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Hazardous Waste Bureau
2905 Rodeo Park Drive East
Santa Fe NM 87105-6303

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OCT 2008
NMED Hazardous Waste Bureau

FROM: 49 CES/CD
550 Tabosa Ave
Holloman AFB NM 88330-8458

Subject: SWMU 8 Voluntary Corrective Measures Work Plan Corrections Holloman AFB, NM6572124422 HWB-HAFB

1. The subject pages are hereby submitted to NMED for review and insertion.

2. I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

3. If you have any questions, please feel free to contact Mr. David Scruggs at (575) 572-5395.

A. DAVID BUDAK
Deputy Base Civil Engineer

Attachment:
SWMU 8 VCM Work Plan pages

cc:

(w/Atch)	(w/o Atch)	(w/o Atch)
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dh

FINAL
VOLUNTARY CORRECTIVE MEASURES WORK PLAN

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SWMU 8 SOIL REMEDIATION
HOLLOMAN AFB, NEW MEXICO

Prepared For:

49 CES/CEV
Holloman Air Force Base
New Mexico

Under Contract To:

U.S. Army Corps of Engineers
Omaha District
Omaha, Nebraska

October 2008
~~December 2005~~

Contract No.: DACA45-03-D-0023
Task Order No.: 017
Bhate Project No.: 9050291.01.01

Prepared By:

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VOLUNTARY CORRECTIVE MEASURES WORK PLAN
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October 2008
~~December 2005~~

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FINAL

VOLUNTARY CORRECTIVE MEASURES WORK PLAN
SWMU 8 SOIL REMEDIATION
HOLLOMAN AFB, NEW MEXICO

REVIEW SHEET

This Work Plan has been reviewed and approved by:

John Hymer Site Manager	Signature	Date
Jim Moore, P.G. Project Manager	Signature	Date
Frank Gardner, P.G. Program Manager	Signature	Date

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VOLUNTARY CORRECTIVE MEASURES WORK PLAN
SWMU 8 SOIL REMEDIATION
HOLLOMAN AFB, NEW MEXICO

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Attachments

Attachment 1 NMED Notice of Deficiency HWB-HAFB-06-002, April 14, 2006

Attachment 2 Response to NMED Notice of Deficiency HWB-HAFB-06-002, June 12, 2006.

Attachment 3 NMED Notice of Approval to Notice of Deficiency, October 12, 2006.

Appendices

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Appendix A3	Portions of *Technical Memorandum Letter Report for SWMU 8 Soil and Groundwater Sampling and Analysis, Holloman AFB NM*, Bhate Environmental Associates, August 2006
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Appendix C	Base Civil Engineer Work Request Air Force Form 332
Appendix D	EPA Innovative Technology Verification Report: *Field Measurement Technologies for Total Petroleum Hydrocarbons in Soil,* September 2001
Appendix E	*NMED TPH Screening Guidelines, October 2006*
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Appendix G	ASTM *Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)*
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Appendix J	NMED Soil Screening Levels, Revision 4.0, June 2006
Appendix K	Site-Specific Addendum to the Basewide Health and Safety Plan

ACRONYMS AND ABBREVIATIONS

AAF	Army Air Field
AFB	Air Force Base
AFCESA	Air Force Civil Engineer Support Agency
AF Fm	Air Force Form
amsl	Above mean sea level
ANSI	American National Standards Institute
AOC	Area of Concern
ASTM	American Society for Testing and Materials
bgs	Below ground surface
Bhate	Bhate Environmental Associates, Inc.
BTEX	Benzene, toluene, ethylbenzene, and xylenes
btoc	Below top of casing
CDW	Construction-Derived Waste
CES/CEV	Civil Engineering Squadron/Combat Engineer Vehicle
CIH	Certified Industrial Hygienist
COC	Chain-of-custody
CRZ	Contamination Reduction Zone
cu yds	Cubic yards
DPT	Direct Push Technology
DQO	Data quality objective
DRO	Diesel range organics
ERPIMS	Environmental Restoration Program Information Management System
EZ	Exclusion Zone
°F	Degrees Fahrenheit
FID	Flame ionization detector
ft	Feet
GC	Gas chromatogram
GRO	Gasoline range organics
HAFB	Holloman Air Force Base
HASP	Health and Safety Plan
IRP	Installation Restoration Program
ln ft	Linear feet
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
µg/kg	Micrograms per kilogram
mL	Milliliter
MS	Matrix spike
MSD	Matrix spike duplicate
NAVFAC	Naval Facilities Engineering Command
NFA	No further action
NMAC	New Mexico Administrative Code

NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
NOA	Notice of Approval
NOD	Notice of Deficiency
ORO	Oil range organics
OSHA	Occupational Safety and Health Administration
OVA	Organic vapor analyzer
OWS	Oil/Water Separator
PAH	Polynuclear aromatic hydrocarbons
PCB	Polychlorinated Biphenyl
PCS	Petroleum-contaminated soils
P.G.	Professional Geologist
PID	Photo ionization detector
POL	Petroleum, Oil, and Lubricants
PPE	Personal protective equipment
ppm	Parts per million
PVC	Polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
SOP	Standard Operating Procedure
SSHO	Site Safety and Health Officer
SSL	Soil Screening Level
SVOC	Semi-volatile organic compounds
SWMU	Solid Waste Management Unit
SWPPP	Storm Water Pollution Prevention Plan
SZ	Support Zone
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total dissolved solids
TPH	Total petroleum hydrocarbons
TRPH	Total recoverable petroleum hydrocarbons
TSD	Treatment, storage, and disposal
UFGS	Unified Facilities Guide Specifications
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
UVF	Ultra violet flourometer
VCMs	Voluntary Corrective Measures
VOC	Volatile organic compounds
WOT	Waste Oil Tank
WRCC	Western Regional Climate Center
WSMR	White Sands Missile Range
WWTF	Waste water treatment facility

1 INTRODUCTION

Bhate Environmental Associates, Inc., (Bhate) has been retained by the U.S. Army Corps of Engineers (USACE), under contract DACA45-03-D-0023, Task Order No. 017, to conduct Voluntary Corrective Measures (VCMs) at several of the Solid Waste Management Units (SWMUs) at Holloman Air Force Base (HAFB), New Mexico. This document is to provide a work plan that will serve as the primary working document for the excavation activities of the petroleum-contaminated soils (PCS) located at SWMU 8 (former Oil/Water Separator) on the south side of Building 231. This plan provides the relevant site specific information and requirements as outlined in the respective Scope of Work for remedial activities at SWMU 8 Soil Remediation. The primary objective of this VCM is to remove, through excavation, and properly dispose the PCS under the covered walkway located between Buildings 231 and 232. Groundwater and soil conditions under Buildings 231 and 232 will be evaluated under a separate Work Plan Addendum. During this process, required data will be collected to support the closure of the site based on guidance from the New Mexico Environment Department (NMED). The ultimate objective is to achieve approval for site closure from NMED.

A Notice of Deficiency (NOD) letter from NMED to HAFB dated April 14, 2006, stated the Base needed to conduct additional site characterization activities prior to conducting the SWMU 8 VCM Soil Remediation Work Plan (Phase III PCS excavation). Comments received from NMED on the NOD (HWB-HAFB-06-002) are provided in Attachment 1. The NOD also required HAFB to utilize the residential NMED Total Petroleum Hydrocarbon (TPH) Screening Guideline for an "unknown oil" (800 milligrams per kilogram [mg/kg]) for performing all subsequent work at SWMU 8. On behalf of HAFB, Bhate submitted a response letter to this NOD from the NMED on June 12, 2006 (Attachment 2). In the response letter, Bhate agreed to make appropriate changes to the SWMU 8 VCM Work Plan based on the NMED comments. Bhate also stated that the additional delineation of soil and groundwater was performed in May 2006, based on the *Memorandum Scope of Work for Soil and Groundwater Sampling and Analysis* (Bhate, 2006a).

In response to the NMED NOD dated April 14, 2006, Bhate was subcontracted to address the recommendations made by NMED concerning additional site characterization. The primary objective of this investigation was to characterize potential soil contamination at the site (that was not underneath the adjacent structures) and to install and sample three groundwater monitoring wells. This additional work had to be completed prior to the approval of the SWMU 8 VCM Work Plan. The field work for the SWMU 8 Additional Site Characterization was conducted in accordance with the *Memorandum Scope of Work for Soil and Groundwater Sampling and Analysis* (Bhate, 2006a) which was verbally approved by the NMED. Results from the additional characterization performed by Bhate in 2006 were reported in the *Technical Memorandum Letter Report for SWMU 8 Soil and Groundwater Sampling and Analysis, Holloman AFB NM* (Bhate, 2006b) (provided in Appendix A3 of this Work Plan).

A notice of approval (NOA) letter from NMED to HAFB dated October 12, 2006 (Attachment 3), stated that NMED concurred with the responses to the NOD letter along with stating that NMED had reviewed the *Memorandum Scope of Work for Soil and Groundwater Sampling and Analysis* (Bhate, 2006a) and *Technical Memorandum Letter Report for SWMU 8 Soil and Groundwater Sampling and Analysis, Holloman AFB NM* (Bhate, 2006b).

As per the NMED NOA letter (Attachment 3) this Work Plan includes all of the required changes indicated in the NOD response letter (Attachment 2).

This document has been written to provide relevant information on the geologic, hydrologic, and other environmental conditions for HAFB and at the site, and the procedures by which the VCM will be completed. Information is provided for the entire Base and its surrounding environ as well as SWMU 8, specifically. This VCM calls for the removal of all PCS at the site through excavation with verification of complete removal via confirmation sampling from the excavation.

1.1 Base and Site Description

1.1.1 HAFB

HAFB is located in southeastern New Mexico in Otero County, New Mexico, approximately 100 miles north-northeast of El Paso, Texas, and 6 miles west of Alamogordo, New Mexico (Figure 1). The following Base information has been taken from: the *Characterization Summary and No Further Action (NFA) Documentation for Installation Restoration Program (IRP) Sites SS-2/5 POL* [Petroleum, Oil, and Lubricants] *Yard (AOC* [Area of Concern] *T), SD-47 POL Washrack Area (SWMU 133), and SS-60 Building 828 (SWMU 230)* by Foster Wheeler (March, 1998) and the *2001 Long-Term Groundwater Monitoring Report, Holloman Air Force Base, New Mexico,* by Foster Wheeler (July 2002). Although neither document pertains directly to the SWMU 8 Soil Remediation site, they do contain descriptive information regarding the Base and general area.

HAFB was first established in 1942 as Alamogordo Army Air Field (AAF). From 1942 through 1945, Alamogordo AAF served as the training grounds for over 20 different flight groups, flying primarily B-17s, B-24s, and B-29s. After World War II, most operations had ceased at the base. In 1947, Air Material Command announced the air field would be its primary site for the testing and development of un-manned aircraft, guided missiles, and other research programs. On January 13, 1948, the Alamogordo installation was renamed Holloman Air Force Base, in honor of the late Col. George V. Holloman; a pioneer in guided missile research. In 1968, the 49th Tactical Fighter Wing arrived at HAFB and has remained since. Today, HAFB also serves as the training center for the German Air Force's Tactical Training Center.

1.1.2 SWMU 8 Site

SWMU 8 is the former underground Oil/Water Separator (OWS) that was located on the south side of Building 231. Building 231 (Auto Hobby Center) is located on the main base at Holloman at 642 West Connecticut Avenue (Figure 2). The OWS was abandoned and filled with sand (Ebasco Services, Inc., 1995). The OWS was 4 feet wide, 8 feet long, and 4 feet deep and was located east of the covered walkway which connects Buildings 231 and 232. Two previous remedial action soil excavations conducted by Ebasco Services (1995) and Foster Wheeler (1997) have removed 80-90 percent of the PCS and the abandoned OWS. Viewing from the southwest, photograph 1, shows the covered walkway and the approximate area where the remaining PCS is located. The locations of the two previous soil excavations are located behind the covered walkway where the shed is located.

Photograph 1. Southwest view of SWMU 8 PCS/Excavation Area

Records indicate that the OWS accepted wash water from a heavy equipment wash rack located adjacent to the unit. Over a period of years, the OWS released wash water rinsate containing oils, detergents, and fuels into the surrounding soil. The initial removal and investigation/ characterization activities began in August 1995 when the abandoned OWS and 21 cubic yards (cu yds) (28 tons) of PCS were removed (Ebasco Services, Inc., 1995). Figure 3 shows the location of the former OWS, and the limits of this excavation.

It was then discovered that contaminated soil extended beyond what had been anticipated for the first phase of remediation. After removal, contamination was identified in the five native subsurface soil samples collected from the excavation corners and one from the center of the excavation. These soil samples were analyzed for total recoverable petroleum hydrocarbons

(TRPH), volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), and Target Analyte List (TAL) metals. All five soil samples obtained from this excavation exceeded the current NMED TPH Screening Guidelines for an Unknown Oil of 800 (mg/kg) (NMED, 2006b). Field activities were postponed in order to determine the most efficient method of closure. The initial excavation was backfilled with clean soil compacted to grade. Subsequently, NMED approved leaving intact TRPH-contaminated soil that extended under in-place structures as long as it posed no risk. Due to this agreement, excavation was determined to be the best closure method (Ebasco, 1995). Excavation activities were continued in April 1997, and the original excavation was extended eastward from the eastern edge of the original excavation (Figure 4). An additional 31.8 cu yds (43 tons) of TRPH-contaminated soil were excavated during the second phase of remediation. Four representative samples of in-place soil were taken from the walls of the new excavation and analyzed for TRPH; VOCs; SVOCs; benzene, toluene, ethylbenzene, and xylenes (BTEX); and metals. The second-phase analytical results, which represent in-place soil conditions upon completion of excavation activities, did not exceed the current NMED TPH Screening Guidelines (NMED, 2006b)~~(NMED, November, 2005)~~. The second excavation was backfilled with clean soil (Foster Wheeler, 1997).

In May 2006 site characterization was performed by Bhate. Three soil borings were advanced using Direct Push Technology (DPT) and converted into 1-inch groundwater monitoring wells (Figure 1, Appendix A3). Soil samples were collected and analyzed for VOCs, SVOCs, TPH-gasoline range organics (GRO), TPH-diesel range organics (DRO), TPH-oil range organics (ORO), TAL metals, and Polychlorinated Biphenyls (PCBs). Groundwater was sampled from the newly installed monitoring wells for VOCs, SVOCs, TPH (DRO/ORO), PCBs, TAL metals, and total dissolved solids (TDS). None of the soil or groundwater samples obtained during this field event contained concentrations which exceeded the current NMED TPH Screening Guidelines (NMED, 2006b). Based on the data generated in this additional site characterization, the extent of soil and groundwater contamination (not underneath adjacent structures) was adequately defined.

1.2 Physiography

1.2.1 Tularosa Basin

HAFB is located within the Sacramento Mountains Physiographic Province on the western edge of the Sacramento Mountains. The region is characterized by high tablelands with rolling summit plains; cuesta-formed mountains dipping eastward and of west-facing escarpments with the wide bracketed basin forming the basin and range complex. HAFB is located in the Tularosa Sub-basin which is part of the Central Closed Basins. The San Andreas Mountains bound the basin to the west (about 30 miles) with the Sacramento Mountains approximately 10 miles to the east. At its widest, the basin is about 60 miles east to west and stretches approximately 150 miles north to south.

1.2.2 HAFB and SWMU 8 Site

HAFB is approximately 59,600 acres in area, and is located at a mean elevation of 4,093 feet above mean sea level (ft amsl). The site's ground surface is relatively flat and covered with gravel, concrete sidewalks, and asphalt parking lots (Figure 3). The covered walkway which connects Buildings 231 and 232 extends over the remaining area of PCS.

1.3 Surface Water

1.3.1 Tularosa Basin

The Tularosa Basin contains all of the surface flow in its boundaries. The nearest inflow of surface waters to the Base comes from the Lost River, located in the north-central region of the Base. The upper reaches of the Three Rivers and the Sacramento River are perennial in the basin. HAFB is dissected by several southwest trending arroyos that control the surface drainage. Hay Draw arroyo is located in the far north. Malone and Rita's Draw, which drain into the Lost River, and Dillard Draw arroyos are located along the eastern perimeter of the Base. Approximately 10,000 years ago, indications are of a much wetter climate as evidenced by the ancient Lake Otero which encompassed a much larger area of possibly upwards of several hundred square miles. Its remains are the Alkali Flat (the exposed lake bed of Lake Otero) and Lake Lucero. Lake Lucero is a temporary feature of merely a few inches in depth during the rainy season as the dry lake bed occasionally partially fills with water.

The ancient lakes and streams deposited water bearing deposits over the older bedrock basement material. Fractures, cracks, and fissures, in the Permian and Pennsylvanian bedrock, yield small quantities of relatively good quality water in the deeper peripheral. Potable water is only found from a handful of wells near the edges of the basin with more saline water towards the center. Two of the principal sources of potable water are a long narrow area on the upslope sides of Tularosa and Alamogordo with the other in the far southwestern part of the basin. Alamogordo's water, as well as the Base's, is supplied from Lake Bonito (which is in the Pecos River Basin).

1.3.2 HAFB and SWMU 8 Site

Within the boundaries of the SWMU 8 Soil Remediation site, the run-off is controlled by the minimal topographic relief as per the existing grade and landscaping with surface drainage towards the adjacent asphalt parking area. Appurtenances can be found placed along the perimeter of the parking area to the southwest for collection into the Base storm water drainage system. Within the walled area of the site, open non-concrete (gravel) areas will allow for precipitation to percolate downward and/or evaporate.

1.4 Groundwater

1.4.1 Tularosa Basin

Groundwater occurs under unconfined conditions in the unconsolidated deposits beneath HAFB. The primary source of recharge for groundwater in the aquifer is percolation of rainfall and stream runoff through the coarse, unconsolidated alluvial fan deposits along the western flank of the Sacramento Mountains. Groundwater percolates downward into the alluvial sediments at the edge of the shallow aquifer and migrates down-gradient through progressively finer-grained sediments into the basin.

1.4.2 HAFB and SWMU 8 Site

Beneath HAFB, groundwater ranges from 5 to 50 ft. Groundwater flow is generally towards the southwest with localized influences from the variations in the topography of the Base. Near the arroyos, groundwater flows directly toward the surface drainage feature. Depth to groundwater at the Building 231 former OWS location is approximately ~~10~~ 5 to 6 feet below ground surface (ft bgs) based on observations during the previous remedial actions and investigations and flows to the west-southwest.

Previous analyses indicate TDS of greater than 10,000 milligrams per liter (mg/L) in groundwater beneath HAFB. This exceeds the New Mexico Water Quality Control Commission (NMWQCC) limit as potable water and thus, the groundwater beneath HAFB has been designated as unfit for human consumption. Likewise, United States Environmental Protection Association (USEPA) guidelines have identified the groundwater as a Class IIIB water source, characterized by TDS concentrations exceeding 10,000 mg/L. Previous groundwater sampling at SWMU 8 showing low TDS indicate influence on groundwater depth and flow direction from leaking underground water supply lines in the vicinity of Building 232.

1.5 Climate

As a whole, New Mexico has a mild, arid to semi-arid continental climate characterized by light precipitation totals, abundant sunshine, relatively low humidity and relatively large annual and diurnal temperature range (Western Regional Climate Center [WRCC], 2003). The climate of the Central Closed Basins varies with elevation. The Base is found in the low areas and is characterized by warm temperatures and dry air. Daytime temperatures often exceed 100 degrees Fahrenheit (°F) in the summer months and middle 50s in the winter. A preponderance of clear skies and relatively low humidity permits rapid night time cooling resulting in average diurnal temperature ranges of 25 to 35°F. Potential evapotranspiration, at 67 inches per year, significantly exceeds annual precipitation, usually less than 10 inches. The very low rainfall amounts resulting in the arid conditions, which with the topographically induced wind patterns combining with the sparse vegetation, tend to cause localized "dust devils". Much of the

precipitation falls during the mid-summer monsoonal period (July and August) as brief, yet frequent, intense thunderstorms culminating to 30 – 40% of the annual total rainfall.

1.6 Geology

1.6.1 Tularosa Basin

The sedimentary rocks which make up the adjacent mountain ranges are between 500 and 250 million years old (White Sands Missile Range [WSMR], 2003). During the period when the area was submerged under the shallow intra-continental sea, the layers of limestone, shale, gypsum, and sandstone were deposited. In time, these layers were pushed upward by tectonic forces forming a large bulge on the surface. Approximately 10 million years ago the center began to subside resulting in a vertical drop of thousands of feet leaving the edges still standing (the present day Sacramento and San Andreas mountain ranges). In the millions of years following, rainfall, snowmelt, and wind eroded the mountain sediments depositing the alluvium in the basin (i.e. Tularosa Sub-basin). Water carrying eroded gypsum and alluvium continues to flow into the basin with no route of exit.

The Tularosa Sub-basin is geologically described as a bolson, which is an extensive flat alluvium-floored depression, into which drainage from the surrounding mountains flows toward a central playa. The overlying alluvium generally consists of unconsolidated gravels (limestone, dolomite, and gypsum), sands, and clays. A fining sequence from the San Andreas and Sacramento Ranges towards the basin's center characterizes the area with the near surface soils as alluvial, eolian, and lacustrine deposits. The alluvial fan deposits are laterally discontinuous units of interbedded sand, silt, and clay while the eolian deposits consist primarily of gypsum sands. The eolian and alluvial deposits are usually indistinguishable due to the reworking of the alluvial sediment by eolian processes. The playa, or lacustrine deposits, consist of silty clay containing gypsum and are contiguous with the alluvial fan and eolian deposits.

Mesozoic rocks in the northwest mark the Colorado Plateau, topped by younger Tertiary strata. Quaternary age sediments have washed off the Southern Rockies into the open basins and the Rio Grande Rift, a failed spreading center or aulacogen. This would-be ocean basin runs up the center of the state with the Rio Grande flowing down its middle, exposing the Paleozoic and Precambrian rocks on its uplifted flanks. Later Cenozoic volcanic intrusions of Quaternary and Tertiary age are also associated with the rifting.

The great Permian Basin of Texas continues into the state from the southeast with younger Quaternary-Tertiary sediments of the Great Plains cover the whole eastern edge. Basin-and-range terrain of Tertiary sediments and volcanics appear in the extreme southwest coupled with wide dry basins choked with Quaternary coarse sediments eroded from the blocks of uplifted older rocks.

1.6.2 HAFB and SWMU 8 Site

The lacustrine deposits are observed throughout HAFB. There has been the identification of stiff caliche layers, varying in thickness, as well at different areas of HAFB. At the site, soils are predominantly silty sands and interbedded clays.

In general, subsurface soils at the site consist of slightly moist clayey silts with varying amounts of medium to fine sand and caliche to depths ranging from 4 to 5 ft bgs. These soils display low to no plasticity and weak cementation of the caliche fraction. Generally, soils beneath 5 ft are characterized as silty medium to fine sands and sandy silts with occasional layers demonstrating higher percentages of clay content. Soils tend to be moist to saturated below the water table.

2 HISTORICAL DATA REVIEW

2.1 Phase I Oil Water Separator Remedial Action

In August 1995, Ebasco removed the abandoned OWS, excavated 21 cu yds of PCS and initiated characterization of the surrounding subsurface soil. As part of the first phase of the project, five native soil closure samples were collected inside the excavation and submitted to an offsite laboratory for analysis (Appendix A1). Four samples were collected from the excavation corners (SWMU-8-01-7 through SWMU-8-04-7), and one from the center of the excavation (SWMU-8-05-7) at a depth of 7 ft bgs (Ebasco, 1995). The sample locations are shown on Figure 3 of this Work Plan.

The five closure samples were analyzed for TRPH, VOCs, SVOCs, and TAL metals. TRPH concentrations of 23,000 mg/kg, 31,000 mg/kg, 6,500 mg/kg, 1,200 mg/kg, and 940 mg/kg were present in samples SWMU-8-01-7, SWMU-8-02-7, SWMU-8-03-7, SWMU-8-04-7, and SWMU-8-05-7, respectively. Several VOC analytes by USEPA Method 8240 were detected in samples SWMU-8-01-7 and SWMU-8-02-7. No VOC analytes were detected above the laboratory quantitation limits in samples SWMU-8-03-7 through SWMU-8-05-7. In the SVOC samples, naphthalene concentrations were present in SWMU-8-01-7 and SWMU-8-05-7. In addition, 2-methylnaphthalene concentrations were present in samples SWMU-8-01-7 through SWMU-8-03-7. None of the other SVOC analytes in USEPA Method 8270 were detected above laboratory quantitation limits in any of the samples. USEPA 6000/7000 Series TAL metals analytical results indicated various metals in all five samples (Ebasco, 1995). With the exception of TRPH, all of the detected petroleum-related compounds were below the current NMED TPH Screening Guidelines (~~NMED, November, 2005~~NMED, 2006b) and all metals were below the NMED Soil Screening Levels (~~NMED, August, 2004~~NMED, 2006a).

2.2 Phase II Petroleum Contaminated Soil Remedial Action

In April 1997, Foster Wheeler extended the original excavation eastward from the eastern edge of the previous excavation and removed an additional 31.8 cu yds of PCS. During the second phase of the project, four soil samples (SWMU08-01-06 through SWMU08-04-06) were taken from the walls of the second excavation (approximately 6 ft bgs) and submitted to an offsite laboratory for analysis (Appendix A2). These samples were analyzed for TRPH, VOCs, SVOCs, BTEX, and metals. The sample locations are illustrated on Figure 4 of this work plan.

TRPH concentrations of 78 mg/kg, <20 mg/kg, 58 mg/kg, and 25 mg/kg were present in samples SWMU08-01-06, SWMU08-02-06, SWMU08-03-06, and SWMU08-04-06, respectively. VOCs (by USEPA Method 8240), SVOCs (USEPA Method 8270B), and BTEX (USEPA Method 8021A) were not detected above laboratory quantitation limits in any of the samples. The analytical results, which represent in-place soil conditions upon completion of the second excavation, did not exceed the current NMED TPH Screening Guidelines (NMED,

2006b~~NMED, November, 2005~~) and all metals were below the NMED Soil Screening Levels (NMED, 2006a~~NMED, August, 2004~~).

2.3 SWMU 8 Additional Site Characterization

In May 2006, Bhate drilled 3 soil borings which were converted into permanent groundwater monitoring wells (SWMU-8-DP01 through SWMU-8-DP03). The locations of the soil borings and subsequent monitoring wells are illustrated on Figure 1 in Appendix A3 of this work plan. Monitoring wells were constructed with 0.02-inch slot pre-packed polyvinyl chloride (PVC) screens and completed at the surface with a protective flush mount cover. One soil sample was collected from SWMU-8-DP01 and SWMU-8-DP02 for laboratory analysis. A soil sample was not collected from SWMU-8-DP03 as this borehole was installed within clean backfill from the Phase II excavation. Appendix A3 contains the boring logs and well construction diagrams for this investigation. Three groundwater samples and a round of water levels were collected from the three monitoring wells on June 7, 2006.

Table 1 in Appendix A3 of this work plan presents the groundwater elevation data collected from the three monitoring wells and a potentiometric surface map was prepared using the data (Figure 2, Appendix A3). The contour map indicates that groundwater flows to the west-southwest across the site at a gradient of approximately 0.013 feet per foot (ft/ft).

2.3.1 Soil Sampling Results

Three soil samples (including one duplicate) were analyzed for VOCs, SVOCs, TPH (GRO/DRO/ORO), TAL metals, and PCBs. Table 2 in Appendix A3 of this work plan presents the analytical results for soil samples collected from the boreholes converted into monitoring wells.

One VOC (naphthalene) was detected in the soil sample collected from SWMU-8-DP01-5; all other VOCs were not detected. The estimated concentration of naphthalene (2.7 micrograms per kilogram [µg/kg]) was well below the NMED soil screening level (SSL) (NMED, 2006a) for naphthalene (79.5 mg/kg). No other SVOCs, TPH (GRO/DRO/ORO), or PCBs were detected. Additionally all TAL metals detected in the subsurface soil samples were below their respective SSL.

2.3.2 Groundwater Sampling Results

The four groundwater samples (including one duplicate) collected from monitoring wells SWMU-8-DP01, SWMU-8-DP02, and SWMU-8-DP03 were analyzed for VOCs, SVOCs, TPH (DRO/ORO), PCBs, TAL metals, and TDS. Table 3 in Appendix A3 of this work plan presents the analytical results for groundwater samples collected from the three monitoring wells installed in May 2006. Low concentrations of four VOCs (bromodichloromethane, chloroform, dibromochloromethane, and o-dichlorobenzene) were detected in the groundwater samples from the three monitoring wells installed at SWMU 8. No other VOCs were detected. All of the

detected VOCs were below the NMWQCC Human Health Standards (New Mexico Administrative Code [NMAC] 20.6.2). No other SVOCs, TPH (DRO/ORO), or PCBs were detected. Additionally, all TAL metals detected in the groundwater samples were below their respective NMWQCC standards.

TDS concentrations ranged from 2,600 to 3,190 mg/L. It was hypothesized that these TDS concentrations are artificially low due to the dilution of natural groundwater from leaking water lines in the area. Interviews with the Postal Service Center (Building 232) personnel indicated that two sink holes had developed along Connecticut Avenue (east side of Building 232) approximately six months prior to this work being completed (Bhate, 2006b). The main Base area at HAFB is known to have a number of leaking underground utilities which can affect groundwater elevations and redirect the local flow direction.

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3 EXCAVATION PROCEDURES

The objective of the soil remediation at SWMU 8 is to excavate, transport, and dispose the remaining PCS located on the southwestern side of the initial excavation (under the covered walkway that connects Buildings 231 and 232). Subsurface soils either contaminated by TPH at levels exceeding ~~880~~ 800 mg/kg or soils posing a risk due to exposures to VOCs and/or SVOCs as established by the NMED soil screening guidance will be removed. Excavation of PCS will also extend to the north of the covered walkway approximately 6 feet. The purpose of extending the excavation north of the covered walkway is to over-excavate the southern portion of the 1995 Ebasco excavation, where TPH levels above 800 mg/kg were encountered in samples SWMU-8-01-7, SWMU-8-04-7, and SWMU-8-05-7 (see Figure 10-1 in Appendix A1 of this work plan). Contaminated soils will be removed to approximately ~~onefoot~~ 5 feet below the site's encountered groundwater table. Groundwater at SWMU 8 has been measured as deep as 5 ft bgs (September, 2008) and as shallow as 2 to 3 ft bgs (Bhate, 2006b) (see Appendix A3 of this work plan). This variation in groundwater depth is due to leaking underground water lines in the vicinity of SWMU 8. Water levels were measured by Bhate in September 2008 on all SWMU 8 monitoring wells. Depth to water in the two monitoring wells in the vicinity of the VCM Excavation (SWMU-8-DP02 and SWMU-8-DP03) was 5.28-ft below top of casing (btoc) and 5.03-ft btoc respectively. Excavating to a depth of 10 to 12 ft below grade ~~This depth~~ will ensure complete removal of PCS and account for any potential smear zone. Horizontally, the excavation will be completed based upon TPH levels of greater than ~~880~~800 mg/kg as determined by soil samples collected subsequent to the excavation and analyzed at a fixed-base laboratory.

The construction general permit requires a project Storm Water Pollution Prevention Plan (SWPPP) to be submitted for excavation sites which will disturb greater than one acre of surface soils. For the planned activities, inclusive of the temporary clean soil stock piles, the total area of disturbance and/or excavation is less than one acre. Therefore, a project SWPPP will not be prepared and submitted.

At this time, excavation is proposed to be bordered to the northwest by Building 231 and to the southeast by Building 232 and will extend approximately ~~15~~ 15 ft to the southwest and 6 feet northeast of the covered walkway wall (see Figure 5 of this work plan). Monitoring well SWMU-8-DP02 which did not show TPH impact will remain intact, as the excavation will terminate prior to the well. Soil analytical data obtained from SWMU-8-DP02 has helped guide the excavation proposed in this Work Plan. Soil and groundwater conditions under Buildings 231 and 232 will be evaluated under a separate Work Plan Addendum. Except where noted below, the excavation activities will be conducted in accordance with the procedures outlined in Unified Facilities Guide Specifications (UFGS) Section 02111 *Excavation and Handling of Contaminated Material* (included in Appendix B of this work plan). The UFGS are a joint effort of the USACE, the Naval Facilities Engineering Command (NAVFAC), and the Air Force Civil Engineer Support Agency (AFCESA). The UFGS are for use in providing construction specifications and guidelines for the military services.

3.1 Pre-Excavation Activities

Before excavation and other site activities can begin, there are several pre-construction documents and approval requirements to be met, including: Form 332 approval, dig permit with utility clearances, site security measures, and facility manager notification of the intended operations. Bhate will coordinate project requests for Base installation support services through the 49th Civil Engineering Squadron/Combat Engineer Vehicle (CES/CEV). Pertinent to the start of activities, a pre-construction meeting and site walk-through will be conducted with the USACE Resident Engineer, HAFB personnel, and the Bhate Site Manager to inspect site conditions for site/equipment access, equipment staging area(s), soil stockpile areas, potential site hazards, and emergency evacuation routes. Also reviewed at this time will be project procedures in accordance with the schedule and planned activities.

Prior to initiating excavation activities, a subsurface soil sample will be collected (3 -7 ft bgs) immediately southwest of the former OWS. The soil sample will be analyzed by the toxicity characteristic leaching procedure (TCLP) for VOCs, SVOCs, PCBs, and TAL metals to characterize the contaminated soil prior to treatment at the FT-31 landfarm.

3.1.1 AF Form 332

Prior to initiating excavation activities, a completed and approved Air Force Form (AF Fm) 332, will be obtained (a blank AF Fm 232 is included as Appendix C), authorizes construction work at HAFB and is required for the initiation of any construction work. This work order describes what activities will take place at the location. Also, the AF Fm 332 is the mechanism by which the utility clearance/dig permit is authorized. Both the AF Fm 332 and dig permit will be reviewed by the appropriate Base utility group for approval to begin work at the excavation site. Prior to the submittal of AF Fm 332, the area of excavation will be clearly delineated with marker flags, stakes, or paint, as appropriate to the surface material.

3.1.2 Dig Permit/Utility Clearances

As noted above, utility clearance approvals will be completed by the appropriate HAFB utility office. Upon receipt of the approved dig permit with the utility clearances, the Bhate Site Manager or other authorized project personnel will complete a site walk-through confirming the dig permit authorizations and make any required changes.

3.1.3 Excavation Area Site Safety

As an Occupational Safety and Health Administration (OSHA) Class II excavation, site safety is concerned with the excavation and the areas around the excavation. Concerns include: the proper designation and demarcation of excavation boundaries (i.e. exclusion zone [EZ], contamination reduction zone [CRZ], and support zone [SZ]), compliance with excavation requirements, posting of potential hazards, and control of un-authorized site personnel. This is

discussed in the 2003 *Basewide Health and Safety Plan* (HASP) (Bhate, 2003b). Because the excavation will occur in a high pedestrian traffic area, site control will be paramount to the safety at the site. Notification of the excavation activities, duration, and alternate routes for pedestrian traffic will be provided to the appropriate personnel in Buildings 231 and 232 prior to the initiation of any field activities.

At a minimum, the site will be secured with caution tape surrounding the perimeter of the site delineating the outer boundary of the SZ. This is essential in the utility clearance process and it serves as the demarcation of the site for both project and non-project persons. A CRZ and/or EZ will be established as guided by the HASP and prevailing site conditions. The depth to the bottom of the excavation is expected to reach 10 to 12 ft below grade. At the immediate edge of the excavation, a temporary construction fence will be erected completely around the excavation site. Postings will indicate the excavation hazard as well.

3.2 Decontamination Procedures

Small equipment, such as sampling tools, will be decontaminated in accordance with the *Basewide Quality Assurance Project Plan* (QAPP) (Bhate, 2003a). Heavy equipment, such as the backhoe, trackhoe, etc., will be decontaminated at a temporary decontamination pad set up at the site.

3.3 Excavation Activities

3.3.1 Excavation Boundary

The approximate limit of the area to be excavated during activities outlined under this VCM Work Plan is shown on Figure 5 as the black dashed line. Based upon the estimated horizontal extent of contamination, an estimated 25 cu yds of overburden will be required to be removed. This material will be temporarily stockpiled on site in an area to be determined.

Prior to the excavation of overburden, the covered walkway and sidewalk will be removed. All construction debris will be transported to the Base re-use area for processing.

3.3.2 Excavation Shoring

During the excavation activities, personnel will not enter the excavation at any time. Shoring may need to be erected ensuring that the excavation sidewalls do not collapse. The determination will be made as the excavation progresses. If any slumping or sidewall failure is evident, then shoring will be implemented.

Excavation activities associated with previous investigations indicates native soils to demonstrate significant stability achieving near vertical walls during excavations. The soils, except for the backfill from the two previous excavations, are native as determined from the previous remedial

actions. The soils associated with the former OWS have not been characterized; their geotechnical properties for stability are unknown. At this time, shoring of the excavation is not intended.

3.3.3 Soil Excavation

Excavation activities will utilize the appropriate excavation equipment and a wheel loader to assist with soil management. All overburden soils determined to be clean will be removed prior to the removal of the contaminated soils. The clean overburden soils will be temporarily stockpiled for subsequent backfilling. Soil stockpiles will be managed as to not allow for any material to be removed or transported off-site via wind or precipitation (Section 6, *Waste Management*).

The contaminated subsurface smear zone is estimated to begin at three to five~~five to seven~~ feet ~~above the groundwater table~~below ground surface. Applicable HAFB Standard Operating Procedures (SOPs) for completing this excavation are located in Appendix A of the *Basewide Quality Assurance Project Plan* (Bhate, 2003a). All contaminated soils will be live loaded and directly transported to the FT-31 Base landfarm or previously approved offsite disposal facility.

3.3.3.1 Soil Screening

Throughout the excavation, observation of discoloration and unusual odors will be documented. Potential PCSs will be field screened for petroleum hydrocarbon contamination using a Ultra violet fluorometer (UVF)-3100A in accordance with the USEPA *Innovative Technology Verification Report Field Measurement Technologies for Total Petroleum Hydrocarbons in Soil* (included in Appendix D of this work plan). Excavated soil will be segregated in the field based on visual observation, headspace readings, and onsite analysis of TPH with laboratory confirmation. Soils that demonstrate a field screened TPH concentration above~~880~~ 800 mg/kg exceed the regulatory limit for PCS and will be managed in accordance with Section 6, *Waste Management,* of this work plan. Soils demonstrating a concentration below ~~880~~800 mg/kg will be stockpiled for backfill once the excavation is complete. All soil stockpiled for backfill will undergo laboratory analysis to verify no TPH hazardous constituents (e.g., VOCs, SVOCs) in excess of NMED residential SSLs are present. The excavation sampling quantities and analysis are summarized in Table 3-1.

The field screening incorporates the initial screening for the segregation of the excavated soils between contaminated and un-contaminated and the corresponding Quality Assurance/Quality Control (QA/QC) confirmation and validation analyses. The soil screening is comprised of three phases: 1) initial field screening, 2) field confirmatory, and 3) laboratory validation. These steps are detailed in Section 4, *Sampling and Analysis,* of this work plan.

3.3.3.2 Soil Segregation

The ~~880~~ 800 mg/kg action level for PCS is found listed in Table 2b of the NMED Residential Direct Exposure Limit for ~~diesel #2/crankcase~~unknown oil in the TPH Screening Guidelines, ~~November, 2005~~October 2006 (Appendix E). This cleanup level is part of a previous agreement between HAFB and NMED. The concentrations for the TPH carbon fractions will be summed for the total TPH value as the comparison to the NMED TPH allowable limit of ~~880~~800 mg/kg for ~~diesel #2/crankcase~~unknown oil contaminated PCS.

The **un-impacted soils** are the overburden soils which have historically demonstrated no contamination and the source of the contamination is not from a surface release. These soils are from the surface to an approximate depth of 4 ft bgs, totaling approximately 25 cu yds. **Suspected contaminated soils** are those primarily within the smear zone. These are typically contained in a 1 to 2 foot zone above the contaminated soils. They will be found in the depth range from 3 to 5 ft bgs with an approximate volume of 50 cu yds. The **contaminated soils** are those that are definitively contaminated as validated by laboratory analytical data. These soils are typically the lower 3 ft ~~just above the water table~~, in a depth range from 5 to 8 ft bgs, totaling approximately 75 cu yds. Due to the small size of this site, suspected contaminated soils will be handled as though they are contaminated and live loaded and directly transported to the FT-31 Landfarm for treatment or to a previously approved offsite treatment facility.

3.3.3.3 Confirmation Soil Sampling

After the excavation is complete, and all suspected petroleum contaminated soils have been removed, sidewall confirmation samples will be collected. Samples will be collected using the bucket of the back-hoe. A soil sample will be obtained from the interior of the bucket to minimize the potential for outside source contamination. Excavation confirmation samples will be collected at a frequency of 2 per 18 linear feet (ln ft) for each side wall at mid-depth of the contamination zone. At a minimum, 1 sample per side wall will be collected for side walls less than 18 ln ft. Also, confirmatory sampling shall be biased to areas with the greatest potential for contamination. ~~Samples will be collected at a frequency of 1 per 20 linear feet (ln ft) per side wall at mid-depth of the contamination zone. At a minimum, 1 sample per side wall will be collected.~~

3.3.4 Excavation Backfilling and Compaction

Clean soils will be obtained for backfill as needed from a local sand/gravel provider. Below 4-ft bgs, the backfill will be placed in 24-inch lifts and compacted using a hydraulic plate compactor (see Appendix F of this work plan) to at least 18 inches. For depths from 4-ft bgs to 1-ft bgs, the excavation will be backfilled in 9-inch lifts with compaction to at least 6 inches. The compaction of the final two base lifts will be confirmed by determination of the soil density via an in-place nuclear densiometer, or similar per American Society for Testing and Materials (ASTM) Method D 2922 (see Appendix G of this work plan). The final 12-inches of backfill will adhere to the specifications of Subgrade Preparation found in UFGS Section 02770A

Concrete Sidewalks and Curbs and Gutters (see Appendix H of this work plan) and discussed in Section 3.3.6.1, *Sidewalk Reconstruction* of this work plan.

3.3.5 Soil Disposal

Contaminated soils exceeding ~~880~~800 mg/kg of TPH will be either transported to the permitted FT-31 Landfarm for treatment/processing, or transported to an off-site treatment, storage, and disposal (TSD) facility. Prior to the mobilization of the excavation effort, if the permitted base landfarm is at operational capacity, disposal of the soils will be to a previously approved off-site facility. Soils will be handled, transported, and managed in accordance with the NMED guidelines and respective facility's requirements.

3.3.6 Site Restoration

Upon completion of site excavation and backfill activities, the site will be restored to its original appearance. Construction equipment and debris will be removed. The site will be canvassed for trash, debris, etc. Final grade for areas of the site which will not have a surface improvement upon them will allow for positive drainage in accordance with the surrounding area.

3.3.6.1 Sidewalk Reconstruction

The section(s) of walk way which have been removed or damaged during the excavation will be replaced in similar construction and match in appearance to that which was removed. The design and construction, inclusive of materials, will be completed in accordance with the UFGS specifications for concrete sidewalks and gutters, Section 02770A *Concrete Sidewalks and Curbs and Gutters*, March 2004 (see Appendix H of this work plan). Matching of the new sidewalk to the existing sidewalk has primacy over the UFGS guideline. The guideline should be adhered to utilizing best management practices and holding to the intent of the guideline. The guideline shall be implemented in its entirety except for the following Parts and/or subparts:

Sections 1.1 through 1.3	Sections 2.2.2 and 2.2.3
Section 1.6.2	Sections 3.7.1.1 and 3.7.1.3

Sections 2.1.3-Reinforcement Steel; 3.5.3-Reinforcement Steel Placement; and 3.7.4-Protective Coating are only applicable if the existing sidewalk is constructed in a similar manner.

4 SAMPLING AND ANALYSIS

Table 3-1 provides the sample methods and number of samples by matrix and Table 4-1 provides a summary of the excavation related field screening and sampling, Table 4-1 also provides the sample collection information inclusive of the container type, quantity, and holding times for soil samples.

4.1 Excavation Sampling

The excavation soil sampling requirements, detailed in Table 3-1, include field screening of overburden soils with headspace analysis via Organic Vapor Analyzer (OVA) and SiteLab UVF, laboratory analysis of stockpiled soils for backfill characterization purposes, and excavation confirmation samples to denote the extent of the excavation. Excavated soil that is suspect or visibly contaminated will be loaded directly into trucks and transported to the FT-31 Landfarm for treatment.

4.1.1 Overburden Field Screening

At the beginning of excavation activities, initial field screening (headspace analysis with an OVA) will be performed on overburden soil at a frequency of one per every 25 cubic yards of excavated soil. If the headspace analysis reveals the presence of significant contamination (>300 parts per million [ppm] on OVA), the soil will be transported to the FT-31 Landfarm for treatment. Otherwise the soil will be stockpiled ~~for soil stockpiled~~ on site for backfill purposes. Every 100 cubic yards of stockpiled soil will undergo confirmatory field TPH analysis with the field fluorometer (SiteLAB® Analytical Test Kit UVF-3100A) in accordance with the USEPA *Innovative Technology Verification Report: Field Measurement Technologies for Total Petroleum Hydrocarbons in Soil*, September 2001 ~~guideline~~ (see Appendix ~~I~~D of this VCM Work Plan). From these samples, final QA confirmation analysis in accordance with the NMED specified gas chromatogra~~phic~~m (GC) methods will be accomplished via a fixed-base laboratory.

4.1.2 Overburden Stockpile Sampling

For backfill characterization purposes, laboratory validation sampling will be performed at a frequency of one sample for every 200 cubic yards of stockpiled overburden soil. The samples will be analyzed for TPH (GRO, DRO, ORO), VOCs, SVOCs, and PCBs. Laboratory analyses will be completed at an expedited turn-around-time of 24 hours.

4.1.3 Excavation Confirmation Sampling

Excavation confirmation samples will be collected at a frequency of 2 per 18 ln ft per side wall at mid-depth of the contamination zone. At a minimum, 1 sample per side wall will be collected for side walls less than 18 ln ft. Also, confirmatory sampling shall be biased to areas with the greatest potential for contamination. Because the excavation is not expected to extend to the water table, excavation confirmation sampling from the bottom of the excavation will follow the

same guidance. Samples will be analyzed by a fixed-base laboratory for TPH (GRO, DRO, ORO), VOCs, SVOCs, PCBs, and TAL metals. If any single sample demonstrates an exceedance of NMED residential SSLs, excavation will continue along that face or to greater depth until field screening deems termination with re-evaluation via laboratory confirmation analysis.

Soil data collected will adhere to project DQO requirements, method reporting limits, duplicate field samples, and QC samples as established within the Basewide QAPP (Bhate, ~~November~~ 2003a). Sample quantities, containers, methods of preservation, and holding times will be consistent with the requirements of associated method protocols. Laboratory analyses will be completed at standard turnaround time of 7 days.

4.2 Analytical Methods

Soil samples (including the field duplicates) will be analyzed for VOCs by Method 8260B, SVOCs by Method 8270C, TPH by Method 8015B PCBs by Method 8082, and TAL metals by 6010/7000 series. A summary of laboratory quality control limits including analytical method reporting limits is provided in Table 4-3.

~~4SOIL SAMPLING AND ANALYSIS~~

~~The project soil sampling requirements, detailed in Table 3-1, include field screening samples, stock pile samples, and confirmation samples. Table 4-1 provides the sample collection information inclusive of the container type, quantity, and holding times.~~

~~4.1Field Screening Sampling~~

~~Soils will be periodically field screened utilizing soil headspace screening techniques via the field organic vapor analyzer (OVA). Confirmatory field TPH analysis of the OVA headspace samples will be performed with the field fluorometer in accordance with the USEPA *Innovative Technology Report: Field Measurement Technologies for Total Petroleum Hydrocarbons in Soil – siteLAB® Analytical Test Kit UVF-3100A*, September 2001 guideline (Appendix D). From these samples, final QA confirmation analysis in accordance with the NMED specified gas chromatogram (GC) Methods will be accomplished via a fixed base laboratory.~~

~~4.1.1Initial Field Screening~~

~~The HAFB Base excavation guideline for PCS requires initial field screening via headspace analysis every 100 cu yds. Due to the relatively small area being excavated, this sampling scheme would allow for only 2 field screening samples and a single field confirmatory sample. To improve the accuracy of the screening of the excavated soils, the field screening frequency will increase to one sample per 25 cu yds removed for a total of 6 samples to be screened via the OVA.~~

~~4.1.2Field Confirmatory Screening~~

~~A field confirmatory frequency of 50% with the ultra-violet fluorometer (UVF) will be implemented instead of the normal 10% per the USACE and USEPA (SW846) guidelines for QA/QC requirements of site investigations for contamination. The adjusted resulting quantity is a total of 3 of the 6 samples to be field checked with the UVF. Confirmatory TPH analysis is by the SiteLAB® Analytical Test Kit UVF 3100A. This test uses a 10 gram sample of soil, where the petroleum compounds are extracted with methanol. The extract is decanted into a quartz cuvette and placed in the chamber of the fluorometer. The TPH concentration is displayed as parts per million, which is equivalent to mg/kg. Although the NMED clean up level is 880 mg/kg, soils resulting in a headspace reading with the UVF above 790 mg/kg will be designated TPH contaminated, allowing for a 10% instrument error and variability between the screening method and the EPA Method analyses.~~

~~4.1.3Laboratory Validation~~

~~Laboratory validation frequency of the UVF screening samples will be at 10%, or 1 sample per site minimum. Laboratory validation will be completed using USEPA Method 8015M for TPH-gasoline range organics (TPH-GRO) [C_6-C_{10}], TPH-DRO [C_{10}-C_{22}], and TPH-oil range organics (TPH-ORO) [C_{22}-C_{36}]. Laboratory validation will also be performed for VOCs (USEPA Method 8260B) and SVOCs (USEPA Method 8270C). Laboratory analyses will be completed at an expedited turn-around time of 24 hours.~~

~~4.2Excavation Confirmation Sampling~~

~~Excavation confirmation samples will be collected at the frequency of one per 20 linear ft of each sidewall within the contamination zone at mid-depth. Analytical confirmation sampling from the bottom of the excavation is not required because excavation will be terminated at one foot below the water table. Samples will be analyzed by a fixed-base laboratory for TPH, DRO and GRO, using USEPA Method 8015B, VOCs (USEPA Method 8260B), SVOCs (USEPA Method 8270C). If any single sample demonstrates a TPH level above the NMED soil value for TPH of 880 mg/kg, excavation will continue along that face until field screening deems termination with re-evaluation via laboratory confirmation analysis. Data will adhere to project data quality objectives (DQO) requirements, method reporting limits, duplicate field samples, and QC samples as established within the *Basewide Quality Assurance Project Plan* (Bhate, November 2003). Sample quantities, containers, methods of preservation, and holding times will be consistent with the requirements of associated method protocols. Laboratory analyses will be completed at a rush turn-around time, 24 hours.~~

~~4.2.1Stockpile Sampling~~

~~Stockpiled overburden soils will be sampled every 500 cu yds. Laboratory analyses will be completed at an expedited turn-around time, 24 hours with analysis for TPH, DRO and GRO,~~

~~using USEPA Method 8015B, VOCs (USEPA Method 8260B), and SVOCs (USEPA Method 8270C).~~

~~4.2.2Analytical Methods~~

~~Each laboratory soil sample (including the field duplicates) will be analyzed for their respective analytes in accordance with Table 4-2. Samples will be analyzed for BTEX, as VOCs, by Method 8260B, polynuclear aromatic hydrocarbons (PAHs), as SVOCs, by Method 8270C, and TPHs by Method 8015B.~~

Laboratory analyzed samples will be completed by Accutest Laboratories in Orlando, Florida. A copy of their USACE validation is included in Appendix I of this work plan.

5 RISK BASED CLEAN-UP APPROACH

The objective of the excavation activities presented is to remove the remaining PCS from the SWMU 8 site to support closure of the site. Data collected as a result of field screening will be evaluated based upon the Data Quality Objectives (DQOs) for the project. The results from the offsite laboratory confirmation samples from the sidewalls of the excavation will be evaluated to determine whether excavation activities at the site have removed the contaminated soil to the point where there is an acceptable risk due to exposure at the site. Soil and groundwater conditions under Buildings 231 and 232 will be evaluated under a separate Work Plan Addendum. If the completed evaluation indicates an acceptable risk, then no further excavation will be required and the site can be considered for closure with no further action.

5.1 Evaluation of TPH

Based on the direction provided by NMED, pertaining to the remediation of petroleum-impacted sites at HAFB, a TPH screening level of~~880~~ 800 mg/kg will be used to evaluate the data provided by the offsite analytical laboratory. As discussed in Section 4 of this report, *Sampling and Analysis*, the ~~880~~800 mg/kg action level for PCS is the Residential Direct Exposure Limit for ~~diesel #2/crankcase~~unknown oil, listed in Table 2b, of the NMED TPH Screening Guidelines, ~~November, 2005~~October 2006 (see Appendix E of this work plan).

5.2 Evaluation of VOCs, ~~and~~ SVOCs, PCBs, and Metals

For any VOCs, ~~or~~ SVOCs, PCBs, ~~or~~or metals that are detected in soil, the concentration will be evaluated against the screening levels provided in the revised NMED guidance document *Technical Background Document for Development of Soil Screening Levels, Revision ~~2~~4.0*, ~~August 2004 (NMED, 2004)~~ June 2006 (NMED, 2006a). Tables containing the SSLs from this guidance document are provided in Appendix J of this work plan. Laboratory data for each collected soil sample will be compared to these SSLs.

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6 WASTE MANAGEMENT

Construction-Derived Waste (CDW) generated by the activities of this excavation include excavated soil, decontamination residuals, and personal protective equipment (PPE) (Table 6-1). Each waste stream will be managed and characterized according to the following guidelines. Waste containers and the decontamination pad will be managed in a secure area.

6.1 Excavated Soil

6.1.1 Clean Soils – Stockpiles

The clean soil stockpiles will be constructed in accordance with best management practices to mitigate soil loss due to erosion, wind, and run-off. They will employ the use of a plastic liner, straw bales for berming or silt fencing and a cover. Soils will be placed on thick plastic sheeting within a constructed berm for protection from off-site transportation by wind and rain until characterization is complete. If laboratory analysis indicates concentrations are below the SSL for TPH of ~~880~~800 mg/kg, and the SSL for each individual VOC and SVOC constituent, the stockpiled soil will be used as backfill once the excavation activities are complete.

6.1.2 Contaminated Soils – Base Landfarm

Excavated contaminated soils will be handled in accordance with Sections 3 and 4 of this work plan. Contaminated soils will be live loaded and transported to the selected location for treatment/disposal; either the FT-31 Landfarm or an offsite subcontractor location.

6.2 Decontamination Water

Decontamination water is anticipated to be non-hazardous and as such, can be disposed of through the HAFB waste water treatment facility (WWTF). When feasible, decontamination water will be allowed to evaporate from the decontamination pad area. Sediment remaining in the decontamination pad area after the water has either evaporated or has been discharged to the WWTF will be combined with the excavated contaminated soil for disposal.

6.3 Personal Protective and Disposable Sampling Equipment

PPE and other site non-hazardous debris/waste shall be placed in plastic trash bags and disposed in a standard trash dumpster or receptacle as directed by HAFB personnel.

6.4 Construction Ruble

Unless visibly stained, all construction debris is assumed to be non-hazardous, non-contaminated, and will be ~~disposed of accordingly at~~ transported to the Base re-use facility.

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7 PROJECT QUALITY ASSURANCE

The laboratory performing the chemical sample analysis will follow the *Basewide Quality Assurance Project Plan* (Bhate, 2003a).

7.1 Standard Operating Procedures

Applicable SOPs for completing this excavation are located in Appendix A of the *Basewide QAPP* (Bhate, 2003a).

7.2 Sample Identification

Each environmental sample will be identified on the sample label and chain-of-custody (COC) records for each sample collected, regardless of type. Field duplicates will be paired with another field sample and will be classified as blind samples. The duplicate samples will appear in sequence with the regular samples. The identifier nomenclature will adhere to the procedures and guidelines established in the *Basewide QAPP*. Sample labeling will adhere to the format provided in the *Basewide QAPP*.

7.3 Project Documentation

The field operations documentation will provide consistent procedures and formats for documentation and management of field records and collected samples.

7.3.1 Sample Documentation

Sample documentation, identification, and tracking will adhere to the prescribed methods found in the *Basewide QAPP*. All sampling activities will include documentation of significant activities, potential environmental influences during sampling, field variances, and sample identification information. At a minimum, field logbooks will be utilized to record dates and times, sampling protocols, project numbers, and sampler's name. Daily Quality Assurance Reports will be completed and submitted weekly to the HAFB Project Manager. Other pertinent information will include COC numbers and air-bill tracking number. Chain-of-custody forms will be completed and included with each sample shipment; one COC per cooler.

At a minimum, the following sample collection information will be logged in the field book:

- Date and time
- Sample identification number
- Project number
- Sampler name
- Preservative (if any)

- Analysis
- Map or schematic of sampling location

If no map of sampling locations is available prior to sampling, a drawing of the site will be sketched on the left page of the field logbook to provide an illustration of all sampling points. Measured distances from sampling points to a fixed reference point will be recorded.

7.3.2 Field Logbook

Personnel will use only bound field logbooks for the maintenance of field records. The Project Manager will ensure that all field notes can be efficiently traced, filed, and retrieved. All entries will be recorded in indelible, waterproof ink. If errors are made, corrections will be made by crossing a single line through the error, correcting the information, and initialing and dating the correction. Entries will be made in the following format:

Documentation and reporting of events and activities will be made in chronological order on the right page of an open logbook. All entries will be dated and time of entry recorded. At the beginning of each day, the first two entries will be "personnel/contractors on site" and "weather". At the end of each day's entry, the personnel will draw a diagonal line originating from the bottom left corner of the page to the conclusion of the entry and sign along the line indicating the conclusion of the entry or the day's activity. Once completed, the field logbooks become accountable documents and will be maintained as part of the project files.

The following general requirements apply to field logbooks:

- The left page of the logbook will be used for auxiliary reporting such as sketches, tables, etc.
- The date will be recorded at the top of every page in the left-hand corner of the right page.
- The time of entry recordings will be in columnar form down the left-hand side of the right page.

7.3.3 Field Analytical Data

The field analytical data collected at the site will include the field screening readings for selection of PPE, as well as field screening for headspace analysis. The breathing zone of the site will be screened for VOCs in the field at the time of sample collection utilizing an OVA. If a high humidity condition exists at the time of sample collecting, a flame-ionization detector (FID) is recommended since a PID is not a completely reliable screening instrument under these conditions. The field screening data will be recorded in the field logbook.

7.3.4 Data Reporting

Data obtained during the excavation, confirmation or field screening samples, will be reported according to the *Basewide QAPP* (Bhate, 2003a). In accordance with USACE EM200-1-6, the investigative data is classified as definitive data. The data will be generated using rigorous, analyte-specific analytical methods where analyte identifiers and quantitations are confirmed and QA/QC requirements have been satisfied. For this project, regular, field duplicate, and matrix spike/matrix spike duplicate (MS/MSD) samples are to be collected concurrently. The data will meet the objectives of the project for level of accuracy and precision required, intended use of the data, analytical methods, time constraints, and allowable decision errors. Risk evaluation and sampling results will be tabulated and summarized in the VCM report for the site. An Environmental Restoration Program Information Management System (ERPIMS) submittal is not required for this project.

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8 HEALTH AND SAFETY REQUIREMENTS

Project Health and Safety practices will adhere to the *Basewide Health and Safety Plan* (Bhate, 2003b) and the Site Specific Addendum to the *Basewide HASP*, as included in Appendix K of this work plan, for the excavation activities. It is anticipated that no greater than modified level D PPE will be required to complete the site inspection and sampling activities. This includes: OSHA approved safety shoes, American National Standards Institute (ANSI) approved safety glasses (Z87.1) and hard hat (Z89.1-1997: Type I), sleeved shirt and long pants, and as required, hearing protection, leather work gloves, and/or nitrile gloves during sampling.

Site security is part of safety at the site for the excavation. Items of concern include the proper designation and demarcation of the investigation boundaries (i.e., SZ, CRZ, and EZ), as appropriate. Likewise, compliance with any intrusive work requirements, posting of potential hazards, and control of un-authorized site personnel will be completed. This is discussed in the *Basewide HASP*.

At a minimum, the site will be secured with caution tape surrounding the perimeter of the site delineating the outer boundary of the SZ. This is essential in the utility clearance process and it serves as the demarcation of the site for both project and non-project persons. A CRZ and/or EZ will be established as guided by the HASP and site prevailing conditions.

Excavation depths are expected to exceed 4 ft, and be less than 12 ft. Sidewall benching will not be completed.

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9 ORGANIZATION AND SCHEDULE

During the corrective measures activities at the SWMU 8 site, Mr. John Hymer will serve as the Bhate Site Manager overseeing and directing all excavation sampling activities. Mr. Hymer will also provide on-site management of any sub-contractors for the project. Mr. Jim Moore is the Bhate Project Manager and will ensure required project documents, permits, contractual agreements, and other program tasks are completed. Key project personnel are listed in Table ~~8~~9-1. The excavation activities are anticipated to begin in late 2008~~mid 2006~~ and will last approximately 2 weeks.

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10 REFERENCES

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TABLES

Table 3-1. Excavation Sampling Quantities and Analysis

SWMU 8 Soil Remediation Voluntary Corrective Measures Work Plan Holloman AFB, New Mexico Bhate Project No. 9050291.01.01						
Sample Type	**Contamination Profile**	**Purpose**	**Frequency**	**Estimated Quantity**	**Method/ Analyses**	**Requested Analyses Time**
Overburden	Un-impacted Soils	Initial Field Screening	Every 25 cu yds	12	OVA: VOCs	24 hours
		Field Confirmatory	Every 50 cu yds	3	UVF: TPH	
Stock Pile (Overburden)	Un-impacted Soils	Backfill Characterization (Lab validation)	Every 200 cu yds	2	Laboratory: TPH, VOCs, SVOCs, and PCBs	24 hours
Excavation Confirmation	Clean wall denoting extent of excavation	Closure	2 every 18 ln ft, at mid-depth within contamination zone, minimum of 1 per side wall if < 18 ln ft	4	Laboratory: TPH, VOCs, SVOCs, and PCBs	7 days

Notes:
cu yds - Cubic yards
ln ft - Linear feet
TPH - Total Petroleum Hydrocarbons
VOCs - Volatile organic compounds
SVOCs - Semi-volatile organic compounds
PCBs - Polychlorinated byphenyls
UVF - Ultraviolet fluorometer
OVA - organic vapor analyzer

~~Table 3-1. Sampling Plan~~

~~WMU 8 Soil Remediation Voluntary Corrective Measures Work Plan Holloman AFB, New Mexico Bhate Project No. 9050291.01.01~~						
~~Sample Type~~	~~Contamination Profile~~	~~Purpose~~	~~Frequency~~	~~Estimated Quantity~~	~~Method/ Analyses~~	~~Requested Analyses Time~~
~~Field Screening~~	~~Un-impacted Soils~~	~~Initial Field Screening~~	~~Every 25 cu yds~~	~~6~~	~~OVA: VOCs~~	~~24 hrs~~
		~~Field Confirmatory~~	~~Every 50 cu yds~~	~~3~~	~~UVF: TPH~~	
		~~Laboratory Validation~~	~~Every 100 cu yds~~	~~1~~	~~Laboratory: TPH, VOCs, and SVOCs~~	
	~~Suspected Contaminated and Contaminated Soils (contamination zone)~~	~~Initial Field Screening~~	~~Every 25 cu yds~~	~~6~~	~~OVA: VOCs~~	
		~~Field Confirmatory~~	~~Every 100 cu yds~~	~~3~~	~~UVF: TPH~~	
		~~Laboratory Validation~~	~~Every 300 cu yds~~	~~1~~	~~Laboratory: TPH, TCLP VOCs, TCLP SVOCs, and TCLP metals~~	
~~Stock Pile~~	~~Un-impacted Soils~~	~~Backfill Characterization~~	~~Every 500 cu yds~~	~~2~~	~~Laboratory: TPH, VOCs, and SVOCs~~	~~24 hrs~~
~~Excavation Confirmation~~	~~Un-impacted Soils~~	~~Closure~~	~~Every 20 ln ft, at mid-depth within contamination zone, minimum of 1 per side wall~~	4	~~Laboratory: TPH, VOCs, and SVOCs~~	~~7 days~~
~~**NOTES:** cu yds = Cubic yards; ln ft = Linear feet; TPH = Total Petroleum Hydrocarbons; VOCs = Volatile Organic Compounds; SVOCs = Semi-volatile Organic Compounds; hrs = Hours; UVF = Ultra-violet flourometer; OVA = Organic vapor analyzer; TCLP = Toxicity Characteristic Leaching Procedure~~						

Table 4-1. Sample Collection Information

SWMU 8 Soil Remediation Voluntary Corrective Measures Work Plan Holloman AFB, New Mexico Bhate Project No. 9050291.01.01								
Soil Collection Information	**ANALYTE METHOD**							
	VOC (8260B)	**SVOC (8270C)**	**TPH (8015B)**	**PCB (8082)**	**Soil Moisture**	**TCLP VOC (1311/8260B)**	**TCLP SVOC (1311/8270C)**	**TAL Metals (6010/7471) or TCLP Metals (1311/6010/7000)**
Container	Encore	4 oz glass jar	4 oz glass jar and Encore ~~Non-preserved 40-mL vial (Terra-core)~~	4 oz glass jar	8 oz glass jar	8 oz glass jar	8 oz glass jar	8 oz glass jar
Container Quantity	3	1	2 ~~1~~	1	1	1	1	1
Holding Time	48 hours	7 days	7 days	7 days	14 days	14 days	14 days	180 days

NOTES: oz = Ounce; mL = Milliliter; TPH = Total Petroleum Hydrocarbons; VOCs = Volatile Organic Compounds; SVOCs = Semi-Volatile Organic Compounds; PCB = Polychlorinated Biphenyls; TAL = Target Analyte List; TCLP = Toxicity Characteristic Leaching Procedure

Table 4-2. Sample Analytes and Methodologies

SWMU 8 Soil Remediation Voluntary Corrective Measures Work Plan Holloman AFB, New Mexico Bhate Project No. 9050291.01.01	
Analysis	**Soil and Groundwater**
BTEX (VOCs)	EPA Method 8260B
PAH (SVOCs)	EPA Method 8270C
TPH (GRO/DRO/ORO)	EPA Method 8015B
~~Carbon Fractions~~PCBs	~~TM 1006~~ EPA Method 8082
TCLP VOCs	EPA Method 1311/8260B
TCLP SVOCs	EPA Method 1311/8270C
TAL Metals	EPA Method 6010/7471
TCLP Metals	EPA Method 1311/6010/7000
NOTES: BTEX = Benzene, toluene, ethylbenzene, and xylenes; TPH = Total Petroleum Hydrocarbons; VOCs = Volatile Organic Compounds; SVOCs = Semi-Volatile Organic Compounds; GRO = Gasoline Range Organics; DRO = Diesel Range Organics; ORO = Oil Range Organics; PCBs = polychlorinated biphenyl's;~~,~~ TAL = Target Analyte List; TCLP = Toxicity Characteristic Leaching Procedure; PAH = Polynuclear Aromatic Hydrocarbons; EPA = Environmental Protection Agency	

~~Table 4-3. Carbon Fractions for Petroleum Hydrocarbons~~

~~SWMU 8 Soil Remediation Voluntary Corrective Measures Work Plan Holloman AFB, New Mexico Bhate Project No. 9050291.01.01~~	
~~Aliphatics~~	~~Aromatics~~
~~C6~~	~~C7-C8~~
~~C6-C8~~	~~C8-C10~~
~~C8-C10~~	~~C10-C12~~
~~C10-C12~~	~~C12-C16~~
~~C12-C16~~	~~C16-C21~~
~~C16-C35*~~	~~C21-C35*~~
~~**NOTES:** Aliphatics = compounds containing only carbon and hydrogen which do not contain a benzene ring and they can be straight-chain, branched chain, or cyclic molecules; Aromatics = any of a large class of hydrocarbon compounds, that includes benzene and compounds that resemble benzene in certain of their chemical properties, that have one or more benzene rings. Common aromatic compounds other than benzene include toluene, naphthalene, and anthracene (the polynuclear aromatic hydrocarbons).~~	

Table 4-3. Summary of Laboratory QC Limits

Parameter	CAS no.	RL / Evaluation Criteria Soil		LCS Soil		Matrix Spike Soil MS Recovery		MSD
		RL	SSL[1]	LCL	UCL	LCL	UCL	RPD
VOCs per EPA Method 8260B		ug/kg	mg/kg	%	%	%	%	%
Acetone	67-64-1	50	28,100	51	136	14	140	33
Benzene	71-43-2	5	10.3	74	124	63	135	23
Bromodichloromethane	75-27-4	5	14.4	74	124	63	126	23
Bromoform	75-25-2	5	621	79	127	54	109	24
Chlorobenzene	108-90-7	5	194	78	117	64	130	24
Chloroethane	75-00-3	5	63.3	63	147	53	172	28
Chloroform	67-66-3	5	4	75	121	68	131	24
Carbon disulfide	75-15-0	5	460	59	148	47	165	29
Carbon tetrachloride	56-23-5	5	3.47	67	131	64	148	24
1,1-Dichloroethane	75-34-3	5	1,400	71	118	64	130	25
1,1-Dichloroethylene	75-35-4	5	206	64	126	55	149	28
1,2-Dichloroethane	107-06-2	5	6.04	72	120	60	114	22
1,2-Dichloropropane	78-87-5	5	6	74	126	65	128	23
Dibromochloromethane	124-48-1	5	14.8	78	120	60	119	23
cis-1,2-Dichloroethylene	156-59-2	5	76.5	75	124	66	132	24
cis-1,3-Dichloropropene	10061-01-5	5	NV	72	120	57	118	25
trans-1,2-Dichloroethylene	156-60-5	5	112	70	122	63	137	27
trans-1,3-Dichloropropene	10061-02-6	5	NV	75	118	58	115	25
Ethylbenzene	100-41-4	5	128	77	120	63	142	25
2-Hexanone	591-78-6	25	NV	68	136	35	109	34
Isopropylbenzene	98-82-8	5	271	79	134	59	177	29
4-Methyl-2-pentanone	108-10-1	25	NV	69	136	44	99	32
Methyl bromide	74-83-9	5	8.51	52	156	38	188	27
Methyl chloride	74-87-3	5	NV	63	142	57	160	29
Methylene chloride	75-09-2	10	182	51	142	40	183	34
Methyl ethyl ketone	78-93-3	25	31,800	63	138	27	112	32
Styrene	100-42-5	5	100	74	120	54	130	26
1,1,1-Trichloroethane	71-55-6	5	563	70	131	70	149	25
1,1,2,2-Tetrachloroethane	79-34-5	5	5.55	76	121	45	121	33

Table 4-3. Summary of Laboratory QC Limits

Parameter	CAS no.	RL / Evaluation Criteria Soil		LCS Soil		Matrix Spike Soil MS Recovery		MSD
		RL	SSL[1]	LCL	UCL	LCL	UCL	RPD
VOCs per EPA Method 8260B		µg/kg	mg/kg	%	%	%	%	%
1,1,2-Trichloroethane	79-00-5	5	11.9	77	118	60	114	25
Tetrachloroethylene	127-18-4	5	12.5	68	127	54	154	27
Toluene	108-88-3	5	252	74	118	62	142	29
Trichloroethylene	79-01-6	5	0.638	72	122	59	143	25
Vinyl chloride	75-01-4	5	2.25	64	144	64	165	27
Xylene (total)	1330-20-7	15	82	78	122	64	142	24
Dibromofluoromethane (surr)	1868-53-7	--	--	78	123	--	--	--
Toluene-D8 (surr)	2037-26-5	--	--	71	137	--	--	--
4-Bromofluorobenzene (surr)	460-00-4	--	--	61	157	--	--	--
1,2-Dichloroethane-D4 (surr)	17060-07-0	--	--	74	125	--	--	--
SVOCs by EPA Method 8270C		µg/kg	mg/kg	%	%	%	%	%
Benzoic Acid	65-85-0	830	NV	55	110	13	117	32
2-Chlorophenol	95-57-8	170	166	61	97	31	113	23
4-Chloro-3-methyl phenol	59-50-7	170	NV	60	105	33	123	38
2,4-Dichlorophenol	120-83-2	170	183	64	102	54	105	20
2,4-Dimethylphenol	105-67-9	170	1,220	50	102	46	104	22
2,4-Dinitrophenol	51-28-5	830	122	41	120	5	110	46
4,6-Dinitro-o-cresol	534-52-1	330	6.11	59	123	27	119	35
2-Methylphenol	95-48-7	170	NV	57	97	44	101	28
3&4-Methylphenol	--	170	NV	56	98	38	107	31
2-Nitrophenol	88-75-5	170	NV	62	100	38	111	21
4-Nitrophenol	100-02-7	830	NV	52	116	44	111	22
Pentachlorophenol	87-86-5	830	29.8	54	111	42	110	25
Phenol	108-95-2	170	18,300	59	96	32	111	29
2,4,5-Trichlorophenol	95-95-4	170	6,110	65	104	53	108	19
2,4,6-Trichlorophenol	88-06-2	170	6.11	64	102	53	107	20
Acenaphthene	83-32-9	170	3,730	66	104	57	106	19
Acenaphthylene	208-96-8	170	NV	66	106	55	110	18
Anthracene	120-12-7	170	22,000	66	109	59	109	21

Table 4-3. Summary of Laboratory QC Limits

Parameter	CAS no.	RL / Evaluation Criteria Soil		LCS Soil		Matrix Spike Soil MS Recovery		MSD
		RL	SSL[1]	LCL	UCL	LCL	UCL	RPD
SVOCs by EPA Method 8270C		µg/kg	mg/kg	%	%	%	%	%
Benzo(a)anthracene	56-55-3	170	6.21	66	111	52	120	20
Benzo(a)pyrene	50-32-8	170	0.621	65	115	48	124	21
Benzo(b)fluoranthene	205-99-2	170	6.21	64	115	50	122	21
Benzo(g,h,i)perylene	191-24-2	170	NV	62	113	50	118	23
Benzo(k)fluoranthene	207-08-9	170	62.1	67	116	54	117	21
4-Bromophenyl phenyl ether	101-55-3	170	NV	68	106	59	107	20
Butyl benzyl phthalate	85-68-7	330	NV	62	114	57	118	20
Benzyl Alcohol	100-51-6	170	NV	58	103	46	106	23
2-Chloronaphthalene	91-58-7	170	3,990	66	97	53	102	19
4-Chloroaniline	106-47-8	330	NV	29	80	25	78	30
Carbazole	86-74-8	170	NV	63	107	58	105	20
Chrysene	218-01-9	170	615	67	112	48	124	20
bis(2-Chloroethoxy)methane	111-91-1	170	NV	57	89	45	94	19
bis(2-Chloroethyl)ether	111-44-4	170	2.44	61	95	47	99	24
bis(2-Chloroisopropyl)ether	108-60-1	170	38.7	56	100	44	100	23
4-Chlorophenyl phenyl ether	7005-72-3	170	NV	68	103	59	105	18
1,2-Dichlorobenzene	95-50-1	170	37.4	61	91	44	95	26
1,3-Dichlorobenzene	541-73-1	170	32.6	59	88	41	91	28
1,4-Dichlorobenzene	106-46-7	170	39.5	59	90	42	93	27
2,4-Dinitrotoluene	121-14-2	170	122	60	108	44	118	26
2,6-Dinitrotoluene	606-20-2	170	NV	63	106	48	115	20
3,3'-Dichlorobenzidine	91-94-1	330	10.8	30	90	15	90	31
Dibenzo(a,h)anthracene	53-70-3	170	0.621	63	110	45	121	23
Dibenzofuran	132-64-9	170	142	65	99	57	101	19
Di-n-butyl phthalate	84-74-2	330	6110	62	110	55	112	20
Di-n-octyl phthalate	117-84-0	330	NV	59	132	58	134	23
Diethyl phthalate	84-66-2	330	48,900	64	109	59	107	19
Dimethyl phthalate	131-11-3	330	100,000	66	105	56	108	20
bis(2-Ethylhexyl)phthalate	117-81-7	330	347	60	118	55	125	21

Table 4-3. Summary of Laboratory QC Limits

Parameter	CAS no.	RL / Evaluation Criteria Soil		LCS Soil		Matrix Spike Soil MS Recovery		MSD
		RL	SSL[1]	LCL	UCL	LCL	UCL	RPD
SVOCs by EPA Method 8270C		µg/kg	mg/kg	%	%	%	%	%
Fluoranthene	206-44-0	170	2,290	63	108	47	119	25
Fluorene	86-73-7	170	2,660	65	109	59	108	18
Hexachlorobenzene	118-74-1	170	3.04	65	106	56	107	21
Hexachlorobutadiene	87-68-3	170	12.2	55	93	42	94	25
Hexachlorocyclopentadiene	77-47-4	170	366	34	95	13	91	25
Hexachloroethane	76-72-1	170	61.1	58	91	40	93	32
Indeno(1,2,3-cd)pyrene	193-39-5	170	6.21	59	115	50	118	26
Isophorone	78-59-1	170	5,120	60	102	52	101	19
2-Methylnaphthalene	91-57-6	170	NV	63	93	42	103	22
2-Nitroaniline	88-74-4	330	NV	60	110	55	108	20
3-Nitroaniline	99-09-2	330	NV	41	90	38	92	20
4-Nitroaniline	100-01-6	330	NV	53	103	42	101	23
Naphthalene	91-20-3	170	79.5	64	94	42	105	24
Nitrobenzene	98-95-3	170	22.8	60	96	42	105	21
N-Nitroso-di-n-propylamine	621-64-7	170	NV	54	99	41	107	23
N-Nitrosodiphenylamine	86-30-6	170	993	68	108	59	111	21
Phenanthrene	85-01-8	170	1,830	67	110	60	110	21
Pyrene	129-00-0	170	2,290	65	115	50	126	25
1,2,4-Trichlorobenzene	120-82-1	170	69.3	64	94	49	98	23
2-Fluorophenol (surr)	367-12-4	--	--	45	114	--	--	--
Phenol-d5 (surr)	4165-62-2	--	--	44	124	--	--	--
2,4,6-Tribromophenol (surr)	118-79-6	--	--	50	128	--	--	--
Nitrobenzene-d5 (surr)	4165-60-0	--	--	41	123	--	--	--
2-Fluorobiphenyl (surr)	321-60-8	--	--	46	122	--	--	--
Terphenyl-d14 (surr)	1718-51-0	--	--	45	135	--	--	--

Table 4-3. Summary of Laboratory QC Limits

Parameter	CAS no.	RL / Evaluation Criteria Soil		LCS Soil		Matrix Spike Soil MS Recovery		MSD
		RL	SSL[1]	LCL	UCL	LCL	UCL	RPD
TAL Metals by EPA Method 6010B/7470A/7471A		mg/kg	mg/kg	%	%	%	%	%
Aluminum	7429-90-5	10	77,800	82	116	50	200	30
Antimony	7440-36-0	1.5	31.3	82	102	20	200	30
Arsenic	7440-38-2	2	3.9	85	104	76	111	30
Barium	7440-39-3	1	15,600	87	112	52	159	30
Beryllium	7440-41-7	0.5	156	84	114	72	105	30
Cadmium	7440-43-9	0.5	39	87	107	40	130	30
Calcium	7440-70-2	20	NV	82	114	43	165	30
Chromium	7440-47-3	1.5	234	84	114	70	200	30
Cobalt	7440-48-4	1	1,520	87	108	72	106	30
Copper	7440-50-8	2	3,130	88	109	37	187	30
Iron	7439-89-6	15	23,500	87	124	70	200	30
Lead	7439-92-1	0.8	400	86	107	70	200	30
Magnesium	7439-95-4	20	NV	90	110	64	145	30
Manganese	7439-96-5	1	3,590	88	109	40	200	30
Mercury	7439-97-6	0.033	6.11	88	111	88	111	30
Nickel	7440-02-0	4	1,560	87	108	61	126	30
Potassium	7440--09-7	300	NV	89	109	56	172	30
Selenium	7782-49-2	1.3	391	83	103	76	104	30
Silver	7440-22-4	1	391	87	114	75	141	30
Sodium	7440-23-5	500	NV	90	112	78	111	30
Thallium	7440-28-0	1.20	5.16	84	106	78	101	30
Vanadium	7440-62-2	2	78.2	88	108	50	169	30
Zinc	7440-66-6	3	23,500	76	114	70	200	30
PCBs by EPA Method 8020		µg/kg	mg/kg	%	%	%	%	%
Aroclor 1016	12674-11-2	10	3.93	71	118	71	118	36
Aroclor 1221	11104-28-2	10	1.12	--	--	--	--	--
Aroclor 1232	11141-16-5	10	1.12	--	--	--	--	--
Aroclor 1242	53469-21-9	10	1.12	--	--	--	--	--

Table 4-3. Summary of Laboratory QC Limits

Parameter	CAS no.	RL / Evaluation Criteria Soil		LCS Soil		Matrix Spike Soil MS Recovery		MSD
		RL	SSL[1]	LCL	UCL	LCL	UCL	RPD
PCBs by EPA Method 8020		µg/kg	mg/kg	%	%	%	%	%
Aroclor 1248	12672-29-6	10	1.12	--	--	--	--	--
Aroclor 1254	11097-69-1	10	1.12	--	--	--	--	--
Aroclor 1260	11096-82-5	10	1.12	65	123	65	123	36
TPH by EPA Method 8015B		µg/kg	mg/kg	%	%	%	%	%
TPH-Gasoline Range Organics (C6-C10)	--	8.3	NA[3]	66	122	37	142	17
4-Bromofluorobenzene (surr)	460-00-4	--	--	62	135	--	--	--
aaa-Trifluorotoluene (surr)	98-08-8	--	--	65	118	--	--	--
TPH-Diesel Range Organics (C10-C22)	--	8.3	NA[2]	50	150	50	150	30
TPH-Oil Range Organics (>C22-C36)	--	5.0	NA[2]	50	150	50	150	30
o-Terphenyll (surr)	84-15-1	--	--	57	115	--	--	--

Notes:

µg/kg = Micrograms per kilogram
EPA = U.S. Environmental Protection Agency
LCL = Lower Control Limit
LCS = Laboratory Control Sample
mg/kg = Milligrams per kilogram
TPH = Total Petroleum Hydrocarbons
PCBs = Polychlorinated Bi-phenyls
CAS no. = Chemical Abstract Number
MCL = Maximum Contaminant Level
SSL = Soil Screening Level
MS = Matrix Spike
MSD = Matrix Spike Duplicate
RL = Reporting Limit
RPD = Relative Percent Difference
UCL = Upper Control Limit
VOCs = Volatile Organic Compounds
SVOCs = Semi-volatile Organic Compounds
TAL = Target Analyte List
NMED = New Mexico Environment Department
NV = No Value

[1]NMED, Technical Background Document for Development of Soil Screening Levels, Revision 4.0, June 2006 (Residential Soil)
[2]Combined TPH values (GRO/DRO/ORO) will be compared to the applicable petroleum products presented in the NMED, TPH Screening Guidelines, October 2006

Table 6-1. Proposed Waste Streams

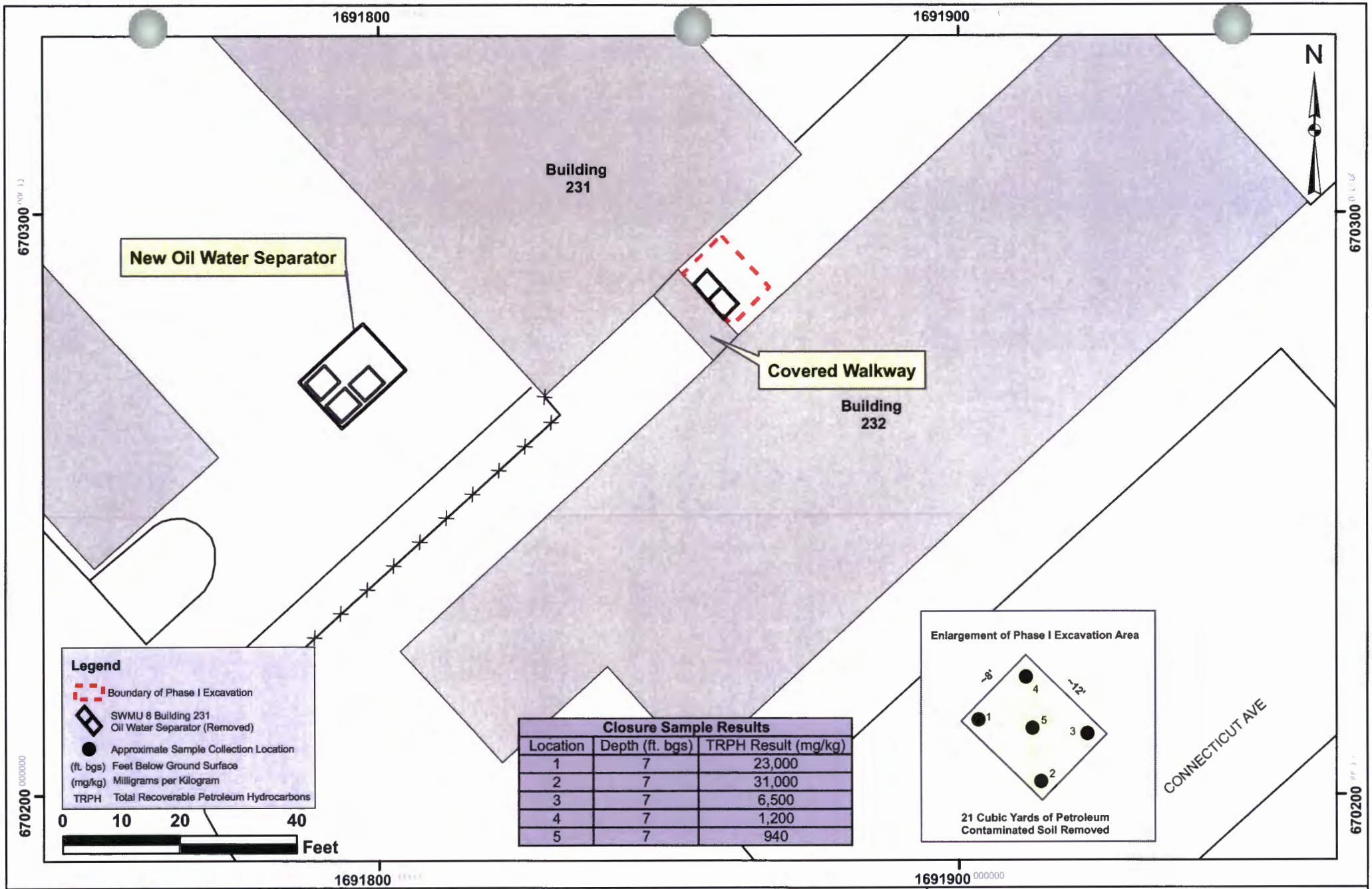
SWMU 8 Soil Remediation Voluntary Corrective Measures Work Plan Holloman AFB, New Mexico Bhate Project No. 9050291.01.01				
Activity	**Waste Stream**			
	PPE	**Soil**	**Water**	**Debris**
Equipment Decontamination	■	■	■	
Excavation	■	■		■

NOTE: PPE = Personal protective equipment

Table ~~8~~ 9-1. Key Personnel and Responsibilities

SWMU 8 Soil Remediation Voluntary Corrective Measures Work Plan Holloman AFB, New Mexico Bhate Project No. 9050291.01.01		
Name	**Project Title/Assigned Role**	**Phone Numbers**
Mr. John Hymer	Site Manager/SSHO	Work: (505) 491-9171
~~To be determined~~ Mr. Jim Moore, P.G.	Field Team Leader	~~To be determined~~ Work: (303) 929-4840
Mr. Frank Gardner, P.G.	Bhate Program Manager	Work: (303) 386-6454
Mr. Jim Moore, P.G.	Senior Geologist/Project Manager	Work: (303) 929-4840
Mr. Brian Muller, CIH, CHMM~~Ms. Judith McBride, CIH~~	Health and Safety Manager ~~Health and Safety Specialist~~	Office: (205) 918-4032 ~~Work: (205) 918-4000~~
NOTES: P.G. = Professional Geologist; SSHO = Site Safety and Health Officer; ~~CIH = Certified Industrial Hygienist~~CIH = Certified Industrial Hygienist, CHMM Certified Hazardous Materials Manager		

FIGURES



Closure Sample Results

Location	Depth (ft. bgs)	TRPH Result (mg/kg)
1	7	23,000
2	7	31,000
3	7	6,500
4	7	1,200
5	7	940

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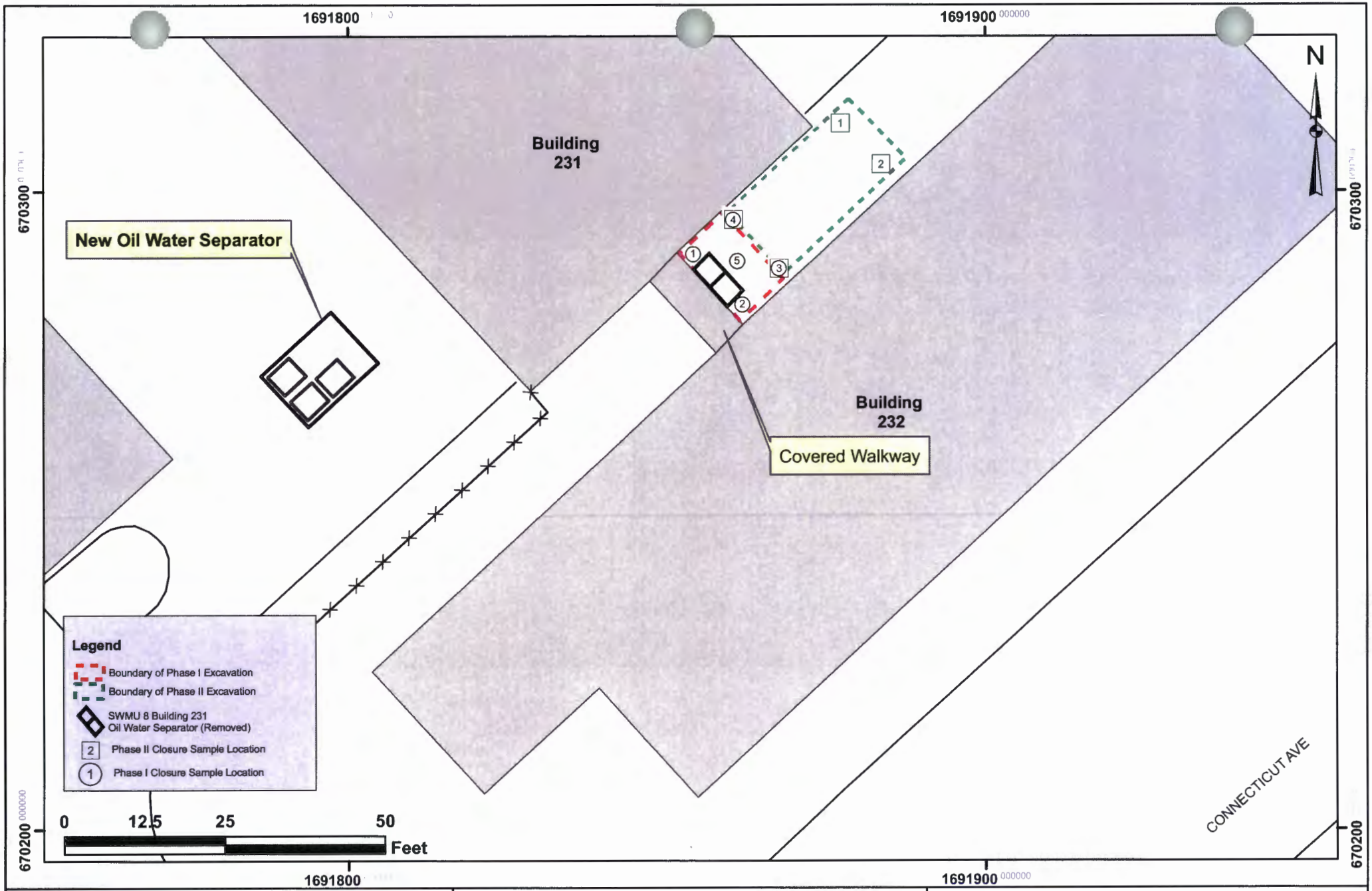
Phase I
SWMU 8 Oil/Water Separator

PROJECT NO.	SCALE	DATE	DRAWN BY:
9050291	1"=20'	9/30/08	cm
			DRAWING NO: fig_3

Remedial Action
Holloman Air Force Base
New Mexico

Figure 3



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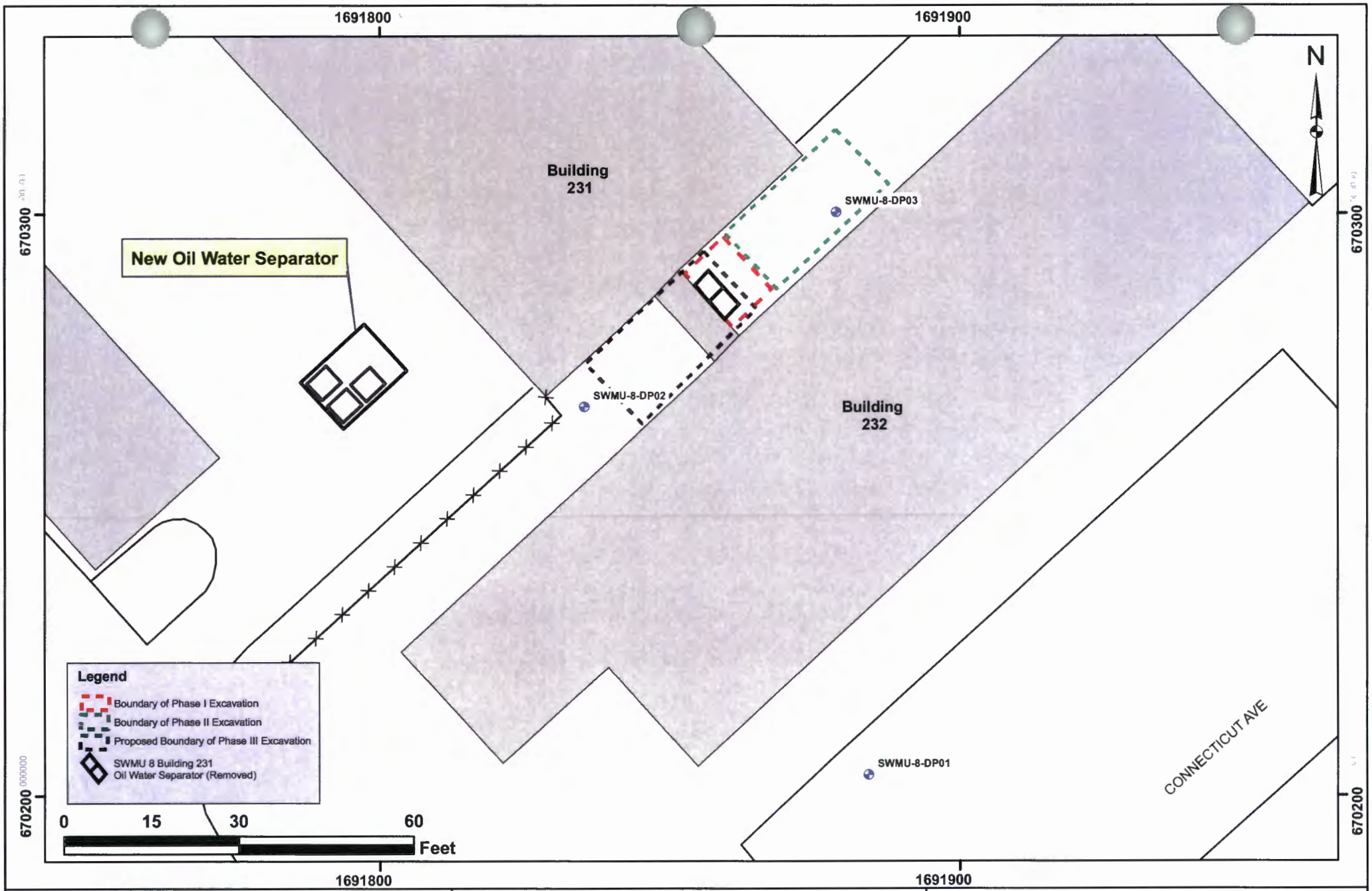
Phase II
SWMU 8 Petroleum Contaminated Soil

PROJECT NO.	SCALE	DATE	DRAWN BY:
9050291	1"=20'	9/30/08	cm
			DRAWING NO: fig_4

Remedial Action
Holloman Air Force Base
New Mexico

Figure 4



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Phase III
SWMU 8 Remediation and Excavation Boundaries

PROJECT NO.	SCALE	DATE	DRAWN BY:
9050291	1"=20'	9/30/08	cm
			DRAWING NO: fig_5

Remedial Action
Holloman Air Force Base
New Mexico

Figure 5

ATTACHMENTS

State of New Mexico
ENVIRONMENT DEPARTMENT
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6303
Telephone (505) 428-2500
Fax (505) 428-2567
www.nmenv.state.nm.us

BILL RICHARDSON
GOVERNOR

RON CURRY
SECRETARY

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

April 14, 2006

Ms. Debbie Hartell
Chief
Environmental Flight
49 CES/CEV
550 Tabosa Ave.
Holloman AFB, NM 88330-8458

SUBJECT: NOTICE OF DEFICIENCY: VOLUNTARY CORRECTIVE MEASURES WORK PLAN, SWMU 8 SOIL REMEDIATION, DECEMBER 2005 HOLLOMAN AIR FORCE BASE, EPA ID# NM6572124422 HWB-HAFB-06-002

Dear Ms. Hartell:

The New Mexico Environment Department (NMED) has reviewed the Holloman Air Force Base (HAFB) document entitled "Voluntary Corrective Measures Work Plan, SWMU 8 Soil Remediation". The following are the deficiencies that HAFB (the Permittee) is required to address before the Work Plan can be approved.

1. <u>General Comment</u>

Based upon review of the subject Work Plan, which included review of applicable portions of the previous Phase I and Phase II remediation reports, the extent of soil and ground water contamination at this site has not been adequately characterized. Therefore, the Permittee is required to conduct additional site characterization activities prior to Phase III soil excavation, as follows:

a) Figure 5 of the Work Plan shows the proposed boundary of the Phase III excavation. However, there is no indication as to how the southwest limit of the excavation was determined, as no soil sampling was conducted in this area. Therefore, the Permittee is required to submit a soil sampling plan as part of the revised Work Plan that will be

required as a result of this Notice. This plan should include a sufficient number of samples to adequately characterize the remaining soil contamination at this site that is not underneath the adjacent structures. NMED understands that soil and ground water conditions under the adjacent structures will be evaluated under a separate Work Plan addendum after the Phase III excavation and sampling is conducted. Soils should be analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), total petroleum hydrocarbons (TPH), polychlorinated biphenyls (PCBs), and target analyte list (TAL) metals (see Comment No. 6).

b) The Work Plan indicates that ground water at SWMU 8 is found at approximately 10 feet below ground surface. The Work Plan states that contaminated soils will be removed to approximately one (1) foot below the encountered ground water table. Contaminated soil is therefore in contact with ground water. The two previous remediation activities did not include ground water sampling and the proposed VCM does not include ground water sampling.

Therefore, the Permittee is required to submit a ground water sampling plan as part of the revised Work Plan that will be required as a result of this Notice. This shall be done prior to performing the Phase III excavation. The plan must include, at a minimum, the installation of two monitoring wells at the site, which can be temporary wells. One well should be installed within the boundary of the Phase II excavation and the other within the boundary of the proposed Phase III excavation. Ground water should be analyzed for VOCs, SVOCs, TPH, PCBs, TAL Metals and total dissolved solids (TDS).

2. **General Comment**

The Permittee is required to submit documentation regarding the Method Detection Limits of all soil and ground water analytes.

3. **Page 3-1, Section 3, Excavation Procedures, 1st Paragraph, 2nd Sentence**

This sentence states that soils contaminated by hydrocarbons at levels exceeding 880 mg/kg TPH will be removed. Based upon the description of the material released from the oil and water separator provided in Section 1.1.2, which included "oils, detergents and fuels" from an auto hobby shop, these materials are classified as "unknown oil". In accordance with the NMED TPH Screening Guidelines (November 2005), the residential TPH screening guideline for unknown oil is 800 mg/kg. Therefore, the Permittee is required to utilize the 800 mg/kg screening level. All sections of the Work Plan specifying TPH screening levels must be revised to reflect this change.

4. **Page 3-4, Section 3.3.3.1, Soil Screening, 1st Paragraph, 5th Sentence**

This sentence states that soils demonstrating a concentration below 880 (to be 800) mg/kg TPH will be stockpiled for backfill. This sentence must be revised to also state that soil used for backfill shall not have TPH hazardous constituent (e.g., VOCs, SVOCs) concentrations in excess of NMED residential soil screening levels.

5. **Page 3-5, Section 3.3.3.3, Confirmation Soil Sampling, Page 4-2, Section 4.2, Excavation Confirmation Sampling, and Table 3-1**

The Work Plan must be revised to show that, in addition to collecting confirmation samples at a frequency of one per 20 linear feet per sidewall and one per sidewall, a minimum of two soil samples shall be collected from any sidewall greater than 18 feet in length. Also, confirmatory sampling shall be biased to areas with the greatest potential for contamination.

6. **Page 4-1, Section 4.1.3, Laboratory Validation, 1st Sentence**

This sentence indicates that a minimum of one sample per site will be subject to laboratory validation. The Permittee shall be required to collect a minimum of two samples from suspect soil for laboratory validation. In addition, the November 2005 NMED TPH Screening Guidelines require that for sites with unknown oil sources, soil analysis must include VOCs, SVOCs, metals (TAL), and PCBs, as well as TPH. Therefore, the Permittee must revise the soil sampling plan to include laboratory analysis of soils for these parameters.

7. **Table 3-1, Sampling Plan and Related Sections**

Table 3-1 includes a column showing the "Frequency" of sample collection. NMED requires that the following changes be made regarding frequency to Table 3-1 and related sections:

a) During "Field Screening" of suspect soils for field confirmatory purposes, sample every 50 cubic yards (cy), not 100, and for laboratory validation purposes sample every 100 cy, not 300.

b) Sample the "Stock Pile" for backfill characterization every 200 cy, not 500.

8. **Figures 3, 4, and 5**

NMED requires that all site figures include a coordinate system (e.g., UTM, latitude/ longitude) and the boundaries of the site must be shown on the figures. Coordinates of

site boundaries must also be shown. High accuracy (+/-3 ft) GPS coordinates are acceptable. The Permittee is required to resubmit the subject figures satisfying these requirements.

Please respond to this Notice of Deficiency by June 15, 2006. If you have any questions regarding this letter, please contact David Strasser of my staff at (505) 222-9526.

Sincerely,

James P. Bearzi
Chief
Hazardous Waste Bureau

JPB:dcs

cc: J. Kieling, NMED HWB
W. Moats, NMED HWB
C. Amindyas, NMED HWB
D. Strasser, NMED HWB
D. Tellez, EPA, Region 6 (6PD-F)
D. Griffin, HAFB
File: Reading and HAFB 2006

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RESPONSIVENESS - INTEGRITY - TEAMWORK

June 12, 2006

New Mexico Environment Department
Hazardous Waste Bureau
Permits Management Program
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

Attention: Mr. John E. Kieling
Program Manager

Subject: Response to Notice of Deficiency: Voluntary Corrective Measures Work Plan, SWMU 8 Soil Remediation, December 2005, Holloman Air Force Base, EPA ID# NM6572124422, HWB-HAFB-06-002.

Dear Mr. Kieling,

Enclosed please find tabulated responses to the subject Notice of Deficiency (HWB-HAFB-06-002). Upon verbal or written concurrence from NMED, Bhate will submit the changed pages to NMED.

If you have any questions, please feel free to call me at 303-815-1762.

Sincerely,
Bhate Environmental Associates, Inc.

Frank Gardner, PG
Program Manager

cc w/ encl: C. Amindyas, NMED HWB
D. Strasser, NMED HWB
D. Griffin, HAFB

Voluntary Corrective Measures Work Plan SWMU 08 Soil Remediation, December 2005 Holloman AFB				
Comment No.	Section	Page	Comment	Response
Author	David Strasser		Date of Comments: April 14, 2006, Notice of Deficiency	Date of Response: June 12, 2006
1	General		Based upon review of the subject Work Plan, which included review of applicable portions of the previous Phase I and Phase II remediation reports, the extent of soil and groundwater contamination at this site has not been adequately characterized. Therefore, the Permittee is required to conduct additional site characterization activities prior to Phase III soil excavation as follows: a) Figure 5 of the Work Plan shows the proposed boundary of the Phase III excavation. However, there is no indication as to how the southwest limit of the excavation was determined, as no soil sampling was conducted in this area. Therefore, the Permittee is required to submit a soil sampling plan as part of the revised Work Plan that will be required as a result of this Notice. This plan should include a sufficient number of samples to adequately characterize the remaining soil contamination at this site that is not underneath adjacent structures. NMED understands that soil and groundwater conditions under the adjacent structures will be evaluated under a separate Work Plan addendum after the Phase III excavation and sampling is conducted. Soils should be analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), total petroleum hydrocarbons, (TPH), polychlorinated biphenyls (PCBSs), and target analyte list (TAL) metals (see Comment No. 6) b) The Work Plan indicates that groundwater at SWMU 8 is found at approximately 10 feet below ground surface. The Work Plan indicates that contaminated soils will be removed to approximately on (1) foot below the encountered ground water table. Contaminated soil is therefore in contact with ground water. The two previous remediation activities did not include ground water sampling and the proposed VCM does	Agreed. Delineation of soil and groundwater contamination at SWMU 08 was carried out in May 22, 2006, using guidance provided in the May 2, 2006, Memorandum Work Plan. The latter was provided and approved by NMED prior to the performance of the characterization. In summary, three groundwater monitoring wells were installed to delineate soil and groundwater conditions within: 1. the formerly excavated area, 2. the area proposed for excavation in the SWMU 08 Soil Remediation Work Plan and, 3. the immediate downgradient area south of Building 232. Although analytical results for soil and groundwater samples collected are not available at this time, they will be used to guide the soil excavation proposed in this work plan. The analyses requested in the NOD were performed on the samples collected on May 22, 2006. Well locations are provided in Figure 1, Attachment 1.

Voluntary Corrective Measures Work Plan SWMU 08 Soil Remediation, December 2005 Holloman AFB				
Comment No.	Section	Page	Comment	Response
Author	David Strasser		Date of Comments: April 14, 2006, Notice of Deficiency	Date of Response: June 12, 2006
			not include ground water sampling. Therefore, the Permittee is required to submit a ground water sampling plan as part of the revised Work Plan that will be required as a result of this Notice. This shall be done prior to performing Phase III excavation. The plan must include, at a minimum, installation of two monitoring wells at the site, which can be temporary wells. One well should be installed within the boundary of the Phase II excavation and the other within the boundary of the proposed Phase III excavation. Ground water should be analyzed for VOCs, SVOCs, TPH, PCBs, TAL Metals and total dissolved solids (TDS).	
2	General		The Permittee is required to submit documentation regarding the Method Detection Limits of all soil and ground water analytes.	Agreed. Table 4-3 has been changed to represent a summary of laboratory quality control criteria to include the method detection limits.
3	Section 3, 1st Para, 2nd sentence	3-1	This sentence states that soils contaminated by hydrocarbons at levels exceeding 880 mg/kg TPH will be removed. Based upon the description of the material released form the oil and water separator provided in Section 1.1.2, which included "oils, detergents and fuels" from an auto hobby shop, these materials are classified as "unknown oil". In accordance with NMED TPH Screening Guidelines (November 2005), the residential TPH screening guideline for unknown oil is 800 mg/kg. Therefore, the Permittee is required to utilize the 800 mg/kg screening level. All sections of the Work Plan specifying TPH screening levels must be revised to reflect this change.	Agreed. The 800 mg/kg TPH standard will be used as the screening level and all relevant sections of the Work Plan will be modified to reflect this change.
4	Section 3.3.3.1, 1st Para, 5th sentence	3-4	This sentence states that soils demonstrating a concentration below 880 (to be 800) mg/kg TPH will be stockpiled for backfill. This sentence must be revised to also state that soil used for backfill shall not have TPH hazardous constituent (e.g. VOCs, SVOC) concentrations in excess of NMED residential screening levels.	The following sentence has been added to the discussion: All soil stockpiled for backfill will undergo laboratory analysis to verify no TPH hazardous constituents (e.g., VOCs, SVOCs) in excess of NMED residential SSLs are present.

Voluntary Corrective Measures Work Plan SWMU 08 Soil Remediation, December 2005 Holloman AFB				
Comment No.	Section	Page	Comment	Response
Author	David Strasser		Date of Comments: April 14, 2006, Notice of Deficiency	Date of Response: June 12, 2006
5	Sections 3.3.3.3 & 4.2 & Table 3-1	3-5 & 4-2	The Work Plan must be revised to show that, in addition to collecting confirmation samples at a frequency of one per 20 linear feet per sidewall, a minimum of two soil samples shall be collected from any sidewall greater than 18 feet in length. Also, confirmatory sampling shall be biased to areas with the greatest potential for contamination.	The affected pages (3-5, 4-2 and Table 3-1) have been modified as follows: Excavation confirmation samples will be collected at a frequency of 2 per 18 linear feet (ln ft) for each side wall at mid-depth of the contamination zone. At a minimum, 1 sample per side wall will be collected for side walls less than 18 ln ft. Also, confirmatory sampling shall be biased to areas with the greatest potential for contamination.
6	Section 4.1.3, 1st sentence	4-2	This sentence indicates that a minimum of one sample per site will be subject to laboratory validation. The Permittee shall be required to collect a minimum of two samples from suspect soil for laboratory validation. In addition, the November 2005 NMED TPH Screening Guidelines require that for sites with unknown soil sources, soil analysis must include VOCs, SVOCs, metals (TAL), and PCBs as well as TPH. Therefore, the Permittee must revise the soil sampling plan to include laboratory anlaysis of soils for these parameters.	Section 4 of the work plan has been streamlined to resonate with the excavation process outlined in Section 3. Essentially, all suspect soil will be treated as contaminated soil and taken to the FT-31 Land farm for treatment. Therefore, sampling of suspect soils is no longer applicable. Table 3-1 has been changed accordingly.
7	Table 3-1		Table 3-1 includes a column showing the "Frequency" of sample collection. NMED requires that the following changes be made regarding frequency to Table 3-1 and related sections: a) During "Field Screening" of suspect soils for field confirmatory purposes, sample every 50 cubic yards (cy), not 100, and for laboratory validation purposes sample every 100 cy, not 300. b) Sample the "Stock Pile" for backfill characterization every 200 cy, not 500.	The requested changes have been made to Table 3-1 with the exception of comment 7a as all suspect soil will be handled as though contaminated and transported to the FT-31 Land farm for treatment. Table 3-1 has been changed to remove all references to suspect soils.
8	Figures 3, 4, and 5		NMED requires that all site figures include a coordinate system (e.g., UTM, latitude/longitude) and the boundaries of the site must be shown on the figures. Coordinates of site boundaries must also be shown. High accuracy (+/- 3 ft) GPS coordinates are acceptable. The	Agreed. Site coordinate information will be added to the indicated figures.

Voluntary Corrective Measures Work Plan SWMU 08 Soil Remediation, December 2005 Holloman AFB				
Comment No.	Section	Page	Comment	Response
Author	David Strasser		Date of Comments: April 14, 2006, Notice of Deficiency	Date of Response: June 12, 2006
			Permittee is required to resubmit the subject figures satisfying these requirements.	
			Response to NOD due by June 15, 2006.	

State of New Mexico
ENVIRONMENT DEPARTMENT
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6303
Telephone (505) 428-2500
Fax (505) 428-2567
www.nmenv.state.nm.us

BILL RICHARDSON
GOVERNOR

RON CURRY
SECRETARY

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

October 12, 2006

REC'D OCT 17 2006

Ms. Debbie Hartell, Chief
Environmental Flight
49 CES/CEV
550 Tabosa Ave.
Holloman AFB, NM 88330-8458

RE: APPROVAL OF THE VOLUNTARY CORRECTIVE MEASURES WORK PLAN, SWMU 8 SOIL REMEDIATION, DECEMBER 2005
HOLLOMAN AIR FORCE BASE, EPA ID# NM6572124422
HWB-HAFB-06-002

Dear Ms. Hartell:

The New Mexico Environment Department (**NMED**) has reviewed Holloman Air Force Base's (the **Permittee's**) June 12, 2006 response to NMED's April 14, 2006 Notice of Deficiency for the SWMU 8 Voluntary Corrective Measures Work Plan, dated December 2005, for the removal of contaminated soils. The NMED has also reviewed the Technical Memorandum Letter Report for SWMU 8 Soil and Groundwater Sampling and Analysis (**Letter Report**), dated August 2006, which was required to be submitted in response to the Notice of Deficiency.

The NMED hereby concurs with the Response and approves the Work Plan for implementation. The Permittee is now required to submit the changed pages, as indicated in the response, for incorporation into the Work Plan. The NMED also concurs that the soil and groundwater sampling results presented in the Letter Report indicate that the extent of contamination has been adequately defined.

If you have any questions regarding this matter, please contact David Strasser of my staff at (505) 222-9526.

Sincerely,

John E. Kieling
Manager
Permits Management Program

JEK:dcs

cc: J. Bearzi, NMED HWB
W. Moats, NMED HWB
C. Amindyas, NMED HWB
D. Strasser, NMED HWB
D. Tellez, EPA Region 6 (6PD-F)
G. Fish, HAFB
File: HAFB 2006 and Reading
HWB-HAFB-06-002

APPENDIX A1

SECTION 10.0 OIL/WATER SEPARATOR REMOVAL AND RECLAMATION AT SWMU 8 – BUILDING 231

EBASCO, NOVEMBER 1995

APPENDIX A2

SECTION 4.0 SITE RESTORATION AT SWMU 8, BUILDING 231 O/WS

FOSTER WHEELER, DECEMBER 1997

APPENDIX A3

PORTIONS OF *TECHNICAL MEMORANDUM LETTER REPORT*

FOR SWMU 8 SOIL AND GROUNDWATER SAMPLING AND ANALYSIS HOLLOMAN AFB, NEW MEXICO

BHATE, 2006

TECHNICAL MEMORANDUM
LETTER REPORT
FOR
SWMU 8 SOIL AND GROUNDWATER SAMPLING AND ANALYSIS
HOLLOMAN AFB, NEW MEXICO

DATE: August 2, 2006

FROM: Jim Moore, Bhate Environmental Associates, Inc.

TO: Dave Griffin, 49 CES/CEV, Holloman Air Force Base, NM

SUBJECT: **SWMU 8 SOIL AND GROUNDWATER SAMPLING AND ANALYSIS**

1.0 INTRODUCTION

This technical memorandum was prepared by Bhate Environmental Associates, Inc. (Bhate) for the Environmental Flight 49th CES/CEV, Holloman Air Force Base (HAFB), New Mexico. This letter report contains the results of the subsurface soil and groundwater water samples that were collected at SWMU 8 (former Oil/Water Separator located at Building 231) in May 2006. This sampling event was conducted in accordance with the *Memorandum Scope of Work for Soil and Groundwater Sampling and Analysis* (Bhate, May 2006). This Scope of Work was performed through the U.S. Army Corps of Engineers (USACE), under contract DACA45-03-D-0023, Task Order No. 017.

The scope of work for SWMU 8 was prepared to meet the requirements for additional soil and groundwater characterization as requested by the New Mexico Environment Department (NMED). General comment No. 1 in the NMED Notice of Deficiency (NOD) letter to Holloman AFB dated April 14, 2006 (Appendix A) requested that additional subsurface soil samples should be collected to characterize the remaining soil contamination at the site (that is not underneath the adjacent structures) and that at least two temporary groundwater monitoring wells be installed and sampled at the site before the Phase III soil excavation can commence.

2.0 SITE LOCATION, DESCRIPTION AND BACKGROUND

SWMU 8 is the former underground Oil/Water Separator (OWS) that was located on the south side of Building 231. Building 231 (Auto Hobby Center) is located on the main base at Holloman at 642 West Connecticut Avenue. The OWS was

abandoned and filled with sand (Ebasco Services, Inc., 1995). The OWS was 4 feet wide, 8 feet long and 4 feet deep and was located east of the covered walkway which connects Buildings 231 and 232 (Figure 1). Two previous remedial action soil excavations conducted by Ebasco Services (1995) and Foster Wheeler (1997) have removed 80-90 percent of the petroleum contaminated soil (PCS) and the abandoned OWS.

Records indicate that the OWS accepted wash water from a heavy equipment wash rack located adjacent to the unit. Over a period of years the OWS released wash water rinsate containing oils, detergents and fuels into the surrounding soil. The initial removal and investigation/characterization activities began in August 1995 when the abandoned OWS and 21 cubic yards (cu yds) (28 tons) of PCS were removed (Ebasco Services, Inc., 1995). Figure 1 shows the location of the former OWS, and the limits of this excavation (Phase I). The initial excavation was backfilled with clean soil compacted to grade.

It was then discovered that contaminated soil extended beyond what had been anticipated for the first phase of remediation. After the Phase I removal, contamination was identified in the five native subsurface soil samples collected from the excavation corners and one from the center of the excavation. Excavation activities (Phase II) were continued in April 1997, and the original excavation was extended eastward from the eastern edge of the original excavation (Figure 1). An additional 31.8 cu yds (43 tons) of TRPH-contaminated soil were excavated during the second phase of remediation. The second excavation was backfilled with clean soil (Foster Wheeler, 1997).

3.0 FIELD ACTIVITIES

To address NMED requirements (NOD letter, April 2006), three soil borings/monitoring wells were installed, soil and groundwater samples were collected to determine the nature and extent of contamination and to provide groundwater flow data.

3.1 Soil Boring and Sampling

In May 2006, three soil borings (DP01 through DP03) were installed around the SWMU 8 (Figure 1) for the purpose of soil sampling in accordance with HAFB Standard Operating Procedures (SOPs) provided in the *Base-wide Quality Assurance Project Plan* (Bhate, November 2003). The soil borings were installed using an AMS Power Probe 9600E direct push technology (DPT) rig, a 48-inch MacroCore® soil sampling device and associated tooling. These soil borings were sampled continuously to a depth of 11 to 14.4 feet (ft) below ground surface (bgs).

Soil samples were visually classified in the field by a geologist according to the Unified Soil Classification System. Soils were screened with a TVA 1000

Organic Vapor Analyzer (OVA) to aid in selecting samples for laboratory analysis. One subsurface soil sample was collected from DP01 and DP02 for laboratory analysis. A soil sample was not collected from DP03 as this borehole was installed within the clean backfill from the Phase II excavation. Appendix B contains the drilling logs for this investigation.

Laboratory analytical services using USEPA SW 846 methodology were procured through Accutest Laboratories, Inc located in Orlando Florida. The *Base-wide Quality Assurance Project Plan* (Bhate, November 2003) was followed throughout the processes of sample collection, handling and laboratory analysis. Soil samples were analyzed for:

- Total Petroleum Hydrocarbons (TPH) (Gasoline Range Organics [GRO] /Diesel Range Organics [DRO]/Oil Range Organics [ORO]) by Method 8015M
- Volatile Organic Compounds (VOCs) by Method 8260B
- Semi Volatile Organic Compounds (SVOCs) by Method 8270C
- Polychlorinated Biphenyls (PCBs) by Method 8082
- Target Analyte List (TAL) Metals by Method 6010 and 7471A

3.2 Groundwater Monitoring Well Installation and Sampling

Permanent monitoring wells were installed in each of the three soil borings for the purpose of collecting groundwater samples. The groundwater monitoring constructed of 1-inch ID polyvinyl chloride (PVC). Each well was screened with 5 or 10 feet of 0.020 inch factory slotted pre-packed PVC. The annular space surrounding the screen was backfilled with 10/20 Colorado silica sand and capped with a 2-foot layer of bentonite pellets. The monitoring wells were completed as flush mount well completions. Appendix C contains the well construction diagrams for these wells. Each well was developed to promote hydraulic communication with the aquifer and to remove fines prior to sampling.

In June 2006, groundwater samples were collected form each of the monitoring wells after each well was developed. Groundwater samples were collected from each well using disposable polypropylene tubing attached to a peristaltic pump. Prior to sampling, the static water level in each well was measured to the nearest 0.01 feet using an electronic water level measuring device. The well was purged of either three standing casing volumes or until dry (and permitted to recover) prior to sample collection. Groundwater samples were collected under low-flow conditions and transferred directly from the sampling tubing to the sample containers provided by the analytical laboratory. The aliquot of groundwater used for TAL metals was field filtered with a 0.45 micron filter. The samples were preserved, placed on ice to 4 degrees centigrade and transported under strict chain-of-custody to the analytical laboratory.

The groundwater samples were analyzed using recognized USEPA SW 846 methodology by Accutest Laboratories, Inc. located in Orlando, Florida. The Base-wide Quality Assurance Project Plan (QAPP) was followed throughout the processes of sample collection, handling and laboratory analysis. Groundwater samples were analyzed for:

- TPH (GRO/DRO/ORO) by Modified Method 8015M
- VOCs by Method 8260B
- SVOCs by Method 8270C
- PCBs by Method 8082
- TAL Metals by Method 6010B and 7470A
- TDS by Method 160.1

3.3 Surveying

Sample locations were surveyed in accordance with methods described in the QAPP (Bhate, November 2003). The locations (DP01, DP02 and DP03) are referenced with horizontal coordinates, and top of casing elevations were obtained for each monitoring well. All elevations are referenced to the North American Datum (NAD) 1983. All horizontal coordinates are referenced to the State Plane Coordinate System, New Mexico Central. Elevations and coordinates are surveyed to the closest 0.001 foot.

3.4 Equipment Decontamination

All reusable equipment associated with soil sampling was decontaminated in accordance with the HAFB SOPs provided in the *Base-wide QAPP* (Bhate, November 2003).

3.5 Waste Handling

All investigation derived waste (IDW) produced during the investigation process was handled in accordance with the HAFB SOPs provided in the *Base-wide QAPP* (Bhate, November 2003).

4.0 SAMPLING RESULTS

This section presents the subsurface soil and groundwater sample results. The DPT soil boring and monitoring well locations are shown on Figure 1. The complete analytical results by sample delivery group are included in Appendix D.

4.1 Soil Sampling Analytical Results

The three subsurface soil samples (including one duplicate) collected from soil borings DP01 and DP02 were analyzed for VOCs, SVOCs, TPH (GRO/DRO/ORO), PCBs, and TAL metals. One VOC (naphthalene) was detected in the soil sample collected from SWMU08DP01-5; all other VOCs were not detected. The estimated concentration of naphthalene (2.7 micrograms per kilogram [µg/kg]) is well below the NMED soil screening level (SSL) (NMED, 2006) for naphthalene (79.5 milligrams per kilogram [mg/kg]). No other SVOCs, TPH (GRO/DRO/ORO) or PCBs were detected. Additionally all TAL metals detected in the subsurface soil samples were below their respective SSLs.

4.2 Groundwater Sampling Analytical Results

The four groundwater samples (including one duplicate) collected from monitoring wells DP01, DP02 and DP03 were analyzed for VOCs, SVOCs, TPH (DRO/ORO), PCBs, TAL metals and total dissolved solids (TDS). Low concentrations of four VOCs (bromodichloromethane, chloroform, dibromochloromethane and o-dichlorobenzene) were detected in the groundwater samples from the three monitoring wells installed at SWMU 8. No other VOCs were detected. All of the detected VOCs were below the New Mexico Water Quality Control Commission (NMWQCC) Human Health Standards (New Mexico Administrative Code [NMAC] 20.6.2). No other SVOCs, TPH (GRO/DRO/ORO) or PCBs were detected. Additionally, all TAL metals detected in the groundwater samples were below their respective NMWQCC standards.

TDS concentrations ranged from 2,600 to 3,190 milligrams per liter (mg/L). It is hypothesized that these TDS concentrations are artificially low due to the dilution of natural groundwater from leaking water lines. Recent interviews with the Postal Service Center (Building 232) personnel indicated that two sink holes had developed along Connecticut Avenue (east side of B232) during the past 6-8 months due to large breaks in the domestic water line.

4.3 Site Hydrogeology

Water levels for the three monitoring wells were measured in July 2006. The northing and easting coordinates, top of casing (TOC), depth to water (DTW) and groundwater elevations are presented in Table 1. The depth to groundwater measurements at SWMU 8 ranged from 2.45 to 4.19 ft below TOC, and groundwater elevations ranged from 4072.483 (DP03) to 4071.852 ft above mean sea level (msl). A map of the potentiometric surface was prepared using the groundwater elevation data (Figure 2). The contour map indicates that groundwater flows to the west-southwest across the site at a gradient of approximately 0.013.

5.0 CONCLUSIONS

The requirements of NMED's NOD letter (HWB-HAFB-06-002) dated April 14, 2006 have been met. Holloman AFB has installed and sampled three groundwater monitoring wells for VOCs, SVOCs, TPH, PCBs, TAL metals and TDS at SWMU 8. One well (DP03) was installed within the boundary of the Phase II excavation and one well (DP02) was installed within the boundary of the proposed Phase III excavation. A third cross gradient well (DP01) was installed to determine the groundwater flow direction. Additionally subsurface soil samples were collected from soil borings DP01 and DP02 to characterize the extent of the remaining soil contamination at the site that is not underneath the adjacent structures (Buildings 231 and 232). The subsurface soil sample results indicate that the extent of minimal soil contamination has been defined.

6.0 REFERENCES

Bhate Environmental Associates, Inc. November 2003. *Final Base-wide Quality Assurance Project Plan.*

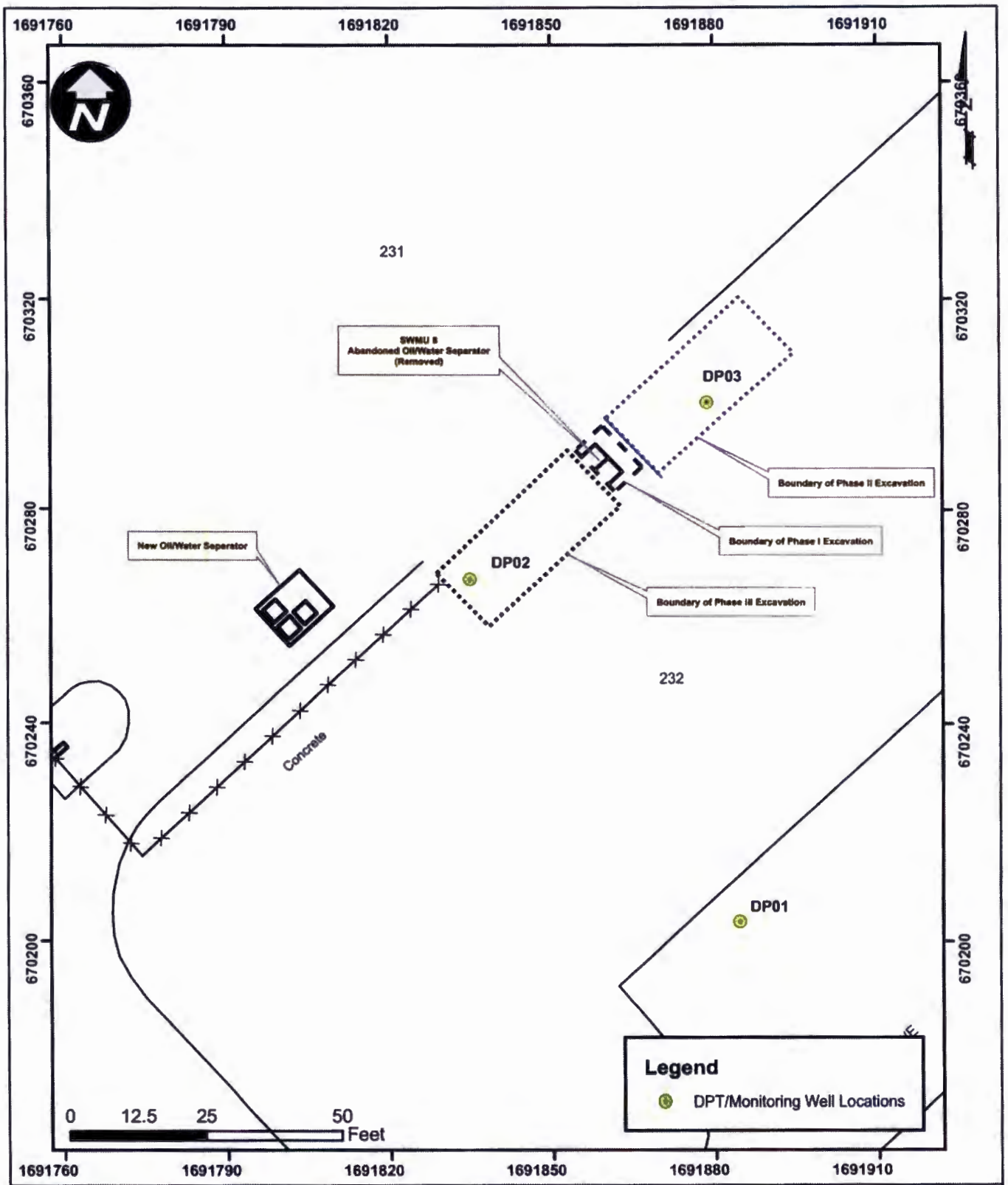
Bhate Environmental Associates, Inc. May 2006. *Memorandum Scope of Work for Soil and Groundwater Sampling and Analysis, Holloman Air Force Base, New Mexico.*

Ebasco Services, Inc. November 1995. *Remediation of POL Contaminated Sites and Oil/Water Separator Removals, Holloman Air Force Base, New Mexico.*

Foster Wheeler. December 1997. *Final Closure Report Addendum, Phase II Remediation of POL-Contaminated Sites and O/WS/WOT Removals Holloman Air Force Base, New Mexico.*

NMAC 20.6.2, New Mexico Water Quality Control Commission Regulations, September 15, 2002. (http://www.nmenv.state.nm.us/NMED_Regs/gwb/20_6_2_NMAC.pdf).

New Mexico Environment Department. June 2006. *NMED Technical Background Document for Development of Soil Screening Levels, Revision 4.0.*



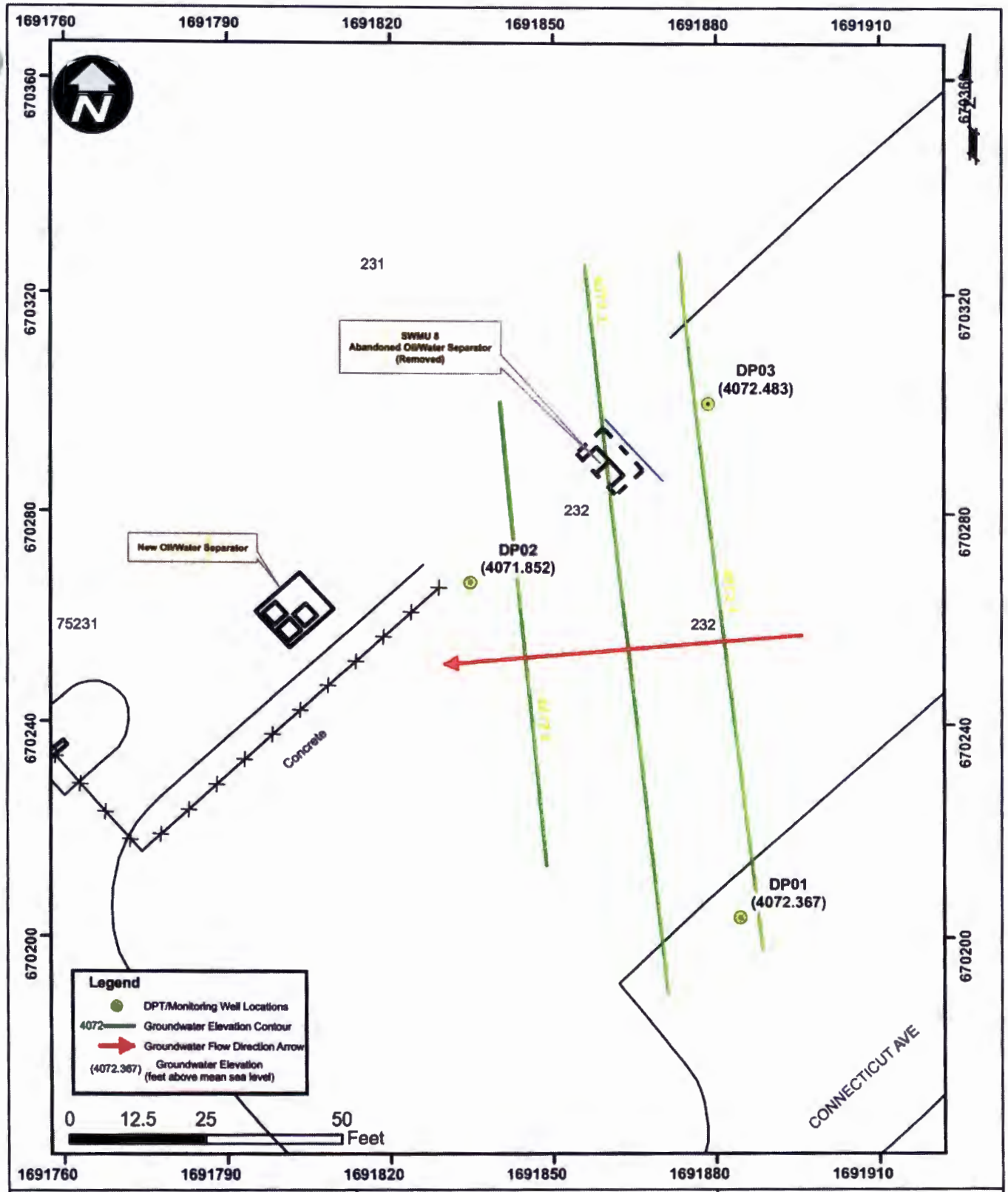
bhate associates
ENGINEERING SCIENCE AND CONSTRUCTION

SWMU 8 Soil Boring and Monitoring Well Locations

PROJECT NO	SCALE	DATE	DRAWN BY
9050291	1"=25'	7/28/06	cm
			DRAWING NO. fig1

Remedial Action
Holloman Air Force Base
New Mexico

Figure 1



bhate associates

ENGINEERING SCIENCE AND CONSTRUCTION

SWMU 8 Potentiometric Surface Map

PROJECT NO	SCALE	DATE	DRAWN BY
9050291	1"=25'	7/28/06	cm

DRAWING NO. fig2

Remedial Action
Holloman Air Force Base
New Mexico

Figure 2

Table 1. Groundwater Elevation Summary
SWMU8
Holloman AFB, NM
Bhate Project No. 9050291.01.01

Well	Northing	Easting	Elevation TOC (ft above msl)	DTW from TOC (ft below TOC)	Groundwater Elevation July 2006 (ft above msl)
DP01	670203.701	1691884.472	4074.827	2.46	4072.367
DP02	670266.812	1691834.779	4076.042	4.19	4071.852
DP03	670300.290	1691878.600	4075.883	3.40	4072.483

NOTES: TOC = Top of Casing; DTW = Depth to Water; ft = feet; msl = mean seal level

Table 2.
Soil Analytical Data (June 2006)
SWMU-8
Holloman Air Force Base, New Mexico

Client Sample ID:	Soil Screening Levels	SWMU08DP01-5		SWMU08DP02-9		SWMU08DP02-9A		TRIP BLANK	
Lab Sample ID:	NMED	F40927-3		F40927-1		F40927-2		F40927-4	
Date Sampled:	Residential[1]	5/22/2006		5/22/2006		5/22/2006		5/22/2006	
Analyte		Result[2]	Q	Result[2]	Q	Result[2]	Q	Result[2]	Q
Volatile Organic Compounds	**mg/kg**	**µg/kg**		**µg/kg**		**µg/kg**		**µg/kg**	
Naphthalene	79.5	2.7	JB	2.9	U	2.7	U	2.0	U
TAL Metals Analysis	**mg/kg**	**mg/kg**		**mg/kg**		**mg/kg**		**mg/kg**	
Aluminum	77800	482		3590		3160		NA	
Antimony	31.3	1.2	J	0.75	U	0.75	U	NA	
Arsenic	3.9	0.82	J	0.95	J	0.56	J	NA	
Barium	15600	13.2	J	31.8		26.8	J	NA	
Beryllium	156	0.058	J	0.16	J	0.21	J	NA	
Calcium	NV	257000		171000		192000		NA	
Chromium	234	0.45	J	3.4		3.3		NA	
Cobalt	1520	0.42	J	0.90	J	0.94	J	NA	
Copper	3130	0.72	J	0.61	J	0.50	J	NA	
Iron	23500	349		3560		3330		NA	
Magnesium	NV	2090		1620		1640		NA	
Manganese	3590	5.7		33.9		30.4		NA	
Mercury	6.11	0.0078	U	0.016	J	0.0084	U	NA	
Nickel	1560	0.69	J	2.4	J	2.2	J	NA	
Potassium	NV	145	J	895	J	847	J	NA	
Selenium	391	0.61	J	0.28	U	0.31	J	NA	
Sodium	NV	175	J	249	J	167	J	NA	
Vanadium	78.2	2.4	J	7.1		7.1		NA	
Zinc	23500	3.7	J	7.7		8.2		NA	
General Chemistry		**%**		**%**		**%**		**%**	
Solids, Percent	NV	75.0		70.3		70.8		NA	

Notes.
NMED = New Mexico Environmental Department
TPH = Total Petroleum Hydrocarbons
µg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
NV = No Value
NA = Not Analyzed
Q = Qualifier
U = Not detected
J = Estimated result. Result is between the Method Detection Limit (MDL) and the Reporting Limit (RL), and/or qualified by the validating chemist (see Appendix H)
[1]NMED, June 2006. Technical Background Document for Development of Soil Screening Levels, Revision 4.0 (Residential Soil)
[2]If results are not detected (U) then the value is set at the Method Detection Limit (MDL)
[3]NMED, October 2006 TPH Screening Guidelines (Diesel #2/crankcase oil, Residential Direct Exposure)
Bold value indicate analytes above NMED Soil Screening Levels (Rev 4.0, Jun 2006) or combined TPH results above NMED TPH Screening Guidelines for Diesel #2/crankcase oil (Table 2b, Oct 2006)

Table 3.
Groundwater Analytical Data (June 2006)
SWMU-8
Holloman Air Force Base, New Mexico

Client Sample ID:	Groundwater Screening Levels		SWMU-08-DP01		SWMU-08-DP01FD		SWMU-08-DP02		TRIP BLANK		SWMU-08-DP03	
Lab Sample ID:	NMWQCC[1]	EPA MCL	F41336-1		F41336-2		F41372-1		F41372-2		F41371-1	
Date Sampled:			6/7/2006		6/7/2006		6/8/2006		6/8/2006		6/8/2006	
Analyte			Result[2]	Q	Result[2]	Q	Result[2]	Q	Result[2]	Q	Result[2]	Q
Volatile Organic Compounds	µg/L	µg/L	µg/L		µg/L		µg/L		µg/L		µg/L	
Bromodichloromethane	NV	NV	9.2		9.7		0.50	U	2.0	U	0.50	U
Chloroform	100	NV	21.0		23.7		0.50	U	2.0	U	1.7	
Dibromochloromethane	NV	NV	1.2		1.2	J	0.40	U	2.0	U	0.40	U
o-Dichlorobenzene	NV	600	0.50	U	0.50	U	0.53	J	2.0	U	0.50	U
TAL Metals Analysis	µg/L	µg/L	µg/L		µg/L		µg/L		µg/L		µg/L	
Aluminum	NV	NV	68.6	J	59.7	J	6820		NV		3450	
Arsenic	100	10	11.3		11.8		7.1	J	NV		6.6	J
Barium	1000	2000	21.6	J	22.2	J	84.3	J	NV		72.2	J
Beryllium	NV	4	2.5	J	2.3	J	4.8	J	NV		4.8	J
Calcium	NV	NV	656000		723000		822000		NV		738000	
Cobalt	50	NV	0.86	J	0.86	J	3.1	J	NV		1.2	J
Magnesium	NV	NV	81600		84100		64300		NV		57300	
Manganese	200	NV	119		227		259		NV		173	
Nickel	200	NV	5.1	J	23.8	J	8.9	J	NV		3.9	J
Potassium	NV	NV	9940	J	10200		15200		NV		6520	J
Selenium	50	50	3.8	J	3.9	J	3.8	J	NV		2.8	U
Sodium	NV	NV	78200		69000		71700		NV		72300	
Vanadium	NV	NV	108		101		29.3	J	NV		7.9	J
Zinc	10000	NV	3.4	J	1.6	U	54.3		NV		27.5	
General Chemistry	mg/L	mg/L	mg/L		mg/L		mg/L		mg/L		mg/L	
Solids, Total Dissolved	1000	NV	3190		2600		3060		NV		2910	

Notes:
NMWQCC = New Mexico Water Quality Control Commission
EPA = Environmetal Protection Agency
MCL = Maximum Contaminant Level
UTL = Upper Tolerance Limit
µg/L = micrograms per liter
mg/L = milligrams per liter
NV = No Value
Q = Qualifier
U = Not detected
J = Indicates an estimated value
[1]Standards for Groundwater, if 10,000 mg/l TDS Concentration or Less, New Mexico Administrative Code 20.6.2.3103
[2] If results are not detected (U) then the value is set at the Method Detection Limit (MDL)
Bold value indicate analytes above New Mexico Groundwater Quality Standard

HTW DRILLING LOG

HOLE NO. SWMU C3-DP01

SHEET 1 OF 2 SHEETS

1 COMPANY NAME: Shute

2 DRILLING CONTRACTOR: ESN Golden, Co

3 PROJECT: [illegible]/DPT Pilot Test

4 LOCATION: SWMU C3

5 NAME OF DRILLER: Dusty McNeil

6 MANUFACTURER'S DESIGNATION OF DRILL: AMS

7 SIZES & TYPES OF DRILLING & SAMPLING EQUIPMENT: AMS Power Probe 33 x 5' rod; 2" Piezo sleeves (5)

8 HOLE LOCATION: North East

9 SURFACE ELEVATION (ft NGVD)

10 DATE STARTED: 5/22/06

11 DATE COMPLETED: 5/22/06

12 OVERBURDEN THICKNESS: NA

13 DEPTH DRILLED INTO ROCK: NA

14 TOTAL DEPTH OF HOLE: 40' bgs

15 DEPTH GROUNDWATER ENCOUNTERED: ~ 2.0 bgs

16 DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED

17 OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18 GEOTECHNICAL SAMPLES: NA | DISTURBED | UNDISTURBED

19 TOTAL NUMBER OF CORE BOXES

20 SAMPLES FOR CHEMICAL ANALYSIS	VOC	SVOC METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21 TOTAL CORE REC
1	X	X	[illegible]	X	X	

22 DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23 SIGNATURE OF INSPECTOR
Temp well		X		[illegible]

ELEV a	DEPTH b	DESCRIPTION OF MATERIALS c	Field Screening Results d	Geotech Sample or Core Box No e	Analytical Sample No f	Blow Counts g	REMARKS h
	0	(0 - 2.5) sandy silt w [illegible] (.5M) Fine gr [illegible] moist [illegible]					Sample [illegible]
	1						
	2						
		[illegible] sand [illegible] gravel (.5) [illegible] fine [illegible] 5Y 4 brown					
	5						

PROJECT

HOLE NO. DP-01

HTW DRILLING LOG

HOLE NO. SWMUC8-DP01

PROJECT Gw Pioneer/DPT Pilot Test

INSPECTOR T Moore

SHEET 1 OF 2 SHEETS

ELEV a	DEPTH b	DESCRIPTION OF MATERIALS c	Field Screening Results d	Geotech Sample or Core Box No e	Analytical Sample No. f	Blow Counts g	REMARKS h
		(5.0-7.5) sand v. fine (SP) moist, well sorted, well rounded, stained 7.5YR 5/6 brown	PID 32.25 FID 2.00				
		7.5-10' [illegible] sand v. [illegible] grains (SM) loose, moist w/ [illegible] pm [illegible] 7.5YR [illegible] brown	PID 1.50 FID [illegible]				
		10-12' fine v.f. gr (SP) [illegible] well sorted, [illegible] wet 5YR 5/6 strong brown	PID 1.5 FID 5				
		[illegible] w/ [illegible] w/ 1 in. (in) [illegible]	PID 3.5 FID 1.5				

PROJECT

HOLE NO. DP-01

HTW DRILLING LOG

HOLE NO. DP 02

SHEET 1 OF 2 SHEETS

1 COMPANY NAME: Bhate

2 DRILLING CONTRACTOR:

3 PROJECT:

4 LOCATION: Sw Mu 08

5 NAME OF DRILLER: Dusty McNeal

6 MANUFACTURER'S DESIGNATION OF DRILL: Ams

7 SIZES & TYPES OF DRILLING & SAMPLING EQUIPMENT: Ams Power Pig Tec-c; 3 1/4 HSA; 1.5 Long Spoons

8 HOLE LOCATION: North East

9 SURFACE ELEVATION (ft NGVD):

10 DATE STARTED: 5/22/00

11 DATE COMPLETED: 5/22/00

12 OVERBURDEN THICKNESS: 14

13 DEPTH DRILLED INTO ROCK: 14

14 TOTAL DEPTH OF HOLE: 14.4' bgs

15 DEPTH GROUNDWATER ENCOUNTERED: 2-2.5 ft bgs

16 DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED:

17 OTHER WATER LEVEL MEASUREMENTS (SPECIFY):

18 GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19 TOTAL NUMBER OF CORE BOXES
14			

20 SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21 TOTAL CORE REC
2 (1-1)	1	X	X	X	pesticides	

22 DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23 SIGNATURE OF INSPECTOR
temp well		X		[illegible]

ELEV a	DEPTH b	DESCRIPTION OF MATERIALS c	Field Screening Results d	Geotech Sample or Core Box No e	Analytical Sample No f	Blow Counts g	REMARKS h
	0	0-2.5' bgs silty sand w/ trace clay (SM) subrounded loose brown 7.5YR 7/4 moist	PID 32.5 FID 1.57				
		2.5-5.0' sand v. fine gr. (SP) subrounded loose saturated w/ H2O	PID 27.05 FID 6.10				

PROJECT

HOLE NO. DP-02

HTW DRILLING LOG

PROJECT [illegible] 8 | INSPECTOR J Moore | HOLE NO DPC2 | SHEET 1 OF 2 SHEETS

ELEV	DEPTH	DESCRIPTION OF MATERIALS	Field Screening Results	Geotech Sample or Core Box No	Analytical Sample No	Blow Counts	REMARKS
		5.0 - 7.5' bgs sand v.f.gr. SP' saturated w/ H2O, well sorted, subrounded, 5YR 6/4 dk. reddish brown	FID 32.11 FID 1.37				
		7.5 - 10' bgs sand same as above not saturated but v. moist 5YR 6/6 reddish yellow	PID 27.60 FID 1.39				collected sample @ SWMU03-DP02-9 and dupe SWMU03-DP02-9
		10 - 12' bgs silty sand w/ clay (SM) moist v.f.gr. 5YR 5/6 yellowish red.	PID 31.6 FID 1.05				
		12 - 14 bgs silty sand (SM) w/ gypsum xtals moist mottled 7.5YR 6/6 reddish yellow.	PID 33.06 FID 1.07				
		TD @ 14.0' bgs					

PROJECT | HOLE NO [illegible] 8 DPC2

HTW DRILLING LOG

HOLE NO. SWMU 08 DP03

1 COMPANY NAME [illegible]	2 DRILLING CONTRACTOR ESN
3 PROJECT	4 LOCATION SWMU 08
5 NAME OF DRILLER [illegible]	6 MANUFACTURER'S DESIGNATION OF DRILL Geoprobe
7 SIZES & TYPES OF DRILLING & SAMPLING EQUIPMENT Geoprobe [illegible]	8 HOLE LOCATION North East
	9 SURFACE ELEVATION (ft NGVD)
	10 DATE STARTED 5/23/06
	11 DATE COMPLETED 5/23/06
12 OVERBURDEN THICKNESS N/A	15 DEPTH GROUNDWATER ENCOUNTERED
13 DEPTH DRILLED INTO ROCK N/A	16 DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED
14 TOTAL DEPTH OF HOLE 11.0 ft bgs	17 OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18 GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19 TOTAL NUMBER OF CORE BOXES

20 SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21 TOTAL CORE REC
NE						

22 DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23 SIGNATURE OF INSPECTOR
				[illegible]

DEPTH a	DESCRIPTION OF MATERIALS b	Field Screening Results d	Geotech Sample or Core Box No. e	Analytical Sample No. f	Blow Counts g	REMARKS h
	As this area has been previously excavated and backfilled to ~ 7-8 ft bgs					

PROJECT

HOLE NO. DP03

Bhate Environmental Associates — **WELL CONSTRUCTION DIAGRAM (Flush Mount)**

Project/Phase:		Well/Boring No.:	DPE1
Location:	SWMU OE: DPE1	Drilling Method:	Direct Push Tech
Client:	USACE Omaha	Date(s):	5/22/10
Drilling Contractor:	ESN	Northing (NAD 83):	
Driller:	Doug McNeil	Easting (NAD 83):	
Geologist:	Jim Meier	Bhate Project #:	

NOT TO SCALE

Surface Elevation: _____

Top of Casing Elevation: _____

Borehole Diameter (in): 3 3/4"

Well Casing Diameter (in): 1.0

Depth to Water (ft): ~ 2.0

During Drilling: ~ 2.0

Date: _____

Pre Development: _____

Date: _____

Post Development: _____

Date: _____

Top of Bentonite Seal: 0.0

Top of Filter Pack: 1.0

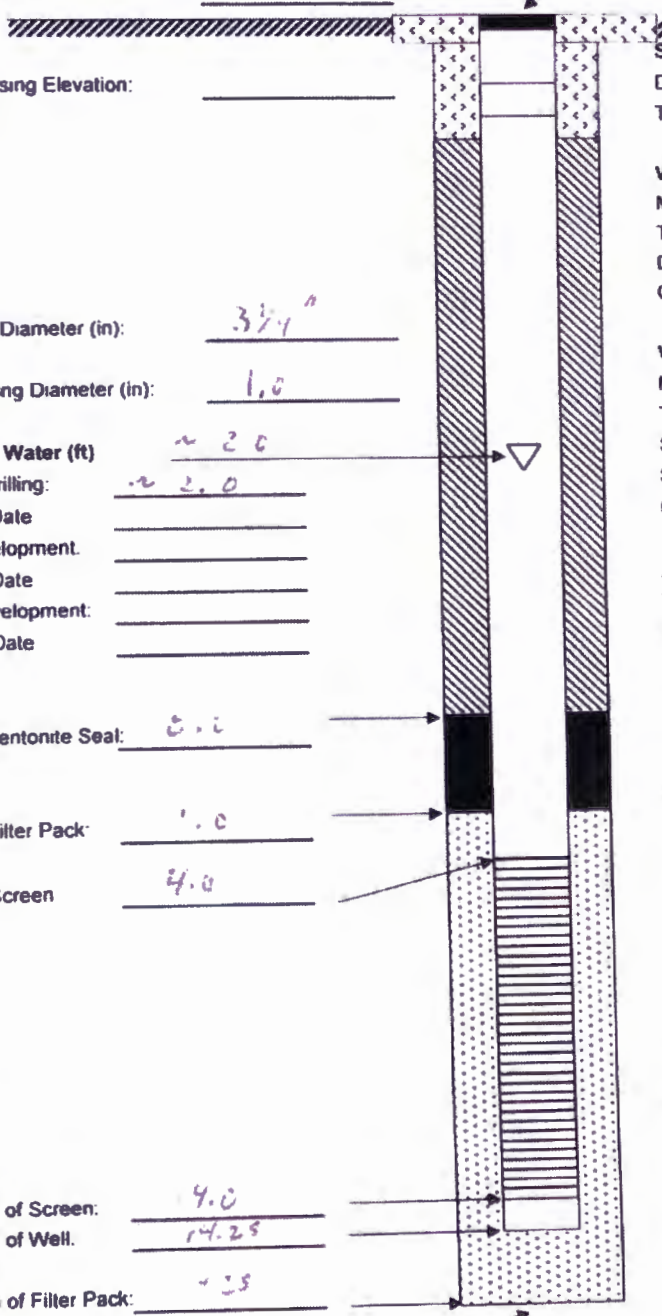
Top of Screen: 4.0

Bottom of Screen: 4.0

Bottom of Well: 14.25

Bottom of Filter Pack: ~ 2.5

Borehole Depth: 14.25



Protective Casing
Type: manhole
Dimensions: 7 inch dia
Length: 6 inches

Existing Surface

Surface Pad
Dimensions: NA
Type: _____

Well Casing (riser)
Manufacturer: EMI
Type/Material: PVC
Diameter (in): 1.0"
Connection: flush thread

Well Screen
Manufacturer: EMI
Type/Material: PVC
Slot Size (in): 0.010
Slot Type: Continuous / Factory Slot
Connection: threaded

Annular Seal
Type: bentonite
Installation: Gravity / Tremie / Pressure

Bentonite Seal
Manufacturer: Cimarron No 8
Type: Pellets / Slurry
Installation: 6-in Lifts / Gravity / Tremie / Pressure
Volume: 1 bag 50 lbs
Hydration Time: _____

Filter Pack Material
Manufacturer: EMI Hydrotech
Product Name: Pre packed
Size: 10/20
Volume (ft3): _____
Installation: Tremie / Gravity

Sump/End Cap
Type: PVC
Length: end cap

Backfill Material
Type: Nat
Volume: _____

Comments:

Bhate Environmental Associates — **WELL CONSTRUCTION DIAGRAM (Flush Mount)**

Project/Phase		Well/Boring No.:	DPC2
Location:	Site MW-3 - DPC2	Drilling Method:	DT
Client:	USAFC Omaha	Date(s):	5/7/06
Drilling Contractor:	SN	Northing (NAD 83):	
Driller:	Rusty McNeil	Easting (NAD 83):	
Geologist:	Tim Moore	Bhate Project #:	

NOT TO SCALE

Surface Elevation:

Top of Casing Elevation:

Borehole Diameter (in): 3 1/4

Well Casing Diameter (in): 1.0

Depth to Water (ft): 2-2.5' bgs

During Drilling: 2-2.5'

Date

Pre Development:

Date

Post Development:

Date

Top of Bentonite Seal: 0.0

Top of Filter Pack: 2.0

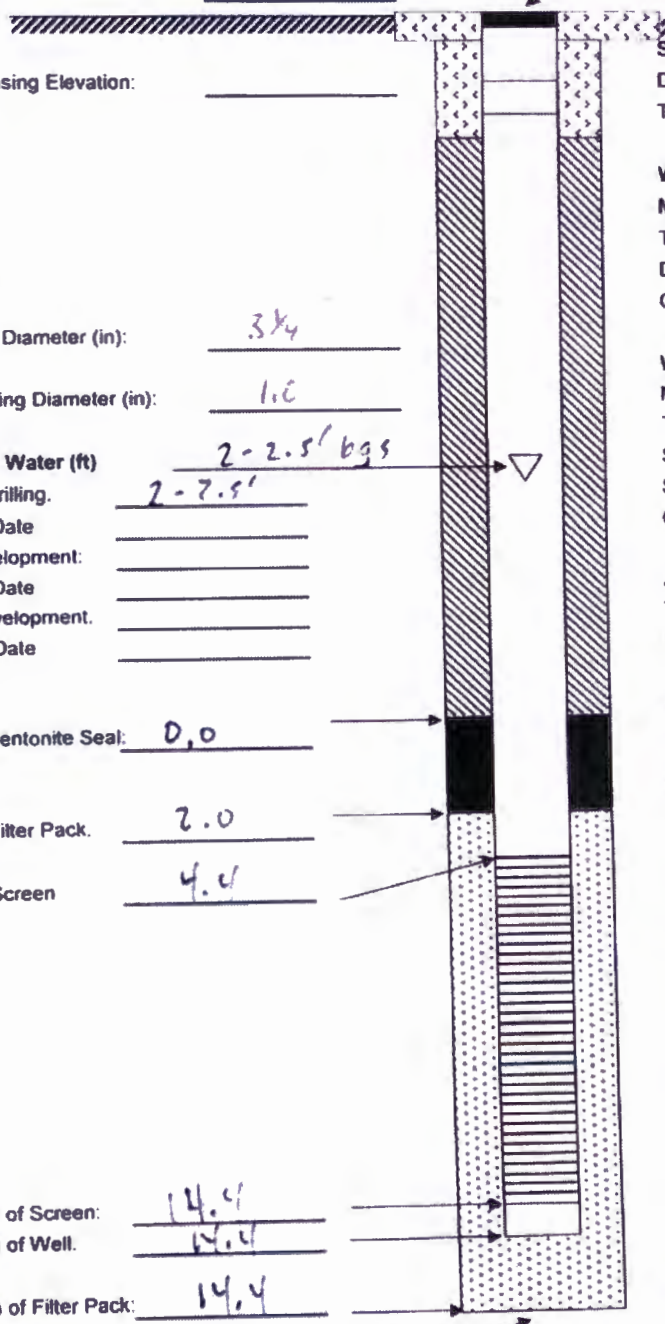
Top of Screen: 4.4

Bottom of Screen: 14.4

Bottom of Well: 14.4

Bottom of Filter Pack: 14.4

Borehole Depth



Protective Casing
Type: manhole
Dimensions: 7-inch dia
Length: 6 inches

Existing Surface

Surface Pad
Dimensions: NA
Type:

Well Casing (riser)
Manufacturer: EMI
Type/Material: PVC
Diameter (in): 1.0
Connection: flush threaded

Well Screen
Manufacturer: EMI
Type/Material: PVC
Slot Size (in): 0.020
Slot Type: Continuous Factory Slot
Connection: flush threaded

Annular Seal
Type: bentonite
Installation: Gravity Tremie Pressure

Bentonite Seal
Manufacturer: Bentonite Enviroplug HR
Type: Pellets Slurry
Installation: 6-in Lifts Gravity
Tremie Pressure
Volume: 1 bg 5 lbs
Hydration Time:

Filter Pack Material
Manufacturer: Colorado Silica
Product Name: Pre packed
Size: 10/20
Volume (ft3):
Installation: Tremie Gravity

Sump/End Cap
Type: PVC
Length: Ex 0.5 cm

Backfill Material
Type: NA
Volume:

Comments:

Bhate Environmental Associates

WELL CONSTRUCTION DIAGRAM (Flush Mount)

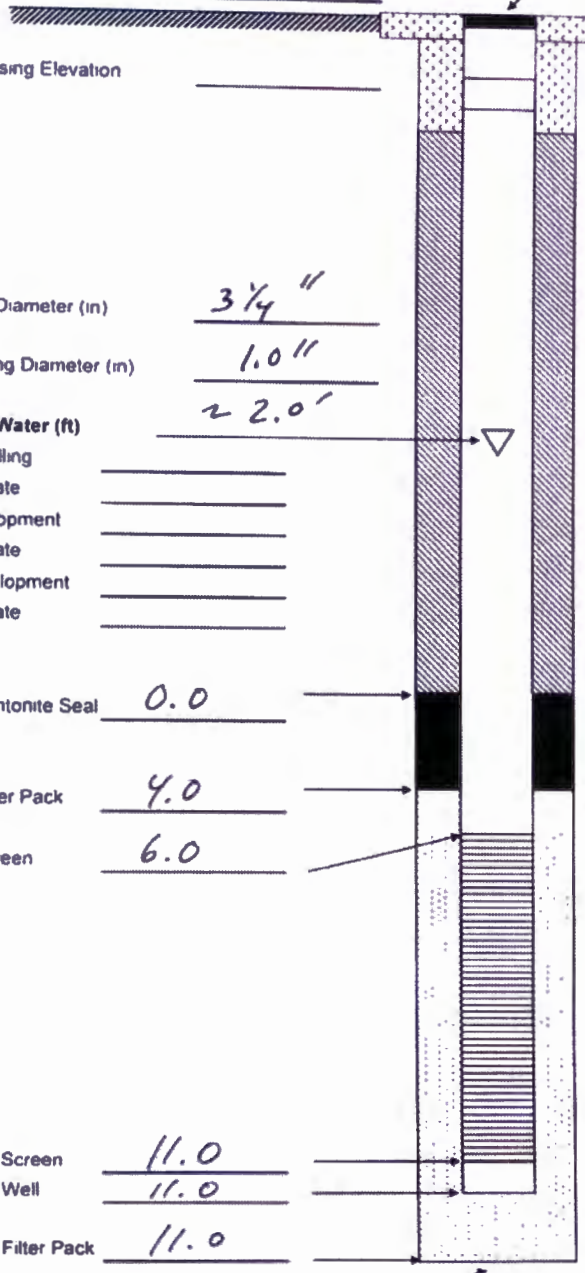
Project/Phase		Well/Boring No.	DP03
Location	SWMU08 - DP03	Drilling Method:	DPT
Client	USACE OMAHA	Date(s):	5/23/06
Drilling Contractor	ESN	Northing (NAD 83):	
Driller	Toby Gonzales	Easting (NAD 83)	
Geologist	Jim Moore	Bhate Project #	

NOT TO SCALE

Surface Elevation

Top of Casing Elevation

Existing Surface



Borehole Diameter (in) 3 1/4"

Well Casing Diameter (in) 1.0"

Depth to Water (ft) ~2.0'

During Drilling

Date

Pre Development

Date

Post Development

Date

Top of Bentonite Seal 0.0

Top of Filter Pack 4.0

Top of Screen 6.0

Bottom of Screen 11.0

Bottom of Well 11.0

Bottom of Filter Pack 11.0

Borehole Depth 11.0

Protective Casing

Type: manhole

Dimensions: 7 inch-dia

Length: 6 inch

Surface Pad

Dimensions: NA

Type:

Well Casing (riser)

Manufacturer: EMI

Type/Material: PVC

Diameter (in): 1.0 inch

Connection: Flush thread

Well Screen

Manufacturer: EMI

Type/Material: PVC

Slot Size (in): 0.020

Slot Type: Continuous (Factory Slot)

Connection: threaded

Annular Seal

Type: bentonite granular

Installation (Gravity) Tremie Pressure

Bentonite Seal

Manufacturer: Enviroplug #8 granular

Type: Pellets Slurry

Installation: 6-in Lifts Gravity Tremie Pressure

Volume: 1 bag ~ 50 lbs

Hydration Time:

Filter Pack Material

Manufacturer: Ogleby/Norton

Product Name: PRC - Packed

Size: 10/20

Volume (ft3):

Installation: Tremie Gravity

Sump/End Cap

Type: PVC

Length: End cap

Backfill Material

Type: NA

Volume

Comments:

APPENDIX B

UFGS SECTION 02111
EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL

SEPTEMBER 2003

APPENDIX C

BASE CIVIL ENGINEER WORK REQUEST AIR FORCE FORM 332

APPENDIX D

EPA INNOVATIVE TECHNOLOGY VERIFICATION REPORT:

FIELD MEASUREMENT TECHNOLOGIES FOR TOTAL PETROLEUM HYDROCARBONS IN SOIL

SEPTEMBER 2001

APPENDIX E

NMED TPH SCREENING GUIDELINES

~~NOVEMBER, 2005~~

OCTOBER, 2006

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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APPENDIX G

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APPENDIX H

UFGS SECTION 02770A

CONCRETE SIDEWALKS AND CURBS AND GUTTERS

MARCH 2004

APPENDIX I

ACCUTEST LABORAORIES USACE LABORATORY VALIDATION APPROVAL US DEPARTMENT OF ARMY

APPENDIX J

NMED SOIL SCREENING LEVELS REVISION 4 ~~2~~.0

~~AUGUST 2004~~

JUNE 2006

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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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-°K 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

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

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

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

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

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

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).

$$H = \frac{VP \times MW}{S}$$

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).

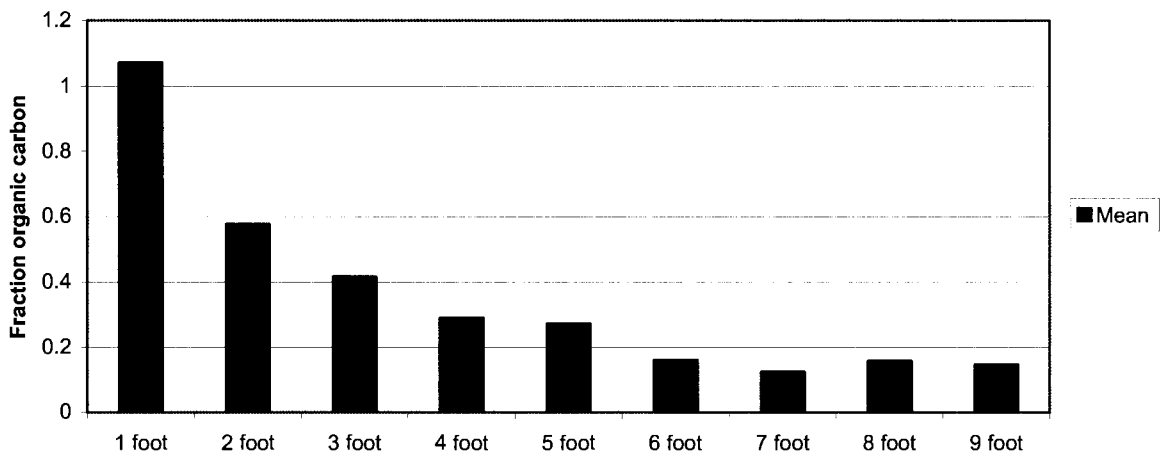
This relationship is generally valid for volatile halogenated hydrocarbons as long as the fraction of organic carbon in soil is above approximately 0.001 (0.1 percent) (Piwoni and Banaerjee, 1989 Schwarzenbach and Westall 1981). For low organic carbon soils ($f_{oc} < 0.001$), Piwoni and Banerjee (1989)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

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

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).

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

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 $(mg/kg\text{-}day)^{-1}$	Reference	RfD_o (mg/kg-day)	Reference	CSF_i $(mg/kg\text{-}day)^{-1}$	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 $(mg/kg\text{-}day)^{-1}$	Reference	RfD_o (mg/kg-day)	Reference	CSF_i $(mg/kg\text{-}day)^{-1}$	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 $(mg/kg\text{-}day)^{-1}$	Reference	RfD_o (mg/kg-day)	Reference	CSF_i $(mg/kg\text{-}day)^{-1}$	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 $(mg/kg\text{-}day)^{-1}$	Reference	RfD_o (mg/kg-day)	Reference	CSF_i $(mg/kg\text{-}day)^{-1}$	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 $(mg/kg\text{-}day)^{-1}$	Reference	RfD_o (mg/kg-day)	Reference	CSF_i $(mg/kg\text{-}day)^{-1}$	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.

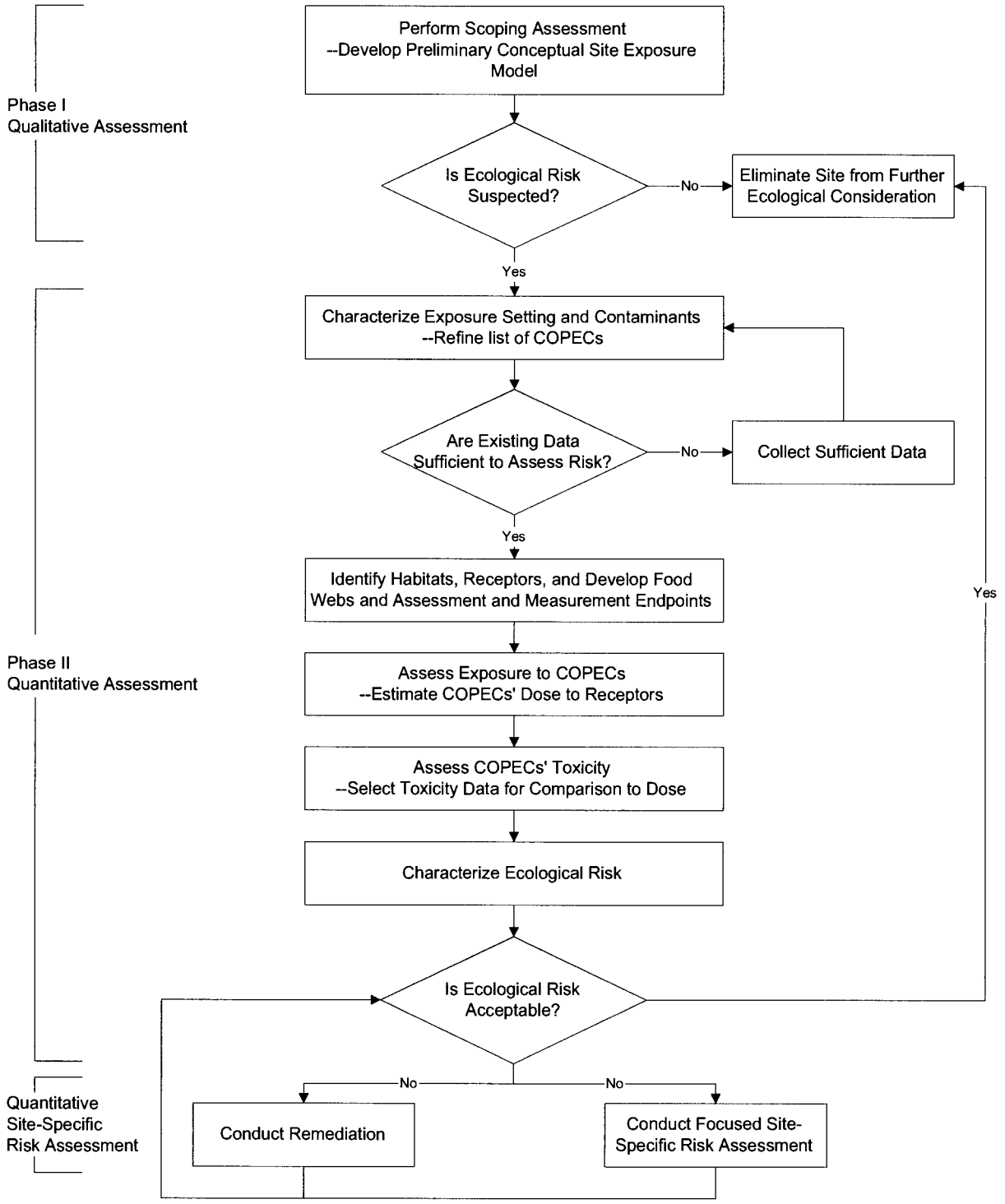
2.4 Developing the Preliminary Conceptual Site Exposure Model

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.

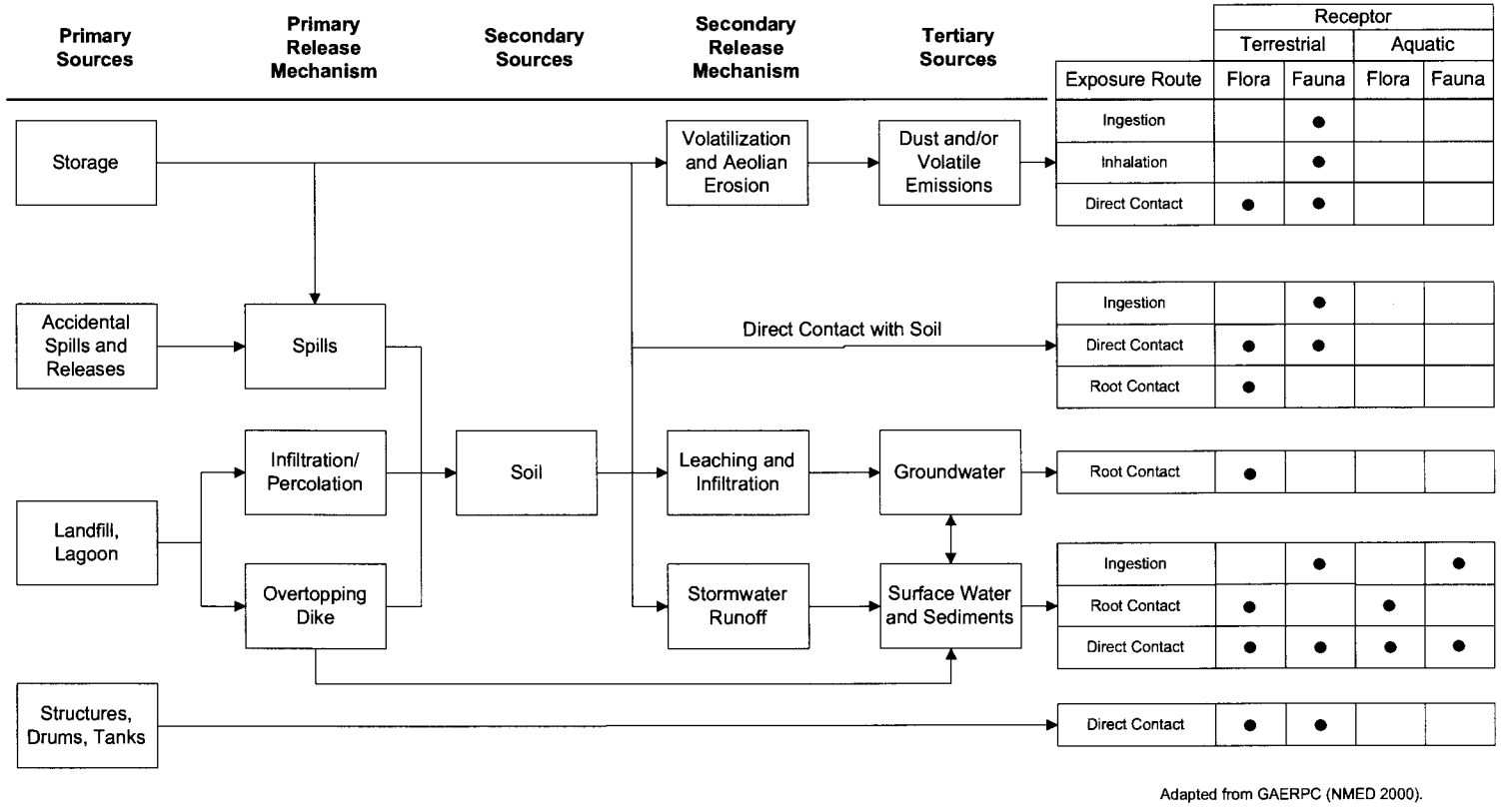


Figure 2. Example Preliminary Conceptual Site Exposure Model Diagram for a Hypothetical Site

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.

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APPENDIX K

SITE-SPECIFIC ADDENDUM TO THE BASEWIDE HEALTH AND SAFETY PLAN