site logbook or on field data sheets the length of the tube used to penetrate the material being sampled. For geotechnical samples, also record the number of blows required to obtain this depth.

5. Withdraw the sampler, and open by unscrewing the bit and head and splitting the barrel. The amount of recovery and soil type should be recorded on the boring log. If a split sample is desired, a cleaned, stainless steel knife should be used to divide the tube contents in half, longitudinally.

6. Without disturbing the core, transfer it to appropriate labeled sample container(s) and seal tightly.

4.2.5 Test Pit/Trench Excavation

A backhoe can be used to remove sections of soil when detailed examination of soil characteristics is required. This is probably the most expensive sampling method because of the relatively high cost of backhoe operation.

The following procedures are used for collecting soil samples from test pits or trenches:

7. Prior to any excavation with a backhoe, it is important to ensure that all sampling locations are clear of overhead and buried utilities.

8. Review the site specific Health & Safety plan and ensure that all safety precautions including appropriate monitoring equipment are installed as required.

9. Using the backhoe, excavate a trench approximately three feet wide and approximately one foot deep below the cleared sampling location. Place excavated soils on plastic sheets. Trenches greater than five feet deep must be sloped or protected by a shoring system, as required by Occupational Safety and Health Administration (OSHA) regulations.

10. A shovel is used to remove a one to two inch layer of soil from the vertical face of the pit where sampling is to be done.

11. Samples are taken using a trowel, scoop, or coring device at the desired intervals. Be sure to scrape the vertical face at the point of sampling to remove any soil that may have fallen from above, and to expose fresh soil for sampling. In many instances, samples can be collected directly from the backhoe bucket.

12. If volatile organic analyses are required, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

13. Abandon the pit or excavation according to applicable state regulations. Generally, shallow excavations can simply be backfilled with the removed soil material.

4.2.6 Special Considerations for use of EnCore™ Samplers

When total VOC concentrations in the soil/sediment are expected to be low (e.g. less than 200 µg/kg), the samples may be collected directly with an EnCore™ sampler. (Gravely or rocky soil may preclude the use of EnCore™ samplers.)

1. Ensure surface to be sampled is freshly exposed (within 30 minutes); use a decontaminated shovel trowel or other tool to expose fresh soil as necessary.

2. Remove the EnCore™ samplers from the laboratory/supplier provided foil pouch; verify with your laboratory how many samplers they require (typically two - three 5g samplers per sampler for 8260B)

3. Complete the label on the pouches, or place a pre-printed labels on the pouches

4. Immediately, place the first sampler into an EnCore™ t-handle, uncap the sampler and push it into the soil, ensuring that the sampler is completely filled with soil

NOTE: It is often necessary to push the sampler repeatedly against a hard object (rock, core liner, clean spoon) in order to completely fill the sampler; be careful not to damage the sealing lip of the sampler.

5. Wipe the outside of the sampler, fasten the cap on, and disconnect it from the handle

6. Seal the filled sampler inside of the sample pouch

7. Place the pouch into a cooler with ice

8. Fill one 40 ml amber glass vial with soil to accompany each sample. Label with the same sample ID as EnCore's, but mark analysis as "moisture only."

9. Repeat the process until all required samplers are filled.

NOTE: EnCore™ samplers are typically delivered to the laboratory within 24 to 48 hours of sample collection. Reference the project Sampling and Analysis Plan to verify delivery requirements.

5. RECORDS

All data must be documented on field data sheets or within site logbooks.

6. REFERENCES

Mason, B.J. 1983. Preparation of Soil Sampling Protocol: Technique and Strategies. EPA-600/4-83-020.

Barth, D.S. and B.J. Mason. 1984. Soil Sampling Quality Assurance User's Guide. EPA-600/4-84-043.

U.S. Environmental Protection Agency. 1984 Characterization of Hazardous Waste Sites - A Methods Manual: Volume II. Available Sampling Methods, Second Edition. EPA-600/4-84-076.

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

ASTM D 1586-98, ASTM Committee on Standards, Philadelphia, PA.

ENVP-014

Sampling Equipment Decontamination

Revision 1

August 28, 2006

Approved:

Doug Jorgensen (See letter number NW-2006-156)	08/28/06
Line Manager	Date

REVISION HISTORY

Revision No.	Effective Date	Sections Affected	Description
0	06/02/06	All	Baseline Document
1	08/28/06	All	Revised document numbers for corporate plans, policies, procedures, and forms, and corrected references to these documents, to reflect the number changes per Letter NW-2006-156. Also made minor formatting changes (i.e., moved definitions and acronyms to the front of the document and changed page numbers) per QAP-061_Rev 2.

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DEFINITIONS

None

ACRONYMS

CFR	Code of Federal Regulations
CRC	Contamination Reduction Corridor
CRZ	Contamination Reduction Zone
DOT	Department of Transportation
ENVP	Environmental Procedure
EPA	Environmental Protection Agency
EZ	Exclusion Zone
H_2O	Water
HZ	Hot Zone
NIOSH	National Institute for Occupational Safety and Health
NWI	North Wind, Inc.
OSHA	Occupational Safety and Health Administration
PEP	Project Execution Plan
pH	Potential of Hydrogen
QA	Quality Assurance
QC	Quality Control
SAP	Sampling and Analysis Plan
SZ	Support or Safe Zone
USCG	United States Coast Guard
USEPA	United States Environmental Protection Agency

1. PURPOSE

The purpose of this procedure is to provide a description of the methods used for preventing, minimizing, or limiting cross-contamination of samples due to inappropriate or inadequate equipment decontamination and to provide general guidelines for developing decontamination procedures for sampling equipment to be used during hazardous waste operations as per 29 Code of Federal Regulations (CFR) 910.120. This procedure does not address personnel decontamination.

2. SCOPE

This procedure is applicable to North Wind, Inc. (NWI) projects that specifically reference this procedure in the Project Execution Plan (PEP), Project Work Plan, or Sampling and Analysis Plan (SAP).

This is a standard operating procedure which may be varied or changed as required, dependent upon site conditions, equipment limitation, or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

This procedure is not applicable where new disposal sampling equipment is used. In addition, direct-push drill tooling does not require the extensive decontamination process described in this procedure because the tooling does not directly contact the material being sampled. Only a pressure wash and/or scrubbing is required for direct-push drill casing.

3. RESPONSIBILITIES

This procedure applies to any personnel performing decontamination of sampling equipment.

3.1 Project Manager/Task Lead

- Ensures appropriate and proper decontamination of sampling equipment is completed, per this procedure.
- Ensures sampling personnel have adequately documented the performance of decontamination on sampling equipment before re-use.
- Ensures sampling equipment has adequately been decontaminated prior to re-use.

3.2 Sampling Technician

- Responsible for following this procedure and other procedures, if applicable, for the decontamination of sampling equipment.

4. SAMPLING EQUIPMENT DECONTAMINATION PROCESS

Removing or neutralizing contaminants from equipment minimizes the likelihood of sample cross contamination, reduces or eliminates transfer of contaminants to clean areas, and prevents the mixing of incompatible substances.

Gross contamination can be removed by physical decontamination procedures. These abrasive and non-abrasive methods include the use of brushes, air and wet blasting, and high and low pressure water cleaning.

The first step, a soap and water wash, removes all visible particulate matter and residual oils and grease. This may be preceded by a steam or high pressure water wash to facilitate residuals removal. The second step involves a tap water rinse and a distilled/deionized water rinse to remove the detergent. An acid rinse provides a low pH media for trace metals removal and is included in the decontamination process if metal samples are to be collected. It is followed by another distilled/deionized water rinse. If sample analysis does not include metals, the acid rinse step can be omitted. Next, a high purity solvent rinse is performed for trace organics removal if organics are a concern at the site. Typical solvents used for removal of organic contaminants include acetone, hexane, or water. Acetone is typically chosen because it is an excellent solvent, miscible in water, and not a target analyte on the Priority Pollutant List. If acetone is known to be a contaminant of concern at a given site or if Target Compound List analysis (which includes acetone) is to be performed, another solvent may be substituted. The solvent must be allowed to evaporate completely and then a final distilled/deionized water rinse is performed. This rinse removes any residual traces of the solvent.

The decontamination procedure described above may be summarized as follows:

1. Physical removal
2. Non-phosphate detergent wash
3. Tap water rinse
4. Distilled/deionized water rinse
5. 10% nitric acid rinse
6. Distilled/deionized water rinse
7. Solvent rinse (pesticide grade)
8. Air dry
9. Distilled/deionized water rinse

If a particular contaminant fraction is not present at the site, the nine (9) step decontamination procedure specified above may be modified for site specificity. For example, the nitric acid rinse may be eliminated if metals are not of concern at a site. Similarly, the solvent rinse may be eliminated if organics are not of concern at a site. Modifications to the standard procedure should be documented in the site specific work plan or subsequent report.

5. SAMPLE PRESERVATION CONTAINERS, HANDLING, AND STORAGE

The amount of sample to be collected and the proper sample container type (i.e. glass, plastic), chemical preservation, and storage requirements are dependent on the matrix being sampled and the parameter(s) of interest.

More specifically, sample collection and analysis of decontamination waste may be required before beginning proper disposal of decontamination and solids generated at a site. This should be determined prior to initiation of site activities.

6. INTERFERENCES AND POTENTIAL PROBLEMS

The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte free (specifically for the contaminants of concern).

The use of an untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal or industrial water treatment system.

If acids or solvents are utilized in decontamination they raise health and safety, and waste disposal concerns.

Damage can be incurred by acid and solvent washing of complex and sophisticated sampling equipment.

7. EQUIPMENT APPARATUS

Decontamination equipment, materials and supplies are generally selected based on availability. Other considerations include the ease of decontaminating or disposing of the equipment. Most equipment and supplies can be easily procured. For example, soft-bristle scrub brushes or long-handled bottle brushes can be used to removed contaminants. Large galvanized wash tubs, stock tanks, or buckets can hold wash and rinse solutions. Children’s wading pools can also be used. Large plastic garbage cans or other similar containers lined with plastic bags can help segregate contaminated equipment. Contaminated liquid can be stored temporarily in metal or plastic cans or drums.

The following standard materials and equipment are recommended for decontamination activities:

7.1 Decontamination Solutions

- Non-phosphate detergent
- Selected solvents (acetone, hexane, nitric acid, etc.)
- Tap water
- Distilled or deionized water

7.2 Decontamination Tools/Supplies

- Long and short handled brushes
- Bottle brushes
- Drop cloth/plastic sheeting
- Paper towels
- Plastic or galvanized tubs or buckets
- Pressurized sprayers (H_20)
- Solvent Sprayers
- Aluminum Foil

7.3 Health and Safety Equipment

Appropriate personal protective equipment (i.e., safety glasses or splash shield, appropriate gloves, aprons or coveralls, respirator, emergency eye wash).

7.4 Waste Disposal

- Trash bags
- Trash containers
- 55-gallon drums

- Metal/plastic buckets/containers for storage and disposal of decontamination solutions

8. REAGENTS

There are no reagents used in this procedure aside from the actual decontamination solutions. Table 1 (Appendix A) lists solvent rinses which may be required for elimination of particular chemicals. In general, the following solvents are typically utilized for decontamination purposes:

- 10% nitric acid is typically used for inorganic compounds such as metals. An acid rinse may not be required if inorganics are not a contaminant of concern.
- Acetone (pesticide grade) [(1)]
- Hexane (pesticide grade) [(1)]
- Methanol [(1)]

[(1)] Only if sample is to be analyzed for organics.

9. PROCEDURES

As part of the health and safety plan, a decontamination plan should be developed and reviewed. The decontamination line should be set up before any personnel or equipment enter the areas of potential exposure. The equipment decontamination plan should include:

- The number, location, and layout of decontamination stations.
- Decontamination equipment needed.
- Appropriate decontamination methods.
- Methods for disposal of contaminated clothing, equipment, and solutions.
- Procedures can be established to minimize the potential for contamination. This may include: (1) work practices that minimize contact with potential contaminants; (2) using remote sampling techniques; (3) covering monitoring and sampling equipment with plastic, aluminum foil, or other protective material; (4) watering down dusty areas; (5) avoiding laying down equipment in areas of obvious contamination; and (6) use of disposable sampling equipment.

9.1 Decontamination Methods

All samples and equipment leaving the contaminated area of a site must be decontaminated to remove any contamination that may have adhered to equipment. Various decontamination methods will remove contaminants by: (1) flushing or other physical action, or (2) chemical complexing to inactivate contaminants by neutralization, chemical reaction, disinfection, or sterilization.

Physical decontamination techniques can be grouped into two categories: abrasive methods and non-abrasive methods, as follows:

9.1.1 Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The mechanical abrasive cleaning methods are most commonly used at hazardous waste sites. The following abrasive methods are available:

9.1.1.1 Mechanical

Mechanical methods of decontamination include using metal or nylon brushes. The amount and type of contaminants removed will vary with the hardness of bristles, length of time brushed, degree of brush contact, degree of contamination, nature of the surface being cleaned, and degree of contaminant adherence to the surface.

9.1.1.2 Air Blasting

Air blasting equipment uses compressed air to force abrasive material through a nozzle at high velocities. The distance between nozzle and surface cleaned, air pressure, time of application, and angle at which the abrasive strikes the surface will dictate cleaning efficiency. Disadvantages of this method are the inability to control the amount of material removed and the large amount of waste generated.

9.1.1.3 Wet Blasting

Wet blast cleaning involves use of a suspended fine abrasive. The abrasive/water mixture is delivered by compressed air to the contaminated area. By using a very fine abrasive, the amount of materials removed can be carefully controlled.

9.1.2 Non-Abrasive Cleaning Methods

Non-abrasive cleaning methods work by forcing the contaminant off a surface with pressure. In general, the equipment surface is not removed using non-abrasive methods.

9.1.2.1 Low-Pressure Water

This method consists of a container which is filled with water. The user pumps air out of the container to create a vacuum. A slender nozzle and hose allow the user to spray in hard-to-reach places.

9.1.2.2 High-Pressure Water

This method consists of a high-pressure pump, an operator controlled directional nozzle, and a high-pressure hose. Operating pressure usually ranges from 340 to 680 atmospheres (atm) and flow rates usually range from 20 to 140 liters per minute.

9.1.2.3 Ultra-High-Pressure Water

This system produces a water jet that is pressured from 1,000 to 4,000 atmospheres. This ultra-high-pressure spray can remove tightly-adhered surface films. The water velocity ranges from 500 meters/second (m/s) (1,000 atm) to 900 m/s (4,000 atm). Additives can be used to enhance the cleaning action.

9.1.2.4 Rinsing

Contaminants are removed by rinsing through dilution, physical attraction, and solubilization.

9.1.2.5 Damp Cloth Removal

In some instances, due to sensitive, non-waterproof equipment or due to the unlikelihood of equipment being contaminated, it is not necessary to conduct an extensive decontamination procedure. For example, air sampling pumps hooked on a fence, placed on a drum, or wrapped in plastic bags are not likely to become heavily contaminated. A damp cloth should be used to wipe off contaminants which may have adhered to equipment through airborne contaminants or from surfaces upon which the equipment was set.

9.1.2.6 Disinfection/Sterilization

Disinfectants are a practical means of inactivating infectious agents. Unfortunately, standard sterilization methods are impractical for large equipment. This method of decontamination is typically performed off-site.

9.2 Field Sampling Equipment Decontamination Procedures

The decontamination line is setup so that the first station is used to clean the most contaminated item. It progresses to the last station where the least contaminated item is cleaned. Ideally, the contamination should decrease as the equipment progresses from one station to another farther along in the line.

A site is typically divided up into the following boundaries: Hot Zone or Exclusion Zone (EZ), the Contamination Reduction Zone (CRZ), and the Support or Safe Zone (SZ). The decontamination line should be setup in the Contamination Reduction Corridor (CRC) which is in the CRZ. The CRC controls access into and out of the exclusion zone and confines decontamination activities to a limited area. The CRC boundaries should be conspicuously marked. The far end is the hotline, the boundary between the exclusion zone and the contamination reduction zone. The size of the decontamination corridor depends on the number of stations in the decontamination process, overall dimensions of the work zones, and amount of space available at the site. Whenever possible, it should be a straight line.

Anyone in the CRC should be wearing the level of protection designated for the decontamination crew. Another corridor may be required for the entry and exit of heavy equipment. Sampling and monitoring equipment and sampling supplies are all maintained outside of the CRC. Personnel don their equipment away from the CRC and enter the exclusion zone through a separate access control point at the hotline. One person (or more) dedicated to decontaminating equipment is recommended.

9.2.1 Decontamination Setup

Starting with the most contaminated station, the decontamination setup should be as follows:

9.2.1.1 Station 1: Segregate Equipment Drop

Place plastic sheeting on the ground. Size will depend on amount of equipment to be decontaminated. Provide containers lined with plastic if equipment is to be segregated. Segregation may be required if sensitive equipment or mildly contaminated equipment is used at the same time as equipment which is likely to be heavily contaminated.

9.2.1.2 Station 2: Physical Removal With A High-Pressure Washer (Optional)

As indicated in 7.1.2, a high-pressure wash may be required for compounds which are difficult to remove by washing with brushes. The elevated temperature of the water from the high-pressure washers is excellent at removing greasy/oily compounds. High pressure washers require water and electricity. A decontamination pad may be required for the high-pressure wash area. An example of a wash pad may consist of an approximately 1 1/2 foot-deep basin lined with plastic sheeting and sloped to a sump at one corner. A layer of sand can be placed over the plastic and the basin is filled with gravel or shell. The sump is also lined with visqueen and a barrel is placed in the hole to prevent collapse. A sump pump is used to remove the water from the sump for transfer into a drum.

Typically heavy machinery is decontaminated at the end of the day unless site sampling requires that the machinery be decontaminated frequently. A separate decontamination pad may be required for heavy equipment.

9.2.1.3 Station 3: Physical Removal With Brushes And A Wash Basin

Prior to setting up Station 3, place plastic sheeting on the ground to cover areas under Station 3 through Station 10.

Fill a wash basin, a large bucket, or child's swimming pool with non-phosphate detergent and tap water. Several bottle and bristle brushes to physically remove contamination should be dedicated to this station. Approximately 10 - 50 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination.

9.2.1.4 Station 4: Water Basin

Fill a wash basin, a large bucket, or child's swimming pool with tap water. Several bottle and bristle brushes should be dedicated to this station. Approximately 10-50 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination.

9.2.1.5 Station 5: Low-Pressure Sprayers

Fill a low-pressure sprayer or squeeze bottle with distilled/deionized water. Provide a 5-gallon bucket or basin to contain the water during the rinsing process. Approximately 10-20 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination.

9.2.1.6 Station 6: Nitric Acid Sprayers

Fill a spray or squeeze bottle with 10% nitric acid. An acid rinse may not be required if inorganics are not a contaminant of concern. The amount of acid will depend on the amount of equipment to be decontaminated. Provide a 5-gallon bucket or basin to collect acid during the rinsing process.

9.2.1.7 Station 7: Low-Pressure Sprayers

Fill a low-pressure sprayer or squeeze bottle with distilled/deionized water. Provide a 5-gallon bucket or basin to collect water during the rinsate process.

9.2.1.8 Station 8: Organic Solvent Sprayers

Fill a spray or squeeze bottle with an organic solvent. After each solvent rinse, the equipment should be rinsed with distilled/deionized water and air dried. Amount of

solvent will depend on the amount of equipment to decontaminate. Provide a 5-gallon bucket or basin to collect the solvent during the rinsing process.

Solvent rinses may not be required unless organics are a contaminant of concern, and may be eliminated from the station sequence.

9.2.1.9 Station 9: Low-Pressure Sprayers

Fill a low-pressure sprayer or squeeze bottle with distilled/deionized water. Provide a 5-gallon bucket or basin to collect water during the rinsate process.

9.2.1.10 Station 10: Clean Equipment Drop

Lay a clean piece of plastic sheeting over the bottom plastic layer. This will allow easy removal of the plastic in the event that it becomes dirty. Provide aluminum foil, plastic, or other protective material to wrap clean equipment.

9.2.2 Decontamination Procedures

9.2.2.1 Station 1: Segregate Equipment Drop

Deposit equipment used on-site (i.e., tools, sampling devices and containers, monitoring instruments radios, clipboards, etc.) on the plastic drop cloth/sheet or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross contamination. Loose leaf sampling data sheets or maps can be placed in plastic zip lock bags if contamination is evident.

9.2.2.2 Station 2: Physical Removal With A High-Pressure Washer (Optional)

Use high pressure wash on grossly contaminated equipment. Do not use high- pressure wash on sensitive or non-waterproof equipment.

9.2.2.3 Station 3: Physical Removal With Brushes And A Wash Basin

Scrub equipment with soap and water using bottle and bristle brushes. Only sensitive equipment (i.e., radios, air monitoring and sampling equipment) which is waterproof should be washed. Equipment which is not waterproof should have plastic bags removed and wiped down with a damp cloth. Acids and organic rinses may also ruin sensitive equipment. Consult the manufacturers for recommended decontamination solutions.

9.2.2.4 Station 4: Equipment Rinse

Wash soap off of equipment with water by immersing the equipment in the water while brushing. Repeat as many times as necessary.

9.2.2.5 Station 5: Low-Pressure Rinse

Rinse sampling equipment with distilled/deionized water with a low-pressure sprayer or squeeze bottle.

9.2.2.6 Station 6: Nitric Acid Sprayers (required only if metals are a contaminant of concern)

Using a spray or squeeze bottle rinse sampling equipment with nitric acid. Begin spraying (inside and outside) at one end of the equipment allowing the acid to drip to the other end into a 5-gallon bucket. A rinsate blank may be required at this station. Refer to Section 9.

9.2.2.7 Station 7: Low-Pressure Sprayers

Rinse sampling equipment with distilled/deionized water with a low-pressure sprayer or squeeze bottle.

9.2.2.8 Station 8: Organic Solvent Sprayers

Rinse sampling equipment with a solvent. Begin spraying (inside and outside) at one end of the equipment allowing the solvent to drip to the other end into a 5-gallon bucket. Allow the solvent to evaporate from the equipment before going to the next station. A QC rinsate sample may be required at this station.

9.2.2.9 Station 9: Low-Pressure Sprayers

Rinse sampling equipment with distilled/deionized water with a low-pressure washer or squeeze bottle.

9.2.2.10 Station 10: Clean Equipment Drop

Lay clean equipment on plastic sheeting. Once air dried, wrap sampling equipment with aluminum foil, plastic, or other protective material.

9.2.3 Post Decontamination Procedures

1. Collect high-pressure pad and heavy equipment decontamination area liquid and waste and store in appropriate drum or container. A sump pump can aid in the collection process. Refer to the Department of Transportation (DOT) requirements for appropriate containers based on the contaminant of concern.

2. Collect high-pressure pad and heavy equipment decontamination area solid waste and store in appropriate drum or container. Refer to the DOT requirements for appropriate containers based on the contaminant of concern.

3. Empty soap and water liquid wastes from basins and buckets and store in appropriate drum or container. Refer to the DOT requirements for appropriate containers based on the contaminant of concern.

4. Empty acid rinse waste and place in appropriate container or neutralize with a base and place in appropriate drum. pH paper or an equivalent pH test is required for neutralization. Consult DOT requirements for appropriate drum for acid rinse waste.

5. Empty solvent rinse sprayer and solvent waste into an appropriate container. Consult DOT requirements for appropriate drum for solvent rinse waste.

6. Using low-pressure sprayers, rinse basins, and brushes. Place liquid generated from this process into the wash water rinse container.

7. Empty low-pressure sprayer water onto the ground.

8. Place all solid waste materials generated from the decontamination area (i.e., gloves and plastic sheeting, etc.) in an approved DOT drum. Refer to the DOT requirements for appropriate containers based on the contaminant of concern.

9. Write appropriate labels for waste and make arrangements for disposal. Consult DOT regulations for the appropriate label for each drum generated from the decontamination process.

10. CALCULATIONS

This section is not applicable to this procedure.

11. QUALITY ASSURANCE/QUALITY CONTROL

A rinsate blank is one specific type of quality control sample associated with the field decontamination process. This sample will provide information on the effectiveness of the decontamination process employed in the field.

Rinsate blanks are samples obtained by running analyte free water over decontaminated sampling equipment to test for residual contamination. The blank water is collected in sample containers for handling, shipment, and analysis. These samples are treated identical to samples collected that day. A rinsate blank is used to assess cross contamination brought about by improper decontamination procedures. Where dedicated sampling equipment is not utilized, collect one rinsate blank per day per type of sampling device.

If sampling equipment requires the use of plastic tubing it should be disposed of as contaminated and replaced with clean tubing before additional sampling occurs.

12. DATA VALIDATION

Results of quality control samples will be evaluated for contamination. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives.

13. HEALTH AND SAFETY

When working with potentially hazardous materials, follow OSHA, U.S. EPA, corporate, and other applicable health and safety procedures.

Decontamination can pose hazards under certain circumstances. Hazardous substances may be incompatible with decontamination materials. For example, the decontamination solution may react with contaminants to produce heat, explosion, or toxic products. Also, vapors from decontamination solutions may pose a direct health hazard to workers by inhalation, contact, fire, or explosion.

The decontamination solutions must be determined to be acceptable before use. Decontamination materials may degrade protective clothing or equipment; some solvents can permeate protective clothing. If decontamination materials do pose a health hazard, measures should be taken to protect personnel or substitutions should be made to eliminate the hazard. The choice of respiratory protection based on contaminants of concern from the site may not be appropriate for solvents used in the decontamination process.

Safety considerations should be addressed when using abrasive and non-abrasive decontamination equipment. Maximum air pressure produced by abrasive equipment could cause physical injury. Displaced material requires control mechanisms.

Material generated from decontamination activities requires proper handling, storage, and disposal. Personal Protective Equipment may be required for these activities.

Material safety data sheets are required for all decontamination solvents or solutions as required by the Hazard Communication Standard (i.e., acetone, alcohol, and trisodiumphosphate).

In some jurisdictions, phosphate containing detergents are banned.

14. RECORDS

The Project Manager will maintain the following records in accordance with QAP-171, Records Control:

- List first record

15. REFERENCES

Field Sampling Procedures Manual, New Jersey Department of Environmental Protection, February, 1988.

A Compendium of Superfund Field Operations Methods, EPA 540/p-87/001.

Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual, USEPA Region IV, April 1, 1986.

Guidelines for the Selection of Chemical Protective Clothing, Volume 1, Third Edition, American Conference of Governmental Industrial Hygienists, Inc., February, 1987.

Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, NIOSH/OSHA/USCG/EPA, October, 1985

APPENDIX A, Table1. Soluble Contaminants and Recommended Solvent Rinse

TABLE 1 Soluble Contaminants and Recommended Solvent Rinse		
SOLVENT[1]	EXAMPLES OF SOLVENTS	SOLUBLE CONTAMINANTS
Water	Deionized water Tap water	Lo-Chain Hydrocarbons Inorganic Compounds Salts Some Organic Acids And Other Polar Compounds
Dilute Acids	Nitric Acid Acetic Acid Boric Acid	Basic (caustic) compounds (e.g., some organic compounds)
Dilute Bases	Sodium bicarbonate (e.g., soap detergent)	Acidic compounds Phenol Thiols Some nitro and sulfonic compounds
Organic Solvents [2]	Alcohols Ethers Ketones Aromatics Straight chain alkalines (e.g., hexane) Common petroleum products (e.g., fuel, oil, kerosene)	Nonpolar compounds (e.g., some organic compounds)
Organic Solvent [2]	Hexane	PCBs

[1] Material safety data sheets are required for all decontamination solvents or solutions as required by the Hazard Communication Standard

[2] WARNING: SOME ORGANIC SOLVENTS CAN PERMEATE OR DEGRADE THE PROTECTIVE CLOTHING.

ENVP-019

MiniRAE Photoionization Detector

Revision 3

February 28, 2007

Approved:

Doug Jorgensen *Original signature on file* 02/27/07

Line Manager Date

REVISION HISTORY

Revision No.	Effective Date	Sections Affected	Description
0	02/06/06	All	Baseline Document
1	03/13/06	Title	Changed Title from “ER” to “ENV”
2	08/28/06	All	Revised document numbers for corporate plans, policies, procedures, and forms, and corrected references to these documents, to reflect the number changes per Letter NW-2006-156. Also made minor formatting changes (i.e., moved definitions and acronyms to the front of the document and changed page numbers) per QAP-061_Rev 2.
3	02/28/07	All	Revised document to incorporate comments from Sylvia Medina.

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DEFINITIONS

None

ACRONYMS

ENVP	Environmental Procedure
eV	electron Volt
LED	Light Emitting Diode
NWI	North Wind, Inc.
PID	Photoionization Detector
ppm	parts per million
QAP	Quality Assurance Procedure
RAE	MiniRAE
VOC	Volatile Organic Compound

1. PURPOSE

The purpose of this procedure is to set guidelines for the calibration of the MiniRAE Photoionization Detector (PID) before use and to provide basic instructions for field screening.

2. SCOPE

This procedure provides instructions for all North Wind Inc. (NWI) personnel who use the MiniRAE for organic field screening and waste profiling. The MiniRAE is a scientific instrument that requires training on its principle and method as well as hands-on practice under supervision prior to actual sampling and data interpretation. First-time user of the MiniRAE must obtain project-specific training on the use of the instrument. This procedure serves as a reference for field screening and a reminder that calibration must be performed every workday prior to use of the MiniRAE.

3. RESPONSIBILITIES

3.1 Field Personnel/Sampling Technician

The Field Personnel/Sampling Technician is responsible for on-site monitoring and field screening using the MiniRAE. The Field Personnel/Sampling Technician conducts instrument calibration and records calibration data in a field logbook. The Field Personnel/Sampling Technician also performs field screening through headspace analysis of field samples and records headspace measurements in the field logbook.

4. PREPARATORY ACTIVITIES

The MiniRAE is a programmable PID that measures organic vapors in hazardous environments. It incorporates a sampling pump and data download capabilities for continuous toxic monitoring, site survey, and leak detection. It is intrinsically safe and easy to use.

The MiniRAE is a compact instrument of 8.2 inches long, 3 inches wide, and 2 inches thick; it weighs 20 ounces. There are three keys under the display screen on the sealed membrane faceplate: The left key is “Y/+”, the center key is “MODE”, and the right key is “N/-“. These keys are used to operate the MiniRAE according to this procedure as well as instructions appearing on the display screen.

The MiniRAE can measure double-bonded organic vapors in the range of 0.1 to 10,000 ppm. Note that both 10.6 eV and 11.7 eV gas discharge lamps are available

for the MiniRAE. The 10.6 eV lamp is most commonly used, detects the largest number of compounds, and is most durable. However, a number of compounds are detected only with the 11.7 eV lamp (e.g. carbon tetrachloride, chloroform, ethanol, formaldehyde, trichloroethane, etc.) Also be aware that a number of organic compounds cannot be detected by the MiniRAE (e.g. carbon monoxide/dioxide, ethane, methane, hydrogens, etc.). If unsure, reference the manufacturer's literature to verify that the target analyte is detectable and to select the proper lamp.

The battery on the MiniRAE drains slowly even when the MiniRAE is turned off. If the unit has not been charged for 4-5 days, the battery voltage will be low. If the unit is left to charge overnight, it will automatically shut itself off when fully charged.

In addition to the MiniRAE, verify that the following items are available on site: spare lamps, calibration gas, zip-lock bags, logbook/sample forms, indelible pens, 110 V power supply (generator or 12 V inverter) for charging.

5. OPERATING PROCEDURES

To turn on the MiniRAE, press the [MODE] key on the faceplate. The audio buzzer will beep once and the display will show "HG-x.xx" or "SU-x.xx" to indicate the operating mode and software version number.

Once the MiniRAE is turned on, follow on-screen instructions to perform calibration and field screening activities.

To turn off the MiniRAE, press the [MODE] key and hold for a few seconds. The message "off" will flash on the Light Emitting Diode (LED) display.

6. CALIBRATION

Calibration must be performed every work day prior to use of the MiniRAE. Additionally, calibration is required after the gas discharge lamp has been replaced. The Field Personnel/Sampling Technician performing calibrations must enter the calibration data in the field logbook as required by the project-specific sampling and analysis plan and health and safety plan.

There are two calibration modes: "Fresh Air" and "Standard Reference Gas". The Fresh Air mode is used to set the zero point of the instrument in the absence of volatile organic compounds (VOCs). After the zero point has been set, the Standard Reference Gas mode is used to set the sensor to the known concentration of a given VOC. This set point will be used as a point of reference in field screening.

To begin calibration, press the "MODE" key and the "N/-" key simultaneously and hold for a few seconds. Instructions will then appear on the display screen. Follow instructions until calibration is completed.

7. FIELD SCREENING PROCEDURES

The Site Personnel/Sampling Technician is responsible for field screening of VOCs. Use of the MiniRAE in field screening is determined by requirements established in project-specific sampling and analysis plan and health and safety plan. Field screening typically requires headspace analysis of soil samples containing various VOCs. Headspace analysis is conducted as outlined below:

- Don clean latex or nitrile gloves before collecting each individual sample.
- Fill a zip lock bag with approximately 8 oz of soil containing the VOC.
- Shake the bag for 15 seconds immediately after filling the bag. Warm the contents to approximately 40ºF (4ºC) - 60ºF (20ºC), with 60°F being the optimum temperature. Check temperature of the soil using an infrared thermometer as needed. If the soil was frozen when filling the bag, shake the bag again after the soil has reached the desired temperature range.
- Let the bag sit for 10 minutes to 1 hour, to allow accumulation of headspace vapor.
- Shake the bag again for 15 seconds immediately before taking the headspace measurement of VOC concentration.
- Open one corner of the bag to allow just enough room for inserting the sample probe (located on top of the MiniRAE) and seal the opening around the probe. Turn on the MiniRAE and follow on-screen instructions to take headspace measurements. Record the highest reading (usually registered within the first 5 seconds of probe insertion) in the field logbook.

8. REFERENCES

None

ENVP-021

Chain of Custody Documentation

Revision 4

May 18, 2007

Approved:

Doug Jorgensen *Original signature on file* 05/18/07
Environmental Restoration Division Manager Date

REVISION HISTORY

Revision No.	Effective Date	Sections Affected	Description
0	02/06/06	All	Baseline Document
1	03/13/06	Title	Changed Title from “ER” to “ENV”
2	07/10/06	4.1	Added information to bullets in section 4.1. Replaced last paragraph in section 4.1.
3	08/28/06	All	Revised document numbers for corporate plans, policies, procedures, and forms, and corrected references to these documents, to reflect the number changes per Letter NW-2006-156. Also made minor formatting changes (i.e., moved definitions and acronyms to the front of the document and changed page numbers) per QAP-061_Rev 2.
4	05/18/07	4.1, App. A	Added language for use of the COC form. Added Appendix A which includes a North Wind chain of custody.

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DEFINITIONS

custody	A sample is considered to be under a person's *custody* if the sample is in the person's physical possession or direct view, if the sample is secured so that no one can tamper with the sample, or if the sample is secured in an area restricted to authorized personnel only.
Chain of custody	The Chain of Custody (COC) document is the written record that traces the sample possession from the time each sample is collected until its final disposition, sometimes called the "cradle to grave" record, or in the EPA Contract Laboratory Program, a "Traffic Report."
Common carrier	For the purpose of this procedure, the common carrier is any commercial carrier utilized for the transportation of the sample(s) from the field to the laboratory.
Forms-2-Lite	EPA developed software, available at no charge for use on government sponsored projects, that can be used to track all sample information, automating sample labels, COC forms, and SAP tables.

ACRONYMS

COC	Chain of Custody
ENVP	Environmental Procedure
EPA	Environmental Protection Agency
NWI	North Wind, Inc.
QA	quality assurance
QC	quality control
QA/QC	Quality Assurance/Quality Control

1. PURPOSE

This procedure establishes the method and responsibilities associated with the maintenance and custody of samples which are to be used to provide data which form a basis for making project related decisions. It outlines the general procedures for maintaining and documenting sample chain of custody from the time of sample collection through sample disposition.

2. SCOPE

This procedure applies to all North Wind, Inc. (NWI) personnel who are responsible for collecting and handling environmental samples. Should specific contracts require use of client-provided chain of custody procedures, then the client-provided procedures shall be used.

3. RESPONSIBILITIES

3.1 Project Manager

- Responsible for ensuring that all sample collection activities are conducted in accordance with this procedure and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

- Responsible for assuring proper Chain of Custody (COC) is initiated at the time the sample(s) are collected and maintained throughout the handling and subsequent transportation of the sample(s) to the designated laboratory. Additionally, he/she is the project authority for determining the disposition and fate of sample(s) which have identified deficiencies (e.g., missed holding times, elevated temperature at receipt, etc.).

3.2 Quality Assurance Manager

- Responsible for periodic review of Chain of Custody records are generated documentation associated with this procedure.

- Responsible for implementation of corrective action (i.e., retraining personnel, additional review of work plans and procedures, variances to Quality Control (QC) sampling requirements, issuing nonconformances, etc.) if problems occur.

3.3 Field Team Leader

- Responsible for maintaining sample custody from the time of sample collection until the sample is delivered to the lab.

- Responsible to ensure that custody documentation is accurate and complete.

3.4 Sampling Technician

- Responsible for proper completion of the Chain of Custody documentation, ensuring that all sample information is accurately recorded on the sample label, in the field logbook, and on the chain of custody form.

3.5 Laboratory Personnel

- Responsible for receipt and entry of samples into the laboratory.
- Responsible to properly document and maintain COC from the moment that they take custody of the sample at the laboratory until the sample material is disposed of or is returned to the client.

4. PROCEDURE/PROCESS

To preserve the integrity of environmental samples, the sampler must maintain and document the custody of the samples from the time of sample collection to completion of the analyses. The primary objective of sample custody is to create an accurate, verifiable written record that may be used to trace the possession and handling of the samples from the moment of collection until receipt by the laboratory. A sample is considered to be under a person's *custody* if the sample is in the person's physical possession or direct view, if the sample is secured so that no one can tamper with the sample, or if the sample is secured in an area restricted to authorized personnel only.

An overriding consideration for data resulting from laboratory analyses is the ability to demonstrate that the samples were obtained from the locations stated and that they reached the laboratory without alteration. Evidence of collection, shipment, laboratory receipt, and laboratory custody until disposal must be documented to accomplish this. Documentation will be accomplished through a COC form that lists each sample and the individuals performing the sample collection, shipment, and receipt.

4.1 Sample Custody Form

The transfer of samples from one person's custody to another (e.g. from the sampler to the laboratory) will be documented on a ENVF-021.1, Chain of Custody Record (COC). If a COC is not provided by the analytical laboratory or if samples are being sent to North Wind, Inc. for analysis, the COC included in Appendix A will be used. It is preferred that this COC be printed as a 2-layer carbon copy form, but it can be used in short notice by printing on regular paper.

When the samples are transferred from one party to another, the individuals will sign, date, and note the time on the form. A separate form will accompany each delivery of

samples to the laboratory. The chain-of-custody form will be included in the cooler used for transport of the samples. The sampling technician will retain a copy of the form. The COC form will be completed by the sampler to include the following information:

- Receiving laboratory name, address and phone number
- Sampler's name, company, address and phone number
- The name of the courier and the waybill number (if applicable).
- An Unique COC reference number
- Project name and NWI project number
- Unique identification number assigned to each sample
- Sample date/time (must match the time recorded on the sample label)
- Sample matrix description
- Analyses requested for each sample
- Preservation method
- Number and type of containers used
- Any special handling or analysis requirements (e.g. MS/MSD identification)
- Signature of person collecting the samples
- Signature of persons involved in the chain of possession.

For small sampling events, carbon copy COC forms are available from the analytical laboratories or the North Wind specific COC is available in Appendix A, which can be filled out by hand. For larger sampling events, electronic COCs are preferred as their proper use minimizes potential for error. Software such as EPA's *Forms-2-Lite* is recommended for generating sample documentation including bottle labels and COC forms.

4.2 Transfer of Custody

The COC document will be initiated in the field by the person collecting the sample and signed by each individual who has the samples in their possession. Each time that sample custody is transferred, the former custodian must sign over the COC as Relinquished By,

and the new custodian must sign on to the COC as Received By. Each signature must be accompanied by the date, time, and the name of their project or company affiliation.

4.2.1 No Common Carrier

If the sampling technician delivers the samples to the laboratory, transfer of COC occurs as follows:

- The sample collector delivers the samples to the laboratory and relinquishes the sample directly to a laboratory representative.
- The collector signs the COC listing his/her name, affiliation, the date, and time. Any person involved in the collection of the sample may act as the sample custodian.
- The laboratory representative must receive the samples by signing his/her name, affiliation, the date, and time on the COC. The laboratory representative may decline to take receipt of the samples if the COC is not properly completed or if the samples are not properly packaged. All designated laboratory personnel may act as the sample custodian.
- One copy of the COC is given to the sample collector to be returned to the project files and one copy is maintained with the samples at the laboratory.

4.2.2 Common Carrier

If the sampling technician transfer sample(s) to the laboratory utilizing a commercial carrier (e.g. Fed Ex), sampling technician will retain COC responsibility and the common carrier is not responsible for maintaining sample custody. The sample collectors are responsible for packaging the samples in a manner that meets the COC definition criteria, that is, the samples are sealed to prevent tampering. When transferring samples to the courier for transport, COC procedures are maintained as follows:

- The sample collector lists the courier affiliation and waybill number on the COC.
- The sample collector relinquishes custody by signing his name, affiliation, date, and time. The collector keeps a copy of the relinquished COC for the project file.
- The relinquished original COC is sealed in a watertight plastic bag and taped to the inside of the lid of the container used for transportation.
- The transportation container is sealed to prevent tampering and given to the courier for delivery to the laboratory.
- The sample collector obtains a copy of the waybill from the courier for the project file.

- The laboratory representative must receive the samples by signing his/her name, affiliation, the date, and time on the COC. This copy is maintained with the samples at the laboratory.

- The laboratory representative obtains a copy of the waybill from the courier for the project file.

4.3 Analytical Laboratory Custody

Upon receipt at the analytical laboratory, the field generated COC document will be signed, dated, time marked, temperature marked, and laboratory identification will be provided in the appropriate spaces. A cooler receipt form will be completed documenting the condition of the samples upon receipt.

Laboratory receipt personnel will enter the samples into the laboratory by implementing the sample custody procedures addressed within their approved Quality Program Plan.

After completion of analytical testing, sample remnants not consumed during testing may be kept for six months beyond the completion of analysis, unless otherwise specified by a notation on the COC that samples are to be returned to the project site for disposal. Once this time period has elapsed, the samples will be disposed of and the disposal record number will be recorded on the laboratory record copy of the COC.

5. RECORDS

The Project Manager will maintain the following records in accordance with QAP-171, Records Control:

- Chain of Custody Form

- Cooler Receipt Form

6. REFERENCES

USEPA, Test Methods for Evaluating Hazardous Waste, (SW-846) Rev.0, Sept. 1994

QAP-171, Records Control

APPENDIX A, Example of ENVF-021.1, North Wind Chain of Custody Record

NORTH WIND, INC.
CHAIN-OF-CUSTODY RECORD

Company Name:	Sampler:		Page ____ of ____
Address:	Phone:	Fax:	Date:
City:	Email:		COC #:
State: Zip:	Project Manager:		
Project Name:	Phone:	Fax:	Carrier/Airbill #:
Project Location:	Email:		

Sample Number	Sample Location	Date	Time	Depth	Sample Preservative	Sample Matrix	Analyses Requested					Type, Volume, and No. of Containers	Remarks/Special Instructions:

Possible Hazard Identification
☐ Non-Hazardous ☐ Skin Irritant ☐ Rad
☐ Flammable ☐ Poison ☐ Unknown

Sample Disposal
☐ Return to Client
☐ Disposal by Lab

Other Comments

Relinquished by: (Signature/Company)	Received By: (Signature/Company)	Date	Time	**Ship to:**
Relinquished by: (Signature/Company)	Received By: (Signature/Company)	Date	Time	
Relinquished by: (Signature/Company)	Received By: (Signature/Company)	Date	Time	

Distribution: White copy accompanies samples during transfer of custody; Yellow copy is retained by customer.

HSP-011

Excavations

Revision 1

August 28, 2006

Approved:

Bruce Miller *(See letter number NW-2006-156)*	08/28/06
Director, Health and Safety	Date
Sylvia Medina *(See letter number NW-2006-156)*	08/28/06
President	Date

REVISION HISTORY

Revision No.	Effective Date	Sections Affected	Description
0	11/22/05	All	This document Supersedes ESH-011, Excavations, Revision 1.
1	08/28/06	All	Revised document numbers for corporate plans, policies, procedures, and forms, and corrected references to these documents, to reflect the number changes per Letter NW-2006-156. Also made minor formatting changes (i.e., moved definitions and acronyms to the front of the document and changed page numbers) per QAP-061_Rev 2.

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DEFINITIONS

Benching

A method of protecting personnel from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

Competent Person

One who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

Excavation

Any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.

Hazardous Atmosphere

An atmosphere that by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

Some specific examples of hazardous atmospheres are provided below.

- Oxygen-deficient atmospheres contain less than 19.5 percent oxygen and can result in a range of disorders from dizziness to unconsciousness and even death at extreme low levels. Normal atmospheres contain 21 percent oxygen (at sea level).
- Oxygen-enriched atmospheres contain greater than 23.5 percent oxygen and can increase the flammability of combustible materials.
- Explosive atmospheres contain flammable gases that exceed 10 percent of the lower explosive limit (LEL).
- Carbon monoxide from the exhausts of earthmoving equipment can collect in excavations. Carbon monoxide causes oxygen starvation and can be fatal at a concentration of 1 percent (10,000 ppm) after a 1 minute exposure. Ventilation or respiratory protection is required when carbon monoxide levels exceed 35 ppm.
- Toxic atmospheres may develop depending on the level of contamination in the soil. Refer to the health and safety plan or field safety instructions for more details.

Shielding

A structure that is able to withstand the forces imposed on it by a cave-in and thereby protects personnel within the structure. Shields can be permanent structures or can be designed to be portable and moved along

	as work progresses. Additionally, shields can be either pre-manufactured or job-built in accordance with OSHA requirements. Shields used in trenches are usually referred to as "trench boxes" or "trench shields."
Shoring	A structure such as a metal hydraulic, mechanical, or timber shoring system that supports the sides of an excavation and that is designed to prevent cave-ins.
Sloping	A method of protecting personnel from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.
Stable Rock	Refers to natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.
Trench	A narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet. If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.
Soil Types	(described in Attachment C – Soil Classification and Definitions)

ACRONYMS

ASTM	American Society for Testing and Materials
CP	Excavation Competent Person
HSP	Health and Safety Plan
HSD	Heath and Safety Director
HS&E	Health, Safety, and Environmental
LEL	Lower Explosive Limit
NPDES	National Pollutant Discharge Elimination System
PM	Project Manager
PPE	Personal Protective Equipment

SCBA	Emergency Self-Contained Breathing Apparatus
SS	Site Supervisor
SSO	Site Safety Officer
SWPPP	Storm Water Pollution Prevention Plan

1. PURPOSE

This Program provides information regarding the hazards and issues associated with excavation operations that must be addressed during a project. All employees who conduct field operations where excavations are present must be aware of these hazards and of the associated safe work practices in compliance with 29 CFR 1926, Subpart P, "Excavations."

Excavation hazards addressed in this procedure include exposure to cave-ins, falls, falling objects, hazardous atmospheres, unstable structures, and excavating into underground utilities. North Wind employees who enter excavations must take precautions to avoid these hazards and be aware of the associated safe work practices.

Note: Some state-OSHA plans (WA, OR, CA) have more stringent excavation requirements. Contact the North Wind Health and Safety Director (HSD) for state-specific information.

2. SCOPE

This procedure applies to North Wind employees and subcontractors who conduct excavations tasks. The Subcontractors' responsibilities are expressly defined through the subcontract terms and conditions, and North Wind's Health and Safety practices in the field are determined based on these defined responsibilities. Consistent with the subcontract, excavation subcontractors must determine how to excavate safely and in compliance with applicable H&S regulations and industry standards, and how to correct deficiencies. North Wind employees shall not direct the means and methods of safe excavation operations or details of corrective actions.

3. RESPONSIBILITIES

3.1 Corporate Health and Safety Director

The HSD is responsible for:

- Discussing concerns raised by the users of this procedure and taking appropriate actions to ensure the effectiveness of this procedure.
- Working with North Wind site supervisors (SS) to ensure this procedure is properly implemented when required.
- Reviewing OSHA requirements and incorporating changes and requirements into this procedure.
- Reviewing the effectiveness of this procedure on an annual basis.

3.2 Site Supervisor

The SS is responsible for:

- Evaluating the specific tasks to be performed to determine if an excavation will be created during the course of the project.
- Ensuring an excavation competent person is assigned to the project where an excavation is present.
- Consulting with the competent person to identify excavation hazards and determine sloping or protective system requirements.
- Informing all affected North Wind employees and subcontractor personnel of the location and hazards of the existing confined spaces.
- Providing field oversight of subcontractors performing excavation tasks and completing the self-assessment checklist for confined-space entry (See Appendix A).
- Suspending excavation operations when a subcontractor is not following excavation procedures.
- Contacting the HSD and PM if the subcontractor is not following excavation procedures.

3.3 Site Safety Officer

The Site Safety Officer (SSO) or SS (if serving in the SSO capacity) is responsible for:

- Supporting the competent person with implementation of excavation hazard mitigation requirements.
- Conducting monitoring of excavation atmosphere if suspected of containing an atmospheric hazard.

3.4 Excavation Competent Person

North Wind or North Wind excavation subcontractors shall provide a competent person to inspect and oversee all excavation activities. The competent person shall have training in and knowledge about soil classification, the use of protective systems, and the requirements of OSHA 29 CFR 1926, Subpart P, “Excavation” standard. The competent person shall be capable of identifying excavation hazards and have the authority to take corrective actions to eliminate the hazards.

The excavation competent person (CP) is responsible for the following:

- Conducting soil classification in accordance with 29 CFR 1926, Subpart P.
- Determining most appropriate protective system for an excavation.

- Designing structural ramps that are used solely by employees as a means of access or egress from excavations.

- Designing structural ramps used for access or egress of equipment, if competent person is qualified in structural design.

- Monitoring the water removal equipment and operations to ensure proper operation if water is controlled or prevented from accumulating by the use of water removal equipment.

- Inspecting excavations subject to runoff from heavy rains.

- Conducting daily inspections of excavations, the adjacent areas, and protective systems shall be made for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions.

- Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.

4. PROCEDURE

The following subsections provide the minimum project operating requirements that will be used at every project site where excavation operations are conducted. Excavation subcontractors are responsible and accountable for implementing these requirements as well as requirements established in their own safety procedures.

North Wind's project SSO (or SS serving as the SSO) may be required to provide oversight of an excavation subcontractor. The following subsections are provided to inform the SSO of established regulations and industry standards so that an appropriate level of oversight may be provided. Subcontractors retain control over their practices, and North Wind's oversight does not relieve them of their own responsibility for effective implementation and enforcement of H&S requirements.

4.1 General Requirements

- A daily safety briefing/meeting should be conducted by the competent person with all excavation personnel to discuss the work planned for the day and the H&S requirements to be followed.

- Excavations that are to be entered shall be inspected each day by the competent person, as needed throughout the work shift, and after every rain or other event that may increase the potential for excavation cave-in. This inspection shall include, at a minimum, indications of possible cave-in, water accumulation, failure of any component of protective systems, stability of spoil piles and adjacent structures, and indications of hazardous atmosphere.

- If the competent person observes any deficiency or unsafe condition, excavation entry will not be permitted and all exposed personnel shall be removed from the excavation until adequate precautions have been taken to ensure safe entry.

- Walkways shall be provided where personnel are required or permitted to cross over excavations. Walkways 6 feet or more above lower levels shall be equipped with standard guardrails.

- Guardrails, fences, or barricades shall be installed at excavations 6 feet or deeper when the excavations are not readily visible because of plant growth or other visual obstruction.

- Wells, pits, shafts, and similar excavations 6 feet or deeper shall be provided with guardrails, fences, barricades, or covers.

- Earthmoving equipment shall be operated in compliance with OSHA 29 CFR 1926, Subpart O, "Motor Vehicles and Mechanized Equipment."

4.1.1 Utility Locations

The exact location of underground utilities and structures must be identified. Many states have a one-call phone number for locating underground utilities (refer to the project's written site safety plan). The assigned competent person has the responsible for this action.

4.1.2 Excavation Subcontractor Selection

Where North Wind is not self-performing the excavation tasks, excavation subcontractors are selected based on project-specific requirements. The "Subcontractor Safety Procedure Criteria—Excavations" found in Appendix A provides the minimum criteria for excavation safety procedures. These criteria shall be used by the SS in conjunction with the SSO and HSS to review subcontractor excavation procedures submitted when North Wind oversight is required.

4.2 Prior to Excavating

- The location of underground utilities such as electric, fuel, water, cable, telephone, and sewer, either in service or abandoned, and underground installations such as foundations, underground storage tanks, and any other structure shall be identified before excavating is permitted. Utility companies and/or installation owners shall be contacted for exact location. When the exact location cannot be identified, detection equipment or other acceptable means of locating the underground installations shall be used before excavation.

- Soil suspected to be contaminated should be sampled and analyzed for characterization prior to excavation.

- If wetlands, endangered species or cultural/historic resources are suspected, they must be identified through field delineation and/or federal or state issued maps. Wetlands may also have protective buffer zones established by state or local regulations.

- A Stockpile Management Plan may be required to address state and local stockpiling requirements. Check with the Project Manager (PM) to determine if a Stockpile Management Plan is required.

- Local requirements for dewatering excavations and discharging must be discussed with the SS.

- A Storm Water Pollution Prevention Plan (SWPPP) or an Erosion and Sediment control Plan may be required where construction activities are greater than a threshold area (1 to 5 acres, depending on project location).

4.3 Excavation Activities

- All rocks, trees, and other surface encumbrances that are undermined or could become unstable as a result of excavating activities shall be removed or supported to prevent them from falling into the excavation.

- Support systems such as shoring, bracing, or underpinning shall be used to support exposed underground utilities that may become unstable due to excavating operations.

- Excavating below the base of a foundation, wall, sidewalk, or other surface structure shall not be permitted unless: 1) a support system is provided to ensure the stability of the structure, 2) the excavation is in stable rock, or 3) a registered professional engineer has determined that the structure is sufficiently removed and will be unaffected by the excavating activity.

- When mobile equipment is required to approach the edge of an excavation and the operator does not have a clear and direct view of the edge, warning systems such as barricades, hand and/or mechanical signals, or stop logs shall be in place to remind the operator of the location of the edge.

- Stockpiles may require liners and covers and excavations may require silt fences, covering or other best management practices to control erosion or runoff.

- Fugitive dust and noise must be monitored and suppressed where necessary.

4.4 Excavation Entry

- Trenches greater than 4 feet deep shall be provided with a ladder, stairway, or ramp positioned so that the maximum lateral travel distance is no more than 25 feet.

- Structural ramps used solely by personnel shall be designed by a competent person. Structural ramps used by equipment shall be designed by a competent person qualified in structural design (generally a registered professional engineer).

- The atmosphere of excavations greater than 4 feet deep shall be tested prior to entry where a hazardous atmosphere exists or could reasonably be expected to exist, such as excavating landfills, hazardous waste dumps, or areas containing sewer or gas utility systems, petroleum distillates, or areas where hazardous substances are stored nearby.

- When atmospheric testing indicates a hazardous atmosphere exists or could reasonably be expected to exist, emergency rescue equipment such as safety harness and lifeline and emergency self-contained breathing apparatus (SCBA) shall be readily available.

- When atmospheric testing indicates a hazardous atmosphere is present, ventilation or appropriate respiratory protection shall be used to eliminate or reduce exposure to safe levels. If ventilation is used, atmospheric testing shall be conducted as often as necessary to ensure safe levels are maintained.

- Personnel shall wear appropriate personal protective equipment (PPE). Minimum protection includes safety-toed shoes/boots, hard hats, and safety glasses. Gloves, coveralls, Tyvek, and respirators may also be required based on the chemical hazards (refer to the project's written site safety plan).

- Excavations that have accumulated water shall not be entered unless precautions have been taken to prevent excavation undermining and cave-ins. Precautions may include special support systems or shield systems, water removal equipment that is monitored by the competent person to ensure proper operation, or safety harnesses and lifelines. No water may be discharged on-site without prior consultation with the SS.

- Adequate precautions such as diversion ditches or dikes shall be used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation when the natural drainage of surface water is interrupted.

- Personnel shall be protected from materials falling or rolling from the face of the excavation by scaling to remove loose material or installing protective barricades.

- Spoil piles, material, and equipment must be kept at least 2 feet from the edge of the excavation or a retaining device must be used to prevent the material from falling into the excavation.

4.5 Protective Systems

The excavation competent person is responsible for determining the appropriate protective system to be used to prevent excavation cave-in. This determination may be based on the soil classification, space limitations, available materials, work to be done in the excavation, and

availability of tabulated data or a registered professional engineer. North Wind must carefully rely on the expertise of the competent person in consultation with the HSD with regard to excavation protective systems. A selection flow chart for protective systems in accordance with 29 CFR 1926 Subpart P, Appendix D is provided in Appendix C, "Selection of Protective Systems." The following information is provided to give a general understanding of the OSHA excavation protective system requirements. For more specific information, refer to "Protective System Requirements Summary" found in Appendix D.

- Sloping, benching, shoring, shielding, or other protective systems are required to protect personnel from cave-ins except when the excavation is made entirely in stable rock, or is less than 5 feet deep and there is no indication of possible cave-in, as determined by the competent person for excavations.

- Protective systems for excavations deeper than 20 feet must be designed or approved by a registered professional engineer.

- If the excavation soil is not classified by the competent person, the maximum allowable slope shall be 34 degrees measured from the horizontal. Refer to Appendix D for details regarding the actual slope and configurations allowed.

- Protective system materials shall be free from damage that might impair their proper function. Damaged components shall be inspected by the competent person to evaluate their suitability for continued use.

- Protective system materials shall be used consistent with manufacturers' recommendations and shall not be subjected to loads exceeding their design limits.

- Protective system materials shall be securely connected together to prevent sliding, falling, kickouts, or other predictable failure.

- Personnel shall be protected from cave-ins while entering and exiting shielding systems.

- Personnel shall not work in shielding systems during installation, removal, or vertical movement. Personnel may remain inside the shield during horizontal movement as long as the shield is not lifted.

4.6 Protective System Removal

- Precautions shall be taken when removing protective system components. Removal shall start at, and progress from, the bottom of excavation. Components shall be released slowly to note any indications of possible failure of remaining components. Temporary structural members may be required to carry the loads imposed on the protective system.

- Backfilling shall take place immediately after removal of the protective system.

4.7 Excavating at Hazardous Waste Sites

The PM and HSM shall be consulted on proper evaluation, disposal, and decontamination procedures involving potential hazardous waste.

- All wastes generated shall be characterized prior to excavation.
- Hazardous waste shall be managed and disposed of in accordance with local, state and federal laws.
- If excavation involves hazardous wastes, the decontamination section of the project site safety plan shall be followed. No potentially contaminated equipment shall be permitted to leave the work site.

4.8 Backfill

Backfill may require a clean fill certification by the client, or under a state or local requirement. Analytical testing or letter from the fill supplier certifying that soil is clean may be required.

4.9 Safety Equipment

Excavation subcontractors are responsible for providing all personal protective equipment (PPE) necessary for its employees. North Wind will provide PPE only for its own employees. Other safety equipment will be provided as delineated in the subcontract and referenced documents.

- Detection equipment shall be provided if the exact location of underground utilities cannot be determined by the utility owner.
- Air monitoring instruments, ventilation equipment, and respiratory protection may be required if the potential for a hazardous atmosphere exists within the excavation.
- Emergency rescue equipment (such as self-contained breathing apparatus, safety harnesses, and lifelines) may be required if a hazardous atmosphere exists within the excavation.
- Minimum PPE includes safety-toed shoes/boots, hard hats, and safety glasses. Body protection (such as gloves, coveralls, or Tyvek) may be needed when chemical hazards exist. Hearing protection may be needed when working in proximity to earthmoving equipment.
- Fall protection shall be provided when personnel are exposed to a fall of 6 feet or greater.
- Water removal equipment may be needed to prevent water accumulation in the excavation.
- Shoring, shielding, and other protective systems may be required to protect excavations from cave-in.

- Stockpile and excavation liners and covers may be required.

4.10 Forms/Permits

There are no North Wind forms or permits required for excavating activities.

The following environmental permits may be required. Check with the PM and SS to determine applicability:

- Waste discharge or NPDES permit may be required for water discharged during excavation de-watering.
- ACOE/CWA 404 permit is required for excavation or filling in wetland areas.
- "Dig permit" may be required at certain client facilities.
- USDA soil permit may be required if the project involves transport of soil from any "regulated area" to a "non-regulated area." Regulated areas include most of the south and southeast coastal states that tend to have nematodes and other soil pests (may include other coastal areas).

Excavation subcontractors of tenant facilities may have written procedures or permits governing excavation activities. North Wind personnel entering a subcontractor's excavation must comply with these procedures.

4.11 Self-Assessment Checklists

The "Health Safety and Environmental (HS&E) Self-Assessment Checklist - Excavations" found in Appendix B is provided as a method of verifying compliance with established safe work practices, regulations, and industry standards pertaining to excavation operations.

North Wind's project competent person, SSO or SS shall use this checklist when: 1) North Wind employees enter excavations and/or 2) North Wind oversight of an excavation subcontractor is required. The HSD shall specify the frequency in which this checklist shall be completed and provide this information in the project's written safety plan. Completed checklists shall be sent to the HSD for review. The HSD shall assist the SSO or SS in resolving any deficiencies identified during the self-assessment. This Program may be used to clarify checklist questions.

5. RECORDS

The Health and Safety Director will maintain all records in accordance with QAP-171, Records Control:

- HSF-011.1, HS&E Self Assessment Checklist

6. REFERENCES

29 CFR 1926 Subpart P, “Excavations”

29 CFR 1926.652(b)(2)

CFR 1926.652©

ASTM Standards D653-85 and D2488

National Bureau of Standards Report BSS-121

QAP-171, Records Control

APPENDIX A, Subcontractor Safety Procedure Criteria--Excavations

The following criteria are not intended to be all inclusive, but are provided as a tool to facilitate development and review of subcontractor safety procedures. Subcontractors are expected to address the following items in their safety procedures.

1. Provide name and qualifications of the "competent person" responsible for excavation activities (years and type of experience, training background, etc.):

2. Describe excavation and protective system inspection criteria or procedures (frequency of inspections - daily, as needed throughout day, after rains; visual vs. written inspections; items that are inspected):

3. Describe methods of identifying underground utilities (contacting utility companies, detection equipment):

4. Describe methods to sample and analyze soil for characterization where contamination is suspected:

5. Describe methods to identify and protect wetlands, endangered species or cultural/historic resources:

6. Describe specific method(s) of cave-in protection to be used on this project (sloping, benching, shoring, shielding):

7. Describe option(s) that will be used for protective systems determination (soil classification, tabulated data, other data, registered professional engineer design):

8. Describe methods to identify hazardous atmospheres and controls (detection equipment, ventilation, respiratory protection, rescue equipment):

9. Describe methods used to prevent water accumulation (water removal equipment, special support systems, harness and lifelines):

10. Describe best management practices for water, erosion, sediment and fugitive dust control (including stockpile construction standards, excavation covering, storm water pollution prevention, erosion and sediment control and disposal of accumulated storm water/wastewater):

11. Describe methods to analyze backfill material, where required:

12. Describe methods used to protect workers from material falling into the excavation (remove or support objects, keep material 2' back or restrain, keep workers off slopes):

13. Describe methods used to support adjacent structures near excavations (shoring, bracing, or underpinning; RPE evaluation):

14. Describe safe work practices for other activities to be performed during this project (use of ladders, fall protection, personal protective equipment, etc.):

15. If hazardous waste project, provide documentation of hazardous waste worker training and medical surveillance records for all project personnel (40-hour or 24-hour training, 8-hour refresher training) and describe methods of hazardous waste management (including accumulation, transport and disposal):

16. Provide summary of equipment that will be needed to perform excavation safely and verify that equipment is in good operational condition (excavation digging equipment, shoring and shielding materials, etc.)

17. Describe methods to certify clean backfill material:

APPENDIX B, Example of HSF-011.1, HS&E Self-Assessment Checklist - Excavations

HS&E SELF-ASSESSMENT CHECKLIST - EXCAVATIONS

This checklist shall be used by North Wind personnel only and shall be completed at the frequency specified in the project's HASP, Task Hazard Analysis, SS or PM.

This checklist is to be used at locations where: 1) North Wind employees enter excavations (complete Sections 1 and 3), and/or 2) North Wind oversight of an excavation subcontractor is required (complete entire checklist).

The competent person or SSO may consult with excavation subcontractors when completing this checklist, but shall not direct the means and methods of excavation operations nor direct the details of corrective actions. Excavation subcontractors shall determine how to correct deficiencies and we must carefully rely on their expertise. Items considered to be imminently dangerous (possibility of serious injury or death) shall be corrected immediately and all exposed personnel shall be removed from the hazard until corrected.

Project Name: _____ Project No.: _____
Location: _____ PM: _____
Auditor: _____ Title: _____ Date: _____

This specific checklist has been completed to (check only one of the boxes below):
☐ Evaluate North Wind compliance with its confined spaces procedure (HSP-11-011)
☐ Evaluate a North Wind subcontractor's compliance with its excavation procedure or program
Subcontractor's Name: _____

☐ Check "Yes" if an assessment item is complete or correct.
☐ Check "No" if an item is incomplete or deficient. Section 2 must be completed for all items checked "No."
☐ Check "N/A" if an item is not applicable.
☐ Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in North Wind HSP-11-011.

SECTION 1

PROCEDURE AREA		Yes	No	N/A	N/O
General Requirements (4.1)					
1	Daily safety briefing/meeting conducted with personnel				
2	Excavation and protective systems adequately inspected by competent person				
3	Defective protective systems or other unsafe conditions corrected before entry				
4	Guardrails provided on walkways over excavation 6' or deeper				
5	Barriers provided at excavations 6' or deeper when not readily visible				
6	Barriers or covers provided for wells, pits, shafts, or similar excavation 6' or deeper				
7	Excavating equipment operated safely				
Prior to Excavation (4.2)					
8	Location of underground utilities and installations identified				
9	Soils characterized prior to excavation where contamination may be present				
10	Excavation area checked for wetlands, endangered species, cultural/historic resources				
11	Stockpile construction and management plan				
12	PM consulted and plan established for wastewater disposal from excavation dewatering				
13	SWPPP prepared for construction site 1-5 acres (depending on project location)				
Excavation Activities (4.3)					
14	Rocks, trees, and other unstable surface objects removed or supported				

EXAMPLE

HS&E SELF-ASSESSMENT CHECKLIST - EXCAVATIONS

15	Exposed underground utility lines supported				
16	Undermined surface structures supported or determined to be in safe condition				
17	Warning system used to remind equipment operators of excavation edge				
18	Stockpile, excavation covers, liners, silt fences in place, where required				
19	Fugitive dust suppressed				
Excavation Entry (4.4)					
20	Trenches > 4' deep provided with safe means of egress within 25'				
21	Structure ramps designed and approved by competent person				
22	Potential hazardous atmospheres tested prior to entry				
23	Rescue equipment provided where potential for hazardous atmospheres exists				
24	Ventilation used to control hazardous atmospheres and air tested frequently				
25	Appropriate respiratory protection used when ventilation does not control hazards				
26	Precautions taken to prevent cave-in from water accumulation in the excavation				
27	Precautions taken to prevent surface water from entering excavation				
28	Protection provided from falling/rolling material from excavation face				
29	Spoil piles, equipment, materials restrained or kept at least 2' from excavation edge				
Protective Systems (4.5)					
30	Protective systems used for excavations 5' or deeper				
31	Protective systems for excavation deeper than 20' designed by registered PE				
32	If soil unclassified, maximum allowable slope is 34 degrees				
33	Protective systems free from damage				
34	Protective system used according to manufacturer recommendations and not subjected to loads exceeding design limits				
35	Protective system components securely connected to prevent movement or failure				
36	Cave-in protection provided while entering/exiting shielding systems				
37	Personnel removed from shielding systems when installed, removed, or vertical movement				
Protective System Removal (4.6)					
38	Protective system removal starts and progresses from excavation bottom				
39	Protective systems removed slowly and cautiously				
40	Temporary structure supports used if failure of remaining components observed				
41	Backfilling taking place immediately after protective system removal				
Excavation at Hazardous Waste Sites (4.7)					
42	Waste disposed of according to HASP/CERCLA/RCRA regulations				
43	Appropriate decontamination procedures being followed, per HASP/THA				
Backfill (4.8)					
44	Backfill certified clean when required by client or local regulation				

SAMPLE

HS&E SELF-ASSESSMENT CHECKLIST - EXCAVATIONS

SECTION 2

Complete this section for all items checked "No" in Section 1. Deficient items must be corrected in a timely manner.

Item #	Imminent Hazard (Y or N)	Corrective Action Planned or Taken	Date Corrected

EXAMPLE

Auditor: _____ Site Supervisor: _____

SSO: _____

Date: _____ Date: _____

Date: _____

APPENDIX C, Soil Classification and Definitions

This attachment describes a method of classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits. This attachment contains definitions, sets forth requirements, and describes acceptable visual and manual tests for use in classifying soils.

1.0 APPLICATION

This appendix applies when a sloping or benching system is designed in accordance with the requirements set forth in 29 CFR 1926.652(b) (2) as a method of protection for employees from cave-ins. This attachment also applies when timber shoring for excavations is designed as a method of protection from cave-ins in accordance with attachment C to subpart P of part 1926, and when aluminum hydraulic shoring is designed in accordance with attachment D. This attachment also applies if other protective systems are designed and selected for use from data prepared in accordance with the requirements set forth in 29 CFR 1926.652(c), and the use of the data is predicated on the use of the soil classification system set forth in this attachment.

2.0 DEFINITIONS

The definitions and examples given below are based on, in whole or in part, the following; American Society for Testing Materials (ASTM) Standards D653-85 and D2488; The Unified Soils Classification System; The U.S. Department of Agriculture (USDA) Textural Classification Scheme; and The National Bureau of Standards Report BSS-121.

Cemented soil - means a soil in which the particles are held together by a chemical agent, such as calcium carbonate, such that a hand-size sample cannot be crushed into powder or individual soil particles by finger pressure.

Cohesive soil - means clay (fine grained soil), or soil with a high clay content, which has cohesive strength. Cohesive soil does not crumble, can be excavated with vertical side slopes, and is plastic when moist. Cohesive soil is hard to break up when dry, and exhibits significant cohesion when submerged. Cohesive soils include clayey silt, sandy clay, silty clay, clay and organic clay.

Dry soil - means soil that does not exhibit visible signs of moisture content.

Fissured - means a soil material that has a tendency to break along definite planes of fracture with little resistance, or a material that exhibits open cracks, such as tension cracks, in an exposed surface.

Granular soil - means gravel, sand, or silt (coarse grained soil) with little or no clay content. Granular soil has no cohesive strength. Some moist granular soils exhibit apparent cohesion. Granular soil cannot be molded when moist and crumbles easily when dry.

Layered system - means two or more distinctly different soil or rock types arranged in layers. Micaceous seams or weakened planes in rock or shale are considered layered.

Moist soil - means a condition in which a soil looks and feels damp. Moist cohesive soil can easily be shaped into a ball and rolled into small diameter threads before crumbling. Moist granular soil that contains some cohesive material will exhibit signs of cohesion between particles.

Plastic - means a property of a soil which allows the soil to be deformed or molded without cracking, or appreciable volume change.

Saturated soil - means a soil in which the voids are filled with water. Saturation does not require flow. Saturation, or near saturation, is necessary for the proper use of instruments such as a pocket penetrometer or sheer vane.

Soil classification system - means, for the purpose of this subpart, a method of categorizing soil and rock deposits in a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing order of stability (see definitions below). The categories are determined based on an analysis of the properties and performance characteristics of the deposits and the characteristics of the deposits and the environmental conditions of exposure.

Stable rock - means natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Submerged soil - means soil which is underwater or is free seeping.

Type A soil - Refers to cohesive soils with an unconfined compressive strength of 1.5 tons per square foot (tsf) or greater. Type A soils include clay, silty clay, sandy clay, clay loam, caliche, hardpan, and sometimes silty clay loam and sandy clay loam. No soil should be classified as type A if it is fissured; subject to vibration from heavy traffic, pile driving, or similar effects; has been previously disturbed; or part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V).

Type B soil - Refers to cohesive soils with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf. Type B soils include granular cohesion-less soils like angular gravel, silt, silt loam, sandy loam, and sometimes silty clay loam and sandy clay loam; previously disturbed soils that are not Type C; fissured soils and soils subject to vibration that would otherwise be classified as type A; dry rock that is not stable; and material that is part of a sloped, layered system where the layers dip on a slope less steep than four horizontal to one vertical (4H:1V).

Type C soil - Refers to cohesive soil with an unconfined compressive strength of 0.5 tsf or less. Type C soils include granular soils such as gravel, sand, and loamy sand; submerged soil; soil from which water is freely seeping; submerged rock that is not stable; or material in a sloped, layered system where the layers dip into the excavation at a slope of four horizontal to one vertical (4H:1V) or steeper.

Unconfined compressive strength - means the load per unit area at which a soil will fail in compression. It can be determined by laboratory testing, or estimated in the field using a pocket penetrometer, by thumb penetration tests, and other methods.

Wet soil - means soil that contains significantly more moisture than moist soil, but in such a range of values that cohesive material will slump or begin to flow when vibrated. Granular material that would exhibit cohesive properties when moist will lose those cohesive properties when wet.

3.0 REQUIREMENTS

3.1 Classification of Soil and Rock Deposits

Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C in accordance with the definitions set forth in paragraph (b) of this appendix.

3.2 Basis of Classification

The classification of the deposits shall be made based on the results of at least one visual and at least one manual analysis. Such analyses shall be conducted by a competent person using tests described in paragraph (d) below, or in other recognized methods of soil classification and testing such as those adopted by the American Society for Testing Materials, or the U.S. Department of Agriculture textural classification system.

3.3 Visual and Manual Analyses

The visual and manual analyses, such as those noted as being acceptable in paragraph (d) of this appendix, shall be designed and conducted to provide sufficient quantitative and qualitative information as may be necessary to identify properly the properties, factors, and conditions affecting the classification of the deposits.

3.4 Layered Systems

In a layered system, the system shall be classified in accordance with its weakest layer. However, each layer may be classified individually where a more stable layer lies under a less stable layer.

3.5 Reclassification

If, after classifying a deposit, the properties, factors, or conditions affecting its classification change in any way, the changes shall be evaluated by a competent person. The deposit shall be reclassified as necessary to reflect the changed circumstances.

3.6 Acceptable Visual and Manual Tests

3.6.1 Visual Tests.

Visual analysis is conducted to determine qualitative information regarding the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the open excavation, and the soil taken as samples from excavated material.

1. Observe samples of soil that are excavated and soil in the sides of the excavation. Estimate the range of particle sizes and the relative amounts of the particle sizes. Soil that is primarily composed of fine-grained material is cohesive material. Soil composed primarily of coarse-grained sand or gravel is granular material.

2. Observe soil as it is excavated. Soil that remains in clumps when excavated is cohesive. Soil that breaks up easily and does not stay in clumps is granular.

3. Observe the side of the opened excavation and the surface area adjacent to the excavation. Crack-like openings such as tension cracks could indicate fissured material. If chunks of soil spall off a vertical side, the soil could be fissured. Small spalls are evidence of moving ground and are indications of potentially hazardous situations.

4. Observe the area adjacent to the excavation and the excavation itself for evidence of existing utility and other underground structures, and to identify previously disturbed soil.

5. Observed the opened side of the excavation to identify layered systems. Examine layered systems to identify if the layers slope toward the excavation. Estimate the degree of slope of the layers.

6. Observe the area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides of the excavation, or the location of the level of the water table.

7. Observe the area adjacent to the excavation and the area within the excavation for sources of vibration that may affect the stability of the excavation face.

3.6.2 Manual Tests

Manual analysis of soil samples is conducted to determine quantitative as well as qualitative properties of soil and to provide more information in order to classify soil properly.

1. Plasticity. Mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as 1/8-inch in diameter. Cohesive material can be successfully rolled into threads without crumbling. For example, if at least a two inch (50 mm) length of 1/8-inch thread can be held on one end without tearing, the soil is cohesive.

2. Dry Strength. If the soil is dry and crumbles on its own or with moderate pressure into individual grains or fine powder, it is granular (any combination of gravel, sand, or silt). If the soil is dry and falls into clumps which break up into smaller clumps, but the smaller clumps can only be broken up with difficulty, it may be clay in any combination with gravel, sand or silt. If the dry soil breaks into clumps which do not break up into small clumps and which can

only be broken with difficulty, and there is no visual indication the soil is fissured, the soil may be considered unfissured.

3. Thumb Penetration. The thumb penetration test can be used to estimate the unconfined compressive strength of cohesive soils. (This test is based on the thumb penetration test described in American Society for Testing and Materials (ASTM) Standard designation D2488 - "Standard Recommended Practice for Description of Soils (Visual - Manual Procedure).") Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated several inches by the thumb, and can be molded by light finger pressure. This test should be conducted on an undisturbed soil sample, such as a large clump of spoil, as soon as practicable after excavation to keep to a minimum the effects of exposure to drying influences. If the excavation is later exposed to wetting influences (rain, flooding), the classification of the soil must be changed accordingly.

4. Other Strength Tests. Estimates of unconfined compressive strength of soils can also be obtained by use of a pocket penetrometer or by using a hand-operated shear vane.

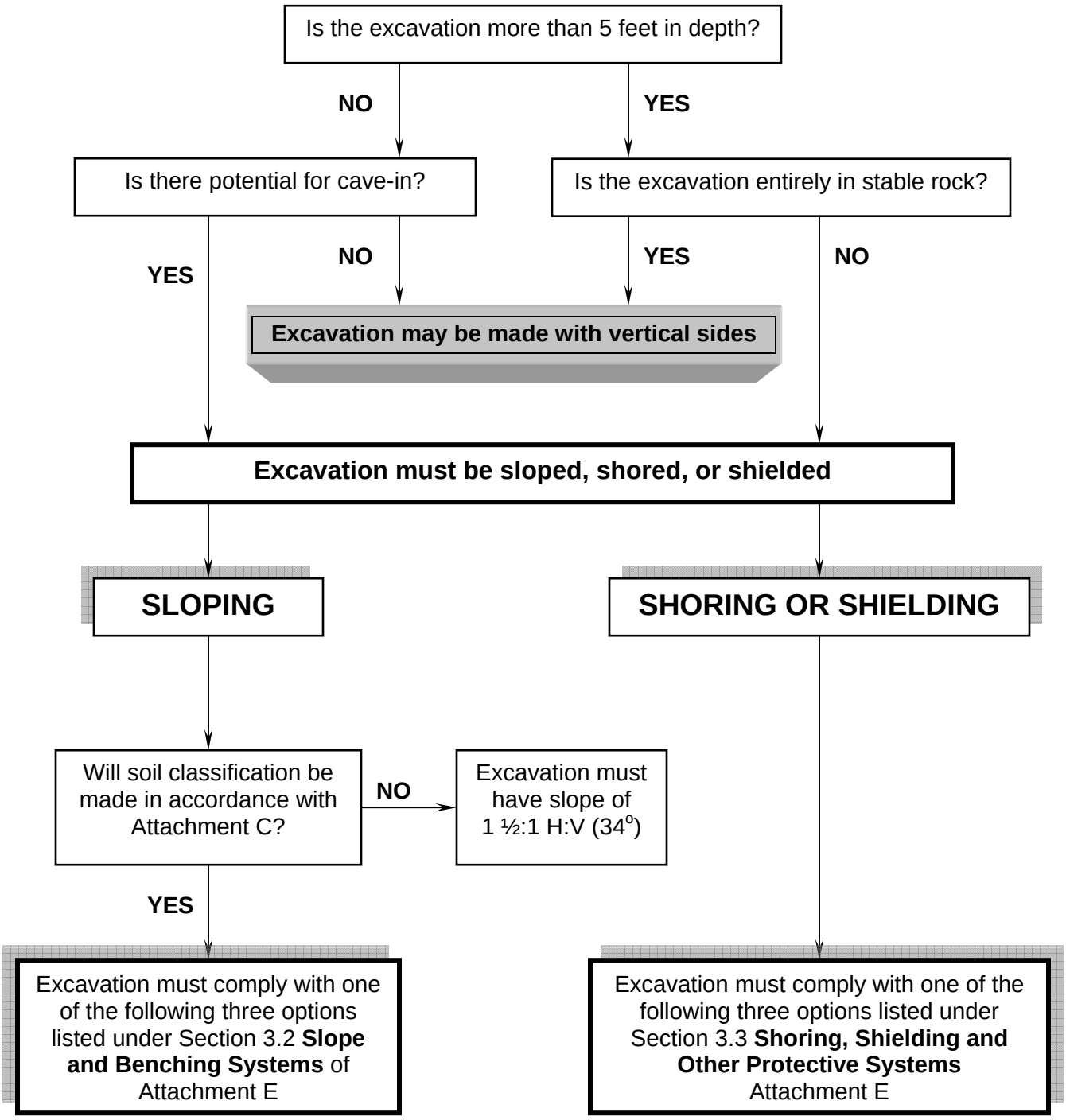
5. Drying Test. The basic purpose of the drying test is to differentiate between cohesive material with fissures, unfissured cohesive material, and granular material. The procedure for the drying test involves drying a sample of soil that is approximately one inch thick (2.54 cm) and six inches (15.24 cm) in diameter until it is thoroughly dry:

   a. If the sample develops cracks as it dries, significant fissures are indicated.

   b. Samples that dry without cracking are to be broken by hand. If considerable force is necessary to break a sample, the soil has significant cohesive material content. The soil can be classified as an unfissured cohesive material and the unconfined compressive strength should be determined.

   c. If a sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

APPENDIX D, Selection of Protective Systems



APPENDIX E, Protective Systems Requirements Summary

1.0 APPLICABILITY

Each employee in an excavation shall be protected from cave-ins by an adequate protective system designed in accordance with this attachment and 29 CFR 1926 Subpart P except when:

- Excavations are made entirely in stable rock; or
- Excavations are less than 5 feet (1.52 m) in depth and examination of the ground by a competent person provides no indication of a potential cave-in.

Protective systems shall have the capacity to resist without failure all loads that are intended or could reasonably be expected to be applied or transmitted to the system.

This attachment contains specifications for sloping and benching when used as methods of protecting employees working in excavations from cave-ins. The requirements of this attachment apply when the design of sloping and benching protective systems is to be performed in accordance with the requirements set forth in 1926.652(b)(2).

2.0 DEFINITIONS

Actual Slope - means the slope to which an excavation face is excavated.

Distress - means that the soil is in a condition where a cave-in is imminent or is likely to occur. Distress is evidenced by such phenomena as the development of fissures in the face of or adjacent to an open excavation; the subsidence of the edge of an excavation; the slumping of material from the face or the bulging or heaving of material from the bottom of an excavation; the spalling of material from the face of an excavation; and raveling, i.e., small amounts of material such as pebbles or little clumps of material suddenly separating from the face of an excavation and trickling or rolling down into the excavation.

Maximum Allowable Slope - means the steepest incline of an excavation face that is acceptable for the most favorable site conditions as protection against cave-ins, and is expressed as the ratio of horizontal distance to vertical rise (H:V).

Short Term Exposure - means a period of time less than or equal to 24 hours that an excavation is open.

Soil Type – Defined in Attachment C

3.0 REQUIREMENTS

3.1 Soil Classification

Soil and rock deposits shall be classified in accordance with Attachment 3.

3.2 Slope and Benching Systems

Sloping and benching systems must be designed by a registered professional engineer for excavations deeper than 20 feet. System design for excavations 20 feet or less in depth must be selected and constructed by using one or more of the following options:

Option 1: *Soil classification not required*. Maximum allowable slope = 1 ½ horizontal (H) to 1 vertical (V) or 34 degrees measured from the horizontal. Acceptable configurations are described below.

Option 2: *Maximum allowable slope based on the soil classification type*. A competent person must classify the soil as Stable rock, Type A, Type B, or Type C based on at least one visual and at least one manual analysis. Acceptable soil classification test methods are outlined in Attachment 3. The maximum allowable slope for given soil classifications is presented in Table 1 below.

Maximum Allowable Slope.

The maximum allowable slope for a soil or rock deposit shall be determined from Table 1 below.

Table 1. Maximum Allowable Slopes

Soil Type	Maximum Allowable Slopes (H:V)[1] for Excavations Less Than 20 Feet Deep[2]
Stable rock	Vertical (90 degrees)
Type A	¾ : 1 (53 degrees)
Type A – open less than 24 hours and 12' or less in depth	½ : 1 (63 degrees)
Type B	1: 1 (45 degrees)
Type C	1 ½ : 1 (34 degrees)

[1] Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.
[2] Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered PE.

Actual Slope (for Options 1 and 2 above)

- The actual slope shall not be steeper than the maximum allowable slope.
- The actual slope shall be less steep than the maximum allowable slope, when there are signs of distress. If that situation occurs, the slope shall be cut back to an actual slope which is at least 1/2 horizontal to one vertical (1/2H:1V) less steep than the maximum allowable slope.
- When surcharge loads from stored material or equipment, operating equipment, or traffic are present, a competent person shall determine the degree to which the actual slope must be reduced below the maximum allowable slope, and shall assure that such reduction is achieved. Surcharge loads from adjacent structures shall be evaluated in accordance with 1926.651(i).

Option 3: *Maximum allowable slope based on other tabulated data, such as tables and charts*. The identity of the approving registered professional engineer must be stamped on the data. The tabulated data must be in written form, describing detailed information on its use and limitations, and must be at the jobsite during construction of the protective system.

Option 4: *Sloping or benching designs prepared and approved by a registered professional engineer*. The identity of the registered professional engineer who approved the data must be stamped on the design. The design must identify the project and the configurations must be determined safe for the project. The design must be at the jobsite during construction of the protective system.

3.2.2 Slope Configurations

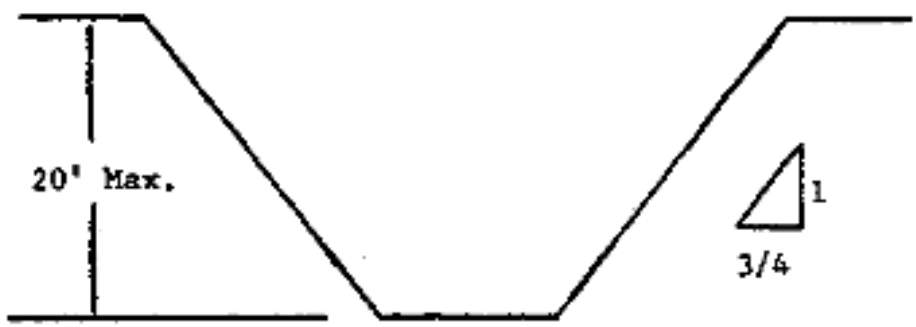
Slope configurations of sloping and benching systems shall be in accordance with the figures below for each soil type (All slopes stated below are in the horizontal to vertical ratio).

EXCAVATIONS MADE IN TYPE A SOIL

Simple Slopes

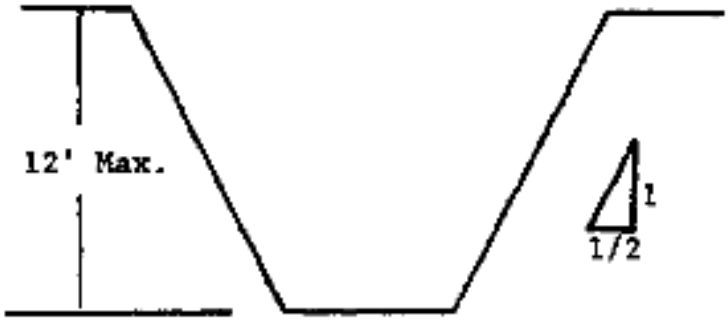
Simple Slope - General

All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of **3/4:1**.



Simple Slope - Short Term

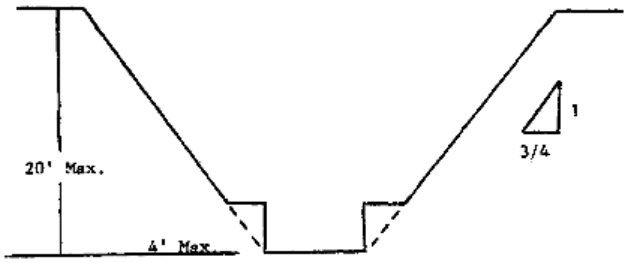
Simple slope excavations which are open 24 hours or less (short term) and which are 12 feet or less in depth shall have a maximum allowable slope of **1/2:1**.



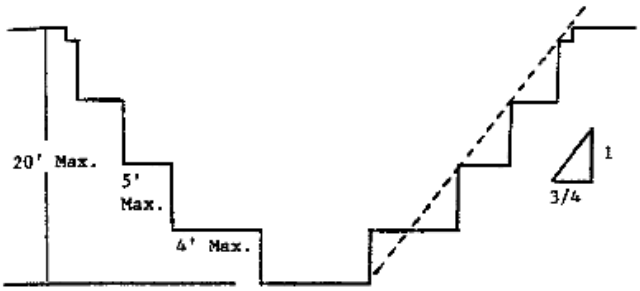
Benched Excavations

Simple Bench

All benched excavations 20 feet or less in depth shall have a maximum allowable slope of **3/4:1** and maximum bench dimensions as follows:



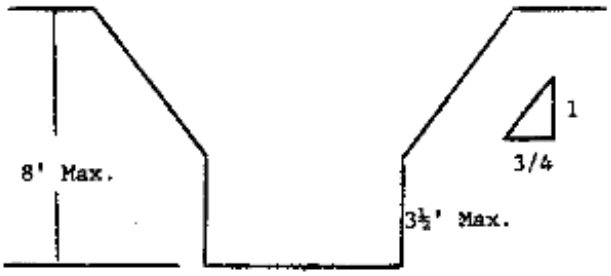
Multiple Bench



Unsupported & Supported Vertical Sided Lower Portion Excavations

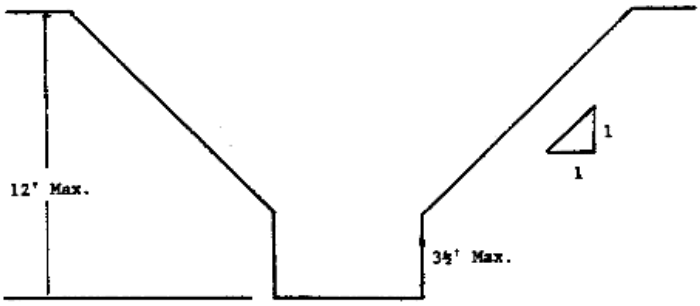
All excavations 8 feet or less in depth which have unsupported vertically sided lower portions shall have a maximum vertical side of **3 1/2 feet**.

Unsupported Vertically Sided Lower Portion - Maximum 8 Feet In Depth



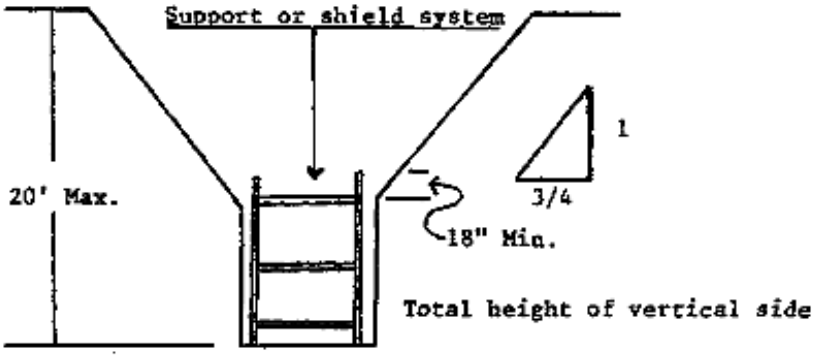
All excavations more than 8 feet but not more than 12 feet in depth with unsupported vertically sided lower portions shall have a maximum allowable slope of **1:1** and a maximum vertical side of **3 1/2 feet**.

Unsupported Vertically Sided Lower Portion - Maximum 12 Feet In Depth



All excavations 20 feet or less in depth which have vertically sided lower portions that are supported or shielded shall have a maximum allowable slope of **3/4:1**. The support or shield system must extend at least 18 inches above the top of the vertical side.

Supported or Shielded Vertically Sided Lower Portion

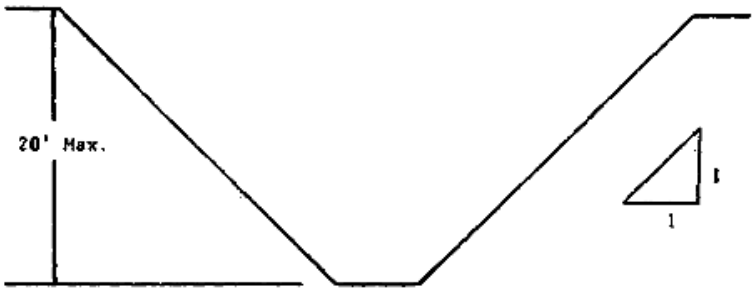


All other simple slope, compound slope, and vertically sided lower portion excavations in Type A soil shall be in accordance with the other options permitted under 1926.652(b).

EXCAVATIONS MADE IN TYPE B SOIL

Simple Slope

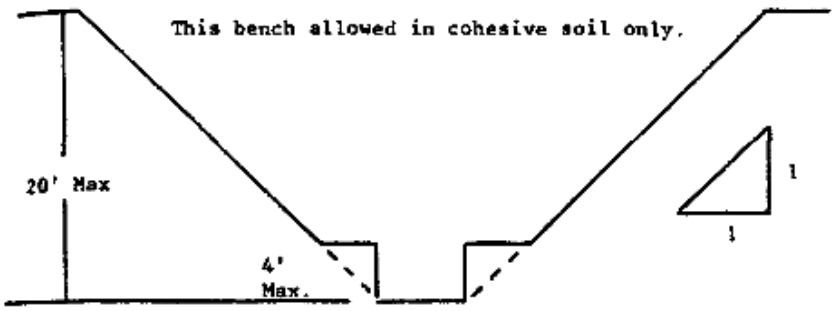
All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of **1:1**.



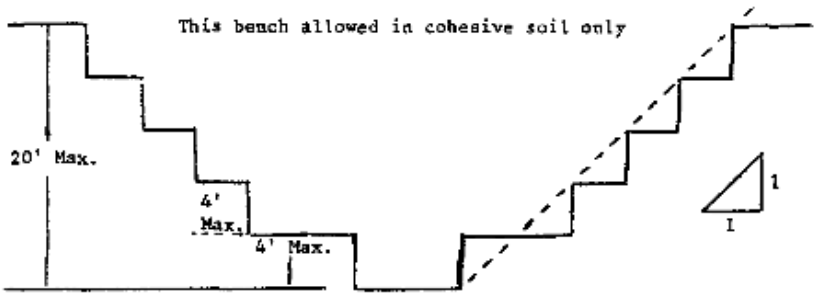
Benched Excavations

All benched excavations 20 feet or less in depth shall have a maximum allowable slope of **1:1** and maximum bench dimensions as follows:

Single Bench



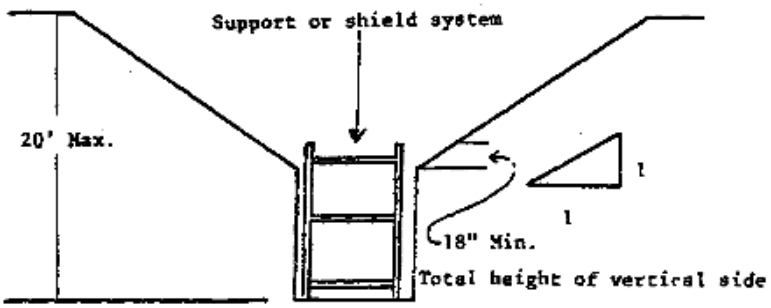
Multiple Bench



<u>Vertical Sided Lower Portion</u>

All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height <u>at least 18 inches above</u> the top of the vertical side. All such excavations shall have a maximum allowable slope of **1:1**.

Vertically Sided Lower Portion

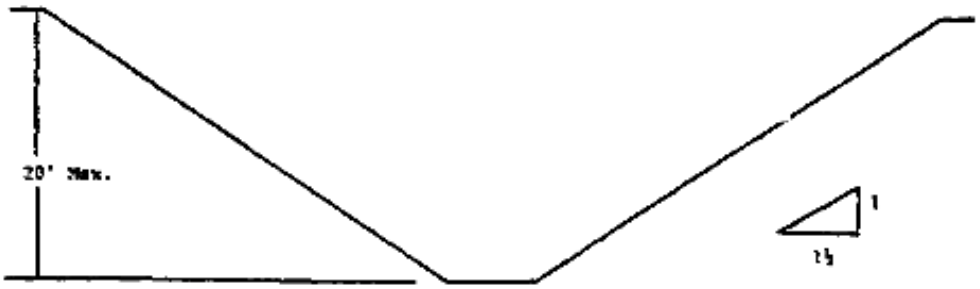


All other sloped excavations in Type B soil shall be in accordance with the other options permitted in 1926.652(b).

EXCAVATIONS MADE IN TYPE C SOIL

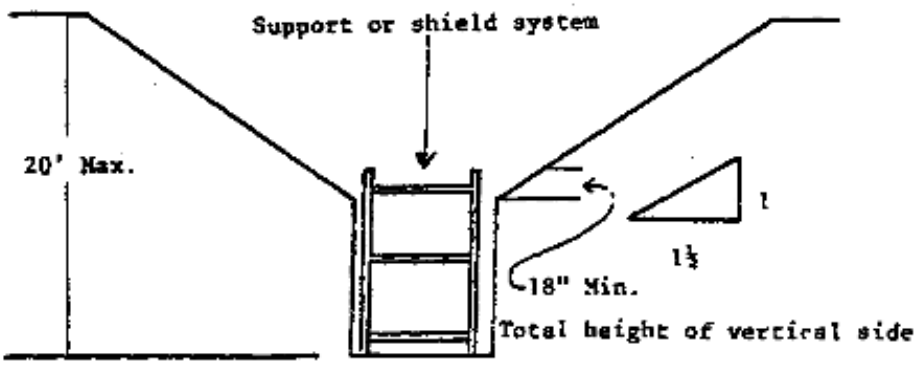
All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of **1 1/2:1**.

Simple Slope



2. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of **1 1/2:1**.

Vertical Sided Lower Portion

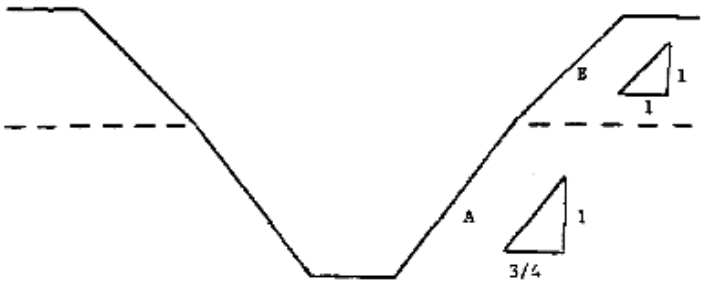


All other sloped excavations in Type C soil shall be in accordance with the other options permitted in 1926.652(b).

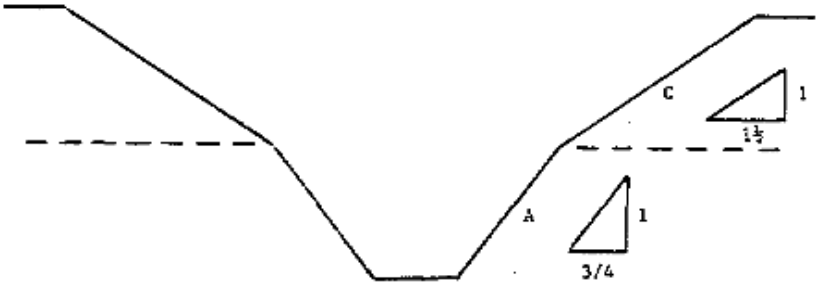
EXCAVATIONS MADE IN LAYERED SOILS

All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below. (A, B, & C below represent the soil type as defined in Attachment C)

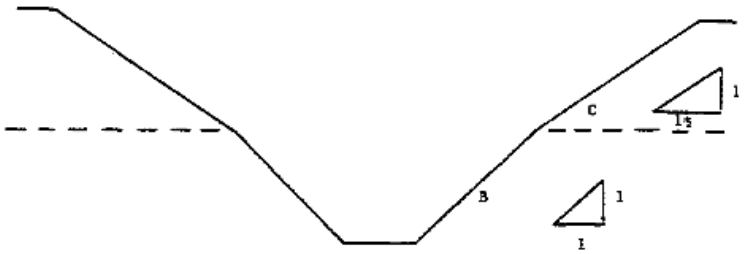
Type B over Type A



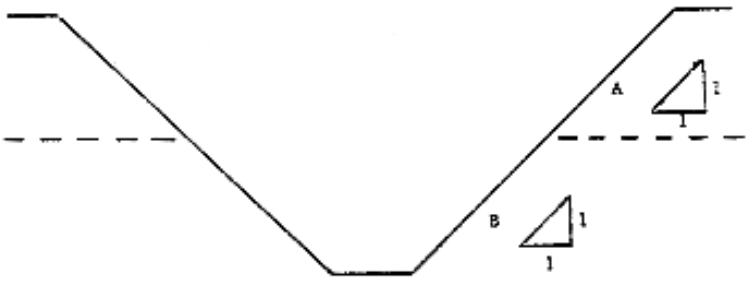
Type C over Type A



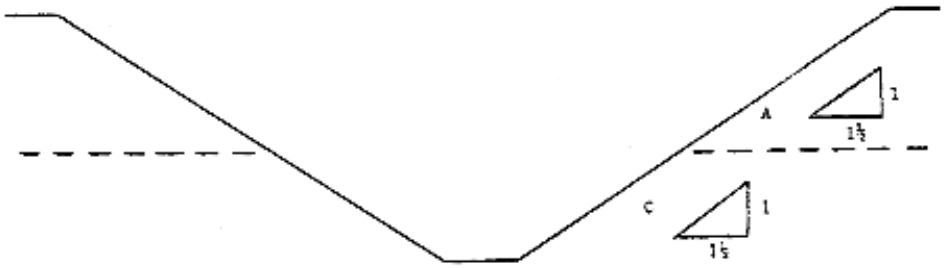
Type C over Type B



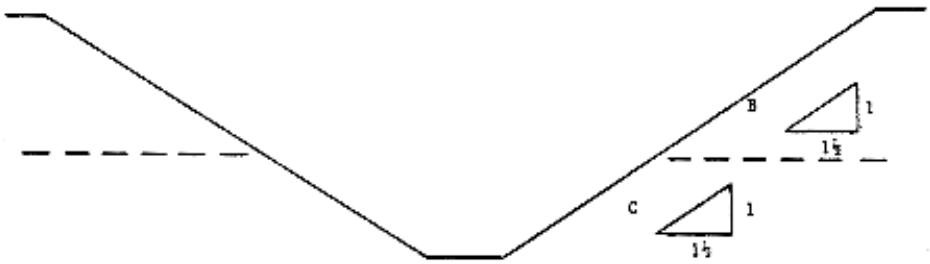
Type A over Type B



Type A over Type C



Type B over Type C



All other sloped excavations in layered soil types shall be in accordance with the other options permitted in 1926.652(b).

3.3 Shoring, Shielding and Other Protective Systems

Shoring, shielding, and other protective systems must be selected and constructed by using one of the following options. Soil classification using Attachment 3 is required for each option.

Option 1: Timber shoring design determined in accordance with the conditions and requirements of Appendix C of OSHA 29 CFR 1926 Subpart P. Aluminum hydraulic shoring design determined in accordance with Option 2, unless the manufacturer's tabulated data cannot be utilized. In such cases Appendix D of OSHA 29 CFR 1926 Subpart P shall be followed. This option may only be used for excavations 20 feet or less in depth.

Option 2: Designs for protective systems determined in accordance with the specifications,

recommendations, and limitations of the manufacturer's tabulated data. The manufacturer must issue written approval to deviate from these requirements and the approval must be available at the jobsite.

Option 3: Protective system designs determined using other tabulated data, such as tables and charts. The identity of the approving registered professional engineer must be stamped on the data. The tabulated data must be in written form, describing detailed information on its use and limitations, and must be at the jobsite during construction of the protective system.

Option 4: Protective system designs prepared and approved by a registered professional engineer. The identity of the registered professional engineer who approved the data must be stamped on the design. The design must identify the project and the configurations must be determined safe for the project. The design must be in written form, describing detailed information on its use and limitations, and must be at the jobsite during construction of the protective system.