DUGWAY PROVING GROUND
DUGWAY, UTAH

DRAFT

PHASE II RCRA FACILITY INVESTIGATION REPORT

SWMU-11
ADDENDUM

Contract Number: GS-10F-0179J
Delivery Order: W91238-04-F-00090

US Army Corps of Engineers

Submitted to:
U.S. Army Corps of Engineers
Sacramento District

March 2007

PARSONS

Prepared by:
PARSONS
Salt Lake City, Utah

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ACRONYMS AND ABBREVIATIONS

ABP	Agent Breakdown Product
AFCEE	Air Force Center for Environmental Excellence
AOC	Area of Concern
AMSL	Above Mean Sea Level
AUF	Area Unit Factor
bgs	Below Ground Surface
C-14	Carbon-14
Co-60	Cobalt-60
Cs-137	Cesium-137
CHPPM	Center for Health Promotion and Preventative Medicine
COC	Chemical of Concern
COPC	Chemical of Potential Concern
CWA	Chemical Warfare Agent
Cpm	Counts Per Minute
CSM	Conceptual Site Model
CAO	Corrective Action Objective
CMS	Corrective Measures Study
DIMP	Diisopropylmethylphosphonate
DPG	Dugway Proving Ground
DQO	Data Quality Objective
DSHW	Division of Solid and Hazardous Waste
DWQ	Division of Water Quality
EERPIMS	Enhanced Environmental Restoration Program Information Management System
EP	Test Pit
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
FIDLER	Field Instrument for the Detection of Low Energy Radiation
f_{oc}	Fraction of Organic Carbon
ft	Feet
GC	Gas Chromatography
GM	Geiger-Mueller
GPS	Global Positioning System
HA	Hand Auger
HI	Hazard Index
HRA	Human Risk Assessment
H-3	Hydrogen-3 or Tritium
HQ	Hazard Quotient
IMPA	Isopropyl Methyl Phosphonic Acid
LOAEL	Lowest Observed Adverse Effect Level
LUST	Leaking Underground Storage Tank
MARSSIM	Multi-Agency Radiant Survey and Site Investment Manual

ACRONYMS AND ABBREVIATIONS

MCL	Maximum Contaminant Level
MDL	Method Detection Limit
µg/L	Micrograms per Liter
µR/hr	Microroentgens per Hour
mR/hr	Milliroentgens per Hour
mg/L	Milligrams per Liter
mg/Kg	Milligrams per Kilogram
MPA	Methyl Phosphonic Acid
mR/hr	
mrem/yr	Millirem Per Year
MS	Mass Spectrometry
MS	Material Sample
ND	Non-Detect
NFA	No Further Action
NOAEL	No Observed Adverse Effect Level
OE	Ordinance and Explosive
O&M	Operation and Maintenance
PAH	Polycyclic Aromatic Hydrocarbon
PCE	Tetrachloroethylene
pCi/g	Picocuries per gram
PQL	Practical Quantitation Limit
PRG	Preliminary Remediation Goal
QAPP	Quality Assurance Project Plan
QC	Quality Control
Ra-226	Radium-226
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RfD	Reference Dose
RfC	Reference Dose
RFI	RCRA Facility Investigation
RL	Reporting Limit
RPD	Relative Percent Difference
SCS	Soil Conservation Service
SLHQ	Screening-Level Hazard Quotient
SOP	Standard Operating Procedure
SQL	Sample Quantitation Limit
SS	Surface Soil
SSL	Soil Screening Level
SR-90	Strontium-90
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TCE	Trichloroethylene

ACRONYMS AND ABBREVIATIONS

TDS	Total Dissolved Solids
TEDE	Total Effective Dose Equivalent
TEQ	Toxicity Equivalence Quotient
TIC	Tentatively Identified Compound
TPH	Total Petroleum Hydrocarbon
TR	Trench
TRV	Toxicity Reference Value
UAC	Utah Administrative Code
UCL	Upper Confidence Limit
UDEQ	Utah Department of Environmental Quality
URF	Unit Risk Factor
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USATHAMA	United States Army Toxic and Hazardous Materials Agency
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
UTL	Upper Tolerance Limit
UXO	Unexploded Ordnance
VOC	Volatile Organic Compound
WDTC	West Desert Test Center
WRS	Wilcoxon Rank Sum
WW	Water Well
Y-90	Yttrium-90
ABP	Agent Breakdown Product
AOC	Area of Concern
AUF	Area Use Factor
bgs	Below Ground Surface
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
CMS	Corrective Measures Study
COPC	Chemical of Potential Concern
CSM	Conceptual Site Model
CWA	Chemical Warfare Agent
CWM	Chemical Warfare Materiel
DAF	Dilution Attenuation Factor
DPG	Dugway Proving Ground
DQA	Data Quality Assessment
DQO	Data Quality Objective
DSHW	Division of Solid and Hazardous Waste
dS/m	deciSiemens per Meter
DWQ	Division of Water Quality
EM	Electromagnetic
EP	Test Pit
EPC	Exposure Point Concentration

ACRONYMS AND ABBREVIATIONS

ERA	Ecological Risk Assessment
f_{oc}	Fraction of Organic Carbon
ft	Feet
GPS	Global Positioning System
GC/MS	Gas Chromatography/Mass Spectrometry
HA	Hand Auger
HC	Hexachloroethane
HI	Hazard Index
HQ	Hazard Quotient
HRA	Human Risk Assessment
Kg	Kilogram
LANL	Los Alamos National Laboratory
LOAEL	Lowest Observed Adverse Effect Level
MDL	Method Detection Limit
mg/L	Milligrams per Liter
mg/Kg	Milligrams per Kilogram
NA	Not Applicable
ND	Non Detect
NFA	No Further Action
NOAEL	No Observed Adverse Effect Level
OE	Ordnance and Explosive
ORNL	Oak Ridge National Laboratory
PQL	Practical Quantitation Limit
PRG	Preliminary Remediation Goal
PUF	Plant Uptake Factor
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RFI	RCRA Facility Investigation
RL	Reporting Limit
RPD	Relative Percent Difference
SAR	Sodium Absorption Ratio
SLHQ	Screening-Level Hazard Quotient
SOP	Standard Operating Procedure
SS	Surface Soil
SSL	Soil Screening Level
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TCDD	tetrachlorodibenzo-p-dioxin
TDS	Total Dissolved Solids
TEQ	Toxic Equivalent
TIC	Tentatively Identified Compound

ACRONYMS AND ABBREVIATIONS

TPH	Total Petroleum Hydrocarbon
TR	Trench
TRV	Toxicity Reference Value
UAC	Utah Administrative Code
URF	Unit Risk Factor
US	United States
USACHPPM	United States Army Center for Health Promotion and Preventive Medicine
USEPA	United States Environmental Protection Agency
UTL	Upper Tolerance Limit
UXO	Unexploded Ordnance
VOC	Volatile Organic Compound
WHO	World Health Organization
WRS	Wilcoxon Rank Sum
WW	Water Well
yd^3	Cubic Yards

EXECUTIVE SUMMARY

The results of the Phase II nature and extent investigation, the risk assessment, and recommendations for Solid Waste Management Unit (SWMU)-11 are presented in this site-specific addendum for Dugway Proving Ground (DPG).

SWMU-11 is situated on the east side of Granite Mountain and is one of seven reported radioactive landfills that were part of the Resource Conservation and Recovery Act (RCRA) facility assessment (RFA). The site consists of six trenches, five mounds, and a CONEX container. SWMU-11 also corresponds to the location for the East Granite Holding Area.

Materials stored at the East Granite Holding Area included tritium and carbon-14, and were reported to be held in this area between 1958 and 1977 (DPG, 1982). During the spring and summer of 1965, DPG received beryllium containing propellant waste. At SWMU-11, a study was conducted to determine the dispersion of beryllium in the environment resulting from burning beryllium-containing missile propellant wastes in an open trench (USAEHA, 1965). Four trenches at the site (TR-1 through TR-4) were used for the propellant burning. Two additional burial areas (TR-5 and TR-6) were discovered during the Phase II investigation, which are most likely associated with radiological waste disposal.

The objective of the initial Phase I activities at SWMU-11 was to determine the types of debris buried at the site and to determine whether hazardous constituents, including radioactivity, have been released to surface and/or subsurface soils. Based on the results of the Phase I investigation, the primary objectives of the Phase II RFI were to: 1) further investigate potential source areas of radioactive contamination; 2) investigate areas for potential chemical contamination; 3) characterize the nature and extent of any such radiological and/or chemical contamination; and 4) collect data to support a risk assessment.

The objectives of the Phase II RFI at SWMU-11 were accomplished by conducting geophysical and radiological surveys; collecting surface soil, subsurface soil, and material samples; and excavating test pits.

Material sample results from TR-2, TR-5, and TR-6 indicated that radioactive materials were disposed at these features; however, radiological survey results indicate that radioactivity levels at TR-1 through TR-4, the CONEX container, and soils associated with TR-6 are at background levels, and meet the free release criteria for radiation. Elevated levels of radiation measured near the surface of TR-5 prevented intrusive activities at this trench; therefore, radiological surveying could not be conducted on subsurface soil or buried waste in TR-5. Although the waste in TR-6 was visually inspected and screened during test pitting, the radiological and/or chemical constituents associated with this waste could not be conclusively identified. Radiological risks from exposure to these uncharacterized/unidentified portions of TR-5 and TR-6 could not be quantified, and are therefore considered *a priori* unacceptable.

Soil samples were collected from biased, worst-case locations. No chemicals were detected in surface soils above both the corresponding background comparison value (if available) and United States Environmental Protection Agency (USEPA) Region 9 (2004) Residential Soil Preliminary Remediation Goal (PRG). Select dioxins/furans and inorganics were detected in subsurface soils in excess of both the corresponding background comparison value (if available) and the USEPA Region 9 (2004) Residential Soil PRG. However, a review of multiple lines of evidence indicated that additional characterization is not required.

Results of the site-attribution analysis for risk assessment indicate that surface and subsurface soil concentrations of select organic and inorganic analytes are inferred to be greater than background levels or do not have background levels; therefore, these analytes were retained as preliminary chemicals of potential concern (COPCs) for analysis in a risk assessment conducted in accordance with Utah Administrative Code (UAC) R315-101 (DSHW, 2001).

Direct sampling of TR-5 for chemical analysis could not be conducted due elevated levels of radiation measured near the surface. Therefore, a risk assessment per UAC R315-101 (DSHW, 2001) was not completed for the chemically uncharacterized surface soil, subsurface soil, or buried wastes within TR-5 or for surface soil in TR-6, which was also chemically uncharacterized. Although the waste in TR-6 was visually inspected and screened during test pit excavation, this material could not be conclusively

identified. Potential chemical risks and/or hazards associated with these uncharacterized and unidentified materials at TR-5 and TR-6 are assumed *a priori* to be unacceptable. Therefore, potential exposure to the uncharacterized and unidentified materials in TR-5 and TR-6 by human and ecological receptors should be prevented.

The results of the human risk assessment (HRA) performed per UAC R315-101 (DSHW, 2001) indicate that the site currently does not qualify for no further action (NFA) based on hypothetical residential land use. Industrial-level risk estimates of exposures of potential intrusive workers to mixed-interval soil identified beryllium as a chemical of concern (COC) to be addressed in the CMS Work Plan. Soil-to-groundwater analysis indicates that future impacts to groundwater from COPCs in soil are not expected.

The results of the ecological risk assessment (ERA) conducted in two sequential tiers (Tiers 1 and 2) indicated that there are no preliminary COCs identified as potential hazards to populations of ecological receptors.

A CMS will be conducted at SWMU-11 to address: 1) the beryllium industrial COC in mixed-interval soil; and 2) the uncharacterized and/or unidentified soils and wastes in TR-5 and TR-6. Steps involved in conducting a CMS include identifying, screening, selecting, and developing alternatives based on the site-specific corrective action objectives (CAOs) developed in the CMS Work Plan.

Two CAOs were established to: 1) prevent exposure to the industrial COC; and 2) prevent exposure to the uncharacterized and unidentified material and satisfy NRC closure requirements for radioactive material. Corrective measures technologies were screened using four criteria: 1) effectiveness in satisfying CAOs; 2) technical implementability; 3) safety hazard potential; and 4) cost.

Technologies to address the CAO for the beryllium industrial COC that were retained based on the results of screening were combined into the following three corrective measures alternatives with various components: 1) site controls; 2) landfill cover; 3) removal of buried waste. Technologies to address the CAO for uncharacterized and unidentified material that were retained based on the results of screening were combined into the following three corrective measures alternatives with various components: 1) site controls; 2) landfill cover; 3) removal of uncharacterized and

unidentified materials. Each of these alternatives will be evaluated specifically in the detailed CMS Report.

SECTION 1.0
INTRODUCTION

The purpose of this addendum to the Dugway Proving Ground (DPG) Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report is to present site-specific data and other information for Solid Waste Management Unit (SWMU)-11. A separate addendum will be submitted for every SWMU investigated during Phase II. Each addendum is a supplement to Volume I of the Phase II RFI Report (Parsons, 2004b), and is not in itself a stand-alone document.

Volume I of the Phase II RFI Report contains general information that applies to all SWMUs, including program methodology and rationale associated with sampling, analysis, risk assessment, and corrective measures studies (CMSs). Universal introductory and background information, such as the regulatory framework and the facility description, is also included in Volume I.

The objective of each SWMU-specific addendum to Volume I is to present the results of the Phase II nature and extent investigation. A risk assessment is also presented in addenda for SWMUs where site characterization results indicate a release may have occurred. Additionally, a CMS Work Plan is presented for SWMUs with unacceptable risk. The submittal of SWMU-specific addenda will allow the presentation of a large amount of data and information in a concise and ordered manner, minimizing unnecessary repetition of text.

1.1 REPORT ORGANIZATION

This SWMU-specific addendum has been organized into the following five sections and six appendices:

Section 1 – Introduction
Section 2 – Nature and Extent Investigation
Section 3 – Human Health and Ecological Risk Assessment Results
Section 4 – Corrective Measures Study Work Plan
Section 5 – References

Appendix A – Field Logs
Appendix B – Photographs
Appendix C – Analytical Results
Appendix D – Site-Attribution Analysis for Risk Assessment and Supporting Soil-to-Groundwater SSL Calculations
Appendix E – Supporting Calculations for Risk Assessment
Appendix F – Radiological Survey Report

1.2 SITE/WASTE-GENERATION HISTORY

SWMU-11 is situated on the east side of Granite Mountain (Figure 1.1) and is one of seven reported radioactive landfills that were part of the RCRA facility assessment (RFA). The site consists of six trenches, five mounds, and a CONEX box container (Figure 1.2). SWMU-11 also corresponds to the location for the East Granite Holding Area. This holding area was reported to be approximately 65 hectares (160.6 acres) and bound on three sides by steep canyon walls with the fourth side cordoned off by a security fence, which is no longer present (DPG, 1982). SWMU-11 was not identified in the available literature as being associated with testing of radiological munitions (tantalum-182). Historical inspection records indicate that buried wastes in the area consisted primarily of contaminated rags and papers. Evidence also suggests that radioactive waste materials repackaged for sea disposal in the Able Area may have been disposed at SWMU-11 after the sea disposal program was discontinued.

It was reported that radioactive waste materials were stored in the CONEX container to protect them from the elements (DPG, 1982). In March 1980, the DPG Radiation Protection Officer collected glassware contaminated with carbon-14 from the East Granite Holding Area and delivered it to the chemical laboratory in Ditto where it was disposed of by the carbon dioxide evolution process. Post-removal monitoring for radiation indicated that the waste containers and materials were at background levels. Materials stored at the East Granite Holding Area included tritium and carbon-14, and were reported to be held in this area between 1958 and 1977 (DPG, 1982). Currently there are no laboratory wastes remaining in the CONEX container.

During the spring and summer of 1965, DPG received 50,000 pounds of propellant waste, of which 300 pounds were estimated to be beryllium metal. Under the direction of the US Air Force and the approval of the state of Utah, a study was

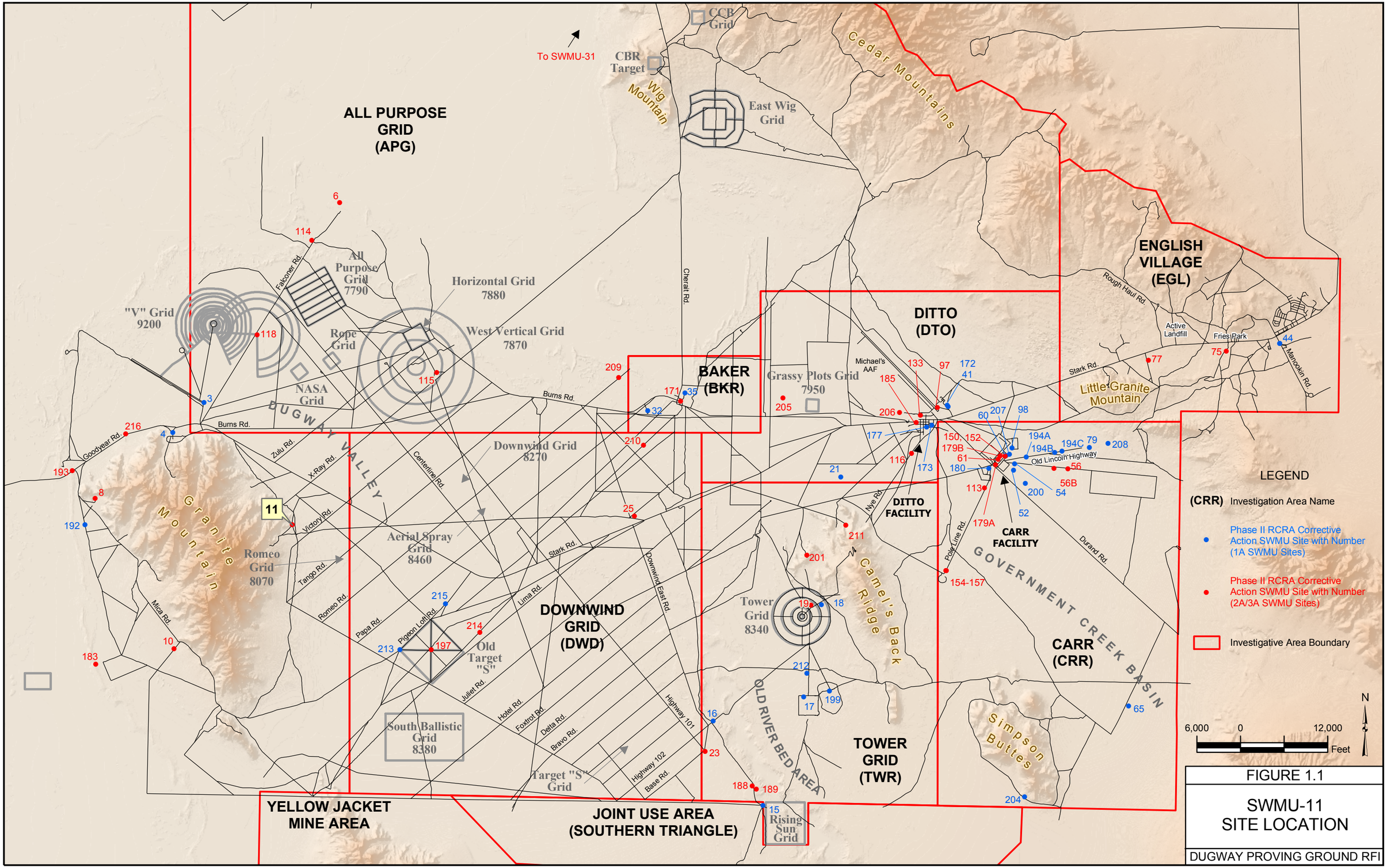

FIGURE 1.1

SWMU-11
SITE LOCATION

DUGWAY PROVING GROUND RFI

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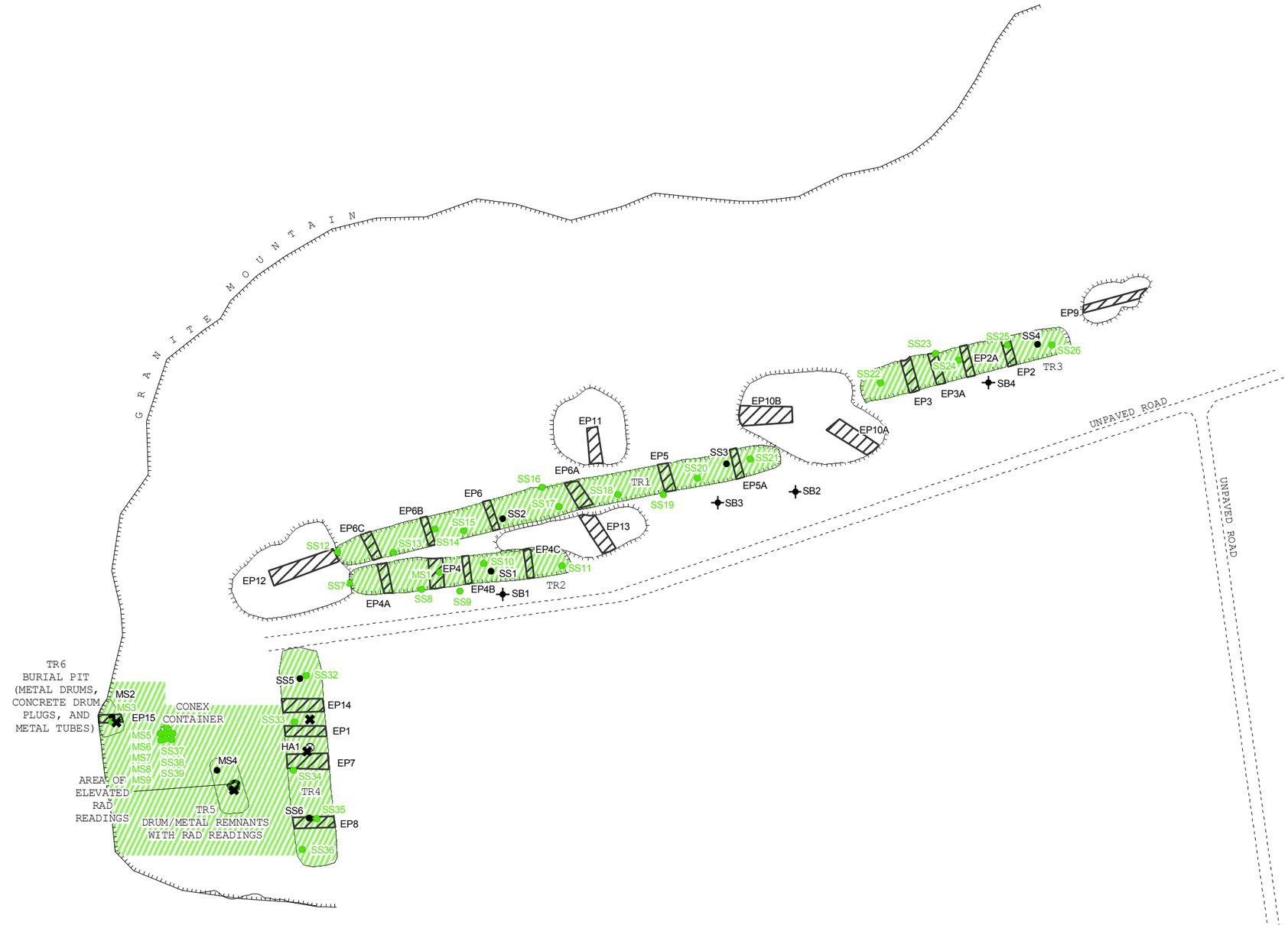

LEGEND

- SWMU MONUMENT
- HAND AUGER (HA)
- MATERIAL SAMPLE (MS)
- SOIL BORING (SB)
- SURFACE SOIL SAMPLE (SS)
- MAGNETIC ANOMALY
- TEST PIT (EP)

SAMPLES IN GREEN ARE FOR RADIOLOGICAL ANALYSIS ONLY

RADIOLOGICAL SURVEY GRID

Radiological analyses were also conducted on other SWMU-11 samples in combination with chemical analyses (Appendix C).

FIGURE 1.2

SITE MAP
SWMU-11, BURIAL PITS
GRANITE MOUNTAIN AREA

DUGWAY PROVING GROUND RFI

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conducted to determine the dispersion of beryllium in the environment resulting from burning beryllium-containing missile propellant wastes in an open trench (USAEHA, 1965). At least two trenches were used during the test and contain residual burned waste material. The first trench (TR-1) is open, runs east-west parallel to the ridge, and is approximately 400 feet (ft) long. The second trench (TR-4) is backfilled to existing grade, runs north-south perpendicular to the ridge, and is approximately 200 ft long surrounded by four metal warning signs stating: "Danger - Contaminated Waste - Buried July 1966." Two additional trenches (TR-2 and TR-3) are parallel to the ridge and near TR-1. These are open trenches which were most likely associated with additional propellant burning operations. Based on the available information (USAEHA, 1965), the beryllium contamination is believed to be confined to the four trenches (TR-1 through TR-4).

Two additional burial areas on the west side of TR-4 were also discovered during Phase II geophysical and radiological surveying. These two backfilled trenches were designated TR-5 and TR-6, and are perpendicular to the ridge approximately 50 and 150 ft west of TR-4, respectively (Figure 1.2). Phase II results indicate that TR-5 and TR-6 are most likely associated with radiological waste disposal.

The site occupies an affected area (the portion of the SWMU where soil has been potentially disturbed or otherwise affected by site activities) of approximately 3.4 acres, and is gently sloping to the east with an average elevation of 4375 ft above mean sea level (AMSL).

A photograph showing the area encompassing SWMU-11 is provided in Figure 1.3. Additional photographs are provided in Appendix B.

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FIGURE 1.3

SWMU-11 – View of the East Granite Holding Area (SWMU-11) looking east.

SECTION 2.0
NATURE AND EXTENT INVESTIGATION

Activities performed and results of the Phase II nature and extent investigation conducted at SWMU-11 in support of the RFI are presented in this section. Activities performed and results of the Phase I investigation conducted at this site are summarized in this section and are presented in their entirety in the Final Phase I RFI Report (Parsons, 1999a). The primary objectives of the nature and extent investigations described in this section are to: 1) present the results of the RFI investigations; 2) determine if sufficient sampling was conducted to adequately characterize the nature and extent of radioactivity and chemicals detected in site media; and 3) provide data to support a site-attribution analysis for risk assessment (Appendix D), and if necessary, a risk assessment.

2.1 INVESTIGATION ACTIVITIES

SWMU-11 was identified as a landfill site type based on available site history and field observations that suggest wastes are present in the six trenches identified at the site. The types of waste present at the site are radioactive waste and wastes associated with beryllium-containing propellant burning. Risks associated with chemicals detected at the site are evaluated in the risk assessment in Section 3. Radiological risks are summarized in Section 3, and evaluated in greater detail in Appendix F.

The objective of the initial Phase I activities at SWMU-11 was to determine the types of debris buried at the site and to determine whether hazardous constituents have been released to surface and/or subsurface soils. The results of the Phase I investigation concluded that contamination was present in the soil at SWMU-11, and further investigation was required. After the completion of the initial Phase I field activities, additional field activities were proposed in the 2A/3A Addendum to the Phase II Work Plan (Parsons, 2000b).

Following identification of the trenches and the CONEX container at the site, the primary objectives of the Phase II RFI were to characterize the general nature and extent

of radioactive and chemical contamination and to collect data to support a risk assessment (if needed).

The objectives of the Phase II RFI at SWMU-11 were accomplished by:

1. Collecting two composite surface soil samples (SS005-SS006) from TR-4 to characterize the surface soil overlying the backfilled trench.
2. Conducting a geophysical survey using a Schonstedt magnetometer to identify areas where buried waste may be present.
3. Excavating 14 test pits (EP02-EP15) to investigate potentially buried wastes in TR-1 through TR-4, TR-6, and the five mounds, and collecting subsurface soil samples from these test pits where evidence of waste was found in order to characterize subsurface soils in these site features.
4. Conducting a radiological survey that consisted of grids over each of the six trenches, the CONEX container, and the additional area of land west of TR-4; screening of test pits and associated debris; and collecting 28 confirmation surface soil samples to be sent to the laboratory for confirmation radiological analysis.
5. Collecting background radiation measurements from nearby unimpacted areas in order to compare the radiological results from the site survey.
6. Collecting three material samples (MS01, MS03, and MS04 from TR-2, TR-6, and TR-5, respectively) from materials identified during test pitting activities which exhibited anomalous radioactivity.
7. Collecting one material sample (MS02) from solidified material found in corroded empty metal drums excavated during test pitting activities at TR-6.
8. Collecting five wipe samples (MS05-MS09) from the CONEX container.
9. Conducting detailed Global Positioning System (GPS) mapping of the site to establish location of samples and relevant objects.

The purpose and type of activities performed to accomplish the Phase II RFI objectives are summarized in Table 2.1. A completeness evaluation presented in Table 2.2 comparing proposed verses completed Phase II activities identified one discrepancy associated with additional test pits excavated to investigate the mounds and further characterize the trenches. These supplemental test pit activities included an additional sample collected from EP15, excavated in TR-6.

2.1.1 Field Screening Activities

Field screening activities were not conducted at SWMU-11 during Phase I.

Phase II field screening activities at SWMU-11 included a geophysical survey and radiological field measurements. Geophysical surveying was conducted at SWMU-11

TABLE 2.1

CHARACTERIZATION OBJECTIVES
SWMU-11

DUGWAY PROVING GROUND, UTAH

Phase	Field Activity	Type	Characterization Objective of Field Activity			
			Determine Disposal Site Boundaries	Evaluate Potential Surface Soil Contamination Source Areas	Evaluate Potential Subsurface Soil Contamination Source Areas	Determine if Contamination is Migrating from Source Areas
I	Surface Soil Sampling	Confirmation		SS001-SS004 Four soil samples		
I	Hand-Auger Borings	Confirmation			HA01 Two soil samples	
I	Test Pits	Confirmation			EP01 Two soil samples	
I	Soil Borings	Confirmation				SB01-SB04 12 soil samples
II	Geophysical Survey	Screening	3.4 acre grid			
II	Surface Soil Sampling	Confirmation		SS005-SS006 Two soil samples		
II	Test Pits	Confirmation			EP02-EP15 14 soil samples	
II	Radiological Survey	Screening	6 grid locations			
II	Radiological Survey	Confirmation		SS007-SS039 33 soil samples		

TABLE 2.2

COMPLETENESS EVALUATION FOR PHASE II INVESTIGATIONS SWMU-11

DUGWAY PROVING GROUND, UTAH

Confirmation Sampling	Locations Proposed	Locations Completed	Samples Proposed	Samples Completed	Location ID	Date	Analyses Proposed	Analyses Completed	Explanation If Any Discrepancy
Surface Soil Sampling[a/]	2	2	2	2	SS005-SS006	2005	SVOCs, Metals, Dioxins/Furans, Explosives	SVOCs, Metals, Dioxins/Furans, Explosives	None required
Test Pits [a/]	7	14	21	14	EP02-EP15	2005	VOCs, SVOCs, Metals, Dioxins/Furans, Explosives	VOCs, SVOCs, Metals, Dioxins/Furans, Explosives	Test pits were added during field operations to investigate potential buried wastes associated with magnetic anomalies and mounds. Not all completed test pits required sampling due to the lack of observed waste or debris. One additional sample was collected at EP15.
Radiological Surface Soil Sampling[b/]	Minimum 20	28	Minimum 20	28	SS007-SS026 and SS032-SS039	2005	Alpha/Beta (Gross), Gamma Spectroscopy	Alpha/Beta (Gross), Gamma Spectroscopy	None required

[a/] Per Final Phase II Work Plan Addendum B – 2A and 3A SWMUs (Parsons, 2000b).
[b/] Per Final Phase II RCRA Facility Work Plan SWMUs 11 and 41 Radiological Survey (Parsons, 2005g).

using a Schonstedt magnetometer. During this survey anomalies were identified in several areas of SWMU-11, including TR-4 and two previously unidentified areas (TR-5 and TR-6). These magnetic anomalies required further investigation and were used to direct Phase II test pitting activities. Since this site is not unexploded ordnance (UXO) related, anomaly avoidance was not required during site investigation activities. Therefore, point-source Schonstedt magnetometer geophysical screening was also conducted over individual site features to direct intrusive activities at SWMU-11.

Field measurements for radiation were collected by establishing survey grids at TR-1 through TR-4, the CONEX container, and the area west of TR-4 where TR-5 and TR-6 were identified (Figure 1.2) in accordance with the Final Phase II RCRA Facility Investigation Work Plan SWMUs 11 and 41 Radiological Survey (Parsons, 2005g). Results of the survey are discussed in Section 2.2.3.4. A complete discussion of the radiological survey is presented in Appendix F.

2.1.2 Confirmation Sampling Activities

Confirmation sampling activities were conducted during both the Phase I and II field programs (Table 2.3) and as described below. Locations of confirmation samples are presented on Figure 1.2.

2.1.2.1 Phase I Confirmation Sampling Activities

Phase I confirmation sampling at SWMU-11 consisted of the following activities:

- Collecting four surface soil samples (SS001-SS004) from TR-1, TR-2, and TR-3.
- Collecting 16 subsurface soil samples from one hand-auger boring (HA01) and one test pit (EP01) in TR-4, and four soil borings (SB01-SB04) drilled adjacent to TR-1, TR-2, and TR-3.

Surface soil samples were collected from the bottom of the three open trenches to identify any impacts to surface soils immediately within these features (TR-1, TR-2, and TR-3; see Figure 1.2 for sample locations). HA01 was drilled in the center of TR-4 to a total depth of 7 ft bgs to investigate potentially buried material within this backfilled trench. No staining or other evidence of buried waste was identified within HA01. EP01 was excavated in the central area of TR-4 to further investigate any potentially buried waste or burnt material within this trench. A burn layer with metal fragments was identified at 8 ft bgs. The four soil borings were drilled adjacent to TR-2 (SB01), TR-1

TABLE 2.3

CONFIRMATION SOIL SAMPLING AND MATERIAL SAMPLING SUMMARY

SWMU-11

DUGWAY PROVING GROUND, UTAH

	Sample Location	Site Feature	Total Depth (ft bgs)	Sampling Depth 1 (ft bgs)	Sampling Depth 2 (ft bgs)	Sampling Depth 3 (ft bgs)	Comments[a/]
Surface Soil Samples	SS001[b/]	TR-2	0.5	0 - 0.5	NA	NA	No staining, waste, or other evidence of contamination.
	SS002[b/]	TR-1	0.5	0 - 0.5	NA	NA	No staining, waste, or other evidence of contamination.
	SS003[b/]	TR-1	0.5	0 - 0.5	NA	NA	No staining, waste, or other evidence of contamination.
	SS004[b/]	TR-3	0.5	0 - 0.5	NA	NA	No staining, waste, or other evidence of contamination.
	SS005	TR-4	0.5	0 - 0.5	NA	NA	No staining, waste, or other evidence of contamination.
	SS006	TR-4	0.5	0 - 0.5	NA	NA	No staining, waste, or other evidence of contamination.
	SS007[c/]	TR-2	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS008[c/]	TR-2	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS009[c/]	TR-2	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS010[c/]	TR-2	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS011[c/]	TR-2	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS012[c/]	TR-1	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS013[c/]	TR-1	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS014[c/]	TR-1	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS015[c/]	TR-1	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS016[c/]	TR-1	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS017[c/]	TR-1	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS018[c/]	TR-1	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS019[c/]	TR-1	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS020[c/]	TR-1	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS021[c/]	TR-1	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS022[c/]	TR-3	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS023[c/]	TR-3	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS024[c/]	TR-3	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS025[c/]	TR-3	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS026[c/]	TR-3	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.

TABLE 2.3 (CONTINUED)

CONFIRMATION SOIL SAMPLING AND MATERIAL SAMPLING SUMMARY

SWMU-11

DUGWAY PROVING GROUND, UTAH

	Sample Location	Site Feature	Total Depth (ft bgs)	Sampling Depth 1 (ft bgs)	Sampling Depth 2 (ft bgs)	Sampling Depth 3 (ft bgs)	Comments[a/]
Surface Soil Samples (Continued)	SS027[c/]	Background	0.5	0 - 0.5	NA	NA	Radiological analysis only. Samples collected from the canyon adjacent to SWMU-11 in an unimpacted area for the purpose of comparing site radiation levels to background levels.
	SS028[c/]	Background	0.5	0 - 0.5	NA	NA	
	SS029[c/]	Background	0.5	0 - 0.5	NA	NA	
	SS030[c/]	Background	0.5	0 - 0.5	NA	NA	
	SS031[c/]	Background	0.5	0 - 0.5	NA	NA	
	SS032[c/]	TR-4	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS033[c/]	TR-4	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS034[c/]	TR-4	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS035[c/]	TR-4	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS036[c/]	TR-4	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS037[c/]	CONEX container	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS038[c/]	CONEX container	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
	SS039[c/]	CONEX container	0.5	0 - 0.5	NA	NA	Radiological analysis only. No staining or other evidence of contamination.
Hand-Auger Boring	HA01[b/]	TR-4	7	0 - 3.5	3.5 - 6	NA	Drilled in the center of TR-4 to investigate potentially buried waste in the backfilled trench. No staining, waste, or other evidence of contamination.
Soil Borings	SB01[b/]	TR-2	15	2 - 4	6 - 8	13 - 15	No staining, waste, or other evidence of contamination.
	SB02[b/]	TR-1	15	2 - 4	6 - 8	13 - 15	No staining, waste, or other evidence of contamination.
	SB03[b/]	TR-1	15	2 - 4	6 - 8	13 - 15	No staining, waste, or other evidence of contamination.
	SB04[b/]	TR-3	15	2 - 4	6 - 8	13 - 15	No staining, waste, or other evidence of contamination.
Test Pits	EP01[b/]	TR-4	10	8	10	NA	A burn layer was identified along with metal fragments at 8 ft bgs. Waste included metal fragments.
	EP02	TR-3	4	4	NA	NA	No staining, waste, or other evidence of contamination.
	EP03	TR-3	4.5	2 - 2.5	4 - 4.5	NA	Burn layer at 2.5 ft bgs and <1 inch thick. Waste included 8-inch conical vitrified clay/graphite plugs and plastic material.
	EP04	TR-2	4.5	1.5 - 2	4 - 4.5	NA	Burn layer at 1.75 ft bgs and 1.5 ft thick. Waste included 8-inch conical vitrified clay/graphite plugs, insulation, masonite sheets and a paper-like material with low-leve radioactivity.
	EP05	TR-1	2.6	1.5 - 1.6	2.5 - 2.6	NA	Burn layer at 1.5 ft bgs and 4 inches thick. Waste included glass bottles, wiring, paper, and 8-inch conical vitrified clay/graphite plugs.
	EP06	TR-1	2.6	1.5 - 1.6	2.5 - 2.6	NA	Burn layer at 1.5 ft bgs and 1 ft thick. Waste included glass bottles, wiring, paper, and 8-inch conical vitrified clay/graphite plugs.

TABLE 2.3 (CONTINUED)

CONFIRMATION SOIL SAMPLING AND MATERIAL SAMPLING SUMMARY

SWMU-11

DUGWAY PROVING GROUND, UTAH

	Sample Location	Site Feature	Total Depth (ft bgs)	Sampling Depth 1 (ft bgs)	Sampling Depth 2 (ft bgs)	Sampling Depth 3 (ft bgs)	Comments[a/]
Test Pits (Continued)	EP07	TR-4	12.5	3.5 - 4	8 - 8.5	12 - 12.5	Burn layer at 8 ft bgs and 2 inches thick. Waste included one corroded empty metal drum.
	EP08	TR-4	7	NA	NA	NA	No staining, waste, or other evidence of contamination. No samples collected
	EP09	Mound	8	NA	NA	NA	No staining, waste, or other evidence of contamination. No samples collected
	EP10	Mound	9	NA	NA	NA	No staining, waste, or other evidence of contamination. No samples collected
	EP11	Mound	6	NA	NA	NA	No staining, waste, or other evidence of contamination. No samples collected
	EP12	Mound	6	NA	NA	NA	No staining, waste, or other evidence of contamination. No samples collected
	EP13	Mound	8	NA	NA	NA	No staining, waste, or other evidence of contamination. No samples collected
	EP14	TR-4	6.5	NA	NA	NA	No staining, waste, or other evidence of contamination. No samples collected
	EP15	TR-6	10	10	NA	NA	No burn layer was present in TR-6. Waste included corroded drums with solidified sand in the bottom (at ~2 ft bgs), numerous unidentified silver-gray metallic tubes filled with a white wax-like substance accompanied by metal rods that appeared to go inside the tubes (at ~4 ft bgs), and two large concrete cylinders that were each shaped like 55-gallon metal drums (at ~6 ft bgs).
	EP16[c/]	Background	8	2	4	8	Radiological analysis only. Samples collected from the canyon adjacent to SWMU-11 in an unimpacted area for the purpose of comparing site radiation levels to background levels. Five samples collected; one from 2 ft (west), two from 4 ft (north and south) and two from 8 ft (north and south).
Material Samples	MS01[c/]	TR-2	NA	NA	NA	NA	Debris composed of thin layers of paper-like material and appeared to have a white to yellowish paint coating on one side. The debris exhibited elevated radioactivity compared to background based on field screening measurements
	MS02[c/]	TR-6	6	6	NA	NA	Solidified sand present inside the corroded drums.
	MS03[c/]	TR-6	NA	NA	NA	NA	Small metal tube that is silver-gray in color and filled with a hard, white, wax-like material. Sample was not sent to the laboratory and remains on site
	MS04[c/]	TR-5	0.5	0-0.5	NA	NA	Partially buried metal drum remnant which had elevated radioactivity compared to background, based on field screening measurements
	MS05[c/]	CONEX container	NA	NA	NA	NA	Wipe samples collected from the interior walls of the CONEX container.
	MS06[c/]	CONEX container	NA	NA	NA	NA	
	MS07[c/]	CONEX container	NA	NA	NA	NA	
	MS08[c/]	CONEX container	NA	NA	NA	NA	
	MS09[c/]	CONEX container	NA	NA	NA	NA	

[a/] Including evidence of contamination, where observed.

[b/] Sample collected during Phase I investigation.

[c/] Sample collected per the Final Phase II RCRA Facility Work Plan SWMUs 11 and 41 Radiological Survey (Parsons, 2005g). Results of this survey, including grid locations, are presented in Appendix F.

(SB02-SB03), and TR-3 (SB04) to investigate potential releases from the trenches to surrounding soil. No staining or other evidence of contamination was identified in these soil borings. A complete discussion of Phase I confirmation sampling is presented in the Final Phase I RFI Report (Parsons, 1999a).

2.1.2.2 Phase II Confirmation Sampling Activities

Phase II confirmation sampling activities were performed in 2005 and 2006. These activities were conducted according to the general sampling strategy described in the work plan for landfill site types. Activities were also performed as outlined in the Phase II RFI and Radiological Survey Work Plans (Parsons, 2000b and 2005g).

Phase II confirmation sampling activities consisted of the following activities:

- Collecting two surface soil samples (SS005-SS006) from TR-4 to investigate potential impacts to surface soil overlying TR-4.
- Collecting 14 subsurface soil samples from seven of the 14 scheduled test pits (EP02-EP07 and EP15) located within TR-1, TR-2, TR-3, TR-4, and TR-6 to investigate potential chemical impacts to subsurface soils from buried wastes.
- Conducting a radiological survey which included collection of 33 surface soil confirmation samples (SS007-SS039; including 5 background samples) and nine material samples from TR-2 (MS01), TR-6 (MS02 and MS03), TR-5 (MS04), and the CONEX container (MS05-MS09; wipe samples).

Based on site history and previous sampling results, the nature of the potential contamination present in all site features was uncertain. Test pits were excavated to investigate potential waste buried in five of the six trenches (TR-1 through TR-4 and TR-6). Descriptions of the beryllium-containing fuel burn in the relevant text (USAEHA, 1965) identified two trenched areas associated with the burning. However, several other trenches were identified at the site. These additional trenches were most likely associated with either beryllium-containing fuel burning and/or low-level radioactive waste disposal. In addition to the 14 Phase II test pits described above, nine supplemental exploratory test pits which were also excavated in association with the scheduled test pits in TR-1 through TR-3 to delineate the extent of burn layers within these features.

Six test pits were excavated at TR-1; two were scheduled test pits (EP05 and EP06) and four were exploratory (EP05A, EP06A, EP06B, and EP06C). This test pitting activity identified a burn layer within TR-1. The burn layer varies in thickness along the

trench; from east to west the layer is 0.5 ft (EP06C), 1.5 ft (EP06B), 1 ft (EP06), 1 inch (EP06A), and 4 inches (EP05) thick, and not present at EP05A. Burnt material included glass bottles, wiring, paper, and small 8-inch conical vitrified clay/graphite plugs (see Photograph 4 in Appendix B). Two samples were collected from each of the two scheduled test pits (EP05 and EP06) at 1.5 ft bgs (measured from the bottom of the open trench) within the burn material and at 2.5 ft bgs in underlying native soil. All test pits and associated soil and debris at TR-1 were qualitatively screened using the instruments described in Appendix F for radioactivity, and no above-background readings were found.

Four test pits were excavated at TR-2; one was a scheduled test pit (EP04) and three were exploratory (EP04A, EP04B, and EP04C). Test pitting activities identified a burn layer within TR-2. The burn layer varies in thickness along the trench; from east to west the layer is 1 ft (EP04A) and 1.5 ft (EP04) thick, and not present at EP04B and EP04C. Burnt material included between 50 and 100 small 8-inch conical vitrified clay/graphite plugs, insulation, and masonite sheets. Also, a small clump of soil with a paper-like material on one side was found while conducting field radiation screening on the excavated material from EP04. The material displayed elevated readings with both the Geiger-Mueller (GM) pancake and Field Instrument for the Detection of Low Energy Radiation (FIDLER), as discussed in Appendix F. All of the excavated material displaying elevated readings was collected as MS01 and sent to the laboratory for radiological analysis. No other evidence of this material was found during the radiation screening of the TR-2 test pits or any other screening and/or test pitting conducted at SWMU-11. Two samples were collected from the scheduled test pit (EP04) at 1.75 ft bgs within the burn layer and at 4.25 ft bgs in underlying native soil.

Four test pits were excavated at TR-3; two were scheduled test pits (EP02 and EP03) and two were exploratory (EP03A and EP02A). This test pitting activity identified a burn layer within TR-3. EP03 and EP03A show a thin (< 1 inch) burn layer at 2.5 ft bgs, and at EP02 and EP02A it is not present. EP02 and EP02A appeared to be clean and no debris or other evidence of contamination was observed. Two samples were collected from EP03 at 2.25 ft below ground surface (bgs) within the burn layer and at 4.75 ft bgs in underlying native soil. One sample was collected from EP02 at 4 ft bgs in native soil.

Burnt material in TR-3 included plastic and small conical vitrified clay/graphite plugs. All test pits and associated soil and debris at TR-3 were qualitatively screened for radioactivity using the instruments described in Appendix F, and no above-background readings were found.

TR-4 was one of the three backfilled trenches identified at SWMU-11; however, this trench was conspicuous since there were four surrounding signs warning of hazardous waste. Three scheduled Phase II test pits were excavated at TR-4 (EP07, EP08, and EP14). EP07 was excavated at the location of one of two similar magnetic anomalies identified during the geophysical survey. Test pitting activities identified a 2-inch burn layer within EP07 at 8 ft bgs and also that the structure of the trench appears to be ramped at both the northern and southern ends presumably for vehicle access. Three samples were collected from EP07 at 3.75 ft bgs (backfill soil), 8.25 ft bgs (within the burn layer), and 12.25 ft bgs (underlying native soil). The other two test pits (EP08 and EP14) showed no evidence of a burn layer, debris, or other evidence of contamination; therefore, no samples were collected at these locations. Debris within TR-4 included black stained soil and metal fragments in Phase I test pit EP01 (Section 2.1.2.1), and a burn layer and one corroded empty metal drum in EP07. All test pits and associated soil and debris at TR-4 were screened for radiation, and no anomalous readings were found.

One magnetic anomaly was delineated within TR-5 and several metal fragments were also identified in the surface soil; additionally, anomalous radioactivity was measured at these locations. Radioactivity measurements in the area were highest at a cleared, slightly depressed area which was located in the approximate center of the anomalous area. Gamma exposure rate measurements ranged from 420 microroentgens per hour (µR/hr) at the maximum immediately over the location, to about 50 µR/hr 3 ft away, to background levels (~30 µR/hr) about 6 ft away. An additional exposure rate measurement was collected after removing about 6 inches of soil from the highest measurement location. After soil removal, the exposure rate over the location increased to approximately 2 milliroentgens per hour (mR/hr). The removed soil did not exhibit elevated radioactivity. The 2 mR/hr measurement exceeded the Parsons health and safety stop-work limit (500 µR/hr), and intrusive activities at TR-5 were canceled. Elevated radiation levels were also found at a depression in TR-5 located to the north, where a

partially buried drum remnant was located. A sample of metal (MS04) was collected from this drum remnant and was sent to the laboratory for radiological analysis. The analytical results indicated that the radioactivity from MS04 was primarily due to the radionuclide strontium-90 (Sr-90). A further discussion of the results from this location is presented in Section 2.2.3.4 below and in Appendix F.

An additional burial area (TR-6) was identified based on the presence of a magnetic anomaly delineated west of TR-4 during a Phase II Schonstedt magnetometer sweep. A test pit was excavated in the vicinity of the magnetic anomaly at TR-6 (EP15). Materials observed in this test pit excavation included:

- Corroded drums with solidified sand in the bottom (at ~2 ft bgs).
- Numerous unidentified silver-gray metallic (appeared to be aluminum) tubes about 8-inches long and 1.5-inches in diameter, which were filled with a white wax-like substance accompanied by 8-inch metal rods that appeared to go inside the tubes (Photograph 2 in Appendix B) (at ~7 ft bgs).
- Two large concrete cylinders that were each shaped like 55-gallon metal drums (apparently remnant cores of concrete-filled drums; Photograph 3 in Appendix B) (at ~7.5 ft bgs).

All materials excavated from TR-6 were screened for radioactivity and slightly elevated readings were detected only from the unidentified metal tubes. One of the tubes was collected as a sample (MS03) to be sent to the laboratory for radiological analysis. However, the item was not sent off-site due to the lack of information about its use and associated hazards; therefore, the source of the radioactivity present in the tubes has not been identified. A sample was also collected from the solidified sand (MS02) present inside the corroded drums and sent to the laboratory for chemical analysis. One soil sample (EP15) was collected at 10 ft bgs from native soil underlying the debris described above.

Test pits were also excavated at the five mounds and no magnetic anomalies were identified and no staining, debris, or other evidence of contamination was present. Therefore, no samples were collected from these five test pits.

Confirmation sampling performed as part of the radiological survey, conducted per the Final Phase II RCRA Facility Investigation Work Plan SWMUs 11 and 41 Radiological Survey (Parsons, 2005g), included 28 surface soils samples collected from

the six trenches and the CONEX container. These samples were sent to the laboratory for radiological analysis of gross alpha/beta levels and gamma spectroscopy. Results of the radiological survey are summarized in Section 2.2.3.4, and a complete discussion of the radiological survey is presented in Appendix F.

2.1.3 Uncharacterized and Unidentified Materials

Soil samples were collected for chemical analysis from five of the six burial features identified at SWMU-11 (TR-1 through TR-4, and TR-6). Radiological field measurements collected after surficial soil was removed from TR-5 exceeded the stop work limit; therefore, direct soil sampling and intrusive activities could not be conducted at this trench. Shallow bedrock precluded drilling angle borings to sample subsurface soil beneath the waste in TR-5. As such, in addition to the uncharacterized waste at TR-5, the overlying surface soil and underlying subsurface soil are also uncharacterized in the absence of samples collected for chemical analysis.

A worst-case soil sample was collected for chemical analysis from TR-6 at 10 ft bgs; however, no surface soil samples were collected from this trench. Although surface soil at TR-6 is likely unimpacted by site activities based on visual observations and radiological screening results, this soil is considered uncharacterized in the absence of direct sampling for chemical analysis. TR-6 contains various types of debris including small metal tubes which have low levels of radioactivity consistent with Cs-137, but which remain unidentified in the absence of conclusive radiological analyses. Although the waste in TR-6 was visually inspected and screened during test pit excavation, this material could not be fully identified. MS03, the representative sample of a metal tube, was not sent off-site for laboratory analysis due to uncertainties regarding the use of this item and the associated hazards. Therefore, since analytical results are not available to conclusively identify the metal tubes, the waste in TR-6 is classified as unidentified.

Potential risks and/or hazards associated with the uncharacterized waste and soils and unidentified waste at SWMU-11 are assumed to be *a priori* unacceptable based on the types of materials that may be present. Therefore, potential exposure to uncharacterized waste and soils and unidentified waste should be prevented.

2.2 INVESTIGATION RESULTS

2.2.1 Geology/Hydrology

SWMU-11 is located at the mouth of a small, northeast-trending alluvial valley along the eastern side of Granite Mountain. The valley is flanked to the south by a small ridge of granite that extends from the main Granite Mountain area, and to the north and west by granite outcroppings characteristic of Granite Mountain. To the east, the valley is open to the broad expanse of the Dugway Basin. Granite Mountain is an isolated, north-south trending mountain block approximately 8 miles long by 6 miles wide. The southern two-thirds of the mountain are dominated by dark colored gneiss and gneissic granite with a thin sliver of schists and phyllites at the extreme southern end. The northern one-third of the mountain is made up of intrusive leuco-granitic rocks that form a gradational contact with the gneissic granite to the south. While past reports and maps have indicated a Precambrian age for Granite Mountain, more recent geologic age-dating conducted by the Utah Geological Survey indicates the rocks of Granite Mountain are Jurassic in age. Quaternary-aged lacustrine, alluvium and colluvium deposits are present along the flanks of Granite Mountain, including the small valley where SWMU-11 is located. Away from the mountain, the surrounding basin floor consists of aeolian sand and silt deposits and Quaternary-aged playa and lacustrine sediments associated with deposits of ancient Lake Bonneville and older pluvial lakes.

Information about the subsurface lithology specific to the SWMU-11 area was obtained from the test pit excavations and soil borings completed at the site. Lithologic data at the site has been collected to a maximum depth of 15 ft bgs, and show that the shallow subsurface at SWMU-11 generally consists of a thin (1-2 ft thick) layer of lacustrine clay and marl, underlain by well sorted sand that grades into coarser-grained sand and gravel at depth. Site-specific information is not available for the deeper subsurface, but regional lithology suggests that SWMU-11 is most likely underlain by coarse-grained Quaternary alluvium and colluvium, consisting chiefly of granitic and gneissic boulders, cobbles, and gravels in a matrix of coarse-grained, gravelly sand. A well-driller's log for water well WW10, located approximately 4 miles northwest of SWMU-11, indicates that this sequence of coarse grained materials continues to a depth of approximately 140 ft, where granitic bedrock is encountered. Depth to bedrock at

SWMU-11 may be greater, based on the higher elevation of this site relative to the ground surface at water well WW10.

Groundwater in the area of SWMU-11 is part of the Dugway Valley aquifer system. Groundwater in this region is generally characterized by high total dissolved solids (TDS) and very flat hydraulic gradients. However, the flanks of Granite Mountain, including the SWMU-11 site, constitute a local recharge zone for basin groundwater. In these localized zones, groundwater is deeper and of higher quality than groundwater beneath the basin floor. As groundwater flows from the local recharge area toward the basin floor, it becomes increasingly laden with dissolved mineral constituents and the quality of groundwater is greatly diminished. The estimated depth to groundwater at SWMU-11 is approximately 100 ft bgs, based on the measurements from water well WW10, which is located in a similar hydrogeologic environment on the north side of Granite Mountain. Groundwater flow at SWMU-11 is likely to the east or northeast, based largely on the local topographic gradient present at the site.

Due to the overall low quality of groundwater in the western DPG region, there have been no potable water resources developed in the Granite Mountain area. Groundwater quality at SWMU-197, located approximately 5 miles southwest of SWMU-11 on the valley floor, is Class IV (saline) per Utah Administrative Code (UAC) R317-6-3 (Division of Water Quality, 2002), with all field TDS measurements exceeding 10,000 milligrams per liter (mg/L), and an average TDS value of approximately 48,700 mg/L. Water well WW32, located 6 miles west-northwest of SWMU-11, is reportedly “very salty” and provides water only for hand washing and toilet flushing purposes at the US Air Force Strategic Training Range Complex west of Granite Mountain. Water well WW10, located approximately 4 miles northwest of SWMU-11, is currently used for dust suppression only. Chemical analysis of WW10 well water presented by Stephens and Sumsion (1978) indicates a Class II (drinking water) rating for the well. However, more recent DPG historical documents indicate that the well is non-potable (Woffinden, 2004). Historical information available from the Utah Division of Water Rights indicates that water from well WW10 was not fit for human consumption and was used only for municipal purposes (e.g., boiler feed, fire suppression, decontamination) at the Granite Peak Installation-2 (GPI-2; SWMU-4) facility.

Groundwater at the SWMU-11 site would likely be similarly characterized, based on the site's similarity in location and environment to that of WW10.

2.2.2 Data Quality

Phase II program laboratory issues and data validation are presented in Section 3.3 of the Volume I Phase II RFI Report (Parsons, 2004b). Phase I data have been previously assessed and a Quality Control (QC) report was issued (Parsons, 1996). Phase I data are used in this report consistent with the data reduction methodology contained in the Risk Assumptions Document (Parsons, 2002a). This discussion is limited to Phase II confirmation data and associated QC results. SWMU-specific QC issues are discussed here in terms of precision, accuracy, representation, and completeness. Discussion of comparability is reserved for the program text in Section 3.3 of the Volume I Phase II RFI Report (Parsons, 2004b). Data, including data validation flags and reason codes, are presented in Appendix C, Table C.1. Tables C.2 through C.6 contain explanatory information for Table C.1. Table C.7 is a data sensitivity summary. QC data are presented beginning with Table C.8. Data assessed here are for all samples collected pursuant to the work plans for SWMU-11, and may not include all data used for site characterization or risk assessment.

2.2.2.1 Precision

Precision is controlled through the use of field duplicates and matrix spike duplicates.

Field Duplicates

In accordance with Section 3.2.7.11 of the Quality Assurance Project Plan (QAPP) (Parsons, 2001b), field duplicates are required at a rate of one per 20 samples of the same matrix per SWMU. Field duplicate acceptance criteria are defined as 35 relative percent difference (RPD) for soil. The QAPP requires that corrective action be taken for field duplicates that exceed RPD limits. Required action is to evaluate the sampling program. Additionally, data validation criteria established in Table 3.12 of the QAPP generally require treating data as estimated ("J" or "UJ" flagging) when field duplicates exceed 70 RPD in soil.

Sixty-one soil samples (including eight material samples) were collected at this site during Phase II. Four field duplicates were collected for soil, meeting the frequency requirement for field duplicates. Table C.8 presents the results of the field duplicate sample for detections in soil. A total of 160 distinct analytes were tested, generating 282 results. Soil test panels included volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), gross alpha/beta, gamma emitters, dioxins and furans, explosives (including nitrocellulose), and metals. The RPD is evaluated when the concentration in the sample is greater than or equal to 10 times the method detection limit (MDL). Precision limits were exceeded for sodium results in one sample and potassium-40 results in another sample, resulting in 99.3-percent compliance in soils. Corrective action consisted of evaluating the results to determine if the sampling program required adjustment. In one sample, it was determined that it was unlikely that this exceedance was caused by the sampling program because of the excellent agreement of the 16 other analytes which were detected in significant (greater than or equal to 10 times the MDL) concentration in the same sample pair. For the other sample, there were 16 analytes which were detected in significant concentration in the same sample pair. No cause was assigned for the two excursions. None of the results exceeded 70 RPD.

Precision was well controlled with respect to field duplicates, since 99.3-percent of duplicate results met established criteria.

Matrix Spike Duplicates

In accordance with Section 3.2.7.10 of the QAPP (Parsons, 2001b), the frequency requirement for matrix spike duplicates is set at one per 20 samples of the same matrix. Because this frequency is not SWMU-specific, and because matrix effects are not generally expected on a SWMU-specific basis, matrix spike duplicates are evaluated on a program basis. However, data flagged at this SWMU for matrix spike duplicate precision are summarized below. Anomalies resulting in data flagged “J” or “UJ” are considered minor, and by definition these anomalies result in usable data. Only “J” flagging was applied for matrix spike duplicate precision at this SWMU.

2.2.2.2 Accuracy

Field control of accuracy is monitored by matrix spikes. In accordance with Section 3.2.7.10 of the QAPP (Parsons, 2001b), matrix spikes are required at a frequency of one per 20 samples of the same matrix. Because this frequency is not SWMU-specific, and because matrix effects are not generally expected on a SWMU-specific basis, matrix spikes are evaluated on a program basis. However, data flagged for this SWMU as a result of matrix spike recovery are summarized below. Anomalies resulting in data flagged "J" or "UJ" are considered minor, and by definition, these anomalies result in usable data. Only minor anomalies were observed with regard to matrix spike recoveries at SWMU-11; these are summarized in Section 2.2.2.5 below.

Since only minor anomalies occurred with regard to matrix spike recoveries, the accuracy of the data was adequately controlled for this SWMU.

2.2.2.3 Representation

Representation is controlled through the Data Quality Objective (DQO) process, and is detailed in the Phase II RFI Work Plan (Parsons, 1998). QC guidelines as established in the work plan, standard operating procedures (SOPs) (Parsons, 1998), and QAPP (Parsons, 2001b), describe management of sampling procedures, use of appropriate sample containers, adherence to holding times, use of proper preservation, and sampling of equipment and trip blanks. Table 3.6 of the QAPP (Parsons, 2001b) describes requirements for containers, preservation, and holding times. Containers and preservation were used in accordance with Table 3.6. Table 3.6 allows collection of soil for VOC analysis in a glass jar or in En Core™ Samplers. Although collection in glass jars is allowed, practice in the Phase II RFI has been to use the En Core™ Samplers. Sample MS02, a material sample, was described as solidified sand or lithified gravel. This material could not be collected in an En Core™ Sampler. Therefore, the material was collected in a glass jar. This results in additional uncertainty in the degree of representation for these results. VOC results of MS02 have been "UJ" flagged to signify this uncertainty. Holding times and equipment blanks were assessed for each analytical result and are discussed here.

Holding Time

Holding times were exceeded for 5.50-percent of (169 of 3075) results, as summarized in Section 2.2.2.5 below. Exceedances between one and two times holding time result in "J" or "UJ" flagging and are considered minor. Data in this condition are defined as usable. Exceedances greater than two times holding time result in "R" flagging and are considered major. Data in this condition are defined as unusable. Therefore, holding times were adequately controlled at this site except for the 38 results which were flagged "R" due to analysis at greater than twice the holding time for VOC analysis.

Holding times for VOCs were exceeded because the laboratory originally analyzed the samples from the wrong (bulk) sample container. The laboratory caught the issue and re-analyzed from the correct sample containers (En Core™ Samplers); however, for several samples holding time had expired. Parsons and the US Army Corps of Engineers (USACE) performed an on-site laboratory audit in response to this issue. A flaw in the way the laboratory tracked and identified containers for analysis was identified during the audit, and was subsequently corrected by the laboratory. As part of its corrective action, the laboratory performed a detailed data review to identify if any prior cases of this error had occurred undetected in the past. No such cases were identified. The impact to the data is insignificant for the following reasons:

- Data for one sample were rejected since they were re-analyzed outside of two times the holding time. The impact of this data loss is discussed below in "Potential Analytical Data Gaps from Rejected Data" subsection.
- Data present a clear picture of contamination in association with the burn layer of TR-1 through TR-4, and this layer will require corrective measures. The impact of data analyzed in excess of holding time is increased uncertainty in the analytical result. In this case because other analytes (metals and dioxins analyzed within holding time) are present at levels that will result in corrective measures, the uncertainty will not impact site decisions.

Therefore, holding times were adequately controlled at this site, since 94.5-percent of results met established criteria, and the impact to site decisions for other data is minimal.

Field Blanks

Equipment blanks were required at a frequency of one per sample technique per 20 samples per SWMU. For purposes of meeting the frequency requirement, "technique"

was interpreted in terms of reusable equipment that came in contact with the sample during sampling. One equipment blank was collected in association with the 53 (not including the 8 material samples) soil samples. Soil samples were collected using two techniques, and therefore insufficient equipment blanks were collected. This has a conservative impact on the data, in that it may result in treating detections as site attributable when in fact they are not. Because the effect is conservative, use of the data is not impacted. In all, 150 analytical results were generated from the one equipment blank analyzed. Test panels included VOCs, SVOCs, dioxins and furans, explosives, metals, and nitrocellulose. Detections are shown on Table C.9. The impact of blank contamination is dependent on the level of contamination observed and the levels of the corresponding analytes in field samples. Mineral-related chemical species at DPG including calcium, chloride, magnesium, sodium, and sulfate commonly occur at levels several orders of magnitude in excess of their MDLs (Parsons, 2004b). It is normal for blanks to contain low levels of these analytes under such conditions. None of these analytes are evaluated as a contaminant.

Sample results associated with equipment or trip blank detections are flagged if they are observed at levels up to five times (10 times for "common laboratory contaminants" [USEPA, 1994b]) the value contained in the blank. Flagged results for equipment and trip blanks are presented in Table C.10. Four of 3075 (0.130-percent of) analytical results were flagged for field blank contamination at SWMU-11.

Results were deemed representative, consistent with the sample design.

2.2.2.4 Analytical Completeness

A total of 10.86-percent of (334 of 3075) analytical results for normal and field duplicate samples were flagged for QC issues, including 41 results that were rejected. All other results met QC criteria. Completeness is defined in Section 3.2.5.5 of the QAPP (Parsons, 2001b) as the percent of usable data. The completeness goal is 95-percent. In all, 3034 of 3075 analytical results were usable, resulting in 98.7-percent analytical completeness and meeting the goal for this SWMU.

2.2.2.5 Summary of Qualified Results

Results were considered qualified in terms of data usability if they were flagged "U", "UJ", "J", or "R" during data validation. Flags are defined in Table C.5. Results may be qualified "U" simply because no analyte was detected. Results may be qualified "J" simply because the detected value is between the MDL and reporting limit (RL) (practical quantitation limit [PQL]) (i.e., is a trace value). Flags are also applied due to QC exceedances. This summary does not consider routine flagging of non-detects and trace results. Qualified results were classified as minor if flagged "U", "UJ", or "J", and major if flagged "R". All results, including Phase I data, are presented in Table C.1.

Minor Data Quality Issues

A total of 293 results were flagged due to minor QC issues. Note that the sum of results below equals more than 293, since some results were flagged for more than one QC issue; however, a total of 293 results were affected. These issues are presented below:

- 18 results (4 antimony, 13 nitrocellulose, and 1 octachlorodibenzo-p-dioxin) were flagged "U" or "UJ" due to laboratory blank issues. "UJ" flags arise in this context when the blank recovery is negative for metals analysis.
- 84 results (8 2-chloroethyl vinyl ether, 13 2-hexanone, 13 acetone, 1 benzo [g,h,i]perylene, 8 carbon disulfide, 5 chloroethane, 1 indeno[1,2,3-c,d]pyrene, 13 methyl ethyl ketone [2-butanone], 13 methyl isobutyl ketone [4-methyl-2-pentanone], 1 sodium, and 8 vinyl acetate) were flagged "UJ" or "J" due to continuing calibration issues. Note that for gas chromatography/mass spectrometry (GC/MS) techniques, continuing calibrations may meet all method requirements and still result in data usability flags.
- 4 nitrocellulose results were flagged "U" due to field blank contamination.
- 19 results (17 antimony and 2 N-nitrosodi-n-propylamine) were flagged "UJ" or "J" due to matrix spike recoveries.
- 1 gross alpha result was flagged "J" due to matrix spike duplicate precision.
- 4 results (1 bismuth-214, 2 mercury, and 1 thorium-232) were flagged "UJ" or "J" due field duplicate precision.
- One nitroglycerin result was flagged "J" due to surrogate recoveries.
- 131 results (3 1,1,1-trichloroethane, 3 1,1,2,2-tetrachloroethane, 3 1,1,2-trichloroethane, 3 1,1-dichloroethane, 3 1,1-dichloroethene, 3 1,2-dichlorobenzene, 3 1,2-dichloroethane, 3 1,2-dichloropropane, 3 1,3-dichlorobenzene, 3 1,4-dichlorobenzene, 3 2-chloroethyl vinyl ether, 3 2-hexanone, 4 acetone, 4 benzene, 1 benzo[g,h,i]perylene,

3 bromodichloromethane, 3 bromoform, 3 bromomethane, 3 carbon disulfide, 3 carbon tetrachloride, 3 chlorobenzene, 3 chloroethane, 3 chloroform, 3 chloromethane, 3 dibromochloromethane, 3 dichlorodifluoromethane, 3 ethylbenzene, 3 m,p-xylene [sum of isomers], 4 methyl ethyl ketone [2-butanone], 3 methyl isobutyl ketone [4-methyl-2-pentanone], 3 methylene chloride, 3 o-xylene [1,2-dimethylbenzene], 3 styrene, 3 tetrachloroethylene [PCE], 4 toluene, 3 trichloroethylene [TCE], 3 trichlorofluoromethane, 3 vinyl acetate, 3 vinyl chloride, 3 cis-1,2-dichloroethylene, 3 cis-1,3-dichloropropene, 3 trans-1,2-dichloroethene, and 3 trans-1,3-dichloropropene) were flagged "UJ" or "J" due to holding time exceedances.

- 58 results (4 1,1,2,2-tetrachloroethane, 1 1,2,3,4,6,7,8-heptachlorodibenzofuran, 1 1,2,3,4,7,8,9-heptachlorodibenzofuran, 1 1,2,3,4,7,8-hexachlorodibenzofuran, 1 1,2,3,6,7,8-hexachlorodibenzofuran, 1 1,2,3,7,8,9-hexachlorodibenzofuran, 4 1,2-dichlorobenzene, 4 1,3-dichlorobenzene, 4 1,4-dichlorobenzene, 1 2,3,4,6,7,8-hexachlorodibenzofuran, 3 2-hexanone, 1 benzo[a]pyrene, 1 benzo[b]fluoranthene, 1 benzo[g,h,i]perylene, 1 benzo[k]fluoranthene, 3 bromoform, 3 chlorobenzene, 1 di-n-octylphthalate, 1 dibenz[a,h]anthracene, 3 dibromochloromethane, 3 ethylbenzene, 1 indeno[1,2,3-c,d]pyrene, 3 m,p-xylene [sum of isomers], 3 o-xylene [1,2-dimethylbenzene], 1 octachlorodibenzo-p-dioxin, 1 octachlorodibenzofuran, 3 styrene, and 3 PCE) were flagged "UJ" or "J" due to internal standard recovery outside control limits.
- 5 results (3 acetone and 2 methyl ethyl ketone [2-butanone]) were flagged "UJ" or "J" due to linear calibration range exceedances.

Major Data Quality Issues

A total of 41 results were flagged due to major QC issues. These issues are presented below:

- 38 results (1 1,1,1-trichloroethane, 1 1,1,2,2-tetrachloroethane, 1 1,1,2-trichloroethane, 1 1,1-dichloroethane, 1 1,1-dichloroethene, 1 1,2-dichlorobenzene, 1 1,2-dichloroethane, 1 1,2-dichloropropane, 1 1,3-dichlorobenzene, 1 1,4-dichlorobenzene, 1 2-chloroethyl vinyl ether, 1 2-hexanone, 1 bromodichloromethane, 1 bromoform, 1 bromomethane, 1 carbon disulfide, 1 carbon tetrachloride, 1 chlorobenzene, 1 chloroethane, 1 chloroform, 1 chloromethane, 1 dibromochloromethane, 1 dichlorodifluoromethane, 1 ethylbenzene, 1 m,p-xylene [sum of isomers], 1 methyl isobutyl ketone [4-methyl-2-pentanone], 1 methylene chloride, 1 o-xylene [1,2-dimethylbenzene], 1 styrene, 1 PCE, 1 TCE, 1 trichlorofluoromethane, 1 vinyl acetate, 1 vinyl chloride, 1 cis-1,2-dichloroethylene, 1 cis-1,3-dichloropropene, 1 trans-1,2-dichloroethene, and 1 trans-1,3-dichloropropene) were flagged "R" due to holding time exceedances.
- 3 nitroglycerin results were flagged "R" due to surrogate recovery failure.

2.2.2.6 Tentatively Identified Compounds

A detailed discussion of procedures for screening tentatively identified compounds (TICs) is presented in Section 3.3.5 of the Volume I Phase II RFI Report (Parsons, 2004b). TIC data were screened against Preliminary Remediation Goals (PRGs) (USEPA Region 9, 1998) and a list of chemical warfare agent (CWA)-related compounds. No TICs requiring further investigation were noted at SWMU-11 based on the results of this screening.

2.2.2.7 Data Quality Conclusions

Several minor QC anomalies occurred at SWMU-11 that did not significantly impact data usability. No TICs were identified for inclusion in site characterization, risk assessment, or corrective measures studies at SWMU-11. Precision, accuracy, representation, and completeness were all substantially under control. The data are suitable for decision-making purposes related to this project such as site characterization, human and ecological risk assessment, and in the determination of corrective action measures, except as flagged "R".

Potential Analytical Data Gaps from Rejected Data

Data rejections are presented in detail in Section 2.2.2.5. All VOC results were rejected in one deep soil sample collected at 2.5 ft bgs from test pit EP06. Samples taken at EP06 at 1.5 ft bgs and EP05 at 1.5 and 2.5 ft bgs define the vertical extent of VOCs for this one rejected VOC sample. Therefore, the rejection of VOCs in this one sample is considered insignificant.

Three nitroglycerin results at EP03, EP04, and EP06 at 2-2.5 ft bgs, 1.5-2 ft bgs, and 1.5-1.6 ft bgs respectively were also rejected. Two samples taken at EP03 and EP04 at 4-4.5 ft bgs and one sample taken at EP06 at 2.5-2.6 ft bgs had no nitroglycerin detections and define the vertical extent of nitroglycerin for the three rejected samples. Therefore, the rejection of these three results is considered insignificant.

2.2.3 Evaluation of Soil Analyses

The purpose of this section is to: 1) present the results of the RFI soil investigation; 2) determine if sufficient sampling was conducted to adequately characterize the nature and extent of chemicals and radiation detected in site soils; and

3) provide data to support a site-attribution analysis for risk assessment (Appendix D), and if necessary, a risk assessment (Section 3).

The steps used to determine whether adequate soil sampling was conducted for chemical constituents are shown on Figure 2.1 (reproduced from Figure 6.1 of the Background Metals Report [Parsons, 2001a]) and are summarized as follows:

1. Identify inorganics and organics detected in site soils that do not have DPG-specific background comparison values (i.e., the lower of the 95-percent upper tolerance limit [UTL] or the maximum detected background soil concentration from the Background Metals Report [Parsons, 2001a]) or that are above corresponding background comparison values.
2. Determine which (if any) chemicals identified in Step 1 exceed corresponding United States Environmental Protection Agency (USEPA) Region 9 (2004) Residential Soil PRGs.
3. Use professional judgment (consisting of a review of site history; an evaluation of the magnitude, frequency, and spatial distributions of chemical concentrations; and/or for inorganics, a review of graphical plots) to determine if adequate soil sampling was conducted for the chemicals (if any) identified in Step 2.

As shown on Figure 2.1, it is also important to demonstrate that soil samples were collected from biased locations with the greatest potential for contamination (i.e., worst-case locations).

The steps used to determine if adequate sampling for radiation was conducted are presented in Appendix F, and the results of this evaluation are summarized in Section 2.2.3.4.

2.2.3.1 Surface Soil Analytical Results

Six surface soil samples (SS001-SS006) were collected from four of the trenches (TR-1 through TR-4) and analyzed for chemical and radiological constituents. These surface soil samples were analyzed for SVOCs, agent breakdown products (ABPs) (SS001-SS004), CWA (SS001-SS004), explosives, dioxins/furans (SS005-SS006), gross alpha/beta and gamma (SS001-SS004), total petroleum hydrocarbons (TPH) (SS001-SS004), and inorganics (metals). Default analytes specific to these test panels are listed by analytical method in Table 3.8 of the QAPP (Parsons, 2001b). Analytical methods, associated analytes specific to this SWMU, and results for all surface soil samples are provided in Appendix C. Detections in surface soil consisted of select inorganics and one dioxin. Locations and concentrations of the dioxin and the inorganic detections in excess

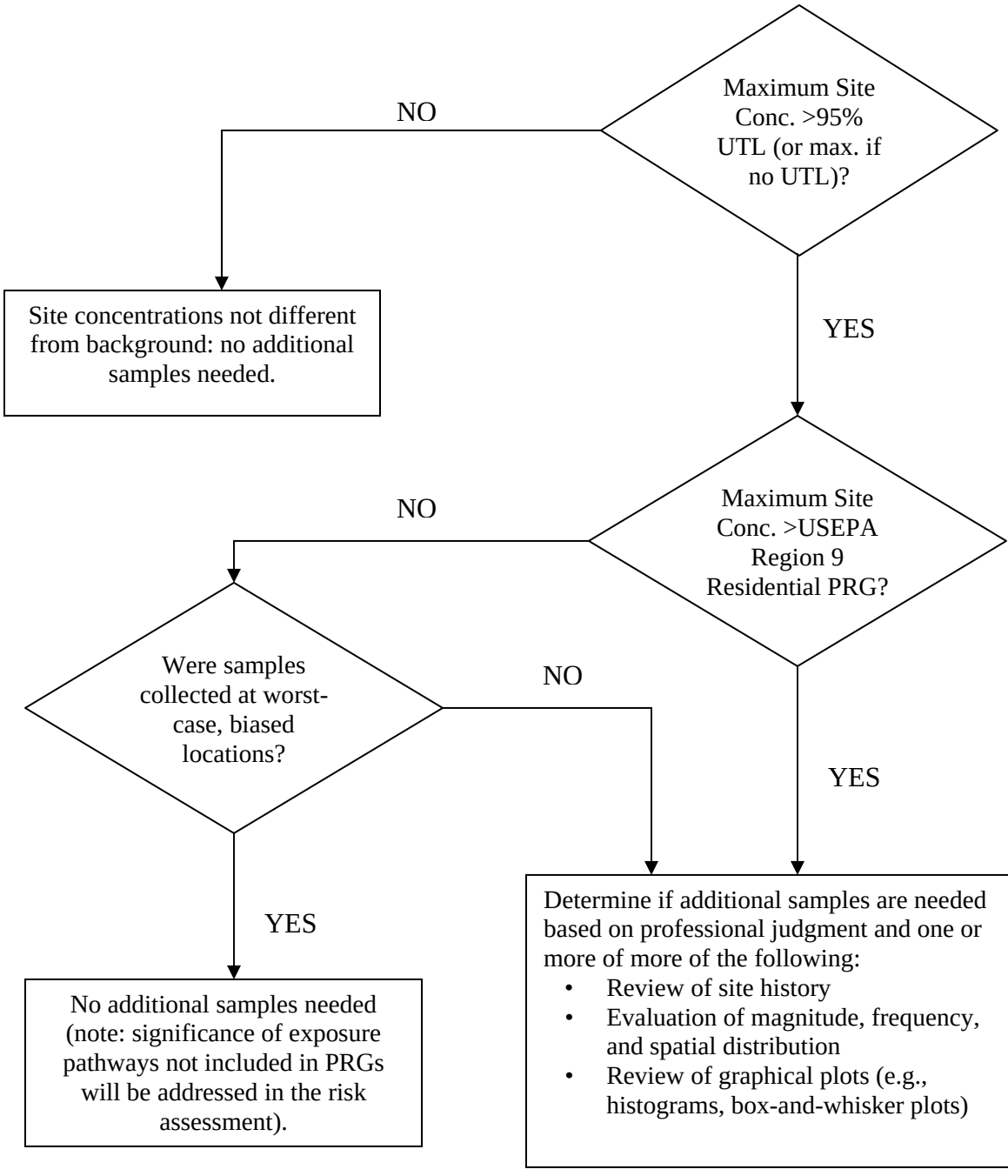


FIGURE 2.1

SITE-TO-BACKGROUND COMPARISONS DURING SITE CHARACTERIZATION

Dugway Proving Ground RFI

PARSONS

of background comparison values (see Attachment 2 of Appendix D) in surface soils are presented on Figure 2.2.

Other SWMU-11 surface soil samples (SS007-SS039) were collected in support of the radiological survey, and were therefore only analyzed for radiological constituents in accordance with the Final Phase II RCRA Facility Investigation Work Plan SWMUs 11 and 41 Radiological Survey (Parsons, 2005g). Results of the radiological analyses are evaluated in Appendices D and F. Results of the radiological survey are summarized in Section 2.2.3.4 below, and are included on Figure 2.2.

Surface soil samples were collected from biased locations with the greatest potential for contamination based on field observations and site history (Parsons, 1998). The additional background comparison value and Residential Soil PRG comparison and professional judgment steps shown on Figure 2.1 are presented below.

Step 1 - Site Concentrations versus Background Comparison Values

Figure 2.2 presents chemicals in surface soil that had maximum site concentrations greater than their corresponding background comparison values, or did not have DPG-specific background comparison values (refer to the summary statistics table for surface soils in Attachment 2 of Appendix D). These chemicals include:

Inorganics

- Beryllium
- Boron
- Calcium
- Magnesium
- Molybdenum
- Silver
- Sodium

Organics

- Octachlorodibenzo-p-Dioxin

Calcium, magnesium, and sodium are essential nutrients and therefore are not shown on Figure 2.2.

Step 2 - Residential Soil PRG Comparison

Consistent with state-approved methods (Parsons, 2001a), although future residential land use is not likely at this SWMU, maximum soil concentrations were conservatively compared with their corresponding USEPA Region 9 (2004) Residential

Soil PRGs as one step in determining whether additional characterization of soils is required.

Of the chemicals listed in Step 1 above, none had maximum site concentrations in surface soil greater than their corresponding USEPA Region 9 (2004) Residential Soil PRGs (refer to the summary statistics table for surface soils in Attachment 2 of Appendix D). The chemicals listed in Step 1 were represented by samples collected from locations biased toward worst-case contamination. Therefore, the professional judgment step is not necessary and additional sampling to characterize surface soils is not required.

Summary of Adequacy of Surface Soil Characterization

As presented on Figure 2.1, additional sampling for site characterization is not required if samples were collected from biased, worst-case locations and if: 1) maximum site concentrations did not exceed corresponding background comparison values (for inorganics); 2) maximum site concentrations exceeded corresponding background comparison values (or background comparison values were not available) but were less than corresponding USEPA Region 9 (2004) Residential Soil PRGs (for inorganics and organics); or 3) the application of professional judgment and additional lines of evidence rule out the need for additional sampling.

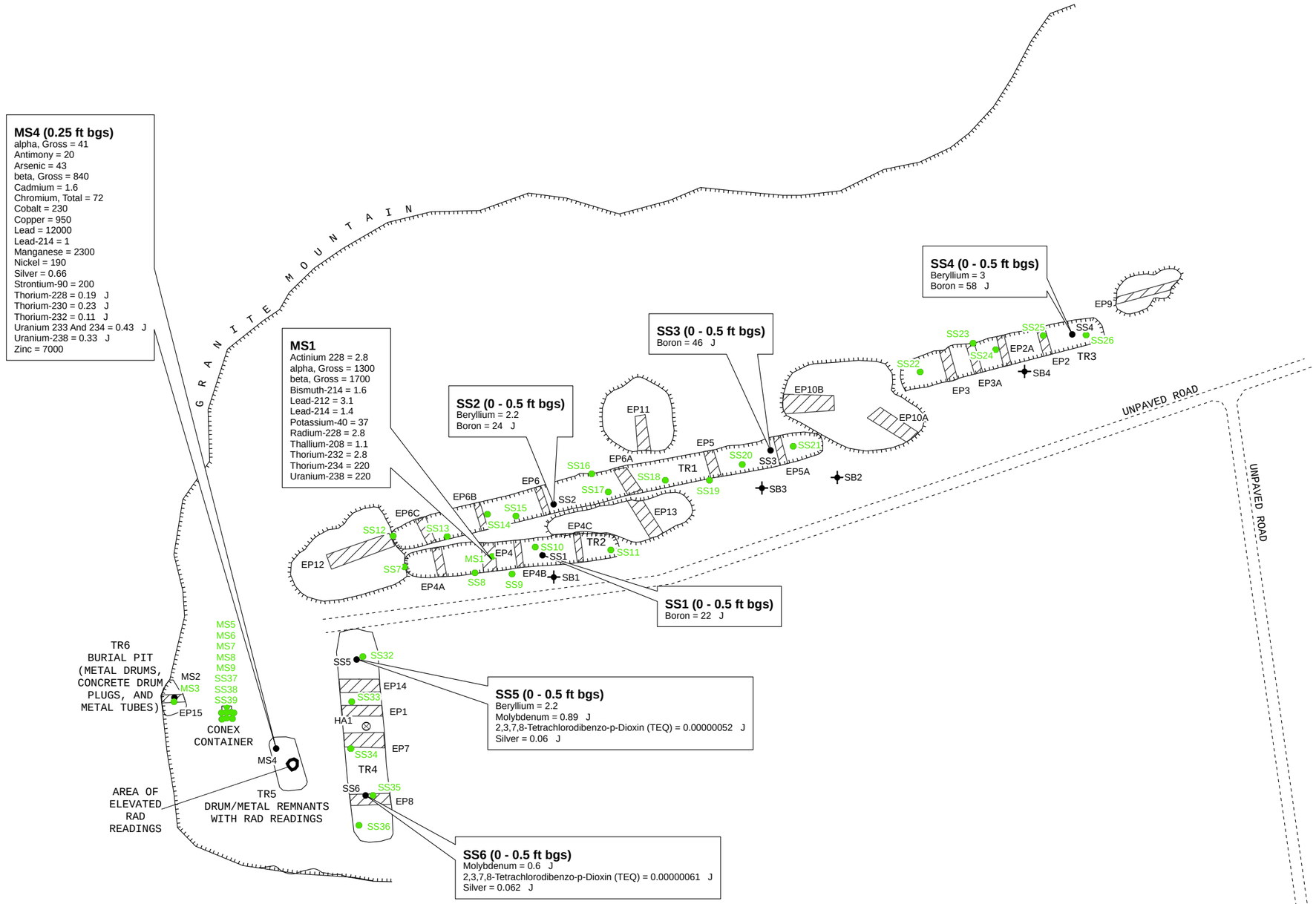
Based on these criteria and as demonstrated above, the nature and extent of chemicals detected in surface soil has been adequately characterized, and additional surface soil sampling is not required.

2.2.3.2 Subsurface Soil Analytical Results

Twenty-nine subsurface soil samples were collected from four soil borings (SB01-SB04), one hand-auger boring (HA01), and eight test pit (EP01-EP07 and EP15) locations (Figure 2.3). Subsurface soil samples were analyzed for VOCs, SVOCs, dioxins/furans (EP02-EP07 and EP15), explosives, gross alpha/beta and gamma (SB01-SB04, HA01, and EP01), ABPs (SB01-SB04, HA01, and EP01), CWA (SB01-SB04, HA01, and EP01), TPH (SB01-SB04, HA01, and EP01), and inorganics. Default analytes specific to these test panels are listed by analytical method in Table 3.8 of the QAPP (Parsons, 2001b). Analytical methods and associated analytes specific to this SWMU are detailed in Table C.1. Detections in subsurface soil samples consisted of VOCs, SVOCs,

DPG Background Comparison Values for Analytes Detected at SWMU-11

Analyte	Background Comparison Value (mg/Kg)
Beryllium	1.6
Boron	None
Molybdenum	None
Silver	None



LEGEND

- SWMU MONUMENT
- HAND AUGER (HA)
- MATERIAL SAMPLE (MS)
- SOIL BORING (SB)
- SURFACE SOIL SAMPLE (SS)
- TEST PIT (EP)

SAMPLES IN GREEN ARE FOR RADIOLOGICAL ANALYSIS ONLY

Radiological results that were determined to be similar to background are not shown.

Inorganic detections in soil below DPG background comparison values not shown.

J equals an estimated value.

Soil sample results reported in mg/Kg.

Field duplicates and essential nutrients not shown.

Analytes less than detection limits not shown.

FIGURE 2.2

SWMU-11 SURFACE SOIL AND MATERIAL SAMPLE CONCENTRATIONS OF ORGANIC, INORGANIC AND RADIOLOGICAL ANALYTES DETECTED ABOVE BACKGROUND COMPARISON VALUES

DUGWAY PROVING GROUND RFI

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EP1 (8 ft bgs)
2-Methylnaphthalene = 0.057
Beryllium = 80
Boron = 11
Petroleum Hydrocarbons (Total) = 26
EP1 (10 ft bgs)
Beryllium = 2.1
Boron = 15

EP2 (4 ft bgs)
Acetone = 0.055
Barium = 530
Methyl Ethyl Ketone (2-Butanone) = 0.02
Molybdenum = 0.87 J
Nitrocellulose = 19

HA1 (3.5 - 6 ft bgs)
Benzyl Alcohol = 0.18
Boron = 36 J

MS2 (6 ft bgs)
2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TEQ) = 0.00000034 J
Arsenic = 160
Chromium, Total = 34
Cobalt = 18
Copper = 41
Lead = 130
Molybdenum = 6.1
Nickel = 17
Silver = 0.11 J

SB1 (2 - 4 ft bgs)
Boron = 35
SB1 (6 - 8 ft bgs)
Boron = 21
SB1 (13 - 15 ft bgs)
Boron = 22

SB2 (2 - 4 ft bgs)
Acenaphthene = 0.12
Acenaphthylene = 0.68
Boron = 25
Fluoranthene = 0.097
Phenanthrene = 0.25
Pyrene = 0.16
SB2 (6 - 8 ft bgs)
Barium = 490
Boron = 34
SB2 (13 - 15 ft bgs)
Boron = 19

SB3 (2 - 4 ft bgs)
Barium = 600
Boron = 21
SB3 (6 - 8 ft bgs)
Barium = 970
Boron = 34

SB4 (2 - 4 ft bgs)
Barium = 490
Boron = 32
SB4 (6 - 8 ft bgs)
Boron = 22

EP3 (2 - 2.5 ft bgs)
2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TEQ) = 0.000017
2-Hexanone = 0.022 J
Acetone = 5.3 J
Benzene = 0.034
Beryllium = 24000
Cadmium = 1.1
Chromium, Total = 85
Copper = 34
Ethylbenzene = 0.014 J
Lead = 60
m,p-Xylene (Sum Of Isomers) = 0.024 J
Methyl Ethyl Ketone (2-Butanone) = 0.71 J
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone) = 0.029 J
Molybdenum = 2.1
Nickel = 19
Nitrocellulose = 5.4 J
o-Xylene (1,2-Dimethylbenzene) = 0.011 J
Phenanthrene = 0.024 J
Silver = 0.18 J
Styrene = 0.0054 J
Toluene = 0.044
Zinc = 830
EP3 (4 - 4.5 ft bgs)
2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TEQ) = 0.00000036
Acetone = 0.083 J
Barium = 540
Beryllium = 1.7
Methyl Ethyl Ketone (2-Butanone) = 0.031 J
Molybdenum = 0.65 J
Nitrocellulose = 14

EP4 (1.5 - 2 ft bgs)
2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TEQ) = 0.0000024
2-Hexanone = 0.062 J
2-Methylnaphthalene = 0.29 J
Acetone = 9 J
Benzene = 0.073
Beryllium = 21000
Chromium, Total = 110
Dibenzofuran = 0.045 J
Ethylbenzene = 0.031
Lead = 83
m,p-Xylene (Sum Of Isomers) = 0.042
Methyl Ethyl Ketone (2-Butanone) = 1.2 J
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone) = 0.063 J
Molybdenum = 1.5
Naphthalene = 0.057 J
Nickel = 16
o-Xylene (1,2-Dimethylbenzene) = 0.022
Phenanthrene = 0.069 J
Silver = 0.094 J
Styrene = 0.023
Toluene = 0.11
Zinc = 500
EP4 (4 - 4.5 ft bgs)
2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TEQ) = 0.00000025
Acetone = 0.04 J
Benzene = 0.0025 J
Beryllium = 7.2
m,p-Xylene (Sum Of Isomers) = 0.00096 J
Methyl Ethyl Ketone (2-Butanone) = 0.011 J
Molybdenum = 0.62 J
Toluene = 0.0024 J

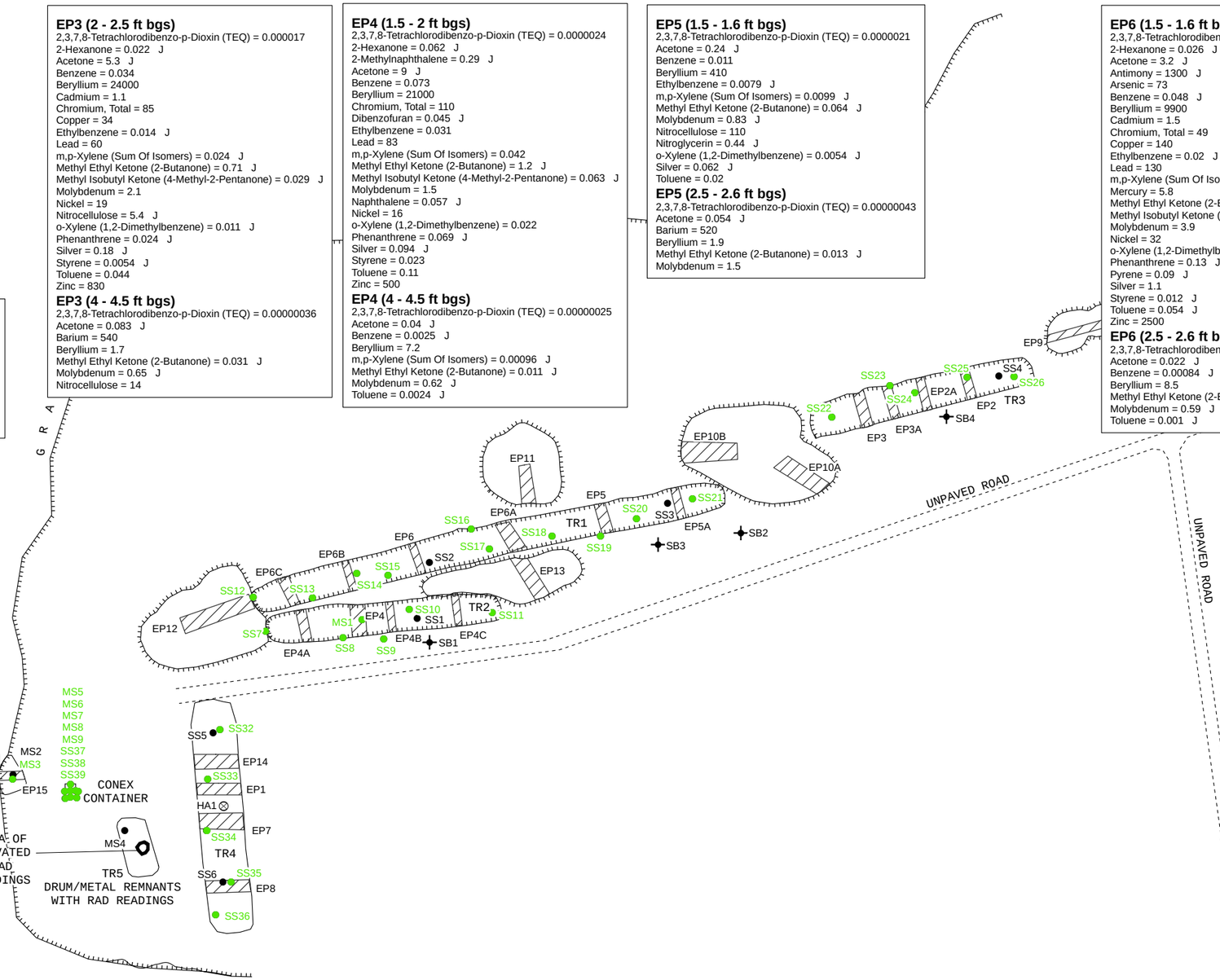
EP5 (1.5 - 1.6 ft bgs)
2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TEQ) = 0.0000021
Acetone = 0.24 J
Benzene = 0.011
Beryllium = 410
Ethylbenzene = 0.0079 J
m,p-Xylene (Sum Of Isomers) = 0.0099 J
Methyl Ethyl Ketone (2-Butanone) = 0.064 J
Molybdenum = 0.83 J
Nitrocellulose = 110
Nitroglycerin = 0.44 J
o-Xylene (1,2-Dimethylbenzene) = 0.0054 J
Silver = 0.062 J
Toluene = 0.02
EP5 (2.5 - 2.6 ft bgs)
2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TEQ) = 0.00000043
Acetone = 0.054 J
Barium = 520
Beryllium = 1.9
Methyl Ethyl Ketone (2-Butanone) = 0.013 J
Molybdenum = 1.5

EP6 (1.5 - 1.6 ft bgs)
2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TEQ) = 0.00046
2-Hexanone = 0.026 J
Acetone = 3.2 J
Antimony = 1300 J
Arsenic = 73
Benzene = 0.048 J
Beryllium = 9900
Cadmium = 1.5
Chromium, Total = 49
Copper = 140
Ethylbenzene = 0.02 J
Lead = 130
m,p-Xylene (Sum Of Isomers) = 0.022 J
Mercury = 5.8
Methyl Ethyl Ketone (2-Butanone) = 0.5 J
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone) = 0.027 J
Molybdenum = 3.9
Nickel = 32
o-Xylene (1,2-Dimethylbenzene) = 0.012 J
Phenanthrene = 0.13 J
Pyrene = 0.09 J
Silver = 1.1
Styrene = 0.012 J
Toluene = 0.054 J
Zinc = 2500
EP6 (2.5 - 2.6 ft bgs)
2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TEQ) = 0.00000046
Acetone = 0.022 J
Benzene = 0.00084 J
Beryllium = 8.5
Methyl Ethyl Ketone (2-Butanone) = 0.0053 J
Molybdenum = 0.59 J
Toluene = 0.001 J

EP7 (3.5 - 4 ft bgs)
2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TEQ) = 0.0000011
Acetone = 0.066 J
Benzene = 0.0036 J
Methyl Ethyl Ketone (2-Butanone) = 0.019 J
Molybdenum = 0.87 J
Toluene = 0.0033 J
EP7 (8 - 8.5 ft bgs)
2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TEQ) = 0.00000025
Acetone = 0.15 J
Benzene = 0.009
Beryllium = 230
Ethylbenzene = 0.003 J
m,p-Xylene (Sum Of Isomers) = 0.0041 J
Methyl Ethyl Ketone (2-Butanone) = 0.052 J
Molybdenum = 0.55 J
Nitrocellulose = 7.7
Toluene = 0.013
EP7 (12 - 12.5 ft bgs)
Acetone = 0.029 J
Benzene = 0.0011 J
Methyl Ethyl Ketone (2-Butanone) = 0.0086 J
Molybdenum = 0.27 J
Toluene = 0.0011 J

EP15 (9.5 - 10.5 ft bgs)
2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TEQ) = 0.00000057
Acetone = 0.044 J
Benzene = 0.0012 J
Methyl Ethyl Ketone (2-Butanone) = 0.011 J
Molybdenum = 0.65 J
Toluene = 0.0011 J

HA1 (0 - 3.5 ft bgs)
Benzyl Alcohol = 0.16
Boron = 20 J



DPG Background Comparison Values for Analytes Detected at SWMU-11

Analyte	Background Comparison Value (mg/Kg)
Antimony	10
Arsenic	13
Barium	470
Beryllium	1.1
Boron	None
Cadmium	0.8
Chromium, Total	17
Copper	20
Lead	22
Mercury	0.2
Molybdenum	None
Nickel	15
Silver	None
Zinc	67

LEGEND

- SWMU MONUMENT
- HAND AUGER (HA)
- MATERIAL SAMPLE (MS)
- SOIL BORING (SB)
- SURFACE SOIL SAMPLE (SS)
- TEST PIT (EP)

SAMPLES IN GREEN ARE FOR RADIOLOGICAL ANALYSIS ONLY

Radiological results that were determined to be similar to background are not shown.

Inorganic detections in soil below DPG background comparison values not shown.

J equals an estimated value.

Soil sample results reported in mg/Kg.

Field duplicates and essential nutrients not shown.

Analytes less than detection limits not shown.

N

100 0 100 Feet

FIGURE 2.3

SWMU-11 SUBSURFACE SOIL AND MATERIAL SAMPLE CONCENTRATIONS OF ORGANIC AND INORGANIC ANALYTES DETECTED ABOVE BACKGROUND COMPARISON VALUES

DUGWAY PROVING GROUND RFI

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dioxins/furans, explosives, TPH, gross alpha/beta and gamma, and inorganics. Locations and concentrations of detections in subsurface soils (including inorganics in excess of background comparison levels; see Attachment 2 of Appendix D) are presented on Figure 2.3. Results of the radiological survey are summarized in Section 2.2.3.4 below.

Subsurface soil samples were collected from biased locations with the greatest potential for contamination based on previous sampling results, field observations, and site history. The additional background comparison value and Residential Soil PRG comparison and professional judgment steps shown on Figure 2.1 are presented below.

Step 1 - Site Concentrations versus Background Comparison Values

Figure 2.3 presents chemicals in subsurface soil that had maximum site concentrations greater than their corresponding background comparison values, or did not have DPG-specific background comparison values (refer to the summary statistics table for subsurface soils in Attachment 2 of Appendix D). These chemicals include:

Inorganics

- Antimony
- Arsenic
- Barium
- Beryllium
- Boron
- Cadmium
- Calcium
- Chromium (Total)
- Copper
- Iron
- Lead
- Mercury
- Molybdenum
- Nickel
- Silver
- Sodium
- Zinc

Organics

- Acenaphthene
- Acenaphthylene
- Acetone
- Benzene
- Ethylbenzene
- 2-Hexanone
- Methyl Ethyl Ketone (2-Butanone)
- Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)
- 2-Methylnaphthalene
- Naphthalene
- Phenanthrene
- Benzyl Alcohol
- Fluoranthene
- Pyrene
- Dibenzofuran
- 1,2,3,4,6,7,8-Heptachlorodibenzofuran
- 1,2,3,4,7,8,9-Heptachlorodibenzofuran
- 1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin
- 1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin
- 1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin
- 1,2,3,7,8,9-Hexachlorodibenzofuran
- 2,3,4,6,7,8-Hexachlorodibenzofuran
- Octachlorodibenzofuran
- Octachlorodibenzo-p-Dioxin
- 1,2,3,7,8-Pentachlorodibenzofuran
- 2,3,4,7,8-Pentachlorodibenzofuran
- 1,2,3,7,8-Pentachlorodibenzo-p-Dioxin
- 2,3,7,8-Tetrachlorodibenzofuran

- Styrene
- Toluene
- o-Xylene (1,2-Dimethylbenzene)
- m,p-Xylene (Sum Of Isomers)
- 1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin
- 1,2,3,4,7,8-Hexachlorodibenzofuran
- 1,2,3,6,7,8-Hexachlorodibenzofuran
- 2,3,7,8-Tetrachlorodibenzo-p-Dioxin
- Nitrocellulose
- Nitroglycerin
- TPH

Calcium, iron, and sodium are essential nutrients and therefore are not shown on Figure 2.3.

Step 2 - Residential Soil PRG Comparison

Consistent with state-approved methods (Parsons, 2001a), although future residential land use is not likely at this SWMU, maximum soil concentrations were conservatively compared with their corresponding USEPA Region 9 (2004) Residential Soil PRGs as one step in determining whether additional characterization of soils is required. TPH, nitrocellulose, and 2-hexanone do not have USEPA (2004) Residential Soil PRGs, and therefore are discussed in the "Other Analytes" subsection.

Of the chemicals listed in Step 1 above, 17 had a maximum site concentration in subsurface soils greater than their corresponding USEPA Region 9 (2004) Residential Soil PRG (refer to the summary statistics table for subsurface soils in Attachment 2 of Appendix D). These chemicals include:

Inorganics

- Antimony
- Arsenic
- Beryllium

Organics

- 1,2,3,4,6,7,8-Heptachlorodibenzofuran
- 1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin
- 1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin
- 1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin
- 1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin
- 1,2,3,4,7,8-Hexachlorodibenzofuran
- 1,2,3,6,7,8-Hexachlorodibenzofuran
- 1,2,3,7,8,9-Hexachlorodibenzofuran
- 2,3,4,6,7,8-Hexachlorodibenzofuran
- 1,2,3,7,8-Pentachlorodibenzofuran
- 2,3,4,7,8-Pentachlorodibenzofuran
- 1,2,3,7,8-Pentachlorodibenzo-p-Dioxin
- 2,3,7,8-Tetrachlorodibenzofuran
- 2,3,7,8-Tetrachlorodibenzo-p-Dioxin

Step 3 - Professional Judgment

The chemicals listed above were detected above the USEPA Region 9 (2004) Residential Soil PRG in samples collected from TR-1, TR-2, TR-3, and TR-4 (EP03-EP07). The majority of these detections above the PRG were from EP06 (TR-1) within the burn layer. Beryllium was detected above the PRG in the five sample locations (EP03-EP07) within the burn layer, and two dioxin/furans were detected in EP03 (within the burn layer) above their PRGs. The chemicals in the bulleted list above were not detected at concentrations above their corresponding PRG and (if available) background comparison value in soil boring samples collected adjacent to these three trenches (SB01-SB04). These chemicals were also not detected above their corresponding PRG and (if available) background comparison value in samples collected at deeper intervals at the same locations (EP03-EP07). Therefore the vertical and horizontal extent of contamination has been adequately characterized and further sampling is not required for the subsurface interval.

Other Analytes

TPH, nitrocellulose, and 2-hexanone do not have USEPA Region 9 (2004) Residential Soil PRGs for comparison in Step 2 above. TPH was detected in one subsurface soil sample at a concentration of 26 mg/Kg in EP01 (Table C.1). Although a USEPA Region 9 (2004) Residential Soil PRG is not available for TPH, this detection in subsurface soils was over two orders of magnitude less than the Leaking Underground Storage Tank (LUST) program (UDEQ, 2000) non-risk-based screening value of 10,000 mg/Kg for total recoverable petroleum hydrocarbons. Therefore, the extent of TPH in subsurface soils has been adequately characterized, and further subsurface soil sampling is not required for this analyte. In addition, TPH was eliminated from further consideration in the risk assessment because: 1) specific organic chemical results (e.g., VOCs and SVOCs) were obtained; and 2) risks and/or hazards are assessed using chemical-specific toxicity data, and not non-specific results from mixtures such as TPH.

The propellant, nitrocellulose, was detected at SWMU-11 in five soil samples collected at EP02, EP03, EP05, and EP07. A background value and USEPA Region 9 (2004) Residential Soil PRG is not available for nitrocellulose. However, USEPA (2004e and 2000f) indicates that nitrocellulose is non-toxic. Therefore, additional sampling for

nitrocellulose is not recommended, given the non-toxic nature of the substance and the evidence that the extent of nitrocellulose is likely confined to the trenched areas of SWMU-11.

Three isolated 2-hexanone concentrations were detected in the shallow samples collected from EP03, EP04, and EP06 (Figure 2.3). This chemical was not detected in underlying deeper samples collected from EP03 or EP04, nor was it detected in EP02 excavated in the same site feature as EP03 (TR-2) or in SB01 drilled adjacent to TR-2 where EP04 is located. Although the 2-hexanone result from the deeper EP06 interval was rejected, this chemical was not detected in the shallow or deep samples collected from EP05, excavated in the same site feature as EP06 (TR-1). Therefore, the extent of 2-hexanone is subsurface soils has been adequately characterized, and additional sampling for this chemical is not required.

Summary of Adequacy of Subsurface Soil Characterization

As presented on Figure 2.1, additional sampling for site characterization is not required if samples were collected from biased, worst-case locations and if: 1) maximum site concentrations did not exceed corresponding background comparison values (for inorganics); 2) maximum site concentrations exceeded corresponding background comparison values (or background comparison values were not available), but were less than corresponding USEPA Region 9 (2004) Residential Soil PRGs (for inorganics and organics); and 3) the application of professional judgment and additional lines of evidence rule out the need for additional sampling.

Based on these criteria and as demonstrated above, the nature and extent of chemicals detected in subsurface soil has been adequately characterized, and additional subsurface soil sampling is not required.

2.2.3.3 Summary of Surface and Subsurface Soil Results

Soil samples were collected from biased, worst-case locations with the greatest potential for contamination based on field observations and site history (Parsons, 1998 and 1999a). No chemical concentrations in surface soils were above both their corresponding background value and their USEPA Region 9 (2004) Residential Soil PRG at SWMU-11 (Figures 2.2 and 2.3); therefore, additional sampling is not required for

surface soils. A total of 17 chemicals were detected in subsurface soils at concentrations that exceeded both their corresponding background comparison value and USEPA Region 9 (2004) Residential Soil PRG. Additional sampling is not required for these 17 chemicals based on the lines of evidence presented in Section 2.2.3.2 for subsurface soils. Characterization objectives have been achieved at this site based on the criteria established for this investigation, and further characterization of the nature and extent of soil contamination is not necessary. An evaluation of potential future soil-to-groundwater impacts is presented in Section 3.1.6.

Results from SWMU-11 surface and subsurface soil samples collected in support of the radiological survey in accordance with the Final Phase II RCRA Facility Investigation Work Plan SWMUs 11 and 41 Radiological Survey (Parsons, 2005g) are summarized in Section 2.2.3.4, with a complete discussion of these results presented in Appendix F. A site-attribution analysis of the radiological survey results is presented in Appendix D.

2.2.3.4 Radiological Survey Summary and Material Sample Results

The purpose of this section is to summarize the results of the radiological survey conducted at SWMU-11 as part of the RFI. Details of the survey and an evaluation of the survey results are presented in Appendix F. A site-attribution analysis of the radiological results is presented in Appendix D.

Based on the site history, the primary constituents of concern for the radiological survey were reported to be hydrogren-3 (H-3, or tritium) and carbon-14 (C-14), which are not expected to persist in the environment. Other radionuclides of concern based on possible DPG usage were cobalt-60 (Co-60) and radium-226 (Ra-226). The radiological investigation was conducted over the six trenches and the CONEX container. Based on site history, visual observations, and geophysical survey results these seven areas constitute the worst-case locations for potential residual radioactive contamination.

The radiological survey was conducted in accordance with the approved SWMU-11 Radiological Survey Work Plan (see Final Phase II RCRA Facility Investigation Work Plan, SWMUs 11 and 41 Radiological Survey [Parsons, 2005g]). The

results of the surveys conducted at each of the seven areas, TR-1 through TR-6 and the CONEX container, are summarized below.

As part of the SWMU-11 RFI, test pit excavations and grid-based radiation surveys were conducted initially in December 2005, and radiological surveys were completed in February 2006. The Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM; USNRC, 2001) was used in the method development of the radiological portion of the RFI at SWMU-11. Due to the potential presence of naturally-occurring radioactivity that may be present in significant amounts in the environment or man-made radionuclides that may be present in the environment due to atmospheric weapons testing, background (i.e., baseline) radiological soil sampling and field measurements were conducted in a canyon immediately south of SWMU-11 to distinguish radiation from these potential sources from radiation derived from SWMU-11 activities.

Radiological surveys at SWMU-11 identified three waste disposal areas that contained wastes/debris with above-background levels of radiation. All other surveyed areas were determined to be similar to background levels and no additional sampling for radioactivity is required for these areas. The three areas with elevated radiation levels include:

- TR-2, where a single piece of radioactive debris (MS01) was found during the excavation of EP04.
- TR-6, where multiple buried metal tubes (MS03), drum remnants, and concrete drum plugs were found during the excavation of EP15.
- TR-5, an area of drum debris and metal remnants (MS04). TR-5 also contained three areas where significantly higher levels of radioactivity indicated buried radioactive sources.

Each of these three areas is discussed below.

Trench TR-2 (sample MS01)

The results of the grid surveys, soil samples, and test pit screenings at trenches TR-1, TR-2, and TR-3 show that radiation levels in these trenches are similar to those measured at the background location. However, during the radiation field screening of debris excavated from EP04, a small (4-6 inch) piece of debris was found to have elevated radiation levels. The debris (MS01) was composed of primarily soil with a thin

layer of a white to yellowish paint coating or paper-like material on one side. Initial gamma spectroscopy analysis of the debris identified uranium-238 and its immediate decay progeny thorium-234. Further isotopic analyses from an off-site commercial laboratory confirmed that the material had elevated uranium levels. A comparison of uranium isotopic ratios indicated that the material had levels of uranium-238 and uranium-235 consistent with depleted uranium, even though visually the material did not appear to be a metal. Further, the absence of elevated levels of uranium decay series progeny such as thorium-230, lead-214, and bismuth-214 suggests that the material was not naturally-occurring. (Uranium processed to any degree would have these impurities removed, and ingrowth takes longer than the waste was likely buried.) No other waste or debris resembling this sample was found during investigative activities at SWMU-11. Table 2.4 lists the radiological analytical results for sample MS01 and corresponding results from the background soil sampling conducted in the canyon south of SWMU-11.

TABLE 2.4

SAMPLE RESULTS FOR MS01
SWMU-11

DUGWAY PROVING GROUND, UTAH

Analyte	Analysis	Sample Result (pCi/g)a/	Average Background (pCi/g)
Gross Alpha	--	1280	35.01
Gross Beta	--	1660	32.12
U-238	Gamma Spectroscopy	217	NR[b/]
Th-234	Gamma Spectroscopy	217	NR
Pa-234m	Gamma Spectroscopy	271	NR
Pb-214	Gamma Spectroscopy	1.39	1.29
Bi-214	Gamma Spectroscopy	1.58	1.32
Th-230	Isotopic Alpha	1.09	NA[c/]
U-234	Isotopic Alpha	32.1	NA
U-235/236	Isotopic Alpha	6.9	NA
U-238	Isotopic Alpha	221	NA

s/ pCi/g = picocuries per gram.
b/ NR = analyte not reported in background gamma spectroscopy results (i.e., it was not detected).
c/ NA = isotopic analysis not used with background samples.

MS01 was comprised of the material with above-background radioactivity levels found in TR-2, and the material was completely removed to produce this sample. Soils adjacent to MS01 were surveyed for radiation and found to be similar to background levels. Therefore, based on the radiological grid and test pit screening results, TR-2 is adequately characterized for radiation and no further sampling is required.

TR-6 (sample MS03)

Debris and buried waste was found during the test pit excavation (EP15) of TR-6 located to the west of the CONEX container (Figure 2.3). This burial area was identified by field crews during a magnetometer sweep of SWMU-11. Debris observed from the excavation included 12-15 corroded empty metal drums, at least two large concrete cylinders that were shaped like a 55-gallon metal drum, and numerous small metal tubes, approximately 8 inches in length and 1.5 inches in diameter (Photographs 2 and 3 in Appendix B, respectively). The small metal tubes were located at a depth of about 7 ft bgs, were silver-gray in color, and were filled with a hard, white, wax-like material. The tubes were found with numerous small, thin metal rods that were threaded on one end and appeared to fit into or connect to the metal tubes. These tubes were screened with field instruments for radiation and a limited number of the metal tubes exhibited low levels of radioactivity. One tube was collected as a material sample (MS03) and was measured using the field gamma spectroscopy system. The gamma radiation emitted by the MS03 tube shares the primary energy peak with cesium-137 (Cs-137), as seen on Figure 2.4. On that basis, it was concluded that the tubes contained a Cs-137 source, and it is suspected that the source may be encased in the white, wax-like material inside the tubes. However, due to potential radiological hazards associated with the unknown Cs-137 source, the nature of this source has not been ascertained, and the inner contents of the metal tubes remain unknown. Likewise, no chemical analysis has yet been performed on the metal tubes or their contents. The metal drums, concrete-filled drum cores, and small metal rods did not exhibit detectable levels of radioactivity. Soils underlying the debris were screened for radiation during the test pitting activity and were found to be at background levels; therefore, soils within TR-6 have been adequately characterized with respect to radiation and no additional soil sampling for radioactive contamination is required. The

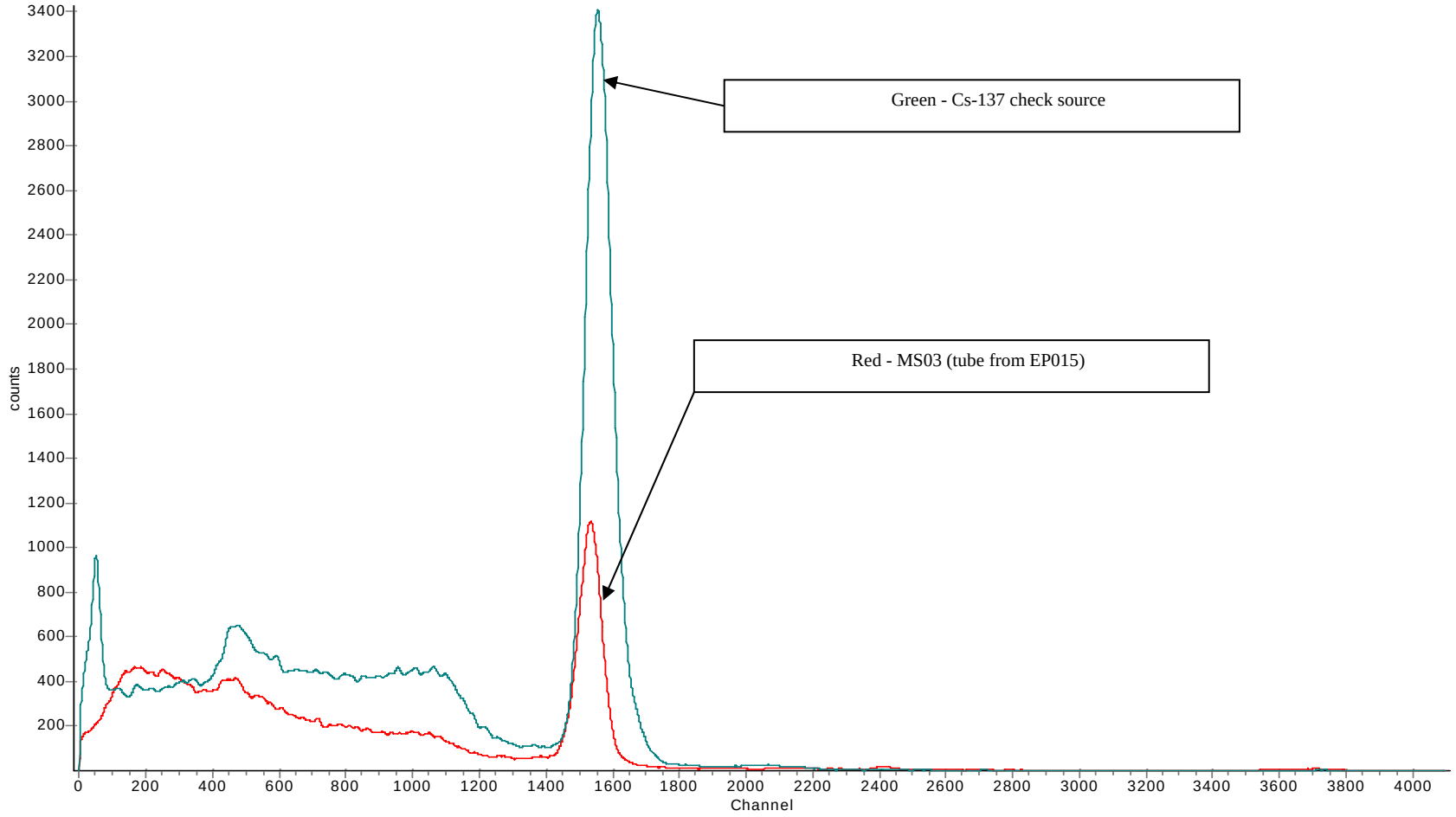


FIGURE 2.4

HISTOGRAMS
SWMU-11
GAMMA SPECTROSCOPY
RESULTS, SAMPLE MS03

DUGWAY PROVING GROUND RFI

PARSONS

waste within TR-6 has been visually described and is presumed to pose a radiological risk; however, the exact nature of the TR-6 waste is not known because it has not been conclusively identified. Since this waste is unidentified, it is assumed to pose *a priori* unacceptable risks and/or hazards based on the types of materials that may be present.

TR-5 Drum Debris and Metal Remnants (sample MS04)

TR-5 is located southeast of the CONEX container (Figure 2.2) and contains several depressions. Some of the depressions contain metal fragments (apparently drum remnants) that protrude from ground surface.

Radiological field measurements of this area initially identified a small (approximately 1 ft x 1 ft) point on the ground surface where elevated radiation readings were observed. This area was also conspicuously devoid of vegetation and was slightly depressed. Gamma exposure rate measurements taken at this point, using a 2" x 2" sodium-iodide (NaI) detector, ranged from 420 µR/hr at the center of the area to 50 µR/hr at a distance of 3 ft. Background radiation levels (approximately 30 µR/hr) were observed about 6 feet away from this point. Additional field measurements taken directly over the area with a FIDLER instrument (measuring gamma radiation) showed readings up to 575,000 counts per minute (cpm). A GM pancake probe (measuring beta radiation) produced readings of 1,200 cpm. Background radiation levels for these instruments at SWMU-11 were between 25,000 and 28,000 cpm for the FIDLER and 75 to 125 cpm for the GM Pancake probe. Field gamma spectroscopy conducted over the area, using the 2" x 2" NaI detector, revealed a broad peak that was initially interpreted to be consistent with depleted uranium. Approximately 4-6 inches of soil was scraped from the area with a shovel and the exposure rate over the spot increased to approximately 2 milliRoetgens per hour (mR/hr), or about five times that observed prior to soil removal. While temporarily staged off to the side, the scraped soil itself was scanned with the GM Pancake and did not exhibit radioactivity above background, indicating that the soil over the anomalous area is not radioactive itself, but is instead covering a buried radioactive source under the area. The scraped soil was placed back over the area and radioactivity returned to the original exposure rate reading of approximately 420 µR/hr. Per the Parsons' Site Safety and Health Plan (Parsons, 2005h), investigation of this area was

terminated because the stop work exposure rate of 500 µR/hr had been exceeded. No intrusive investigations have been performed at this location. The waste and subsurface soil at TR-5 remain uncharacterized with respect to radiation, and potential risks and/or hazards associated with the uncharacterized materials are assumed to be *a priori* unacceptable.

Within TR-5, metal debris with similar gamma spectroscopic characteristics was observed at a location approximately 25 ft away from the anomalous point and sample MS04 was collected from this material and analyzed by an off-site commercial laboratory. Initial results for gross alpha/beta, and gamma spectroscopy analysis from MS04 indicated only elevated gross beta results, which was not consistent with depleted uranium. All of the metal was consumed during the analytical process, and no metal remained to perform additional analyses. Therefore, a second sample was collected at the same location (MS04A), and additional analyses (including gross alpha/beta, gamma spectroscopy, isotopic uranium, isotopic thorium, and strontium-90 [Sr-90] analysis) were performed to further characterize the metal. Results for the two material samples are presented in Table 2.5 below.

The analytical results from MS04 and MS04A are not consistent with depleted uranium; the gross alpha results are at background levels, and uranium levels, as indicated by the isotopic analysis, are insignificant. The Sr-90 level detected in MS04A is consistent with the gross beta level measured in that sample. Sr-90 is a pure beta emitter with a half-life of 28.6 years. Its decay progeny is yttrium-90 (Y-90) which is also a pure beta emitter. Because the half-life of Y-90 is very short (64.1 hours) compared to that of Sr-90, they are in secular equilibrium, and the activity of Y-90 is equal to that of Sr-90. When the Sr-90 from MS04A is multiplied by two (to account for the presence of Y-90) and the average background is added, the total is 199+199+32 = 430 picocuries per gram (pCi/g). While this total is not exactly equal to the MS04A gross beta result (481 pCi/g; Table 2.5), it is within the measurement uncertainty levels.

The field measurements (i.e., high gamma results) and field gamma spectroscopy measurements taken at the anomalous area (discussed above) are also consistent with the Sr-90 analytical results from MS04A. This can be explained if the beta-emitting

radioactive source underlying the anomalous area were shielded inside a metal container, such as a drum, or if minerals within the soil provided shielding.

TABLE 2.5

SAMPLE RESULTS FOR MS04 AND MS04A SWMU-11

DUGWAY PROVING GROUND, UTAH

Analyte	Analysis	Sample Result (pCi/g)[a/]	Average Background (pCi/g)
	MS04		
Gross Alpha	--	40.5	35.01
Gross Beta	--	840	32.12
Pb-214	Gamma Spectroscopy	1.00	1.29
	MS04A		
Gross Alpha	--	41.8	35.01
Gross Beta	--	481	32.12
Pb-214	Gamma Spectroscopy	0.85	1.29
U-234	Isotopic Alpha	0.43	NA[b/]
U-235/236	Isotopic Alpha	ND[c/]	NA
U-238	Isotopic Alpha	0.33	NA
Sr-90	Isotopic Beta	199	NA

[a/] pCi/g = picocuries per gram.
[b/] NA = isotopic analysis not used with background samples.
[c/] ND = nondetected result.

Based on the results presented above, the metal (MS04/4A) is a ferrous metal that has been contaminated with Sr-90, either as an alloy of the metal itself, or more likely, by surface contamination from another source of Sr-90. Also based on these results the unidentified radioactive source (or multiple sources) of Sr-90 buried in TR-5 is a similar material, shielded by ferrous metal. The depth of material in TR-5 is not known; however, based on the depth of the depressions in the area, material may be present as close as 1 to 2 ft bgs. Although the area associated with TR-5 has not been completely characterized with respect to the type and amount of waste present in TR-5, based on visual observations, site history, and magnetic and/or radiological survey results, the buried radioactive material is most-likely confined to a small area in TR-5.

The NRCs NUREG-1757 (USNRC, 2003) generic soil screening level for Sr-90 is 1.7 pCi/g. This value corresponds to a total effective dose equivalent (TEDE) of

25 millirem per year (mrem/yr) to a generic (i.e., non-site-specific) receptor. The MS04A sample result was 199 pCi/g, and was taken at a location with lower field readings relative to other readings taken at TR-5. Therefore, Sr-90 contamination throughout TR-5 could be at least at a concentration of 199 pCi/g, and is likely several times that concentration, especially in the vicinity of the anomalous area. Including the anomalous area, a total of six discrete locations within TR-5 exhibited elevated radioactivity. Readings from the other five locations were above background but were of lower intensity than at the anomalous area. Soils in TR-5 were not sampled, but given the known mobility of Sr-90 in the environment, the potential exists for Sr-90 contamination in the soils immediately adjacent to the contaminated drum fragments.

In conclusion, TR-5 is likely contaminated with Sr-90 from an unknown source or sources, at an unknown depth, and in an unknown quantity. The source of the radiation is most-likely confined to the area of anomalous readings at TR-5.

Conclusions of the Radiological Survey

Radiological field and laboratory investigations at SWMU-11 have identified three areas of concern at the site where above-background radiation has been observed.

One of these locations (TR-2) contained only a single, small piece of waste with detected concentrations of uranium. Uranium isotopic ratios from this debris are consistent with depleted uranium (Table 2.4). The waste appeared to be non-metallic, but was coated with what appeared to be white or yellowish paint. No other radioactive readings or radioactive debris was found in this trench and TR-2 is considered to be adequately characterized.

A previously unknown and unmarked burial pit (TR-6), located to the west of the CONEX container (Figure 1.2), was excavated for purposes of an environmental field investigation. Buried debris observed during this excavation included numerous unidentified small metal tubes several of which exhibited radioactivity consistent with the presence of Cs-137 (Figure 2.4). Other types of debris were recovered from TR-6, but these items did not exhibit above-background radiation.

Another previously unknown and unmarked backfilled trenched area (TR-5) was identified southeast of the CONEX container. This area contained metal fragments

protruding from the subsurface and a few depressions. Radiological field measurements and chemical and radiological laboratory analyses of the metal fragments indicate Sr-90 contamination (Table 2.5). A small, localized point on the ground surface, measuring approximately 1 ft x 1 ft, exhibited very elevated radioactivity, and this anomalous area is likely underlain by a shielded Sr-90 source. Additional locations within TR-5 exhibited similar radioactivity to a lesser degree. Based on the overall site radiological survey the only anomalous known radioactivity of concern at SWMU-11 is the Sr-90 source buried at TR-5.

2.2.4 Evaluation of Surface Water and Groundwater Analyses

Surface water samples were not collected during Phase I or Phase II investigations. There is no surface water or temporary ponding of water at this site. No natural erosion marks or evidence of standing water are evident due to the low precipitation, and no surface water has been observed at this site. There are no defined drainages, and surface water drainage would locally be to the southwest downgradient of the Granite Mountain slope.

Groundwater samples were not collected at this SWMU. Subsurface soil sampling results indicate that the vertical extent of soil contamination is confined to the shallow subsurface (Section 2.2.3.2) in TR-1 through TR-4 and TR-6, where subsurface soil is characterized. Impacts to groundwater are not expected, based on the lack of vertical migration of contamination (Figure 2.3), and the estimated depth to groundwater (approximately 100 ft; Section 2.2.1). Potential future impacts to groundwater were evaluated based on soil-to-groundwater screening using results from soil samples collected at SWMU-11, and are discussed in Section 3.1.6.

2.2.5 Vegetation and Wildlife Description

Based on observations made during an ecological reconnaissance conducted by Parsons in July 2003, SWMU-11 is located in the shadscale-gray molly-greasewood ecological community. Shrubs typifying this community include shadscale (*Atriplex confertifolia*), gray molly (*Kochia americana*), and greasewood (*Sarcobatus vermiculatus*), with sparsely distributed grasses and forbs such as cheat grass (*Bromus secalinus*), clasping pepperweed *(Lepidium perfoliatum*), and halogeton (*Halogeton*

glomeratus). Fifty- to 60-percent of the affected area is vegetated. Plants identified at the site included cheat grass, greasewood, and halogeton. The least chipmunk (*Tamias minimus*), deer mouse (*Peromyscus maniculatus*), and chisel-toothed kangaroo rat (*Dipodomys microps*) are the principal rodents that inhabit this community, and an occasional white-tailed antelope squirrel (*Ammospermophilus leucurus*) or Townsend's ground squirrel (*Spermophilus townsendii*) may occur.

2.3 CONTAMINATION ASSESSMENT

The primary objectives of Section 2 were to: 1) present the results of the RFI; 2) determine if adequate sampling was conducted to characterize the nature and extent of radioactivity and chemicals detected in site media; and 3) provide data to support a site-attribution analysis for risk assessment (Appendix D), and if necessary, a risk assessment (Section 3). In accordance with the general sampling approach, soil samples were collected from worst-case biased locations. Additional soil sampling is not required at SWMU-11 based on the evaluation of site data, which was performed in accordance with Figure 2.1 (reproduced from Figure 6.1 of the Background Metals Report [Parsons, 2001a]). A localized area of highly elevated radioactivity is present at TR-5. Due to the hazards associated with this area intrusive activities were not completed, and the waste present in TR-5 is uncharacterized. In the absence of soil sampling at this site feature, surface and subsurface soil is also uncharacterized. Surface soil at TR-6 is similarly uncharacterized, and the waste in this trench is unidentified. The potential risks and/or hazards to human and ecological receptors associated with these uncharacterized and unidentified materials are assumed to be *a priori* unacceptable (Section 2.3.1).

Inorganics and one dioxin were detected in SWMU-11 surface soil samples. None of these chemicals were detected in surface soil samples at concentrations in excess of both background comparison values and USEPA Region 9 (2004) Residential Soil PRGs. Additional sampling is not required for any chemicals in surface soils based on a comparison of maximum detected site concentrations to background comparison values and USEPA Region 9 (2004) Residential Soil PRGs, and professional judgment, in accordance with Figure 2.1.

Select VOCs, SVOCs, dioxins/furans, explosives, and inorganics as well as TPH were detected in subsurface soil samples at SWMU-11. A total of 17 chemicals were detected in subsurface soil samples at concentrations in excess of both corresponding background comparison values (if available) and USEPA Region 9 (2004) Residential Soil PRGs. A background comparison value or PRG is not available for TPH, nitrocellulose, or 2-hexanone. Additional sampling is not required for TPH, nitrocellulose, 2-hexanone, or the other 17 chemicals based on the lines of evidence presented in Section 2.2.3.2, nor is additional sampling required for any other chemicals detected in subsurface soils based on a comparison of maximum detected site concentrations to background comparison values and USEPA Region 9 (2004) Residential Soil PRGs, and professional judgment, in accordance with Figure 2.1.

The radiological survey conducted at SWMU-11 targeted areas with the greatest potential for residual radioactive contamination, and the results indicated that there were three areas of elevated radiation based on a comparison with background and/or screening values. Two of these areas were associated with materials that were present in TR-2 and TR-6, but soils surrounding these materials were at background radiation levels. The radioactive material in TR-2 was removed during sampling and no further radioactive material above background was found in this feature. TR-6 contains various types of debris including unidentified small metal tubes which have low levels of radioactivity consistent with Cs-137. The third area (TR-5) has highly elevated radiation levels, and due to the unknown hazards associated with this area intrusive activities were not completed, and the waste and subsurface soil present in TR-5 are uncharacterized with respect to radiation. The potential risks and/or hazards to human and ecological receptors associated with the uncharacterized materials are assumed to be *a priori* unacceptable. All other areas of SWMU-11 are considered to be adequately characterized with respect to radiological constituents, and further investigation is not required.

Nature and extent investigation objectives for the RFI at this site (presented in Section 2.1) have been achieved based on the criteria established for the investigation.

2.4 RECOMMENDATIONS

Select organics, inorganics, and radionuclides were detected at SWMU-11 during the Phase II RFI; therefore, a site-attribution analysis (Section 3.1.3.1; Appendix D) and a risk assessment (human health and ecological; Section 3) are recommended for soil in accordance with UAC R315-101 (DSHW, 2001). An evaluation of potential future impacts to groundwater is also recommended (Section 3.1.6) based on soil sampling results. As discussed in Section 2.2.3, the nature and extent investigation objectives for soils have been achieved based on the criteria established for this investigation (refer to Section 3.1.6 for an analysis of future soil-to-groundwater impacts), and further characterization of the nature and extent of soil contamination is not required.

Potential risks associated with the uncharacterized surface and subsurface soils and the uncharacterized and unidentified waste at the site are addressed in the CMS Work Plan, which is presented in Section 4 of this addendum in accordance with the Corrective Action Module of the Part B Permit (US Army, 2001a).

SECTION 3.0
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT RESULTS

As described in the Risk Assumptions Document (Parsons, 2002a), one of the steps of a Phase II RFI includes an evaluation of the risks associated with potential hazardous waste releases at a site. SWMU-11 has been identified as a landfill site type based on available site history and Phase I and Phase II observations that indicate the presence of buried wastes (Section 2.1).

During field measurements, radiation levels greater than the Parsons' Health and Safety stop work limit of 500 μR/hr were encountered at the surface interval of TR-5. Based on geophysical and radiological field measurements of the surface, the radioactive source is most likely confined to the subsurface of TR-5. Given the safety concerns for encountering highly radioactive materials, intrusive activities were not conducted at this site feature and surface or subsurface soil samples were not collected for chemical analysis at TR-5; therefore, these soils as well as the waste buried in TR-5 are considered uncharacterized (Section 2.1.3).

One material sample was collected and analyzed for radiation from metal fragments collected at the surface of TR-5. The confirmation results for this sample were used to identify the potential radioactive source buried within TR-5. Based on evidence presented in Section 2.2.3.4 the radioactive source was determined to mostly likely be Sr-90, which has a half-life of 28.6 years. Since the amount and extent of this contamination are not known, and buried waste and subsurface soil could not be accessed for radiological evaluation, risks associated with exposure to this radionuclide cannot be quantified, and these materials are considered uncharacterized (Section 2.1.3).

Potential risks and/or hazards associated with exposure to the uncharacterized surface soil, subsurface soil, and buried waste at TR-5 are assumed to be *a priori* unacceptable based on the types of materials that may be present.

Although the wastes within TR-6 have been visually described, the nature and extent of these wastes are unknown since they have not been conclusively identified

(Section 2.1.3). Therefore, exposure to the unidentified waste within TR-6 is also assumed *a priori* to pose unacceptable risks. Note however, subsurface soils potentially impacted by the uncharacterized waste within TR-6 have been characterized and the surface soils have also been characterized for radiological constituents. However, surface soil samples were not collected and analyzed for chemical constituents at TR-6, and are therefore considered uncharacterized for these components and assumed *a priori* to pose unacceptable risks (Section 2.1.3). Since the subsurface soils within the waste at TR-6 have been sampled, these analytical results were incorporated into the risk assessment.

This risk assessment was not conducted to assess the cumulative effects of potential exposure to both the uncharacterized/unidentified materials and to the chemicals of potential concern (COPCs) detected in characterized soils. Rather, the objective of the risk assessment was to assess risks and hazards associated with exposure to COPCs in characterized soils in order to determine if remedial strategies also need to include the characterized soils. This is an important distinction for resource managers who may need to consider the characterized soils during decision making for remedial or mitigative strategies. Potential receptor exposure and risks associated with the radioactive contamination at SWMU-11 are discussed in Section 3.2.4 and detailed in Appendix F.

Direct sampling of surface soil at TR-5 and TR-6, as well as the contents of TR-5 and the underlying subsurface soil could not be conducted due to the presence of uncharacterized or unidentified waste containing radioactive or potentially radioactive materials (Section 2.1.3); therefore, a risk assessment per UAC R315-101 (DSHW, 2001) was not completed for the uncharacterized and unidentified materials in these two trenches. Potential risks and/or hazards associated with the uncharacterized and unidentified materials are assumed *a priori* to be unacceptable based on the types of materials that may be present. Therefore, potential exposure to the uncharacterized and unidentified materials in TR-5 and TR-6 should be prevented.

Direct sampling and characterization of impacts to SWMU-11 soils were conducted on surface and/or subsurface soils at all site features with the exception of surface and subsurface soils at TR-5 and surface soil at TR-6. Per Section 2.1.2, surface soil and subsurface soil at all site features where direct sampling was conducted (i.e., surface soil with the exception of TR-5 and TR-6, and subsurface soil with the exception

of TR-5) is considered to be adequately characterized since soil samples were collected from biased "worst-case" locations with the greatest potential for contamination based on previous sampling results (where available), field observations, and site history (Parsons, 1999a and 2000b).

Accounting for the *a priori* assumption that exposure to uncharacterized/unidentified wastes and/or uncharacterized soils at TR-5 and TR-6 should be avoided, the objectives of the human risk assessment (HRA) and ecological risk assessment (ERA) were to:

- Assess potential risks and hazards from exposure to chemicals and/or radiation in characterized surface/subsurface soils
- Support an evaluation under the CMS task to determine if remedial strategies need to include the characterized surface/subsurface soils

Detailed analysis methods and exposure assumptions used to assess potential human and ecological risks/hazards associated with exposure to contaminants are described in the Risk Assumptions Document (Parsons, 2002a), and are consistent with UAC R315-101: Cleanup Action and Risk-Based Closure Standards (DSHW, 2001). The state of Utah DSHW staff have reviewed and approved multiple versions of the Risk Assumptions Document (Parsons, 2002a) in order to ensure that risk- and rule-based decision criteria reflect a consensus among interested parties (e.g., state regulators and DPG). Any modifications of the methodologies and/or exposure assumptions are described herein; otherwise, the reader is referred to the Risk Assumptions Document (Parsons, 2002a). This human and ecological risk assessment was generated November 2006 using current chemical-specific PRGs, toxicity data and toxicity reference values (TRVs), and a facility-specific value for the fraction of organic carbon in soil (f_{oc}) of 0.02 Kg organic carbon per Kg soil (2-percent) (Shaw, 2003).

Appendix F presents an analysis of potential exposure and hazards from radioactive materials present at SWMU-11. Field measurements and confirmation samples were compared with background measurements and dose-based screening levels (i.e. generic NUREG-1757 Volume 2 soil screening levels), respectively, to evaluate the potential impacts to human health from residual radioactive material at the site.

3.1 SHARED HRA/ERA PROTOCOLS AND RESULTS

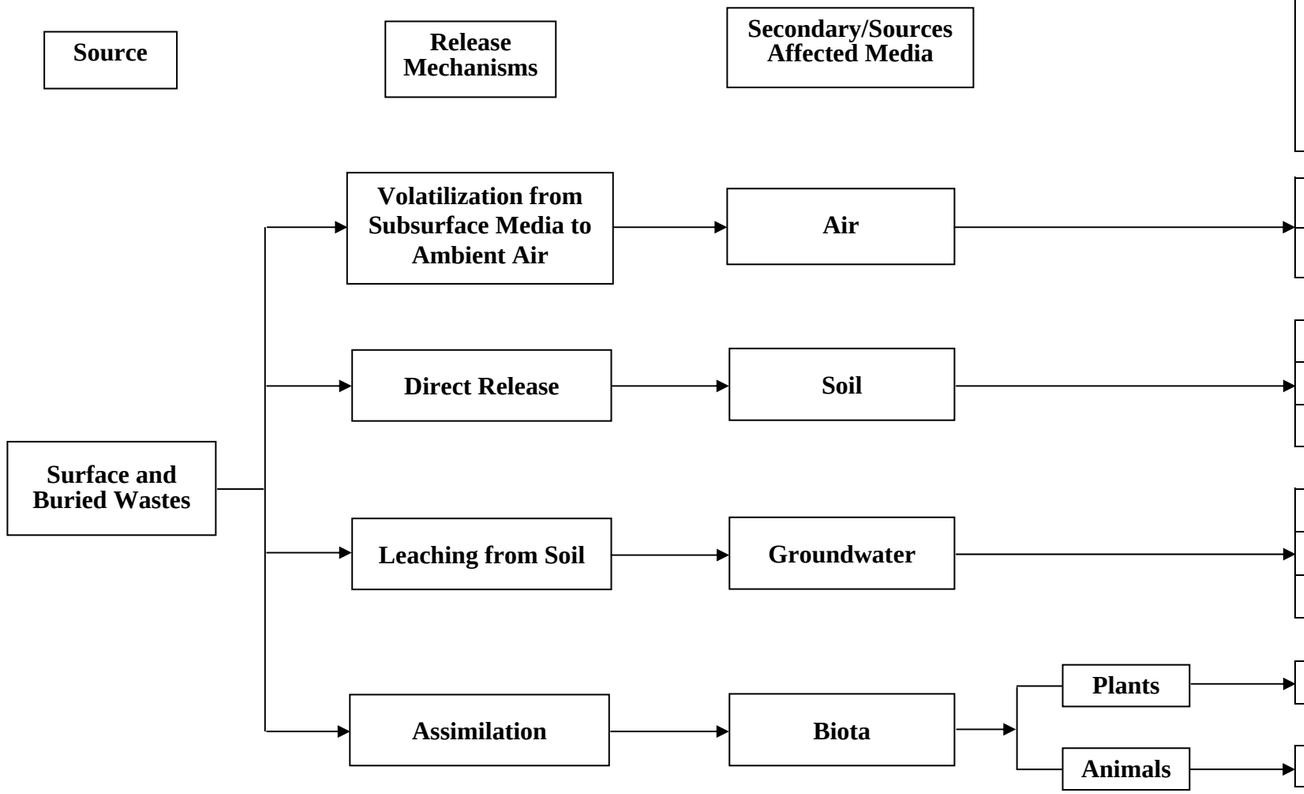
Although there are separate methods for the HRA (Section 3.2) and ERA (Section 3.3), the purpose of this section is to discuss the protocols and results common to both assessments. Chemicals of potential concern (COPCs) are defined as the potential site-related chemicals from Appendix D that have been retained for analysis in the HRA and ERA. Chemicals of concern (COCs) are those identified for potential consideration in a CMS based on the results of the HRA and ERA. Exposure to radioactive materials is addressed in Section 3.2.4 and detailed in Appendix F.

3.1.1 Conceptual Site Model

The site-specific conceptual site model (CSM) for SWMU-11, developed based on the results of the Phase I and II investigations (see Section 2), is shown on Figure 3.1. Potential contaminant sources, release mechanisms, and affected media are discussed in Section 2. Current and future land-use scenarios, potential receptors, and the exposure pathways used in estimating risks and hazards are summarized in the following subsections.

3.1.1.1 Land-Use Scenarios

SWMU-11 has been identified as a landfill site-type based on the presence of buried waste and site history and is located on the east side of Granite Mountain (Figure 1.1; Section 1.2). SWMU-11 is located within area of concern (AOC) 1 in the RCRA Part B Permit (US Army, 2001a). These AOCs were identified as impact ranges or test areas based on historical land use. Current land use at SWMU-11 was assumed to be industrial (Parsons, 2002a). Future residential land use and building on the site is not expected and land use will likely be restricted to activities consistent with an industrial closure as defined in UAC R315-101 (DSHW, 2001) due to: 1) the presence of uncharacterized waste containing radioactive material; 2) the remote location; 3) the active status of the DPG installation and AOC 1, where SWMU-11 is located; and 4) the base Summary Development Plan (AGEISS and HBA, 2000), which summarizes future property development at DPG. Although current and reasonably expected future land use likely will remain industrial, future residential land use was also considered when screening available data in order to determine: 1) if soils meet UAC R315-101 (DSHW,



Exposure Route	Current and/or Future Human Receptors				Current and Future Ecological Receptors (Representative Species)		
	Nonintrusive Worker	Indoor Worker	Intrusive Worker	Resident	Deer Mouse	Horned-lark	Terrestrial Plants
Inhalation of VOCs Volatilized from Subsurface Soil	X	X	X	X	O	O	O
Inhalation of VOCs Volatilized from Groundwater	O	O	O	O	O	O	O
Inhalation [a/]	X	O	X	X	O	O	O
Ingestion	X	O	X	X	X	X	O
Contact	X	O	X	X	O	O	X
Inhalation [b/]	O	O	O	O	O	O	O
Ingestion	O	O	O	O	O	O	O
Contact	O	O	O	O	O	O	O
Ingestion	O	O	O	O	X	X	O
Ingestion	O	O	O	O	X	X	O

Legend:

X = Pathway evaluated quantitatively in the HRA and ERA or, for human receptors, other risk predictions encompass and are protective of the potential receptor's exposures.

O = Pathway evaluated qualitatively and determined to be incomplete and/or insignificant.

[a/] Inhalation of VOCs/Particulates from the mixed soil interval (0-10 ft bgs).

[b/] Inhalation of VOCs volatilized from groundwater during domestic use.

FIGURE 3.1

CONCEPTUAL SITE MODEL FOR RECEPTOR EXPOSURE PATHWAYS AT SWMU-11

DUGWAY PROVING GROUND RFI

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2001) no further action (NFA) requirements; and 2) if further risk calculations would be necessary under an industrial land-use scenario. Corrective action objectives, screening of corrective action technologies, corrective measures alternatives, or remedial options will be assessed during a CMS, if warranted, for both industrial and residential land use.

The degree to which land management activities alter the natural environment affects the composition of biological resources and potential ecological receptors present at a site. The natural environment has been altered by the use of the site for waste disposal. However, the inactive status of the site has resulted in some re-establishment of vegetation at disturbed areas and use of the site by wildlife. The natural environment may be disturbed further by the implementation of future corrective measures or institutional controls (e.g., capping or fencing) that may be required to mitigate potential hazards associated with buried wastes.

3.1.1.2 Potential Receptors

Consistent with USEPA (1989a and 1995a) guidance, current and reasonably anticipated future land uses were considered when selecting potential receptors for evaluation in the risk assessment. Screening-level risks and hazards from exposure to site related chemicals were estimated for a hypothetical resident using maximum detected concentrations from soil samples and USEPA Region 9 (2004) Residential PRGs. Screening-level cancer risk from exposure to radiation was evaluated using the NRC guidance for unrestricted land use (Appendix F). Residential land use is hypothetical and unlikely to be allowed, however, residential screening-level risks and hazards were calculated to determine: 1) if characterized soils meet UAC R315-101 (DSHW, 2001) NFA requirements; and 2) if further risk calculations would be necessary under an industrial land-use scenario. Residential risks from potential exposure to radiation were also assessed by using generic NUREG-1757 Volume 2 soil screening levels to determine if characterized soils meet NFA for radiological components. Site-specific risk-based screening levels were not necessary at SWMU-11 based on the results and lines of evidence presented in Appendix F. In addition to the hypothetical resident, the following potential receptors were evaluated in the human-health risk assessment:

- Current/future nonintrusive site workers (industrial and/or military)

- Future intrusive workers (e.g., construction workers or workers that install/repair utility lines)
- Future indoor worker (for inhalation of VOCs volatilized into indoor air from subsurface media)

Although a portion of DPG is open to limited hunting, permit requirements restrict hunting to designated areas away from SWMU-11. In addition, the site is located in an area that is monitored by DPG range control. Therefore, potential exposure to site-related chemicals and radioactive material by hunters is not likely. Potential exposure of livestock ranchers also is unlikely because of access restrictions. In addition, the exposure (and subsequent risk) for hunters and livestock ranchers would be less than that of an industrial worker due to the reduced exposure frequency. Although a trespasser scenario is possible, a trespasser's exposure would also be less than that of an industrial worker. As such, assessment of industrial worker exposures encompasses potential exposures that a hunter, livestock rancher, or trespasser might encounter and potential exposure and subsequent risks to these receptors were not evaluated quantitatively.

The "default" nonintrusive industrial worker (Parsons, 2002a) was evaluated for potential exposure to site-related COPCs. This site is located more than 0.5 mile from the Carr and Ditto facilities (Section 1.2); therefore, a remote site worker (Parsons, 2002a) was also evaluated, rather than a Carr/Ditto perimeter worker. Risks to industrial workers from potential exposure to radiation were not estimated since radiation levels in characterized soils were similar to background or met NFA criteria (see Appendix F).

Based on observations made during a 2003 ecological reconnaissance of DPG, potential wildlife receptors evaluated were selected from the list of representative, facility-wide receptors presented in the Risk Assumptions Document (Parsons, 2002a). Vegetation was considered a representative receptor for this site because primary productivity is a vital ecological component, and vegetation is an important component of habitat for wildlife receptors. No special-status species of wildlife or plants were identified at or near the site. Based on the foraging ranges for those wildlife species considered to be representative of the ecology at DPG (Parsons, 2002a) and the size of the affected area of soil (3.4 acres; Section 1.2), only the deer mouse (*Peromyscus maniculatus*) and horned lark (*Eremophila alpestris*) conceivably could contact the

affected area of the SWMU to a great enough extent as to receive appreciable exposures to site-related COPCs.

The following were selected as representative receptors for evaluation in the ERA:

- Deer mouse population
- Horned lark population
- Terrestrial plant community

The animal receptors are non-domesticated wildlife that may reasonably be expected to occur at the SWMU given the current and anticipated future site conditions. The plant community is an integral ecological component as well as serving as a potential conduit for exposures of herbivorous wildlife. When considered in conjunction with plants and invertebrates as biotransfer media, the selected wildlife receptors are representative of the food web in the site area. Habitat requirements, dietary requirements, and behavioral traits for each of the representative wildlife receptors at DPG are presented in the Risk Assumptions Document (Parsons, 2002a).

3.1.1.3 Potential Exposure Pathways

Potentially complete exposure pathways to human and ecological receptors are summarized on Figure 3.1. Available data from two soil exposure intervals, 0-0.5 ft bgs (i.e., surface soil interval) and 0-10 ft bgs (i.e., mixed soil interval), were used to estimate exposures to chemicals in soil. A discussion of receptor-specific exposure intervals for soil has been included in the Risk Assumptions Document (Parsons, 2002a) and is not repeated here.

The following exposure pathways were evaluated quantitatively in the risk assessment:

- Incidental ingestion of soil (human and ecological [bird and mammal] receptors)
- Contact with soil (human and ecological [plant] receptors)
- Inhalation of dusts/volatiles from soils (human receptors)
- Ingestion of biota exposed to contaminated soil (ecological [bird and mammal] receptors)
- Inhalation of VOCs volatilized from subsurface soil into indoor air (human receptors)

Wildlife exposures to COPCs in soil via inhalation (of volatiles or dust) and dermal contact were not evaluated quantitatively in the ERA. Since there is a general paucity of toxicological data for chemicals via inhalation and dermal-contact exposure routes for free-ranging wildlife, hazard estimates for these routes would not support defensible or effective decision-making due to a high degree of uncertainty. Since there are few phytotoxicity benchmarks in the available technical literature that are relevant to plants in arid environments, and since plant responses to chemicals in soil are influenced by site-specific conditions (e.g. soil characteristics, climate, moisture), quantitatively assessing risk to plants from contaminant concentrations has high uncertainty. Nonetheless, potential effects to plants were quantitatively evaluated in the ERA (Section 3.3).

Volatilization of chemicals from subsurface soil into outdoor air, and subsequent inhalation would not be quantified due to the uncharacterized nature of subsurface in TR-5, as discussed in the uncertainties section (Section 3.4). Inhalation of outdoor fugitive dust was evaluated with the exception of the uncharacterized surface soils at TR-5 and TR-6.

Risks and hazards from an outdoor intrusive and nonintrusive workers' exposures via the subsurface-to-outdoor air inhalation pathway for the characterized potion of the site would be less than that of an indoor worker since: 1) all receptors would be exposed to potential site-related chemicals volatilized from subsurface soil; 2) the exposure frequencies and duration for intrusive and nonintrusive workers are less than that of an indoor worker; and 3) chemicals volatilized from subsurface media disperse more readily in outdoor air than indoor air, reducing concentrations of COPCs in the outdoor air breathing zone. Therefore, assessment of indoor worker exposures encompasses potential nonintrusive and intrusive worker exposures, and potential exposure and subsequent risks to these receptors via inhalation of VOCs volatilized from subsurface media were not evaluated in the HRA.

Future ingestion of, and dermal contact with, shallow groundwater by intrusive workers were assumed incomplete and/or insignificant exposure pathways because for the dermal contact pathway, depth to groundwater (~100 ft bgs; Section 2.2.1) is greater

than 10 ft bgs, preventing contact by human and ecological receptors (Parsons, 2002a). Groundwater was not sampled during the RFI at this site.

3.1.1.4 Potential Exposure Areas

The portion of the site potentially affected by past activities covers approximately 3.4 acres (Section 1.2) and is comprised of three backfilled trenches, three open trenches, and a CONEX container. The site's affected area was adopted as the direct exposure area for potential nonintrusive workers and ecological receptor contact with COPCs in surface soil, and the characterized features of the site were adopted as the direct exposure area for the intrusive worker and ecological (plant) receptor contact with COPCs in mixed soil. The affected area was also used to define the exposure areas for indirect exposures to soil COPCs via ingestion of vegetation and prey.

3.1.2 Evaluation of Analytical Data for Usability

The usability of Phase I and II soil and groundwater data for risk assessment was reviewed as described in the Risk Assumptions Document (Parsons, 2002a). The location, number/type, and results for soil samples collected during Phases I and II have been discussed in Section 2. A data quality assessment was conducted on the Phase II confirmation analytical data and is presented in Section 2.2.2. The result of this assessment concluded that the data were suitable for decision-making purposes, including human and ecological risk assessment. Soil analytical results are provided in Appendix C. Soil sampling locations, depths, and dates for the data used to assess risks/hazards from potential exposure of human and ecological receptors are summarized in Appendix D. The results of the risk assessment data usability review (e.g., number of "R"-qualified records removed) and summary statistics (e.g., frequencies of detection and ranges of detected concentrations) for soil samples used in the risk assessment are provided in Appendix D.

3.1.3 Identification of Preliminary COPCs

Chemicals detected in the 0-0.5 ft bgs and the 0-10 ft bgs soil intervals (Attachment 2, Appendix D) were eliminated or retained as preliminary COPCs for soil based on one or more of the following steps (Parsons, 2002a):

- Site-attribution analysis

- Essential nutrient screen
- Risk-based toxicity screen

Chemicals that were 100-percent non-detect (ND) were eliminated from further quantitative consideration. The adequacy of detection limits for target analytes that were not detected has been addressed in the state-approved work plan (Parsons, 1998). Non-detect chemicals in soil samples with MDLs that were greater than USEPA Region 9 (2004) Residential Soil PRGs are discussed in Appendix C and in the uncertainty analysis (Section 3.4).

Radiation detected in the 0-0.5 ft bgs and the 0-10 ft bgs soil intervals was determined to be either elevated compared to background or similar to background for soil based on the site attribution analysis presented in Appendix F and summarized in Appendix D.

3.1.3.1 Site-Attribution Analysis

The methodologies for conducting the chemical site-attribution analysis for risk assessment have been described elsewhere (Parsons, 2001a and 2002a) and are not repeated here. The comparison of radiation screening measurements to background levels is discussed in Appendix F.

The risk assessment site-attribution analysis for chemicals detected in soil is provided in Appendix D. All organics that were detected in soils were assumed to be the potential result of site activities and were retained as preliminary COPCs (Parsons, 2002a). The initial list of potential site-related chemical analytes in surface and mixed-soil intervals is shown in Table 3.1, and was based on the results of the site-attribution analysis for risk assessment (Appendix D).

3.1.3.2 Essential-Nutrient Analysis

Calcium, iron, magnesium, and sodium are essential nutrients which were detected above their background comparison values in the mixed soil interval at SWMU-11. Calcium and sodium were detected in soil at maximum concentrations of 500,000 and 23,000 mg/Kg, respectively; however, these nutrients are considered non-toxic and were eliminated from further consideration as preliminary COPCs. Iron was detected in soil at a maximum concentration of 32,000 mg/Kg, which is below its

corresponding essential-nutrient soil screening level of 200,000 mg/Kg (Parsons, 2002a). Magnesium was detected in soil at a maximum concentration of 110,000 mg/Kg, which is below its corresponding essential-nutrient soil screening level of 550,000 mg/Kg (Parsons, 2002a). Therefore, iron and magnesium were eliminated from further consideration as preliminary COPCs.

TABLE 3.1

PRELIMINARY CHEMICALS OF POTENTIAL CONCERN IN SURFACE AND MIXED SOILS FOR RISK ASSESSMENT SWMU-11

DUGWAY PROVING GROUND, UTAH

Surface (0-0.5 ft bgs)[a/] Soil Interval	Mixed (0-10 ft bgs) Soil Interval	Subsurface (>0.5 ft bgs) Soil Interval
Octachlorodibenzo-p-dioxin	Acenaphthene	Acenaphthene
Beryllium	Acenaphthylene	Acenaphthylene
Boron	Acetone	Acetone
Magnesium	Benzene	Benzene
Molybdenum	Ethylbenzene	Ethylbenzene
Silver	2-Hexanone	2-Hexanone
	Methyl Ethyl Ketone (2-Butanone)	Methyl Ethyl Ketone (2-Butanone)
	Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)	Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)
	2-Methylnaphthalene	2-Methylnaphthalene
	Naphthalene	Naphthalene
	Phenanthrene	Phenanthrene
	Styrene	Styrene
	Toluene	Toluene
	o-Xylene (1,2-Dimethylbenzene)	o-Xylene (1,2-Dimethylbenzene)
	m,p-Xylene (Sum Of Isomers)	m,p-Xylene (Sum Of Isomers)
	Benzyl Alcohol	Benzyl Alcohol
	Fluoranthene	Fluoranthene
	Pyrene	Pyrene
	Dibenzofuran	Dibenzofuran
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	1,2,3,4,6,7,8-Heptachlorodibenzofuran
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	1,2,3,4,7,8,9-Heptachlorodibenzofuran
	1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin

TABLE 3.1 (CONTINUED)

PRELIMINARY CHEMICALS OF POTENTIAL CONCERN IN SURFACE AND MIXED SOILS FOR RISK ASSESSMENT SWMU-11

DUGWAY PROVING GROUND, UTAH

Mixed (0-10 ft bgs) Soil Interval	Subsurface (>0.5 ft bgs) Soil Interval
1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin
1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin
1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin
1,2,3,4,7,8-Hexachlorodibenzofuran	1,2,3,4,7,8-Hexachlorodibenzofuran
1,2,3,6,7,8-Hexachlorodibenzofuran	1,2,3,6,7,8-Hexachlorodibenzofuran
1,2,3,7,8,9-Hexachlorodibenzofuran	1,2,3,7,8,9-Hexachlorodibenzofuran
2,3,4,6,7,8-Hexachlorodibenzofuran	2,3,4,6,7,8-Hexachlorodibenzofuran
Octachlorodibenzofuran	Octachlorodibenzofuran
Octachlorodibenzo-p-Dioxin	Octachlorodibenzo-p-Dioxin
1,2,3,7,8-Pentachlorodibenzofuran	1,2,3,7,8-Pentachlorodibenzofuran
2,3,4,7,8-Pentachlorodibenzofuran	2,3,4,7,8-Pentachlorodibenzofuran
1,2,3,7,8-Pentachlorodibenzo-p-Dioxin	1,2,3,7,8-Pentachlorodibenzo-p-Dioxin
2,3,7,8-Tetrachlorodibenzofuran	2,3,7,8-Tetrachlorodibenzofuran
2,3,7,8-Tetrachlorodibenzo-p-Dioxin	2,3,7,8-Tetrachlorodibenzo-p-Dioxin
Nitroglycerin	Nitroglycerin
Antimony	Antimony
Arsenic	Arsenic
Barium	Barium
Beryllium	Beryllium
Boron	Boron
Cadmium	Cadmium
Calcium	Calcium
Chromium, Total	Chromium, Total
Copper	Copper
Iron	Iron
Lead	Lead
Magnesium	Mercury
Mercury	Molybdenum
Molybdenum	Silver
Silver	Sodium
Sodium	Zinc
Zinc	

[a/] ft bgs = Feet below ground surface.

3.1.3.3 Risk-Based Toxicity Screening

Risk-based toxicity screening differs for the HRAs and ERAs and is discussed in Sections 3.2 and 3.3, respectively.

3.1.4 Acute Exposure and Toxicity

Given the presence of radioactivity within TR-5 and the unknown risks associated with the unidentified waste in TR-6 (Section 2), there is the potential for acute exposure to human and ecological receptors. Therefore, risks and hazards from exposure to the buried waste are assumed to be unacceptable *a priori*, and exposure should be prevented. Exposure from uncharacterized soils in TR-5 and TR-6, which are also assumed to present *a priori* unacceptable risks and hazards, should also be prevented. Acute toxic effects are not expected from exposure to characterized soil at SWMU-11 because hazardous levels of radioactivity, UXO, CWM, and OE debris were not anticipated (based on site history; Section 1.2) or observed (during field operations; Section 2.1) in the characterized surface and mixed soils.

3.1.5 Exposure-Point Concentrations

Chemical exposure-point concentrations (EPCs) for surface soil (0-0.5 ft bgs) and mixed soil (0-10 ft bgs) were calculated using the approach described in the 2006 Draft Attachment 7 of the Risk Assumptions Document (Parsons, 2002a). Maximum detected concentrations of preliminary COPCs in the 0-10 ft bgs interval and EPCs for surface and mixed-soil intervals are shown in Table 3.2. The EPCs for dioxins (mammalian and avian), reported as 2,3,7,8-tetrachlorodibenzo-p-dioxin (toxic equivalent [TEQ]), were derived by multiplying the 17 detected dioxin and furan concentrations (including half the MDLs for non-detects) in each soil sample by their World Health Organization toxicity equivalency factors (Van den Berg, et. al., 1998 [birds], Van der Berg, *et al.*, 2006 [mammals]) and summing the adjusted concentrations (see Table E.1 in Appendix E for supporting calculations). For the human EPC, the summed adjusted concentration for each sample (i.e. the TEQ concentration) was then input into the ProUCL software and a UCL was generated based on the assigned distribution.

TABLE 3.2
SURFACE AND MIXED SOIL INTERVAL EXPOSURE-POINT CONCENTRATIONS
SWMU-11

DUGWAY PROVING GROUND, UTAH

Preliminary COPC[a/]	Maximum Soil Concentration (mg/Kg)[b/]	Surface Soil EPC (mg/Kg)[c/]	Mixed Soil EPC (mg/Kg) [c/]
Volatile Organic Compounds			
Acenaphthene	0.12	--[d/]	0.12
Acenaphthylene	0.68	--	0.68
Acetone	9.0	--	9.0
Benzene	0.073	--	**0.054**
Ethylbenzene	0.031	--	0.031
2-Hexanone	0.062	--	0.062
Methyl Ethyl Ketone (2-Butanone)	1.2	--	1.2
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)	0.063	--	0.063
2-Methylnaphthalene	0.29	--	0.29
Naphthalene	0.057	--	0.057
Phenanthrene	0.25	--	0.25
Styrene	0.023	--	0.023
Toluene	0.11	--	0.11
o-Xylene (1,2-Dimethylbenzene)	0.022	--	0.022
m,p-Xylene (Sum Of Isomers)	0.042	--	0.042
Semivolatile Organic Compounds			
Benzyl Alcohol	0.18	--	0.18
Dibenzofuran	0.045	--	0.045
Fluoranthene	0.097	--	0.097
Pyrene	0.16	--	0.16
Dioxins and Furans			
2,3,7,8-Tetrachlorodibenzo-p-Dioxin TEQ	0.00046 (0.00086)[e/]	0.00000061 (0.00000078)	**0.00039** (0.00086)
Explosives			
Nitroglycerin	0.44	--	0.44
Inorganics			
Antimony	1300	--	**470**
Arsenic	73	--	**16**
Barium	970	--	**340**
Beryllium	24,000	3.0	**13,000**
Boron	58	58	58
Cadmium	1.5	--	1.5
Chromium, Total	110	--	110
Copper	140	--	140
Lead	130	--	130
Mercury	5.8	--	5.8
Molybdenum	3.9	0.88	3.9
Silver	1.1	0.062	1.1
Zinc	2500	--	**1000**

[a/] COPC = chemical of potential concern. VOC classification was determined based on USEPA Region 9 (2004) criteria.
[b/] Maximum soil concentration refers to the maximum detected concentration from 0-10 ft bgs; mg/Kg = milligrams per kilogram.
[c/] EPC = Exposure-point concentration; EPC is the maximum detected concentration for the soil interval except where bolded.
[d/] "--" = Not a preliminary COPC for this interval (Appendix D).
[e/] TEQs are for humans/mammals; values in parenthesis are TEQs for avian receptors.
Bolded Values = EPC is based on the upper confidence limit (UCL) for reasons discussed in Section 3.1.5.

3.1.6 Evaluation of Potential Groundwater Impacts

Compliance with UAC R315-101-3 (DSHW, 2001) (potential soil-to-groundwater impacts and the Principle of Non-Degradation) was determined by evaluating the potential for chemicals detected in characterized surface and subsurface soils to impact groundwater in the future. The potential for future soil-to-groundwater impacts is discussed in the following paragraphs.

Evaluation of soil-to-groundwater impacts due to radioactive soil contamination were not required since the characterized surface and subsurface soils at the site were screened for radioactivity and were determined to be similar to background levels. Therefore, since these soils have not been impacted by radioactive constituents there are no potential future threats to groundwater from radiation.

The potential for future impacts to groundwater underlying SWMU-11 was evaluated by comparing concentrations of site-related analytes in surface and subsurface soils (Appendix D) with generic and source-area-specific soil-to-groundwater screening levels (SSLs) calculated using USEPA (1996b) methodology. Generic and source-area-specific soil-to-groundwater SSLs were based on the following algorithm recommended by the USEPA (1996a):

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

where:

Parameters			Value
SSL	=	Soil screening-level (mg/Kg)	Calculated
C_w	=	Target soil leachate concentration (mg/L) and $C_w = PRG \times DAF$ where:	Calculated
	PRG =	USEPA Region 9 (2004) Tap Water Preliminary Remediation Goal (mg/L)	Chemical-specific
	DAF =	Dilution attenuation factor (unitless)	Default of 20 or Source-area-specific
K_d	=	Soil-water partitioning coefficient (L/Kg) and K_d for organic constituents = $K_{oc} \times f_{oc}$ where:	Chemical-specific
	K_{oc} =	Soil organic carbon (OC)-water partitioning coefficient (L/Kg_{oc})	Chemical-specific
	f_{oc} =	Fraction of organic carbon in the soil (Kg_{oc}/Kg_{soil}); site specific.	0.02 (2-percent)

ρ_b	=	Dry soil bulk density (Kg/L)	1.5
θ_w	=	Water-filled soil porosity (L_{water}/L_{soil})	0.3
θ_a	=	Air filled soil porosity (L_{air}/L_{soil}) and $\theta_a = n - \theta_w$	0.13
		where:	
n	=	Derived soil porosity ($L_{porespace}/L_{soil}$) and $n = 1 - (\rho_b/\rho_s)$	0.43
		and where:	
ρ_s	=	Soil particle density (Kg/L)	2.65
H'	=	Dimensionless Henry's law constant	Chemical-specific

Generic soil-to-groundwater SSLs were calculated based on USEPA (1996a) recommended parameters, including a default dilution attenuation factor (DAF) of 20. With the exception of a facility-specific f_{oc} of 2-percent (Shaw, 2003), soil-to-groundwater SSLs were calculated using USEPA (1996a and 2002f) recommended input assumptions, methodology and USEPA Region 9 (2004) Tap Water PRGs (Table D.11, Appendix D). Potential future soil-to-groundwater impacts were evaluated further for chemicals with maximum detected soil concentrations that exceeded generic soil-to-groundwater SSLs by using source-area average concentrations and source-area-specific DAFs. These DAFs are based on chemical-specific source area(s) and 95th percentile DAFs shown in Appendix E, Figure 5 of the USEPA (1996b) Technical Support Document. Supporting source-area-specific soil-to-groundwater SSL calculations are provided in Appendix D, Table D.12.

PRGs are not available for TPH, nitrocellulose, or 2-hexanone which therefore were not evaluated for potential future soil-to-groundwater impacts. This does not affect the outcome of the soil-to-groundwater analysis because:

- Evaluation of non-specific results from mixtures such as TPH was not necessary since potential future impacts were evaluated using specific organic chemical results (e.g., VOCs and SVOCs).
- Nitrocellulose is considered nontoxic by USEPA (2004e; 2000f) and was eliminated as a COPC (Appendix D). Furthermore, nitrocellulose is not likely to migrate to groundwater since the primary transport mechanism is in the aqueous phase through the vadose zone, and it is insoluble in water (www.ChemFinder.com).
- There is no evidence of vertical migration associated with any of the three isolated 2-hexanone detections. This chemical was not detected in samples

collected beneath and/or adjacent to each of these detections (Section 2.2.3.2), indicating that migration of 2-hexanone has not occurred in the approximately 30 to 50 years since active operations at this site (Section 1.2).

As shown in Table 3.3, benzene, antimony, arsenic, chromium (total), nitroglycerin, and 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ (human) were detected at maximum concentrations that exceeded corresponding generic soil-to-groundwater SSLs. Potential future soil-to-groundwater impacts for benzene, antimony, arsenic, chromium (total), nitroglycerin, and 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ (human) were evaluated further using source-area-specific DAFs and source area concentrations (Table 3.4). Source area concentrations were calculated using analytical results from surface and subsurface soil samples collected from areas where potential anthropogenic releases may have occurred, substituting one-half the MDL for non-detects within those potential source areas. Multiple potential source areas were identified for benzene, chromium (total), and 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ, since isolated detections were spread out and separated by larger areas of non-detects. The following rationale was used for developing the source area sizes, source area concentrations, source-area-specific DAFs, and source-area-specific SSLs shown in Table 3.4 for benzene, antimony, arsenic, chromium (total), nitroglycerin, and 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ (human):

Benzene

Five potential benzene source areas were identified at SWMU-11.

- Benzene was detected in the subsurface soil samples collected from both EP05 and EP06 in TR-1. Therefore, a site specific source area of approximately 9800 ft^2 was calculated, which corresponds to the entire area of TR-1. An average concentration of 0.015 mg/Kg was used for the source area concentration of benzene in this feature.
- Benzene was detected in the subsurface soil samples collected from EP04 excavated in TR-2. Since subsurface soil samples in TR-2 were only collected from EP04, a site specific source area of approximately 4800 ft^2 was calculated, which corresponds to the entire area of TR-2. An average concentration of 0.038 mg/Kg was used for the source area concentration of benzene in this feature.
- Benzene was detected in only one sample in TR-3, the shallow (2-2.5 ft bgs) subsurface soil sample collected from EP03 excavated in the western half of TR-3. Benzene was not detected in the subsurface soil sample collected from EP02 in the eastern half of TR-3. Therefore, a site specific source area of approximately

2400 ft^2 was calculated, which corresponds to the area of the western half of TR-3. An average concentration of 0.017 mg/Kg was used for the source area concentration of benzene in this portion of TR-3.

- Benzene was detected in the subsurface soil samples collected from EP07 excavated in the southern half of TR-4. Benzene was not detected in the subsurface soil samples collected from EP01 or HA01 in the northern half of TR-4. Therefore, a site specific source area of approximately 3300 ft^2 was calculated, which corresponds to the area of the southern half of TR-4. An average concentration of 0.0046 mg/Kg was used for the source area concentration of benzene in this portion of TR-4.
- Benzene was detected in the subsurface soil sample collected from EP15 excavated in TR-6. Since no additional soil samples were collected from this feature, a site specific source area of approximately 1200 ft^2 was calculated, which corresponds to the entire area of TR-6. The 0.0012 mg/Kg benzene concentration in the EP15 subsurface soil sample was used for the source area concentration in TR-6, since only one soil sample was collected from this feature.

Antimony

One potential antimony source area was identified at SWMU-11.

- Antimony was detected in excess of the range of background concentrations in only one sample at the site, the shallow (1.5-1.6 ft bgs) subsurface soil sample collected from EP06 excavated in the western half of TR-1. Antimony was not detected in excess of the background comparison value in SS003 or in subsurface soil samples collected from EP05 in the eastern half of TR-1. Therefore, a site specific source area of approximately 4900 ft^2 was calculated, which corresponds to the area of the western half of TR-1. An average concentration of 430 mg/Kg was used for the source area concentration of antimony in this portion of TR-1.

Arsenic

One potential arsenic source area was identified at SWMU-11.

- Arsenic was detected in excess of the range of background concentrations in only one sample at the site, the shallow (1.5-1.6 ft bgs) subsurface soil sample collected from EP06 excavated in the western half of TR-1. Arsenic was not detected in excess of the background comparison value in SS003 or in subsurface soil samples collected from EP05 in the eastern half of TR-1. Therefore, a site specific source area of approximately 4900 ft^2 was calculated, which corresponds to the area of the western half of TR-1. An average concentration of 25 mg/Kg was used for the source area concentration of arsenic in this portion of TR-1.

Chromium (Total)

Three potential chromium (total) source areas were identified at SWMU-11.

- Chromium (total) was detected in excess of the range of background concentrations in only one sample in TR-1, the shallow (1.5-1.6 ft bgs) subsurface soil sample collected from EP06 excavated in the western half of TR-1. Chromium (total) was not detected in excess of the background comparison value in SS003 or in subsurface soil samples collected from EP05 in the eastern half of TR-1. Therefore, a site specific source area of approximately 4900 ft2 was calculated, which corresponds to the area of the western half of TR-1. An average concentration of 20 mg/Kg was used for the source area concentration of chromium (total) in this portion of TR-1.
- Chromium (total) was detected in excess of the range of background concentrations in only one sample in TR-2, the shallow (1.5-2 ft bgs) subsurface soil sample collected from EP04 excavated in this trench. Since subsurface soil samples were only collected from EP04 in TR-2, a site specific source area of approximately 4800 ft2 was calculated, which corresponds to the entire area of TR-2. An average concentration of 38 mg/Kg was used for the source area concentration of chromium (total) in this feature.
- Chromium (total) was detected in excess of the range of background concentrations in only one sample in TR-3, the shallow (2 - 2.5 ft bgs) subsurface soil sample collected from EP03 excavated in the western half of TR-3. Chromium (total) was not detected in excess of the background comparison value in SS004 or in the subsurface soil sample collected from EP02 in the eastern half of TR-1. Therefore, a site specific source area of approximately 2400 ft2 was calculated, which corresponds to the area of the western half of TR-3. An average concentration of 45 mg/Kg was used for the source area concentration of chromium (total) in this portion of TR-3.

Nitroglycerin

One potential nitroglycerin source area was identified at SWMU-11.

- Nitroglycerin was detected in only one sample at the site, the shallow (1.5-1.6 ft bgs) subsurface soil sample collected from EP05, excavated in the eastern half of TR-1. Since nitroglycerin was not detected in subsurface soil samples collected from EP06 in the western half of TR-1, a site specific source area of approximately 4900 ft^2 was calculated, which corresponds to the area of the eastern half of TR-1. An average concentration of 0.27 mg/Kg was used for the source area concentration of nitroglycerin in this portion of TR-1.

2,3,7,8-Tetrachlorodibenzo-p-dioxin TEQ

Five potential 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ source areas were identified at SWMU-11.

- 2,3,7,8-Tetrachlorodibenzo-p-dioxin TEQ was detected in the subsurface soil samples collected from both EP05 and EP06 in TR-1. Therefore, a site specific

source area of approximately 9800 ft^2 was calculated, which corresponds to the entire area of TR-1. An average concentration of 1.2E-4 mg/Kg was used for the source area concentration of 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ in this feature.

- 2,3,7,8-Tetrachlorodibenzo-p-dioxin TEQ was detected in the subsurface soil samples collected from EP04 excavated in TR-2. Since subsurface soil samples in TR-2 were only collected from EP04, a site specific source area of approximately 4800 ft^2 was calculated, which corresponds to the entire area of TR-2. An average concentration of 1.3E-6 mg/Kg was used for the source area concentration of 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ in this feature.
- 2,3,7,8-Tetrachlorodibenzo-p-dioxin TEQ was detected in the subsurface soil samples collected from EP03 excavated in the western half of TR-3. Analyses necessary to determine 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ were not performed on other soil samples collected from TR-3. Therefore, a site specific source area of approximately 4900 ft^2 was calculated, which corresponds to the entire area of TR-3. An average concentration of 8.4E-6 mg/Kg was used for the source area concentration of 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ in this feature.
- 2,3,7,8-Tetrachlorodibenzo-p-dioxin TEQ was detected in the subsurface soil samples collected from EP07 excavated in the southern half of TR-4 and in surface soil samples SS005 and SS006 collected in the northern and southern portions of TR-4. Therefore, a site specific source area of approximately 6700 ft^2 was calculated, which corresponds to the entire area of TR-4. An average concentration of 6.2E-7 mg/Kg was used for the source area concentration of 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ in this feature.
- 2,3,7,8-Tetrachlorodibenzo-p-dioxin TEQ was detected in the subsurface soil sample collected from EP15 excavated in TR-6. Since no additional soil samples were collected from this feature, a site specific source area of approximately 1200 ft^2 was calculated, which corresponds to the entire area of TR-6. The 5.7E-7 mg/Kg 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ concentration in the EP15 subsurface soil sample was used for the source area concentration in TR-6, since only one soil sample was collected from this feature.

Chemical-specific SSLs (Table 3.4) were then calculated using USEPA (1996a) methodology and USEPA Region 9 (2004) Tap Water PRGs. An additional evaluation was conducted using the MCL (2004e) for antimony (6 µg/L), arsenic (10 µg/L), benzene (5 µg/L), and 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ (0.00003 µg/L).

All source area concentrations of chromium (total) and nitroglycerin were less than corresponding source-area-specific soil-to-groundwater SSLs (Table 3.4). Source area concentrations of benzene in TR-3, TR-4, and TR-6, and source area concentrations

TABLE 3.3

SCREENING FOR POTENTIAL SOIL-TO-GROUNDWATER IMPACTS SWMU-11

DUGWAY PROVING GROUND, UTAH

Analyte[a/]	Maximum Soil Concentration (mg/Kg)[b/]	Soil-to-GW SSL(mg/Kg)[c/]	Potential Soil-to-GW Impacts?[d/]
Volatile Organic Compounds			
2-Methylnaphthalene	0.29	29	No
Acenaphthene	0.12	1000	No
Acenaphthylene[e/]	0.68	900	No
Acetone	9.0	23	No
Benzene	0.073	0.0099	**Yes**
Ethylbenzene	0.031	200	No
m,p-Xylene (Sum Of Isomers)[e/]	0.042	38	No
Methyl Ethyl Ketone (2-Butanone)	1.2	39	No
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)	0.063	17	No
Naphthalene	0.057	5.0	No
o-Xylene (1,2-Dimethylbenzene)[e/]	0.022	31	No
Phenanthrene[e/]	0.25	15,000	No
Styrene	0.023	520	No
Toluene	0.11	56	No
Semivolatile Organic Compounds			
Benzyl Alcohol	0.18	110	No
Fluoranthene	0.097	62,000	No
Pyrene	0.16	7700	No
Inorganics			
Antimony[e/]	1300	13	**Yes**
Arsenic	73	0.028	**Yes**
Barium	970	2700	No
Beryllium	24,000	100,000[f/]	No
Boron	58	470	No
Cadmium[e/]	1.5	1600	No
Chromium, Total[e/]	110	31	**Yes**
Copper	140	1000	No
Lead[e/]	130	400[g/]	No
Mercury	5.8	44	No
Molybdenum	3.9	74	No
Silver	1.1	400	No
Zinc	2500	100,000[f/]	No

TABLE 3.3 (CONTINUED)

SCREENING FOR POTENTIAL SOIL-TO-GROUNDWATER IMPACTS SWMU-11

DUGWAY PROVING GROUND, UTAH

Analyte[a/]	Maximum Soil Concentration (mg/Kg)[b/]	Soil-to-GW SSL(mg/Kg)[c/]	Potential Soil-to-GW Impacts?[d/]
Explosives			
Nitroglycerin	0.44	0.27	**Yes**
Dioxins and Furans			
2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TEQ)[h/]	0.00046	0.000026	**Yes**
Dibenzofuran	0.045	55	No

a/ Refer to Appendix D for a list of essential nutrients at the site. Essential nutrient soil-to-groundwater impacts were not evaluated because unacceptable impacts are not expected (USEPA, 1996a). PRGs are not available for TPH, nitrocellulose, or 2-hexanone which therefore were not evaluated for potential future soil-to-groundwater impacts.

b/ mg/Kg = Milligrams per kilogram. Maximum concentrations from surface/subsurface soil samples are listed.

c/ Soil-to-GW SSL = Soil-to-Groundwater Soil Screening Level based on USEPA (1996a) recommended default dilution attenuation factor (DAF) of 20. With the exception of a facility-specific f_{oc} of 0.02 (i.e., 2-percent), soil-to-groundwater SSLs were calculated using USEPA (1996a, 2002f) recommended input assumptions, methodology and USEPA Region 9 (2004) preliminary remediation goals (PRGs) (Appendix D).

d/ Soil-to-groundwater impacts are not expected if maximum detected soil concentration is less than the Soil-to-GW SSL.

e/ The toxicity data for these chemicals were not derived via traditional methods and are described in Section 3.4.

f/ The value is a "ceiling limit" concentration because the risk-based value was greater than the USEPA Region 9 (2004) recommended ceiling limit of 100,000 mg/Kg.

g/ A soil-to-groundwater SSL was not calculated for lead; a value of 400 mg/Kg is recommended by USEPA (1996b).

h/ TEQ = Toxic Equivalent. Concentrations of the 17 detected dioxins and furans were converted to

i/ 2,3,7,8-tetrachlorodibenzo-p-dioxin (TEQ) using the 2005 World Health Organization toxicity equivalency factors (Van den Berg, et. al., 2006; see Appendix E for supporting calculations).

TABLE 3.4

REFINED SCREENING FOR POTENTIAL SOIL-TO-GROUNDWATER IMPACTS
SWMU-11

DUGWAY PROVING GROUND, UTAH

Analyte	Source Area Feature(s)[a/]	Surface Area (ft^2) of Feature[b/]	Source Area Specific DAF[c/]	Source Area Concentration (mg/Kg)[d/]	Source Area SSL[e/] (mg/Kg)	Potential Soil-to-Groundwater Impacts?[f/]
Volatile Organic Compounds						
Benzene	TR-1	9800	26	0.015	0.013 (0.18)[g/]	**Yes** (No)
Benzene	TR-2	4800	60	0.038	0.030 (0.42)[g/]	**Yes** (No)
Benzene	Western Half of TR-3	2400	150	0.017	0.074	No
Benzene	Southern Half of TR-4	3300	97	0.0046	0.048	No
Benzene	TR-6	1200	410	0.0012	0.20	No
Inorganics						
Antimony[h/]	Western Half of TR-1	4900	58	430	38 (16)[g/]	**Yes** (Yes)
Arsenic	Western Half of TR-1	4900	58	25	0.082 (18)[g/]	**Yes** (Yes)
Chromium, Total[h/]	Western Half of TR-1	4900	58	20	91	No
Chromium, Total[h/]	TR-2	4800	60	38	93	No
Chromium, Total[h/]	Western Half of TR-3	2400	150	45	230	No
Explosives						
Nitroglycerin	Eastern Half of TR-1	4900	58	0.27	0.79	No
Dioxins and Furans						
2,3,7,8-Tetrachlorodibenzo-p-Dioxin TEQ[i/]	TR-1	9800	26	0.00012	0.000034 (0.0023)[g/]	**Yes** (No)
2,3,7,8-Tetrachlorodibenzo-p-Dioxin TEQ[i/]	TR-2	4800	60	0.0000013	0.000079	No
2,3,7,8-Tetrachlorodibenzo-p-Dioxin TEQ[i/]	TR-3	4900	58	0.0000084	0.000077	No
2,3,7,8-Tetrachlorodibenzo-p-Dioxin TEQ[i/]	TR-4	6700	40	0.00000062	0.000053	No
2,3,7,8-Tetrachlorodibenzo-p-Dioxin TEQ[i/]	TR-6	1200	410	0.00000057	0.00053	No

a/ Feature with soil concentration in excess of generic Soil-to-GW SSL.

b/ ft^2 = Square feet.

c/ DAF = Dilution attenuation factor. DAFs estimated as described in the text.

d/ mg/Kg = Milligrams per kilogram. Source area concentrations from surface and subsurface soil samples are listed.

e/ Source Area SSL = Source Area Soil Screening Level based on source area specific DAF. With the exception of a facility-specific f_{oc} of 0.02 (i.e., 2-percent), source area SSLs were calculated using USEPA (1996a, 2002f) recommended input assumptions, methodology and chemical-specific PRG from USEPA Region 9 (2004) (Appendix D).

r/ Soil-to-GW impacts are not expected if source area soil concentration was less than the source area SSL.

g/ Source Area SSL in parentheses calculated using the USEPA MCL (2003j) for antimony (6 µg/L), arsenic (10 µg/L), benzene (5 µg/L), and 2,3,7,8-tetrachlorodibenzo-p-dioxin Toxicity Equivalence Quotient (TEQ) (0.00003 µg/L).

h/ The toxicity data for these chemicals were not derived via traditional methods and are described in Section 3.4.

i/ TEQ = Toxic Equivalent Quotient. Concentrations of the 17 detected dioxins and furans were converted to 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ using the 2005 World Health Organization toxicity equivalency factors (Van den Berg, *et al.*, 2006; see Appendix E for supporting calculations).

of 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ in TR-2, TR-3, TR-4, and TR-6 were also less than corresponding source-area-specific soil-to-groundwater SSLs. However, average soil concentrations of antimony, arsenic, benzene, and 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ in TR-1 were greater than corresponding source-area-specific soil-to-groundwater SSLs, as were source area concentrations of benzene in TR-2.

Soil-to-groundwater SSLs developed using USEPA (1996a) methodology incorporate the following conservative simplifying assumptions:

- Infinite source (i.e., steady-state concentrations maintained over the exposure period)
- Uniformly distributed contamination from the surface to the top of the water-bearing zone
- No contaminant attenuation (i.e., adsorption, biodegradation, or chemical degradation) in soil
- Instantaneous and linear equilibrium soil/water partitioning
- Unconfined, unconsolidated aquifer with homogeneous and isotropic hydrologic properties
- Drinking water receptor well 25 ft downgradient of the edge of the source and screened within the contaminant groundwater plume
- No contaminant attenuation in the groundwater

The above assumptions are overly conservative (i.e., not valid) at SWMU-11, particularly the assumptions of an infinite contaminant source, a uniform distribution of the contamination from ground surface to the top of the water-bearing zone, and a nearby drinking water receptor well.

Indications of an infinite contaminant source area were not observed during test pit excavations at TR-1, TR-2, or other site features (Appendix A). The heterogeneity of detected concentrations (Figure 2.3) also indicates that the presence of an infinite contaminant source area is unlikely.

There is no evidence of vertical migration of antimony or arsenic in subsurface soils. As shown on Figure 2.3, antimony and arsenic were only detected above the range of background concentrations in one isolated soil sample collected from the shallow (1.5-1.6 ft bgs) sample interval in EP06, located in the western half to TR-1. Antimony and

arsenic concentrations decreased significantly (over three and one orders of magnitude, respectively) to less than the background comparison level in the underlying (2.5-2.6 ft bgs) EP06 sample interval. Therefore, the elevated (with respect to background) antimony and arsenic concentrations in the shallow subsurface are not uniformly distributed from the surface to the top of the water-bearing zone, in contrast to the conservative simplifying assumptions in the USEPA (1996a) methodology.

Figure 2.3 also illustrates that benzene and 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ concentrations in TR-1 subsurface soil, as well as benzene in TR-2 subsurface soil decreased significantly with depth. TR-1 benzene detections in the deep (2.5-2.6 ft bgs) EP05 and EP06 subsurface soil samples and TR-2 benzene detections from the deep (4-4.5 ft bgs) EP04 subsurface soil samples ranged from non-detect to over an order of magnitude less than concentrations in the overlying shallower samples (1.5-1.6 ft bgs in TR-1, and 1.5-2 ft bgs in TR-2). TR-1 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ detections in the deep (2.5-2.6 ft bgs) EP05 and EP06 subsurface soil samples similarly ranged from nearly one to over three orders of magnitude less than concentrations in the overlying shallow (1.5-1.6 ft bgs) samples. Therefore, benzene and 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ concentrations in the shallow subsurface are also not uniformly distributed from the surface to the top of the water-bearing zone, in contrast to the conservative simplifying assumptions in the USEPA (1996a) methodology.

There are no sources of potable groundwater in the region surrounding SWMU-11 (Section 2.2.1). The closest water well is WW10, located approximately 4 miles northwest of SWMU-11, which is currently used for dust suppression only. This well is located cross-gradient of the estimated groundwater flow direction at SWMU-11, and recent DPG historical documents indicate that the well produces non-potable water (Woffinden, 2004). Therefore, in contrast to the conservative simplifying assumptions in the USEPA (1996a) methodology, there is no drinking water receptor well 25 ft downgradient of the edge of any potential source area at SWMU-11.

Benzene and 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ source area-specific soil-to-groundwater SSLs were calculated using the MCL to provide a more appropriate and useful comparison value. Significant future impacts to groundwater are not expected from the source area concentrations of benzene and 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ

based on a comparison with the source area-specific soil-to-groundwater SSL derived using the MCL (Table 3.4). Antimony and arsenic source area-specific soil-to-groundwater SSLs were also calculated using MCLs. The source area concentration of arsenic slightly exceeded (was less than two times) the corresponding source area-specific soil-to-groundwater SSL derived using the MCL (Table 3.4). The source area concentration of antimony also exceeded the corresponding MCL-based source area-specific soil-to-groundwater SSL, as anticipated since the MCL for antimony is less than the USEPA Region 9 (2004) Tap Water PRG (Table 3.4). However most importantly, as discussed above, antimony and arsenic were not detected above the background comparison value in samples collected from soil 1 ft below the isolated elevated antimony and arsenic concentrations (Figure 2.3), clearly demonstrating that concentrations are not uniformly distributed from the surface to the top of the water-bearing zone, in contrast to the conservative simplifying assumptions in the USEPA (1996a) methodology.

Antimony, arsenic, benzene, and 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ in TR-1 soils and benzene in TR-2 soils are likely not present at concentrations expected to impact groundwater significantly in the future, based on the conservative simplifying assumptions of the USEPA (1996a) methodology which do not apply to this site.

3.2 HUMAN HEALTH RISK ASSESSMENT

In accordance with USEPA (1989a) guidance, HRAs follow a four-step evaluation process that includes data collection and evaluation, exposure assessment, toxicity assessment, and risk characterization. The results of the HRA are presented in this section and supporting calculations are provided in Appendix E.

3.2.1 Data Collection and Evaluation

With the exception of the toxicity screening step, the results from the data collection and evaluation step described in the Risk Assumptions Document (Parsons, 2002a) have been discussed in Sections 2 and 3.1, respectively. The risk-based toxicity screening for preliminary COPCs detected in soil is described below.

Risk-based toxicity screening is typically one of the steps used to identify COPCs (Parsons, 2002a). This screening was not used to identify HRA soil COPCs, but instead

was used to estimate cancer risks and noncancer hazards for a hypothetical residential land-use scenario, and to determine if further risk calculations were necessary under an industrial land-use scenario. Screening-level risk/hazard estimates for a hypothetical resident potentially exposed to COPCs in soil were estimated using maximum detected concentrations in the mixed-soil interval (0-10 ft bgs) and USEPA Region 9 (2004) Residential Soil PRGs and guidance, as discussed in the Risk Assumptions Document (Parsons, 2002a). Residential screening-level cumulative cancer-risk (3E-04) and noncancer hazard index (HI) (200) estimates associated with potential exposures to COPCs in soils were above the DSHW (2001) NFA target risk (1E-06) and HI (1) values (Table 3.5). The maximum detected concentration of lead (130 mg/Kg) in the mixed soil interval was below the residential soil screening level of 400 mg/Kg recommended by USEPA (1994a). Because residential risks and hazards are above the target levels, further risk and hazard calculations (i.e., the subsequent quantitative exposure, toxicity, and risk characterization steps) are necessary for an industrial land-use scenario.

USEPA Region 9 (2004) Soil Residential PRGs incorporate all exposure pathways described in Figure 3.1 and required under UAC R315-101 (DSHW, 2001), except inhalation of chemicals volatilized from subsurface soil and ingestion of contaminated/potentially contaminated food (i.e., ingestion of homegrown produce). Inhalation of chemicals volatilized from subsurface media is discussed in Section 3.2.2. Ingestion of homegrown produce was not evaluated since NFA target levels were already exceeded.

In summary, further risk calculations were necessary under an industrial land-use scenario since screening-level soil cumulative risk and hazard estimates for the hypothetical resident were above DSHW (2001) NFA target levels. The *a priori* assumption that exposure to uncharacterized/unidentified buried wastes and uncharacterized subsurface soil by hypothetical intrusive workers and exposure to uncharacterized surface soil by hypothetical nonintrusive workers should be prevented given the presence of radioactive debris (Section 2; Appendix F) and/or the absence of direct sampling for chemical analysis will need to be addressed during a CMS (Section 4). In addition, further risk calculations from potential exposure to site-related radiation levels (i.e. site-specific DCGLs) were not necessary since characterized soils

TABLE 3.5

SOIL RISK SCREENING USING RESIDENTIAL PRGs[a/]
SWMU - 11
DUGWAY PROVING GROUND, UTAH

Preliminary COPC[b/]	CAS #[c/]	Maximum Site Concentration (mg/Kg)[d/]	Residential PRG[e/] (mg/Kg)		Residential HQ[f/]	Residential Cancer Risk[g/]
			Noncancer	Cancer		
Volatile Organic Compounds						
2-Hexanone	591-78-6	0.062	--[h/]	--	--	--
2-Methylnaphthalene	91-57-6	0.29	1.8E+02	--	2E-03	--
Acenaphthene	83-32-9	0.12	3.7E+03	--	3E-05	--
Acenaphthylene[i/]	208-96-8	0.68	3.7E+03	--	2E-04	--
Acetone	67-64-1	9.0	1.4E+04	--	6E-04	--
Benzene	71-43-2	0.073	3.3E+01	6.4E-01	2E-03	1E-07
Ethylbenzene	100-41-4	0.031	1.9E+03	--	2E-05	--
Methyl Ethyl Ketone (2-Butanone)	78-93-3	1.2	2.2E+04	--	5E-05	--
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)	108-10-1	0.063	5.3E+03	--	1E-05	--
Naphthalene	91-20-3	0.057	5.6E+01	--	1E-03	--
Phenanthrene[i/]	85-01-8	0.25	2.2E+04	--	1E-05	--
Styrene	100-42-5	0.023	4.4E+03	--	5E-06	--
Toluene	108-88-3	0.11	6.6E+02	--	2E-04	--
m,p-Xylene (Sum Of Isomers)[i/]	1330-20-7	0.042	2.7E+02	--	2E-04	--
o-Xylene (1,2-Dimethylbenzene)[i/]	1330-20-7	0.022	2.7E+02	--	8E-05	--
Semivolatile Organic Compounds						
Benzyl Alcohol	100-51-6	0.18	1.8E+04	--	1E-05	--
Fluoranthene	206-44-0	0.097	2.3E+03	--	4E-05	--
Pyrene	129-00-0	0.16	2.3E+03	--	7E-05	--
Inorganics						
Antimony[i/]	7440-36-0	1300	3.1E+01	--	4E+01	--
Arsenic	7440-38-2	73	2.2E+01	3.9E-01	3E+00	2E-04

TABLE 3.5 (CONTINUED)
SOIL RISK SCREENING USING RESIDENTIAL PRGs[a/]
SWMU - 11
DUGWAY PROVING GROUND, UTAH

Preliminary COPC[b/]	CAS #[c/]	Maximum Site Concentration (mg/Kg)[d/]	Residential PRG[e/](mg/Kg) Noncancer	Cancer	Residential HQ[f/]	Residential Cancer Risk[g/]
Barium	7440-39-3	970	5.4E+03	--	2E-01	--
Beryllium	7440-41-7	24,000	1.5E+02	1.1E+03	2E+02	2E-05
Boron	7440-42-8	58	1.6E+04	--	4E-03	--
Cadmium[i/]	7440-43-9	1.5	7.4E+01	1.4E+03	2E-02	1E-09
Chromium, Total[i/]	7440-47-3	110	1.6E+03	1.5E+03	7E-02	7E-08
Copper	7440-50-8	140	3.1E+03	--	5E-02	--
Lead[i/]	7439-92-1	130	4E+02		--	
Mercury	7487-94-7	5.8	2.3E+01	--	3E-01	--
Molybdenum	7439-98-7	3.9	3.9E+02	--	1E-02	--
Silver	7440-22-4	1.1	3.9E+02	--	3E-03	--
Zinc	7440-66-6	2500	2.3E+04	--	1E-01	--
Explosives						
Nitroglycerin	55-63-0	0.44	--	3.5E+01	--	1E-08
Dioxins and Furans						
2,3,7,8-Tetrachlorodibenzo-p-Dioxin	1746-01-6	0.00046	--	3.9E-06	--	1E-04
Dibenzofuran	132-64-9	0.045	1.5E+02	--	3E-04	--
			Cumulative Hazard and Risk		200	3E-04

a/ PRG = Preliminary remediation goal; USEPA Region 9 (2004).

b/ COPC = Chemical of potential concern.

c/ CAS = Chemical abstracts service number.

d/ mg/Kg = Milligram per kilogram. Maximum site concentrations are from the 0-10 ft bgs exposure interval.

e/ Noncancer and cancer PRGs are from the "Soils" spreadsheet in USEPA Region 9 (2004).

f/ HQ = Hazard Quotient; HQ = (THQ X C_{max}/PRG), where target hazard quotient (THQ) = 1 and C_{max} = Maximum site concentration. All values have been rounded to one significant figure (including cumulative hazard and risk estimates).

g/ Cancer Risk = (C_{max} X TCR/PRG), where target cancer risk (TCR) = 1E-6 and C_{max} = Maximum site concentration.

h/ "--" = USEPA Region 9 PRGs were not available for the indicated endpoint of toxicity.

i/ The toxicity data for these chemicals were not derived via traditional methods and are described in Section 3.4.

were determined to be similar to background radiation levels and/or other lines of evidence show that these soils have not been impacted by radioactive contamination (see Appendix F). Therefore, TR-1 through TR-4, the CONEX container and the soils associated with TR-6 meet the criteria for free release and do not need to be considered in the CMS for residual radiation. However, although the soils at TR-6 meet the free release criteria for radiation the surface soils still remain uncharacterized for chemical constitutes and are addressed in the CMS.

3.2.2 Exposure Assessment

Characterization of the exposure setting, identification of all potentially exposed commercial/industrial receptors and exposure pathways, and finalization of the CSM are discussed in Section 3.1. COPC-specific exposures in soil were estimated using the algorithms and exposure parameters described in the Risk Assumptions Document (Parsons, 2002a). Chemical-specific physical properties used in estimating exposure to soil COPCs are listed in Table 3.6. Exposure estimates associated with soil COPCs were combined with results from the toxicity assessment (Section 3.2.3) and are provided in Appendix E.

The algorithms and exposure parameters for estimating volatilization of subsurface soil COPCs into indoor air were not included in the Risk Assumptions Document (Parsons, 2002a), but are presented in the following subsection..

3.2.2.1 Volatilization of COPCs from Subsurface Soil into Indoor Air

Indoor-air EPCs were estimated using a volatilization model. The Johnson and Ettinger model (USEPA, 2004f) is a one-dimensional analytical solution to passive diffusion and convective vapor-transport through the vadose zone, and consists of the following three components: 1) estimation of soil vapor concentrations at the subsurface source; 2) diffusion through the unsaturated zone; and 3) convective and diffusive transport into the building.

TABLE 3.6

PHYSICAL PROPERTIES FOR CHEMICALS OF POTENTIAL CONCERN
SWMU - 11
DUGWAY PROVING GROUND, UTAH

COPC[b/]	CAS Number[c/]	Parameter Value[a/] H'	Ref[d/]	D^{air} (cm^2/s)[e/]	Ref	D^{wat} (cm^2/s)[e/]	Ref	Koc (L/kg)[e/]	Ref	Kd (cm3/g)[e/]	Ref	OAF	Ref	DAF	Ref
Volatile Organic Compounds															
2-Hexanone	591-78-6	0.00381	EPI	0.073	W9	0.0000087	W9	13.02	EPI	0.2604	CA	**[f/]	B	--[g/]	
2-Methylnaphthalene	91-57-6	0.0212	EPI	0.0522	W9	7.75E-06	W9	2976	EPI	59.52	CA	**	B	0.13	U
Acenaphthene	83-32-9	0.00636	SSL	0.0421	SSL	7.69E-06	SSL	7080	SSL	141.6	CA	**	U	0.13	U
Acenaphthylene[h/]	208-96-8	0.00744	EPI	0.0421	SSL	7.69E-06	SSL	6123	EPI	122.46	CA	**	U	0.13	U
Acetone	67-64-1	0.00159	SSL	0.124	SSL	0.0000114	SSL	0.575	SSL	0.0115	CA	**	B	--	
Benzene	71-43-2	0.228	SSL	0.088	SSL	0.0000098	SSL	58.9	SSL	1.178	CA	**	B	--	
Ethylbenzene	100-41-4	0.32308	SSL	0.075	SSL	0.0000078	SSL	363	SSL	7.26	CA	**	B	--	
Methyl Ethyl Ketone (2-Butanone)	78-93-3	0.00233	EPI	0.0808	W9	0.0000098	W9	3.827	EPI	0.07654	CA	**	B	--	
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)	108-10-1	0.00564	EPI	0.075	W9	0.0000078	W9	10.91	EPI	0.2182	CA	**	B	--	
Naphthalene	91-20-3	0.0198	SSL	0.059	SSL	0.0000075	SSL	2000	SSL	40	CA	**	U	0.13	U
Phenanthrene[h/]	85-01-8	0.00173	EPI	0.0375	W9	7.47E-06	W9	20830	EPI	416.6	CA	**	U	0.13	U
Styrene	100-42-5	0.113	SSL	0.071	SSL	0.000008	SSL	776	SSL	15.52	CA	**	U	--	
Toluene	108-88-3	0.272	SSL	0.087	SSL	0.0000086	SSL	182	SSL	3.64	CA	**	B	--	
m,p-Xylene (Sum Of Isomers)[h/]	1330-20-7	0.271	EPI	0.073	W9	9.23E-06	W9	443.1	EPI	8.862	CA	**	U	--	
o-Xylene (1,2-Dimethylbenzene)[h/]	1330-20-7	0.213	SSL	0.087	SSL	0.00001	SSL	363	SSL	7.26	CA	**	U	--	
Semivolatile Organic Compounds															
Benzyl Alcohol	100-51-6	0.0000138	EPI	0.0708	W9	8.97E-06	W9	15.7	EPI	0.314	CA	**	B	--	
Fluoranthene	206-44-0	0.00066	SSL	0.0302	SSL	6.35E-06	SSL	107000	SSL	2140	CA	**	U	0.13	U
Pyrene	129-00-0	0.000451	SSL	0.0272	SSL	7.24E-06	SSL	105000	SSL	2100	CA	**	U	0.13	U
Inorganics															
Antimony[h/]	7440-36-0	--	NU	--	NU	--	NU	--	NU	45	SSL	0.15	U	--	
Arsenic	7440-38-2	--	NU	--	NU	--	NU	--	NU	31	SSL	**	U	0.03	U
Barium	7440-39-3	--	NU	--	NU	--	NU	--	NU	52	SSL	0.07	U	--	
Beryllium	7440-41-7	--	NU	--	NU	--	NU	--	NU	100000	SSL	0.007	U	--	
Boron	7440-42-8	--	NU	--	NU	--	NU	--	NU	3	BAES	**	B	--	
Cadmium[h/]	7440-43-9	--	NU	--	NU	--	NU	--	NU	4300	SSL	0.025	U	0.001	U

TABLE 3.6 (CONTINUED)

PHYSICAL PROPERTIES FOR CHEMICALS OF POTENTIAL CONCERN
SWMU - 11
DUGWAY PROVING GROUND, UTAH

		Parameter Value[a/]													
COPC[b/]	CAS Number[c/]	H'	Ref[d/]	D^{air} (cm^2/s)[e/]	Ref	D^{wat} (cm^2/s)[e/]	Ref	Koc (L/kg)[e/]	Ref	Kd (cm^3/g) [e/]	Ref	OAF	Ref	DAF	Ref
Chromium, Total[h/]	7440-47-3	--	NU	--	NU	--	NU	--	NU	14	SSL	0.013	U	--	
Copper	7440-50-8	--	NU	--	NU	--	NU	--	NU	35	BAES	0.3	B	--	
Lead[h/]	7439-92-1	--	NU	--	NU	--	NU	--	NU	900	BAES	0.15	B	--	
Mercury	7487-94-7	--	NU	--	NU	--	NU	--	NU	200	SSL	0.07	U	--	
Molybdenum	7439-98-7	--	NU	--	NU	--	NU	--	NU	20	BAES	0.38	B	--	
Silver	7440-22-4	--	NU	--	NU	--	NU	--	NU	110	SSL	0.04	U	--	
Zinc	7440-66-6	--	NU	--	NU	--	NU	--	NU	530	SSL	0.2	B	--	
Explosives															
Nitroglycerin	55-63-0	1.04E-07	EPI	0.029	W9	7.76E-06	W9	130.8	EPI	2.616	CA	--	--	--	--
Dioxins and Furans															
2,3,7,8-Tetrachlorodibenzo-p-Dioxin	1746-01-6	0.00205	EPI	0.104	W9	0.0000056	W9	146300	EPI	2926	CA	**	U	0.03	U
Dibenzofuran	132-64-9	0.00871	EPI	0.0238	W9	0.000006	W9	11290	EPI	225.8	CA	--		0.1	U

[a/] Parameters defined as: H' = Henry's law constant (unitless); D^{air} = Diffusivity in air; D^{wat} = Diffusivity in water; Koc = Organic carbon partition coefficient; Kd = Soil-water partition coefficient; OAF = Oral absorption factor; DAF = Dermal absorption factor.

[b/] COPC = Chemical of potential concern.

[c/] CAS = Chemical abstracts service number.

[d/] Ref = References; SSL = USEPA (2002f, Inorganic K_d values based on a site specific pH of 8.0); U = USEPA (2004c); B = Bast & Borges (1996); W9 = USEPA (2004d) Water9 software; EPI = USEPA EPI (2005) EPISuite software; CA = Calculated per USEPA (1996a) guidance; BAES = Baes *et al.* (1984); NU = Not used.

[e/] Units are defined as: cm^2/s = Square centimeters per second; L/kg = Liters per kilogram; and cm^3/g = Cubic centimeters per gram.

[f/] "**" = Per USEPA (2004d) guidance, toxicity factors were not adjusted for chemicals with gastrointestinal absorption values greater than 50-percent.

[g/] "--" = Data unavailable.

[h/] The toxicity data for these chemicals were not derived via traditional methods and are described in Section 3.4.

Soil Vapor Concentration at the Subsurface Source

The soil vapor concentration at the subsurface source is estimated based on the following equation (USEPA, 2004f):

$$C_{source} = \frac{H'_{ts}\, C_R \rho_b}{\theta_w + K_d \rho_b + H'_{ts}\, \theta_a}$$

where:

C_{source} = Soil vapor concentration at the subsurface source (g/cm^3-v);
H'_{TS} = Dimensionless Henry's Law constant at the system temperature;
C_R = Initial soil concentration (g/g);
ρ_b = Soil dry bulk density (g/cm^3);
θ_w = Soil water-filled porosity (cm^3/cm^3);
K_d = Soil-water partition coefficient (cm^3/g) (= K_{oc} * f_{oc}), where:
K_{oc} = Soil organic carbon partition coefficient (cm^3/g), and
f_{oc} = Soil organic carbon weight fraction (unitless);
θ_a = Soil air-filled porosity (cm^3/cm3).

Diffusion Through the Unsaturated Zone

Diffusion through the unsaturated (vadose) zone is estimated based on the following equation (USEPA, 2004f):

$$D_T^{eff} = D_a(\theta_a^{3.33} / n^2) + (D_W / H'_{TS})(\theta_w^{3.33} / n^2)$$

where:

D_T^{eff} = Total overall effective diffusion coefficient (cm^2/s);
D_a = Diffusivity in air (cm^2/s);
θ_a = Soil air-filled porosity (cm^3/cm^3);
n = Soil total porosity (cm^3/cm^3);
D_w = Diffusivity in water (cm^2/s);
θ_w = Soil water-filled porosity (cm^3/cm^3);
H'_{TS} = Dimensionless Henry's Law constant at the system temperature.

Convective and Diffusive Transport

Under the assumption that mass transfer is steady state, the solution for the attenuation coefficient (α) is calculated as (USEPA, 2004f):

$$\alpha = \frac{\left(\frac{D_T^{eff} A_B}{Q_{building} L_T}\right) \times e^{\left(\frac{Q_{soil} L_{crack}}{D_{crack} A_{crack}}\right)}}{\left\{e^{\left(\frac{Q_{soil} L_{crack}}{D_{crack} A_{crack}}\right)} + \left(\frac{D_T^{eff} A_B}{Q_{building} L_T}\right) + \left(\frac{D_T^{eff} A_B}{Q_{soil} L_T}\right) \times \left[e^{\left(\frac{Q_{soil} L_{crack}}{D_{crack} A_{crack}}\right)} - 1\right]\right\}}$$

where:

α = Steady-state attenuation coefficient (unitless);
D_T^{eff} = Total overall effective diffusion coefficient (cm^2/s);
A_B = Area of the enclosed space below grade (cm^2);
$Q_{building}$ = Building ventilation rate (cm^3/s);
L_T = Source-building separation (cm);
Q_{soil} = Volumetric flow rate of soil gas into the enclosed space (cm^3/s);
L_{crack} = Enclosed space foundation or slab thickness (cm);
A_{crack} = Area of total cracks (cm^2);
D_{crack} = Effective diffusion coefficient through the cracks (cm^2/s) (assumed equivalent to D_T^{eff}).

Indoor air concentrations ($C_{building}$) of chemicals volatilized from the subsurface soil are calculated using the following equation (USEPA, 2003f):

$$C_{building} = \alpha \times C_{source}$$

The electronic spreadsheets that are available for download from the USEPA website (www.epa.gov/superfund/programs/risk/airmodel/johnson_ettinger.htm) incorporate the algorithms described above and were used to estimate indoor air concentrations and subsequent risks and hazards associated with inhalation of chemicals volatilized from subsurface soil into the indoor air. The spreadsheets that were used to calculate risks and hazards are provided in Appendix E.

Default and site-specific parameters used in the above algorithms are provided in Table 3.7. A brief rationale for each parameter and the supporting reference citation are also provided (Table 3.7), and are explained in further detail below.

The shallow subsurface soil at SWMU-11 general consists of a thin (1-2 ft thick) layer of clay, underlain by well sorted sand that grades into coarser-grained sand and gravel to at least 15 ft bgs (see Section 2.2.1 of this document). According to the ternary

TABLE 3.7

PARAMETERS USED FOR MODELING VOLATILIZATION FROM SUBSURFACE SOIL INTO INDOOR AIR SWMU-11

DUGWAY PROVING GROUND, UTAH

Parameter		Typical Range	Value Used in Calculations	Rationale	Reference
Symbol	Description				
C_s	Initial soil concentration (mg/Kg)[a/]	Chemical and site-specific	Various; see Table 3.3	Maximum detected soil concentration at SWMU-11	Table 3.2
T_S	Average soil-groundwater temperature (°C)[a/]	2.8-25 (USEPA, 2004f)	11	Recommended Default Value for Northern Utah	USEPA, 2004f
L_F	Depth below grade to bottom of enclosed space floor (cm)[a/]	15 or 200 (USEPA, 2004f)	15	Assuming future industrial buildings will not have basements.	USEPA, 2004f
L_t	Depth below grade to top of contamination (cm)	ND[b/]	Chemical-specific	Sampling depth where VOCs were detected	USEPA, 2004f
L_b	Depth below grade to bottom of contamination (cm)	ND	0, 122, and 183	Default if value is unknown	USEPA, 2004f
SCS Soil Type	Soil Conservation Service Soil Type	ND	Sand[c/]	Default based on site-specific clay, sand, and silt content[c/]	Section 2.2.1
ρ_b	Soil dry bulk density (g/cm^3)[a/]	1.66 (USEPA, 1996a)	1.5	USEPA Recommended Default Value	USEPA, 2004f
θ_T	Soil total porosity (unitless)	0.35-0.55 (Conner, *et al.* , 1996)	0.375	Default value (calculated per USEPA, 1996a)	USEPA, 2004f
θ_{ws}	Soil water-filled porosity (cm^3-water/cm^3-soil)[a/]	0.13-0.52 (Conner, *et al.* , 1996)	0.054	Default value	USEPA, 2004f
f_{oc}	Soil organic carbon fraction (unitless)	ND	0.02	Organic matter content in soil at DPG	Shaw, 2003
L_{crack}	Enclosed space floor thickness (cm)	ND	10	USEPA Recommended Default value	USEPA, 2004f
ΔP	Soil-building pressure differential ($g/cm\text{-}s^2$)[a/]	ND	40	USEPA Recommended Default value	USEPA, 2004f
L_B	Enclosed space floor length (cm)	ND	1000	USEPA Recommended Default value	USEPA, 2004f
W_B	Enclosed space floor width (cm)	ND	1000	USEPA Recommended Default value	USEPA, 2004f
H_B	Enclosed space height (cm)	ND	244	USEPA Recommended Default value	USEPA, 2004f
W_B	Floor-wall seam crack width (cm)	ND	0.1	USEPA Recommended Default value	USEPA, 2004f
ER	Indoor air exchange rate (1/hr)[a/]	0.5-0.83 (ASTM, 1995)	0.83	Indoor exchange rate for an industrial building	ASTM, 1995

[a/] Parameter units are defined as follows: mg/Kg = milligrams per kilogram; °C = degrees Celsius; cm = centimeter; g/cm^3 = grams per cubic centimeter; cm^3-water/cm^3-soil = cubic centimeters of water per cubic centimeter of soil; $g/cm\text{-}s^2$ = grams per centimeter per square second; 1/h = inverse hour.

[b/] ND = Not determined.

[c/] Subsurface soil above and within the contamination zone at SWMU-11 consists of predominantly sand with some clay (Section 2.2.1), therefore, the USDA soil type "sand" was specified for the model.

diagrams in USEPA (2000d) and Conner et al. (1997), this corresponds to the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) "sand". The SCS soil classification is used by USEPA (2000d); therefore, a "sand" soil type was specified for the model.

USEPA (2004f) default values for sand soil type were selected for total soil porosity, volumetric air content, and volumetric water content in vadose zone soils. Physical properties for COPCs used to estimate soil exposures are shown in Appendix E. Exposure estimates associated with soil COPCs were combined with results from the toxicity assessment (Section 3.2.3) and are provided in Appendix E.

3.2.3 Toxicity Assessment

In order to evaluate the risks/hazards associated with potential exposure to COPCs, the types of health effects that may result from exposure to each COPC and the quantitative relationship between the amount of exposure and the extent of potential effects must be identified. Toxicity factors (Table 3.8) were identified using the hierarchy of sources recommended by USEPA (USEPA, 2003i).

3.2.4 Risk Characterization

Site-specific cancer risks and non-cancer hazards were estimated for all industrial receptors, exposure pathways, and COPCs per the methods described in previous sections and in the Risk Assumptions Document (Parsons, 2002a). The pathway-specific and cumulative risks/hazards are summarized in Table 3.9 for each receptor. All COPCs conservatively were assumed to act on the same target organ when calculating the cumulative non-cancer hazard (HI).

The estimated HIs (0.0004 to 0.3) and cancer risks (8E-11 to 2E-05) for nonintrusive and indoor worker receptors were less than the DSHW (2001) target HI of one and the risk level of 1E-04 that require corrective action under actual/potential land-use scenarios (Table 3.9). The cumulative cancer risk (1E-06) for outdoor intrusive workers was also below the DSHW (2001) target risk level of 1E-04, but the estimated HI (6) was slightly above the target HI of one. The cumulative risk and hazard estimates for outdoor industrial receptors did not include inhalation of VOCs volatilized from subsurface soil. However, significant cumulative risks and hazards are not expected since

TABLE 3.8

TOXICITY DATA FOR CHEMICALS OF POTENTIAL CONCERN
SWMU - 11
DUGWAY PROVING GROUND, UTAH

		Parameter Value [a/]							
COPC[b/]	CAS Number[c/]	RfDo (mg/kg-d)[d/]	Ref[e/]	CSFo (mg/kg-d)$^{-1}$	Ref	RfC (µg/m^3)[f/]	Ref	URF (µg/m^3)$^{-1}$[f/]	Ref
Volatile Organic Compounds									
2-Hexanone	591-78-6	--[g/]		--		--		--	
2-Methylnaphthalene	91-57-6	0.004	I	--		3	I	--	
Acenaphthene	83-32-9	0.06	I	--		--		--	
Acenaphthylene[h/]	208-96-8	0.06	I	--		--		--	
Acetone	67-64-1	0.9	I	--		--		--	
Benzene	71-43-2	0.004	I	0.055	I	30	I	0.0000078	I
Ethylbenzene	100-41-4	0.1	I	--		1000	I	--	
Methyl Ethyl Ketone (2-Butanone)	78-93-3	0.6	I	--		5000	I	--	
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)	108-10-1	0.08	H	--		3000	I	--	
Naphthalene	91-20-3	0.02	I	--		3	I	--	
Phenanthrene[h/]	85-01-8	0.3	I	--		--		--	
Styrene	100-42-5	0.2	I	--		1015	I	--	
Toluene	108-88-3	0.08	I	--		5000	I	--	
m,p-Xylene (Sum Of Isomers)[h/]	1330-20-7	0.2	I	--		100	I	--	
o-Xylene (1,2-Dimethylbenzene)[h/]	1330-20-7	0.2	I	--		100	I	--	
Semivolatile Organic Compounds									
Benzyl Alcohol	100-51-6	0.3	H	--		--		--	
Fluoranthene	206-44-0	0.04	I	--		--		--	
Pyrene	129-00-0	0.03	I	--		--		--	
Inorganics									
Antimony[h/]	7440-36-0	0.0004	I	--		--		--	
Arsenic	7440-38-2	0.0003	I	1.5	I	--		0.0043	I
Barium	7440-39-3	0.2	I	--		0.49	H	--	
Beryllium	7440-41-7	0.002	I	--		0.02	I	0.0024	I
Boron	7440-42-8	0.2	I	--		19.95	H	--	
Cadmium[h/]	7440-43-9	0.001	I	--		--		0.0018	I

TABLE 3.8 (CONTINUED)

TOXICITY DATA FOR CHEMICALS OF POTENTIAL CONCERN
SWMU - 11
DUGWAY PROVING GROUND, UTAH

		Parameter Value [a/]							
COPC[b/]	CAS Number[c/]	RfDo (mg/kg-d)[d/]	Ref[e/]	CSFo (mg/kg-d)$^{-1}$	Ref	RfC (µg/m^3)[f/]	Ref	URF (µg/m^3)$^{-1}$[f/]	Ref
Chromium, Total[h/]	7440-47-3	0.021	I	--		0.7	I	0.00171	I
Copper	7440-50-8	0.04	H	--		--		--	
Lead[h/]	7439-92-1	--		--		--		--	
Mercury	7487-94-7	0.0003	I	--		--		--	
Molybdenum	7439-98-7	0.005	I	--		--		--	
Silver	7440-22-4	0.005	I	--		--		--	
Zinc	7440-66-6	0.3	I	--		--		--	
Explosives									
Nitroglycerin	55-63-0	--	--	0.014	E	--		--	
Dioxins and Furans									
2,3,7,8-Tetrachlorodibenzo-p-Dioxin	1746-01-6	--		150000	H	--		42.9	H
Dibenzofuran	132-64-9	0.002	E	--		--		--	

[a/] Parameters defined as: CSFo = Oral cancer slope factor; RfDo = Oral reference dose; URF = Unit risk factor; RfC = Reference concentration.

[b/] COPC = Chemical of potential concern.

[c/] CAS = Chemical abstracts service number.

[d/] mg/Kg-d = Milligram per kilogram per day.

[e/] Ref = References; I = USEPA (2006a), Integrated Risk Information System (IRIS); H = USEPA (1997) Health Effects Assessment Summary Tables (HEAST); E = USEPA National Cehter for Environmental Assessment per USEPA Region 9 (2004).

[f/] µg/m^3 = Micrograms per cubic meter.

[g/] "--" = Data unavailable.

[h/] The toxicity data for these chemicals were not derived via traditional methods and are described in Section 3.4.

TABLE 3.9
SUMMARY OF CANCER RISKS AND NONCANCER HAZARDS
SWMU-11

DUGWAY PROVING GROUND, UTAH

Receptor/Exposure Route	Route-Specific Cancer Risk	Route-Specific Hazard Index	Chemicals with Hazard Quotient > 1	Chemical-Specific Hazard Quotient	Percent of Total
Nonintrusive Worker					
Incidental Ingestion	--	2E-03			
Dermal Contact	--	--			
Inhalation of Volatiles/Particulates	4E-10	8E-06			
Cumulative Risk/Hazard	**4E-10**	**2E-03**			
Nonintrusive Remote Site Worker					
Incidental Ingestion	--	4E-04			
Dermal Contact	--	--			
Inhalation of Volatiles/Particulates	8E-11	5E-06			
Cumulative Risk/Hazard	**8E-11**	**4E-04**			
Intrusive Worker					
Incidental Ingestion	9E-07	6	Beryllium	5	83%
Dermal Contact	8E-08	4E-03			
Inhalation of Volatiles/Particulates	7E-08	9E-02			
Cumulative Risk/Hazard	**1E-06**	**6**			
Indoor Worker					
Inhalation of VOCs Volatilized from Subsurface Soil	2E-05	0.3			
Cumulative Risk/Hazard	**2E-05**	**0.3**			

exposure and subsequent risks and hazards for an outdoor worker would be less than that of an indoor worker. In addition, industrial receptor estimates did not incorporate potential hazards from lead exposure, although the maximum detected concentration of lead (130 mg/Kg) is well below the industrial soil screening range of 700-1500 mg/Kg (USEPA, 1996c). Therefore, adverse health effects to any potential human receptor are not expected from exposure to lead in soils at the site. However, cross-media cumulative impacts to a nonintrusive worker from inhalation of COPCs potentially volatilized from uncharacterized subsurface soils at TR-5 into outdoor (or indoor) air could not be quantified (Section 3.2.1) and in the absence of other data: 1) are assumed *a priori* to be unacceptable; and 2) will need to be addressed in the CMS Work Plan (Section 4).

In conclusion, the *a priori* assumption that exposure to uncharacterized or unidentified wastes and uncharacterized surface and/or subsurface soils in TR-5 and TR-6 (including exposure to COPCs via potential emission/reentrainment and/or volatilization from uncharacterized surface [TR-5 and TR-6] and subsurface [TR-5] soils) should be prevented given the materials that may be present will need to be addressed during the CMS (Section 4). Screening-level risk and hazard estimates for the hypothetical resident potentially exposed to soil (Table 3.5) exceeded UAC R315-101 (DSHW, 2001) target cumulative cancer risk and noncancer HI levels. Potential risks and hazards were conservatively evaluated further assuming an industrial land-use scenario. Cumulative noncancer HIs and cancer risks for nonintrusive and indoor industrial workers potentially exposed to soil COPCs in soils were less than the DSHW (2001) target HI of one and risk level of 1E-04 (Table 3.9). Cumulative cancer risk to intrusive workers was also below the DSHW industrial target level. However, the cumulative HI for intrusive workers (6) was slightly greater than the DSHW (2001) target HI of one that requires corrective action; this HI is predominantly attributable to the concentration of beryllium in the soil. Therefore, beryllium is considered a soil industrial preliminary COC and will be addressed in the corrective measures discussed in Section 4.

The beryllium site-wide industrial HQ of six corresponding to an EPC of 13,000 mg/Kg is near the target level HI of one. The burn layer associated with TR-1 through TR-3 account for the majority (if not all) of the hazards associated with beryllium at the site. The maximum concentration detected at TR-4 (230 mg/Kg) is

several orders of magnitude below the site-wide EPC of 13,000 mg/Kg. The concentrations at TR-4 would produce an HQ well below the target level and is therefore not expected to pose unacceptable risk to industrial receptors. Since the beryllium concentrations at TR-4 do not pose a threat to human health or the environment, remedial strategies associated with beryllium do not need to include TR-4.

Field survey measurements and soil sample results from trenches TR-1 through TR-4 and the CONEX container indicate that no adverse health affects are expected from exposure to radiation. However, TR-5 contains uncharacterized waste that has levels of radioactivity that could potentially cause adverse health affects to human receptors and is addressed in the CMS. The nature (chemical and radiological) of the waste in TR-6 has not been determined and the risk associated with exposure to this waste is assumed *a priori* to be unacceptable and is addressed in the CMS (Section 4).

The uncertainties associated with the HRA are discussed in Section 3.4.

3.3 ECOLOGICAL RISK ASSESSMENT

The objective of this ERA was to evaluate potential risks to ecological receptors that may be exposed to site-related chemicals in surface- and mixed-interval soil in the waste-pile areas of SWMU-11. This objective was accomplished by: 1) formulating the CSM and identifying assessment endpoints; 2) analyzing ecological receptor exposures to, and the toxicity of, soil contaminants detected at the site; and 3) characterizing the potential hazards to ecological receptors.

The approach for conducting site-specific ERAs at DPG is described in the Risk Assumptions Document (Parsons, 2002a and 2002b). The analysis and risk characterization results from each site-specific ERA will support a risk-management decision regarding the need for a more detailed evaluation through the next level of ERA or implementation of corrective measures (if required).

The site-specific ERA for SWMU-11 was conducted in two sequential assessment tiers. Tier 1 serves as a screening-level assessment that uses site-specific data and conservative exposure assumptions to identify preliminary COPCs that pose an acceptable exposure situation and do not pose a hazard. Preliminary COPCs that do not pose a hazard in the Tier 1 evaluation are eliminated from further assessment.

Preliminary COPCs that "fail" the Tier 1 evaluation (that is, indicate a potentially unacceptable hazard to a receptor) are retained as "final COPCs" and are evaluated further in the Tier 2 Assessment. The Tier 2 assessment provides a more-refined analysis of potential effects on ecological receptor populations by incorporating additional site-specific information and more-realistic exposure assumptions. The Tier 1 and Tier 2 assessments are organized according to the following key elements of an ERA, which are adapted from USEPA (1997b and 1998) guidance: problem formulation, analysis, and risk characterization. The problem-formulation step is combined for the Tier 1 and Tier 2 assessments, while the analysis and risk characterization steps are evaluated separately.

3.3.1 Problem Formulation

The ERA problem formulation step included developing a CSM and defining the assessment endpoints, ecological receptors, and contaminants to be evaluated at the site. A site-specific CSM that identifies site-specific contaminant sources, affected media, representative receptors (i.e., assessment endpoints), and exposure pathways is presented on Figure 3.1. The assessment endpoints and representative receptors for use in all DPG ERAs were originally defined in the Risk Assumptions Document (Parsons, 2002a); for SWMU-specific ERAs, the representative receptors include the deer mouse and horned lark populations, and the terrestrial plant community.

The Risk Assumptions Document and Addenda (Parsons, 2002a and 2002b) indicate the terrestrial-plant community will be evaluated qualitatively, and quantitatively *if* applicable toxicological benchmarks are available. There are available effect-concentrations for plants (Efroymson et al., 1997), but these have high uncertainty associated with their relevance to the plant community observed at SWMU-11 or throughout DPG. The majority of phytotoxicity studies used to derive the screening-benchmarks are based on root or shoot lengths, root or shoot weights, harvestable biomass, or other productivity-related indices relevant to agricultural crops (e.g., soybean, barley, radish, lettuce, wheat, rye, etc.). Indeed, effect-concentrations for antimony, chromium, selenium, vanadium, and zinc are below the background comparison values for the DPG. Efroymson et al. (1997; page 1-2) comment "…if a benchmark is exceeded by background soil concentrations, it is generally safe to assume that the benchmark is a poor measure of risk to the plant community at the site." While

there are some benchmarks that are greater than the background comparison values, the relevance of a set of benchmarks derived from primarily agricultural crops is tenuous (at best). The productivity-related responses of agricultural crops grown in agricultural or greenhouse settings cannot be directly related to the high-desert conditions experienced by the plants growing on and near SWMU-11. The abiotic conditions (e.g., moisture regime, temperature, irradiance, climate, and site-specific soil conditions), the ecological characteristics of the DPG vegetative communities (i.e., how the communities respond to and interact with their high-desert environment), and the species-specific characteristics of the specific plants growing at SWMU-11 (e.g., nutrient requirements, tolerance, and adaptability to soil conditions) are far too different from the collective conditions used in the studies for the benchmark derivation to give the benchmarks relevance to site-specific vegetation. Despite the uncertainty associated with these toxicological benchmarks, the terrestrial-plant community will be evaluated quantitatively in the Tier 1 analysis. The Tier 1 Risk Description will also include a qualitative consideration of the uncertainty in conjunction with other available lines of evidence for characterizing hazard to plants.

The preliminary COPCs identified for evaluation at SWMU-11 are listed in Table 3.1. The representative wildlife receptors (see Section 3.1) and preliminary COPCs identified for SWMU-11 are quantitatively evaluated through the following Tier 1—and if warranted, Tier 2—analysis and risk characterization steps.

3.3.2 Tier 1 ERA Analysis and Risk Characterization

The Tier 1 ecological risk analysis and risk characterization are presented in this section. The analysis step includes an assessment of the potential pathways for exposures of receptors to preliminary COPCs and the potential toxicity of these preliminary COPCs to receptors. The risk characterization step presents risk estimates and describes the risk results. Supporting tables for wildlife receptors are provided in Appendix E (Tables ERA.1 through ERA.12).

3.3.2.1 Tier 1 Analysis

Tier 1 Exposure Assessment

As discussed in Section 2, soil samples were collected from multiple locations at SWMU-11. For the purposes of the Tier 1 (screening-level) ERA, direct exposure

pathways from these soil locations were assumed to be complete for all representative species identified for the site (i.e., deer mouse, horned lark, and the plant community [Section 3.1]). Therefore, exposures to maximum detected concentrations of preliminary COPCs in the mixed-soil interval (0-10 ft bgs) from the characterized portion of the site (see Table 3.1) were evaluated in the Tier 1 ERA.

Tier 1 exposure doses for each wildlife receptor and preliminary COPC were calculated using the Tier 1 algorithms and species-specific body weights, dietary composition, and food-ingestion rates presented in the Risk Assumptions Document (Parsons, 2002a). The following conservative exposure assumptions were used in estimating Tier 1 exposure doses for wildlife:

- One hundred-percent of the receptor's diet was assumed to contain the maximum concentration of each preliminary COPC detected in mixed soil (0-10 ft bgs).
- The minimum reported adult body weights and maximum total dietary intake rates for the terrestrial wildlife receptor species evaluated were used to maximize estimated intakes.
- The receptor foraging ranges were assumed to be equal to the size of the affected area of the SWMU (i.e., the area use factor [AUF] was equal to 1.0), ensuring 100-percent of the predicted exposure is from the affected area of the SWMU.
- The bioavailability of preliminary COPCs in soil is assumed to be 100-percent.

Tier 1 exposure doses are presented in the risk characterization section (Section 3.3.2.2), where they are also used in the estimation of potential ecological risk.

Tier 1 Effects Assessment

Chemical- and receptor-specific toxicity information was compiled from the literature and other sources in order to characterize the potential adverse (i.e., toxic) ecological effects of preliminary COPCs on the wildlife receptors (refer to Appendix E for literature citations). No-observed-adverse-effect-level (NOAEL)-based toxicity reference values (TRVs) were derived for use as measures of effect (Parsons, 2002a) and are indicative of a dose at or below which an individual contaminant is unlikely to cause adverse ecological effects (USEPA, 1997b). The purpose of using NOAEL-based TRVs is to indicate (by comparison with an estimated exposure dose) those receptor and exposure-pathway combinations that should be evaluated further. However, estimated exposure doses greater than NOAEL-based TRVs *do not* indicate that adverse effect

would be expected, because such TRVs are, by definition, "no-effect" levels. Receptor-specific NOAEL-based TRVs for the preliminary COPCs were derived for deer mice and horned larks (Appendix E, Tables ERA.1 and ERA.2).

For the plant-community receptor, there are limited data available with regards to established toxicity benchmarks for plant receptors. Available phytotoxicity benchmarks were derived for the Oak Ridge National Laboratory (Efroymson et al., 1997) and the Los Alamos National Laboratory (LANL, 2004), and are used herein. In addition, USEPA has provided an approach to developing soil-screening benchmarks (USEPA, 2005f) and has published soil plant screening levels for some chemicals (2005a,b,c,d,e), but only the published values (USEPA, 2005a,b,c,d,e) are used herein. Soil benchmarks for plants are provided in Table 3.10.

3.3.2.2 Tier 1 Risk Characterization

Risk characterization includes processes of risk estimation and risk description. The risk estimation process is the derivation of mathematical indices of the potential for ecological hazard(s); the risk description highlights the significant results of the Tier 1 risk estimation for wildlife receptors and provides the qualitative evaluation of the terrestrial-plant community as a representative receptor.

Tier 1 Risk Estimation

The Tier 1 risk-estimation step involved comparing the screening-level exposure doses (or concentrations) to the NOAEL-based TRVs (or soil-screening concentrations) in ratios referred to as screening-level hazard quotients (SLHQs). These values represent conservative indicators of the potential that adverse effects on the assessment endpoints could result from the estimated exposures to those receptors (USEPA, 1998).

Per USEPA (1997a), an SLHQ of one is considered to be the indicator threshold at or below which the contaminant alone is unlikely to cause adverse ecological effects. Exposure pathways for which the preliminary COPC and receptor combination have an SLHQ value less than or equal to one do not indicate a potential for adverse ecological effects, and are eliminated from further evaluation. Therefore, preliminary COPCs with SLHQs greater than one were retained, as "final COPCs," for further evaluation in Tier 2. The combinations of chemical- and receptor-specific screening-level exposure doses and

TRVs used to calculate Tier 1 SLHQs, along with the resulting Tier 1 SLHQs, are presented in detail for the wildlife receptors in Appendix E, Tables ERA.3 and ERA.4.

TABLE 3.10

EFFECTS-CHARACTERIZATION BENCHMARKS FOR PLANTS SWMU-11

DUGWAY PROVING GROUND, UTAH

Preliminary COPC[a/]	Soil-Screening Concentrations (mg/Kg soil dry weight)[a/]	
	Efroymson et al., 1997	Other Sources
Volatile Organics		
Styrene	**300**	
Toluene	**200**	
Polycyclic Aromatic Hydrocarbons (PAHs)		
Acenaphthene	**20**	
Inorganics		
Antimony	**5**	
Arsenic	10	**18** (USEPA, 2005b)
Barium	**500**	
Beryllium	**10**	
Boron	**0.5**	
Cadmium	4	**32** (USEPA, 2005c)
Chromium (Total)	**1**	
Copper	**100**	
Lead	50	**120** (USEPA, 2005e)
Mercury	**0.3**	
Molybdenum	**2**	
Silver	**2**	
Zinc	**50**	190 (USEPA, 2000b)
All other preliminary COPCs	**--**	--

[a/] COPC = Chemical of potential concern; mg COPC/Kg soil dry weight = Milligram COPC per kilogram soil dry weight.
Bold values indicate the selected benchmark value.

Available soil benchmarks, background concentrations, exposure concentrations, and SLHQs for the plant-community receptor are presented in Table 3.11.

For plants, site-related exposure concentrations exceeded available background concentrations (which is a defining characteristic of preliminary COPCs) and the available effect-concentrations (Table 3.11).

TABLE 3.11

EFFECT, BACKGROUND, AND EXPOSURE CONCENTRATIONS, AND SCREENING-LEVEL HAZARD QUOTIENTS FOR THE PLANT COMMUNITY SWMU-11

DUGWAY PROVING GROUND, UTAH

COPC[a/]	Effect Concentration[a/] (mg COPC / Kg soil dry weight)	Background Comparison Value[b/] (mg /Kg)	Exposure Concentration[c/] (mg/Kg)	Screening-Level Hazard Quotient[d/]
Volatile Organics				
Styrene	300	Not applicable	0.023	8E-05
Toluene	200	Not applicable	0.11	6E-04
Polycyclic Aromatic Hydrocarbons (PAHs)				
Acenaphthene	20	Not applicable	0.12	6E-03
Inorganics				
Antimony	5	10	1300	**3E+02**
Arsenic	18	13	73	**4E+00**
Barium	500	470	970	**2E+00**
Beryllium	10	1.1	24000	**2E+03**
Boron	0.5	Not available	58	**1E+02**
Cadmium	32	0.8	1.5	5E-02
Chromium (Total)	1	17	110	**1E+02**
Copper	100	20	140	1E+00
Lead	120	22	130	1E+00
Mercury	0.3	0.2	5.8	**2E+01**
Molybdenum	2	Not available	3.9	**2E+00**
Silver	2	Not available	1.1	6E-01
Zinc	50	67	2500	**5E+01**

a/ Taken from Table 3.1; only COPCs with phytotoxicity benchmarks are displayed.
b/ Refer to Appendix D.
c/ Taken from Table 3.1.
d/ Screening-level hazard quotients (SLHQs) were calculated as the ratio of the exposure concentration to the effect concentration.
A **bold** value indicates an SLHQ value greater than one.

Tier 1 Risk Description

The results of the Tier 1 risk estimation for wildlife receptors are summarized in Table 3.12. As shown in Table 3.12, several preliminary COPCs identified at SWMU-11 (e.g., 2,3,7,8-TCDD bird and mammal TEQs, antimony, arsenic, barium, beryllium, and boron) have SLHQs greater than one for one or more receptors, and were retained as final COPCs for evaluation in the Tier 2 assessment. Based on the SLHQs, not all retained chemicals are considered final COPCs for all receptors.

TABLE 3.12

SUMMARY OF TIER 1 SCREENING-LEVEL HAZARD QUOTIENTS FOR WILDLIFE RECEPTORS SWMU-11

DUGWAY PROVING GROUND, UTAH

Preliminary COPC[b/]	SLHQs for Representative Ecological Receptors[a/]	
	Deer Mouse	Horned Lark
Volatile Organics		
Acetone	1E-01	4E-02
Benzene	5E-04	No TRV
Ethylbenzene	1E-04	No TRV
2-Hexanone	6E-05	6E-03
Methyl Ethyl Ketone	3E-04	No TRV
Methyl Isobutyl Ketone	1E-04	No TRV
Styrene	5E-05	No TRV
Toluene	2E-04	No TRV
o-Xylene	5E-05	7E-04
m,p-Xylenes	9E-05	1E-03
Semivolatile Organics		
Benzyl alcohol	7E-04	2E-01
Dibenzofuran	No TRV	No TRV
Explosives		
Nitroglycerin	6E-02	No TRV
Dioxins and Furans		
2,3,7,8-TCDD TEC (birds)	No TRV	**4E+01**
2,3,7,8-TCDD TEC (mammals)	**2E+02**	No TRV
Polycyclic Aromatic Hydrocarbons (PAHs)		
Acenaphthene	8E-04	7E-04
Acenaphthylene	4E-03	4E-03
Fluoranthene	3E-04	6E-04
2-Methylnaphthalene	8E-04	2E-03
Naphthalene	3E-04	3E-04
Phenanthrene	1E-02	1E-03
Pyrene	8E-04	1E-03
Inorganics		
Antimony	**2E+03**	No TRV
Arsenic	**4E+00**	**5E+01**
Barium	**8E+00**	**5E+01**
Beryllium	**3E+02**	No TRV
Boron	8E-01	1E+00
Cadmium	2E-01	7E-01
Chromium (Total)	3E-02	**7E+01**
Copper	7E-01	**6E+00**
Lead	**6E+00**	**8E+01**
Mercury	2E-01	**1E+01**

TABLE 3.12 (CONTINUED)

SUMMARY OF TIER 1 SCREENING-LEVEL HAZARD QUOTIENTS FOR WILDLIFE RECEPTORS SWMU-11

DUGWAY PROVING GROUND, UTAH

Preliminary COPC[b/]	SLHQs for Representative Ecological Receptors[a/]	
	Deer Mouse	Horned Lark
Molybdenum	**3E+00**	4E-01
Silver	9E-03	1E-01
Zinc	**6E+00**	**5E+00**

[a/] Screening-level hazard quotients (SLHQs) were calculated as the ratio of the Tier 1 exposure dose to theTier 1 toxicity reference value. A bold value indicates an SLHQ greater than one; the associated compound will be retained as a receptor-specific final COPC in the Tier 2 ERA.

[b/] Preliminary COPC = Preliminary chemical of potential concern (Section 3.3.2.1).

For the terrestrial-plant community, potential site-related analytes (the preliminary COPCs) are by definition either: 1) indicative of the presence of anthropogenic organic compounds; or 2) indicative of inorganics at concentrations which exceeded available background concentrations. There are available toxicological data for evaluating site-related concentrations, but the toxicity data have a very high level of uncertainty; the quantitative results (screening-level hazard quotients, SLHQs) are presented in Table 3.11. Several of the SLHQs are greater than one, indicating some exposure concentrations exceed effect concentrations for (primarily) agricultural crops.

Based on the visual observations made and a review of the available site-specific data collected during the RFI, past waste-disposal activities have had an impact on plant growth and survival at the site. However, because of slow re-colonization of disturbed areas by native plants in arid environments, the physical disruption of the plant ecology caused by excavation, backfilling, and vehicle movement (i.e., by physical stressors) has resulted in decreased plant cover in localized spots at the site relative to surrounding undisturbed areas. Although backfill trenches TR-5 and TR-6 (for example) and some other areas have less vegetative cover, the surrounding landscape (in areas where physical disruption is not evident) also exhibits a patchy landform, with small open areas devoid of vegetation that, in the absence of any stained soil or other visual clues, appear identical to on-site nonvegetated areas. Qualitatively, the available information is insufficient to distinguish among ecological succession, physical disruption, chemical

presence, or ecological variability as potential influences on the terrestrial-plant community at SWMU-11.

Vegetation at SWMU-11, although identified as a representative receptor, is not expected to be a target of environmental-management objectives, and is unlikely to be a driver for the CMS. That is, this site does support vegetation that can play an ecological role in primary productivity and serve as food or cover habitat for animals. However, the vegetation at this site is not unique, nor does the setting provide an important vegetation resource relative to the expanse of the surrounding landscape. Therefore, vegetation will not be considered further as a representative receptor, but *will be retained* as a critical food-web component for the Tier 2 evaluation of wildlife receptors.

3.3.2.3 Tier 1 Conclusions: Final COPCs

Based on SLHQs less than or equal to one, or other lines of evidence, the following combinations of preliminary COPC and receptors are eliminated from further consideration:

- All preliminary COPCs (plants).
- Acetone, benzene, ethylbenzene, 2-hexanone, methyl ethyl ketone, methyl isobutyl ketone, styrene, toluene, o-xylene, m,p-xylenes, benzyl alcohol, dibenzofuran, nitroglycerin, acenaphthene, acenaphthylene, fluoranthene, 2-methylnaphthalene, naphthalene, phenanthrene, pyrene, boron, cadmium, chromium (total), copper, mercury, and silver (deer mouse).
- Acetone, benzene, ethylbenzene, 2-hexanone, methyl ethyl ketone, methyl isobutyl ketone, styrene, toluene, o-xylene, m,p-xylenes, benzyl alcohol, dibenzofuran, nitroglycerin, acenaphthene, acenaphthylene, fluoranthene, 2-methylnaphthalene, naphthalene, phenanthrene, pyrene, antimony, beryllium, boron, cadmium, molybdenum, and silver (horned lark).

The lack of effect benchmarks for plants, as well as the applicability of available benchmarks for conditions at DPG, will be addressed in the uncertainty section. The lack of TRVs for horned larks exposed to VOCs will also be discussed in Section 3.4.

Based on SLHQs greater than one, the following combinations of preliminary COPCs and receptors were retained for further evaluation in Tier 2 as the receptor-specific final COPCs:

- 2,3,7,8-TCDD TEQ, antimony, arsenic, barium, beryllium, lead, molybdenum, and zinc (deer mice); and

- 2,3,7,8-TCDD TEQ, arsenic, barium, chromium (total), copper, lead, mercury, and zinc (horned larks).

3.3.3 Tier 2 ERA Analysis and Risk Characterization

The Tier 2 analysis and Tier 2 risk characterization of the SWMU-11 ERA are presented in this section. Tier 2 provides a more-refined analysis of potential effects on receptor populations from exposure to the final COPCs in soil by incorporating additional site-specific information, more-realistic exposure assumptions for the selected receptors, and effect-based TRVs for evaluating potential adverse effects in *populations* of receptors. Only those receptor-specific preliminary COPCs retained after the Tier 1 ERA (i.e., the final COPCs; chemicals with bolded values in Table 3.12) were evaluated in the Tier 2 assessment.

3.3.3.1 Tier 2 Analysis

Tier 2 Exposure Assessment

Potentially complete exposure pathways were identified in the site-specific CSM (Section 3.1.1). Using the EPCs for the surface-soil and mixed-soil exposure intervals (Table 3.1), each of these potential ecological exposure pathways was quantitatively evaluated in the Tier 2 ERA.

Tier 2 exposure doses for each terrestrial wildlife receptor and final COPC were calculated using the Tier 2 algorithms and species-specific body weights, dietary composition (including incidental soil ingestion), and food-ingestion rates detailed in the Risk Assumptions Document (Parsons, 2002a). The Tier 2 exposure assumptions for terrestrial wildlife receptors included the use of average food ingestion rates and adult body weights. The receptors also were assigned site-specific AUFs, calculated as the ratio of the 3.4-acre affected area to each receptor's average foraging range.

Additional computations were made in the Tier 2 exposure-dose estimates to account for accumulation of final COPCs through the trophic levels utilized by the wildlife receptors (Parsons, 2002a). Tier 2 bioaccumulation factors were used to estimate exposure-point concentrations in representative food items (plants and invertebrates) for the receptors, as presented in Appendix E, Tables ERA.5 and ERA.6. The results of the Tier 2 exposure-dose calculations for wildlife receptors are presented in Appendix E,

Tables ERA.7 and ERA.8, and were used in the risk characterization section to estimate potential ecological hazards.

Tier 2 Effects Assessment

The Tier 2 effects assessment for wildlife involved compiling available chemical- and receptor-specific toxicity information and deriving lowest-observed-adverse-effect-level (LOAEL)-based TRVs to supplement the NOAEL-based TRVs derived for Tier 1. LOAEL-based TRVs (that is, *effect*-based TRVs) are necessary for making inferences about the potential occurrence of adverse ecological effects; hazard quotients (HQs) derived using NOAEL-based TRVs cannot be used to indicate effect, because such TRVs are, by definition, "no-effect" levels. LOAEL-based TRVs calculated for deer mice and horned larks for all final COPCs are presented in Appendix E, Tables ERA.9 and ERA.10.

3.3.3.2 Tier 2 Risk Characterization

Tier 2 risk characterization includes processes of risk estimation (using NOAEL- and LOAEL-based TRVs) and risk description. The risk estimation process is the derivation of mathematical indices (HQs and HIs); the risk description integrates the risk estimate values with other lines of evidence to provide context to the overall risk-assessment results.

Tier 2 Risk Estimation

The Tier 2 risk-estimation step involved comparing the Tier 2 exposure dose with NOAEL- and LOAEL-based TRVs to develop NOAEL- and LOAEL-based HQs. The chemical- and receptor-specific exposure doses and NOAEL- and LOAEL-based TRVs used to calculate Tier 2 HQs, along with the resulting Tier 2 NOAEL- and LOAEL-based HQs, are presented in Appendix E, Tables ERA.11 and ERA.12. These results are summarized in Table 3.13.

TABLE 3.13

HAZARD QUOTIENTS AND HAZARD INDICES FOR WILDLIFE RECEPTORS SWMU-11

Preliminary COPC[a/]	Deer Mice		Horned Larks	
	NOAEL HQ[b/]	LOAEL HQ[b/]	NOAEL HQ	LOAEL HQ
Dioxins and Furans				
2,3,7,8-TCDD TEQ (birds)	Not a receptor-specific COPC		7E-02	7E-03
2,3,7,8-TCDD TEQ (mammals)	2E-01	2E-02	Not a receptor-specific COPC	
Inorganics				
Antimony	**3E+01**	**5E+00**	Not a receptor-specific COPC	
Arsenic	7E-03	2E-03	7E-02	2E-02
Barium	8E-02	5E-02	4E-01	1E-01
Beryllium	3E-01	6E-02	Not a receptor-specific COPC	
Chromium (Total)	Not a receptor-specific COPC		9E-02	2E-02
Copper	Not a receptor-specific COPC		9E-02	7E-02
Lead	4E-02	4E-03	4E-01	4E-02
Mercury	Not a receptor-specific COPC		3E-01	1E-01
Molybdenum	2E-01	5E-02	Not a receptor-specific COPC	
Zinc	1E-01	3E-02	7E-02	1E-02
LOAEL $HI_{Reproduction}$[c/]	--	8E-02	--	2E-01

a/ Final COPC = Chemical of potential concern for the Tier 2 assessment.
b/ HQ = Hazard quotient; NOAEL = no-observed-adverse-effect level; LOAEL = lowest-observed-adverse-effect level. A bold value indicates an HQ greater than one.
c/ HI = Hazard index; a sum of the HQs for receptor-specific COPCs that elicit adverse reproductive effects:
deer mice: 2,3,7,8-TCDD TEQ, lead, and molybdenum; and
horned larks: 2,3,7,8-TCDD TEQ, chromium (total), lead, mercury, and zinc.

In the absence of special-status species as receptors, the focus of ecological risk assessment is on populations of receptor species. Adverse reproductive effects potentially caused by exposures to COPCs have, in the absence of overt acute toxicity, an obvious potential for affecting receptor populations over time. For those final COPCs that have reproduction-related endpoints, the effect-based (i.e., LOAEL-based) HQs can be summed to generate an HI for reproductive effects ($HI_{Reproduction}$) as a potential indicator of cumulative effects (Parsons, 2002a,b). NOAEL-based HQs should not be summed to generate HIs, as a summation of HQs based on no-effect doses is a summation that does not result in a biologically meaningful index. Based on the specifications of toxicological endpoints (see Appendix E, Tables ERA.9 and ERA.10), the $HI_{Reproduction}$ for the deer mouse population is based on the summation of HQs for 2,3,7,8-TCDD TEQ (mammal), lead, and molybdenum, while the $HI_{Reproduction}$ for the horned lark population is based on

the summation of HQs for 2,3,7,8-TCDD TEQ (bird), chromium (total), lead, mercury, and zinc. HIs ensure that the potential for additive effects to a common endpoint from the final COPCs were addressed. HQs and HIs are summarized in Table 3.13.

Tier 2 Risk Description

The risk description step involves summarizing and interpreting Tier 2 risk estimates in context with other available lines of evidence. Parallel to the logic used in Tier 1 risk characterization, a Tier 2 NOAEL-based HQ of one is an indicator threshold at or below which the contaminant is unlikely to cause adverse ecological effects. Exposure pathways for which the final COPC and receptor combination have a Tier 2 NOAEL-based HQ value less than or equal to one do not indicate a site-specific potential for adverse ecological effects and are eliminated from further evaluation. A Tier 2 NOAEL-based HQ that is greater than one indicates that the estimated site-specific exposure exceeds a no-effect dose. Tier 2 NOAEL-based HQs are greater than one for estimated exposures of the deer mouse population to antimony. Therefore, antimony is the only final COPCs that should be evaluated further to characterize the likelihood of adverse effects in ecological receptors using effect-based TRVs.

Effect (LOAEL)-based HQs or HIs better indicate the potential for adverse effects on receptors because of the reliance on effect-based toxicological data. In addition, the consideration of Tier 2 LOAEL-based HQs is appropriate for SWMU-11 because the representative receptors are not endangered or threatened, and LOAELs better reflect potential population-level (rather than individual-organism) responses (USEPA Region 8, 1997). Final COPCs with a LOAEL-based HQ greater than one are then considered in light of other lines of evidence (e.g., see Parsons, 2002a and 2002b) to provide a more-detailed context in which to interpret the risk estimates. The lines of evidence are used to supplement the quantitative results to determine if there are any preliminary COCs at a given site. COCs then become the focus of the CMS (Section 4).

The first line of evidence for risk description involves interpretation of the value of the HQs or HIs. As discussed in the Risk Assumptions Document (Parsons, 2002a), Menzie et al. (1993) early in the historical development of formalized processes for ERA recommended the following guidelines for interpreting HQs or HIs:

- Adverse effects (to populations of receptors) are not expected for HQ or HI values less than one.
- A low potential for adverse effects may be indicated by HQ or HI values between one and 10.
- A significant potential for adverse effects on ecological receptors and biological communities may be indicated by HQ or HI values greater than 10, particularly if they exceed a value of 100.

These initial categorizations were an approach for interpreting the mathematical results developed in quantitative ERAs. However, quantitative ERAs often produce HQs with mathematical values greatly exceeding one (see, for example, Tannenbaum et al., 2003), but such a mathematical result does not necessarily indicate that adverse effects would be expected or would occur (see, for example, Tannenbaum, 2003). An HQ is a derived value that integrates a host of assumptions about exposures and toxicity; if any of those assumptions do not completely apply to the site-specific conditions, then the mathematical HQ might not reflect a realistic likelihood of adverse effects to the assessment endpoint. In addition, there may be other site-specific ecological conditions (i.e., lines of evidence) which further support conclusions about the likely presence, or absence, of chemical hazards to ecological receptors. In fact, the norm (not the exception) may be that healthy, sustained populations of a variety of avian and mammalian wildlife are present at areas with a long history of contamination and with no documented "population-level" effects, despite various HQs "greater than one" (e.g., Tannenbaum, 2003). Nevertheless, the derivation of HQ values can be a tool useful during risk-management decision-making processes, provided their interpretation is placed in an ecological context.

Nearly all the LOAEL-based Tier 2 HQs and both $HI_{Reproduction}$ values are less than one for estimated exposures of populations of deer mice or horned larks to final COPCs. The only LOAEL-based Tier 2 HQ exceedance of one is for exposure of deer mice to antimony. However, the likely hazard would be under the threshold value based the distribution of antimony is soil. Antimony was detected in ten of thirty samples; however, all but one of the detected concentrations were well below the background comparison value (10 mg/Kg-dry weight of antimony in soil). Antimony was measured at 1300 mg/Kg at location EP06, the remaining nine detected concentrations ranged from

0.058 to 1.3 mg/Kg. The area represented by EP06, where the single elevated antimony concentration in soil is located, is 161 ft^2 (approximately 0.004 acre). This area is approximately two orders of magnitude less than the average foraging area of a single deer mouse (0.3 acre). The likelihood that any individual deer mouse would forage exclusively in this small parcel is unlikely; furthermore, the likelihood that a population of deer mice would forage in the area of elevated antimony in soil enough to have appreciable exposure is even less likely. The relatively low HQ for antimony exposures to deer mice, in addition to these lines of evidence, demonstrate that antimony in soil is not likely to impact populations of deer mice at SWMU-11. Therefore, antimony is eliminated as an ecological COC.

In conclusion, concentrations of inorganic final COPCs (including antimony) are not expected to pose unacceptable hazards to small mammal and bird populations that may utilize SWMU-11 during some of their foraging activities. Remedial strategies, therefore, do not need to further consider characterized soils to ensure protection of ecological resources. It is assumed *a priori* that unacceptable hazards from potential exposures of ecological receptors to the uncharacterized surface soil, subsurface soil, and buried waste in TR-5 and unidentified buried waste and uncharacterized surface soil in TR-6 (including exposures to radiological wastes) are present. Prevention of exposures to these uncharacterized and unidentified materials in TR-5 and TR-6 by ecological receptors will need to be addressed in the CMS. Radiological risks to ecological receptors from potential exposures to soils in the remainder of the site are not expected based on estimated exposures less than the USDOE (2002) screening level of 1 mGy/d (36.5 mrem/yr) for terrestrial animals (Appendix F).

3.4 UNCERTAINTIES ASSOCIATED WITH THE HRA AND ERA

All risk assessments involve the use of assumptions, professional judgment, and imperfect data to varying degrees, which results in uncertainty in the final estimates of hazard and risk. The overall uncertainties associated with the DPG HRAs and ERAs are evaluated qualitatively in the Risk Assumptions Document (Parsons, 2002a). Site-specific uncertainties associated with the SWMU-11 HRA and ERA are reviewed in this subsection:

Site Characterization

- The soil sampling data may not fully represent the distribution of contamination in the evaluated site exposure area, which could result in underestimation or overestimation of potential risks and hazards from identified chemicals in the affected media. Six surface soil samples and 30 mixed-interval soil samples were collected from the receptor exposure areas at this site. The use of maximum detected concentrations of most preliminary COPCs as the EPCs in the HRA and ERA results in conservative exposure estimates for the range of concentrations observed. Therefore, it is unlikely that the potential for deleterious levels of contaminants is underestimated for the site conditions represented by the data, and exposure is more likely to have been overestimated through the use of maximum concentrations.

- CWA compounds were not detected at this site and they were not included in the method detection sensitivity table in Appendix C. Although the Dugway laboratory MDLs are higher than the calculated residential PRGs for CWA (U.S. Army Center for Health Promotion and Preventive Medicine [CHPPM], 1999). Section 2b of Appendix A of Module IV of the Dugway Part B Permit recognizes that the detection limit for CWA compounds is technology driven. The MDLs provided by the DPG laboratory at the time of the RFI Phase II Work Plan development were reviewed and approved as being the lowest levels that could be reliably achieved. This referenced portion of the Permit further states that Soil Protection Standard for "agent free concentration levels" for CWAs are the MDLs. In addition, CWA compounds are rapidly decomposed by hydrolysis, forming much less toxic ABPs. It is reasonable to expect that residual low concentration levels of CWA (concentrations between USACHPPM calculated PRGs and the MDLs) in soils would be identified by the detection of associated ABPs. ABPs were analyzed for and were not detected above their detection level, indicating that it is unlikely that CWAs are present at the site.

- Uncharacterized or unidentified buried wastes are present in TR-5 and TR-6, uncharacterized surface soil is present in both these site features, and uncharacterized subsurface soil is present in TR-5. The magnitude of the potential risks or hazards that these uncharacterized and unidentified materials may pose is unknown. Risks and hazards from inhalation of VOCs volatilized into outdoor air from uncharacterized subsurface soils could not be quantified, but in the absence of other data, are assumed to be unacceptable for TR-5. Similarly, potential risks from the reentrainment/emission of particulates from uncharacterized surface soils could also not be quantified, but is assumed to be unacceptable for TR-5 and TR-6 in the absence of other data.

- Quantitative ERA for populations of receptors at SWMU-11 is ecologically conservative. SWMU-11 contains a relatively small affected area (3.4 acres) and is unlikely to support substantial numbers of individual wildlife receptors (based

on foraging ranges of 0.3 acre for a deer mouse and 4 acres for a horned lark; Parsons, 2002a). In addition, habitat quality is assumed to be uniformly suitable across the SWMU and in essence, equivalent to the habitat quality of the surrounding unaffected areas. In general likelihood, the disturbed conditions present at SWMU-11 reduce the habitat quality of the affected area.

Exposure Characterization

- The Tier 1 and Tier 2 exposure estimates in the ERA incorporate an assumption of 100-percent bioavailability of the COPC in the ingested medium. For Tier 1, this is a justifiably conservative (protective) assumption, but for Tier 2, this would result in an over-estimation of exposure (erring on the side of protection of ecological resources). Actual absorbed doses are expected to be less than these estimated exposure concentrations.
- Inhalation exposures of the wildlife receptors to VOCs were not estimated. In general, inhalation exposures are usually insignificant contributors to the overall chemical intake by surface-dwelling wildlife (with the majority coming from ingestion-related exposures). As the horned lark is a surface-inhabiting bird, any VOCs emanating from the surface soil would dilute significantly in the air above the SWMU; the deer mouse will den in burrows, but in the absence of a significant source of VOC contaminants, it is thought that inhalation exposures are relatively minor compared to ingestion exposures.

Toxicity Data

- Supplemental toxicity criteria (e.g., criteria that have been evaluated by USEPA, but that are not codified as "final" values in the Integrated Risk Information System [IRIS]) were used in the HRA for chemicals lacking USEPA IRIS toxicity criteria. Because the toxicity criteria have not been formally accepted by USEPA, there is uncertainty associated with these values, and therefore, with the risks calculated using these supplemental values. It is thought, however, that the quantitative use of supplemental values results in less overall uncertainty than does the complete absence of data in support of a qualitative evaluation.
- Surrogate and/or chemical-specific data were used to derive toxicity values for the analytes listed below. The toxicity data were not derived via traditional methods and may therefore introduce a limited amount of uncertainty. However, the quantitative use of "non-traditional" toxicity data results in less overall uncertainty than does the complete absence of data in support of a qualitative evaluation:
    - The PRG for acenaphthylene is based on the PRG for acenaphthene from the "soils" spreadsheet in USEPA Region 9 (2004). Residential Soil and Tap Water PRGs were not available for acenaphthylene because toxicity data are not available.

- The antimony oral RfD listed on Integrated Risk Information System (IRIS) has high uncertainty (USEPA, 2004a). Confidence in the study chosen to obtain the oral RfD is rated as low because, "only one species was used, only one dose level was used, no NOEL was determined, and gross pathology and histopathology were not well described" (USEPA, 2004a). Per USEPA (2004a), "Confidence in the data is low due to lack of adequate oral exposure investigations, resulting in low confidence of the oral RfD."
- The Residential noncancer PRG for cadmium was based on the assumption that a child exposed for six years is the most sensitive receptor. Studies indicate that chronic exposure to cadmium has the potential to result in renal tubular dysfunction (USEPA, 2004a). However, this effect is only observed after cadmium accumulates to a critical concentration of 200 µg/g in the kidney cortex (ATSDR, 1999a; Lauwerys, et al., 1993). Attainment of this critical level is a function of both the duration and intensity of exposure. It is highly unlikely that renal tubular dysfunction would occur after only 6 years of childhood exposure. Accordingly, a Residential PRG based on a 6-year exposure period is overly conservative (i.e., screening level risk estimates were overestimated).
- Total chromium is assumed to consist of CrVI:CrIII at a ratio of 1:6 (USEPA Region 9, 2004). PRGs for chromium (total) are based on unadjusted toxicity data from USEPA (2004a) and USEPA Region 9 (2004) methods (Parsons, 2002b).
- The Residential Soil PRG for lead was based on a pharmacokinetic model designed to predict blood lead levels for children between six months and 12 years of age. For more information on lead models used to estimate Residential and Industrial PRGs, refer to http://www.epa.gov/oerrpage/superfund/programs/lead/.
- The PRG and toxicity data for phenanthrene are based on the PRG and toxicity data for anthracene from the "soils" spreadsheet in USEPA Region 9 (2004). USEPA Region 9 (2004) Residential Soil and Tap Water PRGs were not available for phenanthrene because toxicity data are not available.
- The PRGs for xylenes (total) (USEPA Region 9, 2004) were used for m,p-xylenes. Residential Soil and Tap Water PRGs were not available for m,p-xylenes because toxicity data are not available.
- The PRG for xylenes (total) were used for o-xylene. Residential Soil and Tap Water PRGs were not available for o-xylene because toxicity data are not available.

- Available phytotoxicity benchmarks for the exposures of plants to COPCs have a very high degree of uncertainty associated with them, as they are based predominantly on productivity-related endpoints in agricultural species from non-

arid environments. Therefore, potential ecological effects in terrestrial vegetation resulting from the presence of COPCs in the soil at SWMU-11 can be evaluated quantitatively, but the comparisons lack value for interpretation. Although vegetation conditions at the site exhibit evidence of physical disruption, there are no visually-apparent indications that the plant community on-site differs substantively from adjacent off-site habitat. However, as there were relatively few preliminary COPCs and vegetation is not expected to serve as a key component for environmental-management decisions, this uncertainty is not expected to affect remedial decision-making. Vegetation was evaluated as an important component of food-web exposures for wildlife receptors.

- Phytotoxicity benchmarks for the exposures of plants to some organic constituents were not available, and potential ecological effects in terrestrial vegetation resulting from the presence of organic contaminants in the soil at SWMU-11 could not be evaluated. However, because vegetation is unlikely to serve as a key component for risk-management decisions, this uncertainty is not expected to affect remedial decision-making.
- Tier 1 toxicity values from chemical surrogates were used for some of the PAH TRVs for both deer mice and for horned larks. However, the use of quantitative data from chemical surrogates is thought to result in less overall uncertainty in ecological-risk characterization than would the absence of any quantitative value.
- There are no data for deriving TRVs for several of the preliminary COPCs, most notably lacking are toxicological data for avian receptors. The lack of a TRV generally leads to an underestimation of potential risk. For deer mice, one preliminary COPC lacks a TRV, while there are TRVs for the other 33 preliminary COPCs; for horned larks, there are 24 preliminary COPCs with TRVs and 10 preliminary COPCs that lack TRVs. Volatile organics constitute the chemical group with the fewest avian TRVs (only four of 10 preliminary COPCs). In general, inhalation would be expected to be the major route of exposure to volatile compounds, but inhalation is generally an insignificant contributor to the overall chemical intake by surface-dwelling wildlife (with the majority coming from ingestion-related exposures). As horned larks are surface-inhabiting birds, any VOCs emanating from the surface soil would dilute significantly in the air above the SWMU, although soil ingestion could occur. In the absence of a significant apparent source of VOC contaminants, it is thought that exposures are relatively minor, although the lack of TRVs (for VOCs and other preliminary COPCs) does result in an underestimate of potential hazard.

Risk Characterization

- Cumulative risk and hazard estimates for outdoor industrial receptors at did not include inhalation of VOCs volatilized from subsurface media. This presents limited uncertainty because significant cumulative risks and hazards are not

expected, since exposure and subsequent risks and hazards for an outdoor worker would be less than that of an indoor worker.

- The HQ (or HI) method carries intrinsic uncertainties, some shared between ERA and HRA, and others unique to ERA. Limitations of the method (Tannenbaum et al., 2003) include:
  - HQs (and HIs) are not measures of a potential hazard to ecological or human health, but only indicate if estimated exposure exceeds a particular toxicological value.
  - HQs (and HIs) generally lack population-level relevance, with HRA being directed towards a hypothetical individual in a sensitive sub-population, while ERA toxicity data are commonly based on responses of individuals in test populations despite populations of ecological receptors being the focus of assessment-endpoint specifications for ERAs (in the absence of special-status species).
  - HQ (and HI) values in HRA and ERA seemingly indicate a linear relationship (e.g., an HQ=100 appears to be 100-fold worse than an HQ=1), whereas the underlying toxicological relationships may not be linear.
  - Conservatism, assumptions, and uncertainties combine to produce HQs in ERAs that can be markedly greater than one for inorganic chemicals in soil present at naturally occurring "background" concentrations, independent of any contamination.
  - Conservatism, assumptions, and uncertainties (particularly the use of "uncertainty factors" in deriving proxy values for no-effect TRVs) can combine to produce highly elevated HQ values that reflect toxicologically implausible conditions (e.g., extant conditions could be interpreted to be acutely lethal with respect to chemical concentrations, yet habitat is present and occupied by organisms) (see also Tannenbaum, 2003).
- Although naturally occurring and ubiquitous anthropogenic sources of PAHs may have contributed to detectable site concentrations, background levels of PAHs were not established at DPG. Per the Risk Assumptions Document (Parsons, 2002a), all organics detected at this SWMU were retained as COPCs for analysis in the risk assessment (Section 3). This likely resulted in overestimating risks and hazards from exposure to PAHs. However, this presents a limited uncertainty since PAHs did not contribute significantly to cumulative risk and hazard estimates.
- Inhalation toxicity data (RfC and URF) were not available for acetone, acenaphthene, acenaphthylene, and phenanthrene. Therefore, cumulative risks and hazards for inhalation of VOCs volatilized from subsurface soil did not include risk and hazard estimates for these four COPCs. Acetone, a common laboratory contaminant, was detected in 13 out of 29 soil samples close to the MDL.

Phenanthrene, acenaphyhene, and acenaphthylene, SVOCs by Method SW8270C, and only considered VOCs based on USEPA Region 9 (2004) criteria; were detected in 4, 1, and 1 of 29 soil samples, respectively. Therefore, the uncertainty contributed by lack of these toxicity data is limited.

- Some combinations of chemicals may induce toxic effects in the same target organ(s) or on the same biological functions. Tier 2 HQs for all relevant COPCs were summed to generate reproductive-endpoint HIs to ensure the potential additive effects among these chemicals were addressed. Based on the HI results, and other lines of evidence, adverse effects on small mammal and songbird populations from exposure to combinations of chemicals in soils at SWMU-11 are unlikely.

3.5 CONCLUSIONS OF THE RISK ASSESSMENT

One of the steps of a Phase II RFI includes an evaluation of the risks associated with potential hazardous waste releases at a site. Direct sampling of the contents of TR-5 (including surface and subsurface soil) could not be conducted due to the presence of uncharacterized waste containing radioactive debris (Section 2.1); therefore, a risk assessment per UAC R315-101 (DSHW, 2001) was not completed for the potential buried wastes within TR-5, for surface or subsurface soil at this site feature, or for surface soil in TR-6, which was also uncharacterized. Additionally, the waste uncovered at TR-6 was unable to be identified. Potential risks and hazards associated with these uncharacterized and unidentified soils and waste are assumed *a priori* to be unacceptable based on the types of materials that may be present. Therefore, potential exposure to the uncharacterized and unidentified materials in TR-5 and TR-6 by all human receptors (including exposure to COPCs via potential emission/reentrainment and/or volatilization from uncharacterized surface [TR-5 and TR-6] and subsurface [TR-5] soils) and burrowing ecological receptors should be prevented. The potential presence of radioactive and/or unidentified debris and uncharacterized soils (Section 2) and the *a priori* assumption that potential risks and hazards associated with these materials are unacceptable will be addressed in the CMS Work Plan (Section 4).

Accounting for the *a priori* assumption that exposure to uncharacterized/unidentified wastes and/or uncharacterized soils at TR-5 and TR-6 should be avoided, the objectives of the HRA and ERA were to:

- Assess potential risks and hazards from exposure to contaminants in soils.

- Support development of either an NFA decision (if no unacceptable risks or hazards are identified), or of cleanup goals and remedial alternatives under a CMS task (if unacceptable risks or hazards are identified).

The first objective was met through tiered processes beginning with generic protective assumptions and progressing to the incorporation of increasingly site-specific data, realistic exposure scenarios, and refined assumptions about toxicity values. The results of the HRA performed per UAC R315-101 (DSHW, 2001) indicate that the site currently does not qualify for NFA under UAC R315-101 (DSHW, 2001) based on hypothetical residential land use. Soil-to-groundwater analysis indicates that future impacts to groundwater from COPCs in soil are not expected. However, there is one industrial soil COC (beryllium) that needs to be evaluated in the CMS. Cross-media cumulative risks and hazards from inhalation of COPCs volatilized from subsurface soil at SWMU-11 are not expected since the predicted risks and hazards associated with inhalation of subsurface soil VOCs volatilized into indoor air were an order of magnitude below the DSHW (2001) industrial target risk level of 1E-04 and HI of one. Based on a comparison of radiological data to background levels, generic NUREG-1757 Volume 2 soil screening levels, and other lines of evidence presented in Appendix F, trenches TR-1 through TR-4, the CONEX container and the soils within TR-6 meet the free release criteria for radiation at the site. The uncharacterized waste in TR-5 and the unidentified waste in TR-6 are assumed *a priori* to pose unacceptable risk from exposure to potential radioactive sources to human and ecological receptors and will be evaluated in the CMS. There are no preliminary COCs identified as potential hazards for populations of ecological receptors. Remedial or mitigation strategies to address risks and hazards associated with potential exposure to uncharacterized/unidentified soils and materials in TR-5 and TR-6 at SWMU-11 will be evaluated in the CMS (Section 4).

SECTION 4.0

CORRECTIVE MEASURES STUDY WORK PLAN

4.1 INTRODUCTION

Module IV-Corrective Action for SWMUs in the DPG RCRA Part B Permit requires investigation, and if necessary, corrective action at SWMUs (US Army, 2001a). A CMS will be conducted at SWMU-11 in accordance with the corrective action module of the Part B Permit due to: 1) the presence of beryllium in TR-1 through TR-3 at concentrations exceeding industrial-level risk estimates for potential intrusive site worker exposure to mixed-interval soil; and 2) uncharacterized or unidentified waste and soils in TR-5 and TR-6 which are assumed to pose *a priori* unacceptable risk to hypothetical intrusive and nonintrusive site workers and ecological receptors (including burrowing ecological receptors). SWMU-11 is a landfill formerly used for the disposal of radioactive waste, and uncharacterized and unidentified radioactive material is present in TR-5 and TR-6, respectively. Therefore to obtain closure in accordance with NRC requirements, the CMS for this site must demonstrate that the dose limits as defined in Code of Federal Regulations Title 10, Chapter 20 (10 CFR 20), and applicable state of Utah guidance (Rule R313-15) are met (Appendix F, Section F.2.2). The purpose of this CMS is to identify, evaluate, and select alternatives for corrective action to:

<u>TR-1 through TR-3</u>

- Address potential exposure to the beryllium industrial COC in TR-1 through TR-3.

<u>TR-5 and TR-6</u>

- Address potential exposure to uncharacterized or unidentified waste and soils in TR-5 and TR-6.
- Address potential exposure from reentrainment of particulates from uncharacterized surface soil in TR-5 and TR-6, and volatilization from uncharacterized subsurface soil in TR-5.
- Demonstrate that the dose limits as defined in Code of Federal Regulations Title 10, Chapter 20 (10 CFR 20), and applicable state of Utah guidance (Rule R313-15) are met for the radioactive material in TR-5 and TR-6.

The Army's objective in conducting this CMS is to protect human health and the environment during continued military use.

Corrective action at SWMU-11 will be conducted under actual land-use conditions (i.e., industrial scenario) in accordance with UAC R315-101, Cleanup Action and Risk-Based Closure Standards (DSHW, 2001). Future residential land use and building on the site is not expected, and land use will likely be restricted to activities consistent with an industrial closure as defined in UAC R315-101 (DSHW, 2001) due to: 1) the active status of the DPG installation; 2) the remote location; and 3) the base Summary Development Plan (AGEISS and HBA, 2000), which summarizes future property development at DPG.

4.1.1 Purpose and Scope of Work Plan

This work plan is the first step of the USEPA (1989c) CMS process of identifying, screening, selecting, and developing alternative(s) for containment, treatment, removal, and/or other remedial actions based on the site-specific objectives established for corrective action. Specifically this work plan includes: 1) a review of the site characterization results (Section 2) and risk assessment (Section 3) in order to develop corrective action objectives (CAOs); 2) the identification and screening of individual process option components of corrective measures technologies with respect to effectiveness, implementability, safety hazard, and cost criteria (USEPA, 1988a and 1997c); and 3) based on the results of the screening step, the selection of remedial alternatives, which include the corrective actions necessary to ensure the safety of potential human receptors (and potential ecological receptors in the case of TR-5 and TR-6), and meet regulatory requirements.

4.1.2 CMS Report

A detailed analysis of the corrective action remedial alternatives proposed in this work plan will be conducted in the CMS Report using USEPA (1988a, 1989c, and 1997c) guidance. The report will include a cost estimate consisting of both capital and operation and maintenance (O&M) costs, and a detailed evaluation of each remedial alternative with respect to the following criteria established by the permit:

1. Technical – The alternatives will be evaluated based on performance, reliability, implementability, and safety.

A. Performance includes the effectiveness and useful life of the remedy. Any specific waste or site characteristics that could impede effectiveness will be considered. Each corrective measures alternative shall be evaluated in terms of the projected service lives of its component technologies.

B. Reliability measures the risk and effect of failure, and includes O&M requirements and their demonstrated effectiveness under similar conditions. Technologies requiring complex and frequent O&M should be regarded as less reliable than technologies requiring occasional or basic O&M. Demonstrated technologies are considered more reliable.

C. Implementability includes relative ease of installation (constructability) and the time required to achieve a given level of response. Constructability may include factors such as equipment availability, special permit requirements, location of existing facilities, and costs.

D. Safety considerations include threat to workers, nearby communities, and the environment during implementation.

2. Environmental – The environmental assessment will focus on facility conditions and the exposure pathways addressed by each alternative. The assessment will include the short- and long-term effects of corrective measures, effects on environmentally sensitive areas, and an analysis of measures to mitigate any adverse effects.

3. Human Health – Each alternative will be evaluated to determine the extent to which it mitigates short- and long-term potential exposure to any residual contamination and protects human health, both during and after implementation of the corrective measure.

4. Institutional – Each alternative will be evaluated to assess its compliance with federal and state regulations and standards.

4.2 REVIEW OF SITE CHARACTERIZATION

DPG has completed an RFI at SWMU-11, during which geophysical and radiological surveying was completed, and surface and subsurface soil samples were collected. The site has been identified as a former radioactive waste landfill.

Soil samples were collected for chemical analysis from five of the six burial features identified at the site (TR-1 through TR-4, and TR-6). Radiological field measurements collected after surficial soil was removed from TR-5 exceeded the stop

work limit; therefore, direct soil sampling and intrusive activities could not be conducted at this trench. Shallow bedrock precluded drilling angle borings to sample subsurface soil beneath the waste in TR-5. As such, in addition to the uncharacterized waste at TR-5, the overlying surface soil and underlying subsurface soil are also uncharacterized in the absence of samples collected for chemical analysis. A worst-case soil sample was collected for chemical analysis from TR-6 at 10 ft bgs; however, no surface soil samples were collected from this trench. Surface soil at TR-6 is therefore also uncharacterized in the absence of samples collected for chemical analysis. TR-6 contains various types of debris including small metal tubes which have low levels of radioactivity consistent with Cs-137, but which remain unidentified in the absence of conclusive radiological analyses. Although the waste in TR-6 was visually inspected and screened during test pit excavation, this material could not be fully identified. MS03, the representative sample of a metal tube, was not sent off-site for laboratory analysis due to uncertainties regarding the use of this item and the associated hazards. Since analytical results are not available to conclusively identify the metal tubes, the waste in TR-6 is classified as unidentified.

Surface soil samples were collected from worst-case locations in TR-1 through TR-4. None of the chemicals detected in surface soil at concentrations above (or without) background comparison values were also detected in excess of corresponding USEPA Region 9 (2004) Residential Soil PRGs. Therefore, surface soil at SWMU-11 has been adequately characterized, and additional sampling is not required (Section 2.2.3.1).

Subsurface soil samples were collected from worst-case locations in TR-1 through TR-4, TR-6, and adjacent soil borings SB01-SB04. Select inorganics greater than (or without) background comparison values and/or select dioxins/furans detected in subsurface soil samples from TR-1 through TR-4 and TR-6 also exceeded corresponding USEPA Region 9 (2004) Residential Soil PRGs. TPH, nitrocellulose, and 2-hexanone were also detected in subsurface soil; however, background comparison values or USEPA Region 9 (2004) Residential Soil PRGs are not available for these chemicals. Except where noted above, subsurface soil at SWMU-11 has been adequately characterized, and additional sampling is not required based on numerous lines of evidence (Section 2.2.3.2).

The radiological survey conducted at SWMU-11 targeted areas with the greatest potential for residual radioactive contamination (Appendix F), and the results indicated that there were three areas of elevated radiation based on a comparison with background and/or screening values. Two of these areas were associated with wastes that were present in TR-2 and TR-6; however, soils surrounding these materials did not exceed background radiation levels. The radioactive material in TR-2 was removed during sampling, and no additional radioactive material above background was observed in this feature. TR-6 contains various types of debris including small metal tubes which have low levels of radioactivity consistent with Cs-137 based on screening data, but which remain unidentified in the absence of conclusive radiological analyses. Therefore, the hazards associated with the tubes and other wastes at TR-6 have not been thoroughly assessed. The third area of elevated radiation was designated TR-5, and contained the relatively highest radiation levels measured during the survey. These levels exceeded stop work limits beneath surficial soils, preventing direct soil sampling and intrusive activities at this trench.

The results of the HRA performed per UAC R315-101 (DSHW, 2001) indicate that the site currently does not qualify for NFA based on hypothetical residential land use. Industrial-level risk estimates of exposures of potential intrusive site workers to mixed-interval soil identified beryllium as a COC in TR-1 through TR-3. The burn layer associated with TR-1 through TR-3 accounts for the majority (if not all) of the hazards associated with beryllium at the site. The maximum beryllium concentration detected at TR-4 is not expected to pose unacceptable risk to human health or the environment; therefore, remedial strategies associated with beryllium do not need to include TR-4 (Section 3.2.4).

The results of the ERA indicate that there are no preliminary COCs identified as potential hazards for populations of ecological receptors. Chemicals detected in characterized surface and subsurface soils are not expected to impact groundwater significantly in the future based on the results of the soil-to-groundwater analysis and various lines of evidence presented in Section 3.1.6.

The potential hazards to human and ecological receptors associated with the uncharacterized surface soil, subsurface soil, and waste in TR-5, and the unidentified

waste and uncharacterized surface soil in TR-6 are assumed to be *a priori* unacceptable. All other areas of SWMU-11 are considered to be adequately characterized with respect to radiological and/or chemical constituents, and further investigation is not required.

4.3 CORRECTIVE ACTION OBJECTIVES

Two CAOs were developed for SWMU-11. The first CAO was developed to address beryllium, identified as an industrial COC in the mixed-interval soil in TR-1 through TR-3. The second CAO was developed to address the uncharacterized surface soil, subsurface soil, and waste in TR-5, and the unidentified waste and uncharacterized surface soil in TR-6.

Industrial quantitative protection or media cleanup standards were not established for the uncharacterized surface soil, subsurface soil, and waste in TR-5, and the unidentified waste and uncharacterized surface soil in TR-6, because the risks associated with these materials are unknown. Any quantitative standards that may be required associated with remedial options to address the beryllium industrial COC will be developed in the CMS Report. The qualitative CAOs are as follows:

1. Prevent exposure to the industrial COC: Specific goals include preventing intrusive site worker exposure to the beryllium industrial COC in TR-1 through TR-3.
2. Prevent exposure to the uncharacterized and unidentified material and satisfy NRC closure requirements for radioactive material: Specific goals include: 1) preventing intrusive and nonintrusive site workers and ecological receptors (including burrowing ecological receptors) from accidental contact with the uncharacterized surface soil, subsurface soil, and waste in TR-5, and the unidentified waste and uncharacterized surface soil in TR-6; 2) physically minimizing or eliminating the potential risks associated with inhalation of VOCs volatilized from uncharacterized TR-5 subsurface soils, and reentrainment of particulates from uncharacterized TR-5 and TR-6 surface soils; and 3) demonstrating that the dose limits as defined in Code of Federal Regulations Title 10, Chapter 20 (10 CFR 20), and applicable state of Utah guidance (Rule R313-15) are met for the radioactive material in TR-5 and TR-6.

4.4 SCREENING OF CORRECTIVE MEASURES TECHNOLOGIES

Based on site information and the CAOs presented in the previous sections, a range of response actions and associated technologies was identified to provide potential remedies or components of remedial alternatives for SWMU-11. Potential corrective

measures considered in the screening process were evaluated with respect to the following factors:

- Effectiveness in satisfying the CAOs
- Technical implementability
- Safety hazard potential
- Cost

Technologies are presented and screened according to the site, contamination, and waste characteristics and the technology limitations criteria. A separate screening evaluation is presented for each CAO, since the CAOs address different hazards in geographically distinct areas of the site. Corrective measures alternatives are also identified separately for each CAO (Section 4.5).

4.4.1 Screening of Corrective Measures Technologies for the Industrial COC

Based on the screening information presented in Table 4.1, the following corrective measures technologies were evaluated for the CAO to prevent intrusive site worker exposure to the beryllium industrial COC in TR-1 through TR-3.

No Action

1. Natural Degradation: Dependent on the types of contaminants present and the physical environment within which they occur.

   Effectiveness - Low. The beryllium in TR-1 through TR-3 will not be degraded naturally.

   Implementability - High. No action is required.

   Safety Hazard - None.

   Costs - None.

   Reject - The No Action alternative was rejected since it does not satisfy the CAO.

Institutional Control

2. Access Restrictions - Fencing and Placards: Used to limit access and exposure.

TABLE 4.1
EVALUATION OF PROCESS OPTIONS FOR BERYLLIUM INDUSTRIAL COC AT SWMU-11

DUGWAY PROVING GROUND, UTAH

Corrective Measure Technology	Technology Type	Process Option	Effectiveness	Implementability	Safety Hazard	Cost	Comments	Retain/ Reject
No Action	Natural Degradation	Not Applicable	Low	High	None	None	Not effective. Does not satisfy CAO.	Reject
Institutional Control	Access Restrictions	Fencing and Placards	Moderate	High	Low	Low	Limits access. Low costs.	Retain
		Land Use Restrictions	Moderate	High	None	Low	Restricts access. Effective in combination with other process options.	Retain
Containment	Capping	Native Soil Cover	Moderate to High	Moderate	Moderate	Moderate	Limits access. Safety concerns.	Retain
		Geosynthetics and Soil Cover	Moderate to High	Low to Moderate	Moderate	Moderate to High	Also limits access. Higher costs. Safety concerns.	Retain
Buried Waste Removal	Excavation	Man-Operated Excavator	High	Moderate	Moderate to High	Moderate to High	Effective in eliminating COC. Significant safety concerns.	Retain
Disposal	Off-Site Disposal	Trucking	High	High	Low	Moderate	Limited based on types of hazardous wastes encountered.	Retain
	On-Site Disposal	Trucking	High	High	Low	Low	Limited based on types of non-hazardous wastes encountered.	Retain

Effectiveness - Moderate. The potential risk associated with the beryllium industrial COC requires access limitations. Fencing would limit access to human receptors.

Implementability - High. Fencing would not limit military activities at DPG.

Safety Hazard - Low.

Costs - Low.

Retain - This option was retained for further consideration due to effectiveness in reducing exposure to the beryllium industrial COC. This option alone does not completely satisfy the CAO, and would require land use restrictions.

3. Access Restrictions - Land Use Restrictions: Administrative measures to restrict activities that may be performed on the property, including installation of water supply wells. The Army is developing a site-wide land-use tracking program to identify future land use and restricted land use. This site and any identified restrictions would be tracked in the Army's database through this program.

Effectiveness - Moderate. This option does not physically protect intrusive site workers from being exposed to the beryllium industrial COC, but rather provides administrative action to restrict these activities.

Implementability - High. Requires only administrative action.

Safety Hazard - None.

Costs - Low.

Retain - This option was retained for further consideration in conjunction with other process options. This option alone does not satisfy the CAO.

Containment

4. Capping - Native Soil: Using native soil evaporative cover to prevent direct exposure to the beryllium industrial COC.

Effectiveness - Moderate to High. A native soil cover combined with other institutional controls (placards and/or fencing) will reduce the likelihood of exposure to the beryllium industrial COC.

Implementability - Moderate. This option is implementable, and required equipment is readily available.

Safety Hazard - Moderate. Installation of a native soil cover can be performed safely with the proper precautions and engineering controls.

Costs - Moderate. Soil cover material is available from DPG.

Retain - This option was retained for further consideration due to effectiveness in reducing exposure to the beryllium industrial COC. This option alone does not completely satisfy the CAO, and would require institutional controls.

5. Capping - Geosynthetics and Soil Cover: Using geosynthetics and an engineered soil cover to prevent direct exposure to the beryllium industrial COC.

Effectiveness - Moderate to High. Geosynthetics and engineered soil cover combined with other institutional controls (placards and/or fencing) will reduce the likelihood of direct exposure to the beryllium industrial COC.

Implementability - Low to Moderate. This option is implementable, but would require placement of a native soil grading layer prior to installing geosynthetics components to prevent rupture or tearing of materials.

Safety Hazard - Moderate. Installation of a geosynthetics and engineered soil cover can be performed safely with the proper precautions and engineering controls.

Costs - Moderate to High. Soil cover material is available from DPG, but geosynthetics materials would have to be imported.

Retain - This option was retained for further consideration due to effectiveness in reducing exposure to the beryllium industrial COC. This option alone does not completely satisfy the CAO, and would require institutional controls.

Buried Waste Removal

6. Waste Removal: Removal and proper disposal of waste (i.e., the burn layer) present in TR-1 through TR-3 will remove the potential for exposure to the beryllium industrial COC. Excavation of waste would be followed by confirmation sampling and backfilling. Waste disposal is addressed in a separate option.

Effectiveness - High. Excavation, backfilling, and confirmation sampling followed by proper the waste disposal is an effective option to permanently remove the burn layer in TR-1 through TR-3 which accounts for the majority (if not all) of the hazards associated with the beryllium COC at the site.

Implementability - Moderate. Removal of waste in TR-1 through TR-3 is implementable, and required equipment is readily available.

Safety Hazard - Moderate to High. Removal of waste in TR-1 through TR-3 can be performed safely with the proper precautions and engineering controls.

Costs - Moderate to High. Disposal and labor costs would be incurred.

Retain - This option was retained for further consideration in conjunction with the disposal process options due to high effectiveness in satisfying the CAO.

Disposal

The following disposal options are to be considered in conjunction with the buried waste removal option:

7. Off-site Land Disposal: Disposing of hazardous waste at a regulated landfill.
8. On-site Land Disposal: Disposing of non-hazardous materials at the DPG landfill.

Effectiveness (for Options 7 and 8) - High. Proper on-site and off-site disposal following excavation, collection, and segregation of buried waste will effectively eliminate risks posed by the beryllium industrial COC.

Implementability (for Options 7 and 8) - High. Off-site disposal of hazardous waste and on-site disposal of non-hazardous materials is readily implementable.

Safety Hazard (for Options 7 and 8) - Low. Off-site disposal of hazardous waste and on-site disposal of non-hazardous materials can be conducted with minimal safety concerns.

Costs (for Options 7 and 8) - Low to Moderate. Off-site disposal per unit cost would be relatively higher (moderate) relative to on-site disposal (low).

Retain - The on-site and off-site disposal options were retained for further consideration in conjunction with the buried waste removal option.

4.4.2 Screening of Corrective Measures Technologies for the Uncharacterized and Unidentified Materials

Based on the screening information presented in Table 4.2, the following corrective measures technologies were evaluated for the CAO to prevent intrusive and nonintrusive site workers and ecological receptors (including burrowing ecological receptors) from accidental contact with the uncharacterized surface soil, subsurface soil, and waste in TR-5, and the unidentified waste and uncharacterized surface soil in TR-6.

No Action

1. Natural Degradation: Dependent on the types of contaminants present and the physical environment within which they occur.

Effectiveness - Low. The identified radionuclides (i.e., Sr-90 and Cs-137) each have a radioactive half-life of around 30 years, so each will decay to negligible levels in approximately 300 years. However, additional longer-lived radionuclides may be present but not identified. In addition, the uncharacterized and unidentified materials present will not be degraded naturally.

Implementability - High. No action is required.

Safety Hazard - None.

Costs - None.

Reject - The No Action alternative was rejected since it does not satisfy the CAO.

Institutional Control

9. Access Restrictions - Fencing and Placards: Used to limit access and exposure. Prior to installation of any fencing and placards, additional review of site history and available historical documents (including licensing) would be necessary to

obtain more information regarding the types and amounts of radioactive waste potentially present within the restricted area.

Effectiveness - Moderate. The potential risk associated with the uncharacterized and unidentified materials, including the radioactive material, requires access limitations. Fencing would limit access to these materials by human receptors and minimize potential exposure to and subsequent risks from inhalation of VOCs volatilized from uncharacterized TR-5 subsurface soils, and reentrainment of particulates from uncharacterized TR-5 and TR-6 surface soils. Fencing would also limit access to some ecological receptors; however, other ecological receptors could potentially still access the waste.

Implementability - High. Fencing would not limit military activities at DPG.

Safety Hazard - Low.

Costs - Low.

Retain - This option was retained for further consideration in conjunction with other process options. This option alone does not satisfy the CAO.

10. Access Restrictions - Land Use Restrictions: Administrative measures to restrict activities that may be performed on the property, including installation of water supply wells. The Army is developing a site-wide land-use tracking program to identify future land use and restricted land use. This site and any identified restrictions would be tracked in the Army's database through this program.

    Effectiveness - Moderate. This option does not physically protect human receptors from being exposed to the uncharacterized and unidentified materials (including the radioactive material), nor does this option prevent exposure to and subsequent risks from inhalation of VOCs volatilized from uncharacterized TR-5 subsurface soils, and re-entrainment of particulates from uncharacterized TR-5 and TR-6 surface soils. Rather, this option provides administrative action to restrict these activities. This option would also not physically protect ecological receptors from being exposed to these materials.

TABLE 4.2
EVALUATION OF PROCESS OPTIONS FOR UNCHARACTERIZED AND UNIDENTIFIED MATERIALS AT SWMU-11

DUGWAY PROVING GROUND, UTAH

Corrective Measure Technology	Technology Type	Process Option	Effectiveness	Implementability	Safety Hazard	Cost	Comments	Retain/ Reject
No Action	Natural Degradation	Not Applicable	Low	High	None	None	Not effective for all materials. Does not satisfy CAO.	Reject
Institutional Control	Access Restrictions	Fencing and Placards	Moderate	High	Low	Low	Limits access. Low Costs. Effective in combination with other process options. Would require historical records review prior to implementation.	Retain
		Land Use Restrictions	Moderate	High	None	Low	Restricts access. Effective in combination with other process options.	Retain
Containment	Capping	Native Soil Cover	Moderate to High	Moderate	Moderate	Moderate	Limits access. Safety concerns. Would require historical records review prior to implementation.	Retain
		Geosynthetics and Soil Cover	Moderate to High	Low to Moderate	Moderate	Moderate to High	Also limits access. Higher costs. Safety concerns. Would require historical records review prior to implementation.	Retain
Removal of Uncharacterized and Unidentified Waste	Excavation	Man-Operated Excavator	High	Moderate	Moderate to High	Moderate to High	Effective in eliminating hazards. Significant safety concerns. Would require historical records review prior to implementation.	Retain
Disposal	Off-Site Disposal	Trucking	High	High	Moderate	High	Limited based on types of hazardous wastes encountered. Would require disposal of radioactive materials.	Retain
	On-Site Disposal	Trucking	High	High	Low	Low	Limited based on types of non-hazardous wastes encountered.	Retain

Implementability - High. Requires only administrative action.

Safety Hazard - None.

Costs - Low.

Retain - This option was retained for further consideration in conjunction with other process options. This option alone does not satisfy the CAO.

Containment

11. Capping - Native Soil: Using native soil evaporative cover to prevent exposure to the uncharacterized and unidentified materials; prevent potential exposure to and subsequent risks from inhalation of VOCs volatilized from uncharacterized TR-5 subsurface soils, and reentrainment of particulates from uncharacterized TR-5 and TR-6 surface soils; and meet radiological dose limits. Prior to any cap installation, additional review of site history and available historical documents (including licensing) would be necessary to obtain more information regarding the types and amounts of radioactive waste in the uncharacterized and unidentified materials that would be capped. Following any cap installation, confirmation radiological surveys and/or sampling would also be required to demonstrate compliance with the appropriate dose limits.

    Effectiveness - Moderate to High. A native soil cover combined with other institutional controls (placards and/or fencing) will reduce the likelihood of exposure to the uncharacterized and unidentified materials and potential exposure to and subsequent risks from inhalation of VOCs volatilized from uncharacterized TR-5 subsurface soils, and reentrainment of particulates from uncharacterized TR-5 and TR-6 surface soils. A native soil cover would also be an effective barrier to prevent direct exposure to radioactive material remaining in TR-5 and TR-6.

    Implementability - Moderate. This option is implementable, but may require special equipment and procedures due to the safety concerns related to radiation levels potentially present.

    Safety Hazard - Moderate. Elevated radiation levels are potentially present, and a risk evaluation would be required to determine the potential exposure of construction workers.

Costs - Moderate. Soil cover material is available from DPG. Additional costs are expected to alleviate safety concerns and conduct confirmation radiological surveys and/or sampling.

Retain - This option was retained for further consideration due to effectiveness in reducing exposure. This option alone does not completely satisfy the CAO, and would require institutional controls.

12. Capping - Geosynthetics and Soil Cover: Using geosynthetics and an engineered soil cover to prevent exposure to the uncharacterized and unidentified materials; prevent potential exposure to and subsequent risks from inhalation of VOCs volatilized from uncharacterized TR-5 subsurface soils, and re-entrainment of particulates from uncharacterized TR-5 and TR-6 surface soils; and meet radiological dose limits. Prior to any cap installation, additional review of site history and available historical documents (including licensing) would be necessary to obtain more information regarding the types and amounts of radioactive waste in the uncharacterized and unidentified materials that would be capped. Following any cap installation, confirmation radiological surveys, and/or sampling would also be required to demonstrate compliance with the appropriate dose limits.

Effectiveness - Moderate to High. Geosynthetics and engineered soil cover combined with other institutional controls (placards and/or fencing) will reduce the likelihood of direct exposure to the uncharacterized and unidentified materials and potential exposure to and subsequent risks from inhalation of VOCs volatilized from uncharacterized TR-5 subsurface soils, and re-entrainment of particulates from uncharacterized TR-5 and TR-6 surface soils. A geosynthetics and engineered soil cover would also be an effective barrier to prevent direct exposure to radioactive material remaining at TR-5 and TR-6.

Implementability - Low to Moderate. This option is implementable, but may require special equipment and procedures due to the safety concerns related to radiation levels potentially present.

Safety Hazard - Moderate. Elevated radiation levels are potentially present, and a risk evaluation would be required to determine the potential exposure of construction workers.

Costs - Moderate to High. Soil cover material is available from DPG, but geosynthetics materials would have to be imported. Additional costs are expected to alleviate safety concerns and conduct confirmation radiological surveys and/or sampling.

Retain - This option was retained for further consideration due to effectiveness in reducing exposure. This option alone does not completely satisfy the CAO, and would require institutional controls.

Removal of Uncharacterized and Unidentified Materials

13. Removal: Removal and proper disposal of the uncharacterized surface soil, subsurface soil, and waste in TR-5, and the unidentified waste and uncharacterized surface soil in TR-6 will remove the potential for exposure to these materials (including potential exposure to and subsequent risks from inhalation of VOCs volatilized from uncharacterized TR-5 subsurface soils, and reentrainment of particulates from uncharacterized TR-5 and TR-6 surface soils). Removal and proper disposal of these materials would also eliminate radioactive material in TR-5 and TR-6, and meet radiological dose limits. Waste disposal is addressed in a separate option. Prior to any removal, additional review of site history and available historical documents (including licensing) would be necessary to obtain more information regarding the types and amounts of radioactive waste in the uncharacterized and unidentified materials that would be removed. Excavation of waste would be followed by confirmation sampling (including required confirmation radiological surveys and/or sampling to demonstrate compliance with the appropriate dose limits) and backfilling.

Effectiveness - High. Excavation, backfilling, and confirmation sampling followed by proper disposal of excavated materials is an effective option to permanently remove the uncharacterized and/or unidentified waste and soil (including radioactive material).

Implementability - Moderate. Removal of these materials is implementable, but may require special equipment and procedures due to the safety concerns related to radiation levels potentially present.

Safety Hazard - Moderate to High. Elevated radiation levels are potentially present, and a risk evaluation would be required to determine the potential exposure of construction workers.

Costs - Moderate to High. Disposal and labor costs would be incurred. Additional costs are expected to alleviate safety concerns and conduct confirmation sampling (including confirmation radiological surveys and/or sampling).

Retain - This option was retained for further consideration in conjunction with the disposal process options due to high effectiveness in satisfying the CAO.

Disposal

The following disposal options are to be considered in conjunction with the removal option:

14. Off-site Land Disposal: Disposing of hazardous waste at a regulated landfill.
15. On-site Land Disposal: Disposing of non-hazardous materials at the DPG landfill.

Effectiveness (for Options 7 and 8) - High. Proper on-site and off-site disposal following excavation, collection, and segregation of uncharacterized and/or unidentified soil and waste (including radioactive material) will effectively eliminate risks these pose.

Implementability (for Options 7 and 8) - High. Off-site disposal of hazardous waste and on-site disposal of non-hazardous materials is readily implementable.

Safety Hazard (for Options 7 and 8) - Low to Moderate. On-site disposal of non-hazardous materials can be conducted with minimal safety concerns (low). Off-site disposal of hazardous waste may require additional safety precautions if radiation hazards are identified (moderate).

Costs (for Options 7 and 8) - Low to High. Off-site disposal per unit cost would be relatively higher (high) relative to on-site disposal (low).

Retain - The on-site and off-site disposal options were retained for further consideration in conjunction with the removal option.

4.5 IDENTIFICATION OF CORRECTIVE MEASURES ALTERNATIVES

Technologies identified and retained in the screening evaluation have been combined into remedial alternatives for corrective measures at this site.

4.5.1 Corrective Measures Alternatives for the Industrial COC

The nature of contamination, site characteristics, and limitations associated with technologies presented in Section 4.4.1 were considered in the development of the three remedial alternatives (Remedial Options 1, 2, and 3) presented below.

4.5.1.1 Remedial Option 1: Site Controls

- Site controls including site documentation, access restrictions, fencing, placards, and land-use restrictions to prohibit residential use of the site

4.5.1.2 Remedial Option 2: Landfill Cover

- Site controls including site documentation, access restrictions, fencing, placards, and land-use restrictions to prohibit residential use of the site
- Installation of an evaporative cover, a protective native soil layer, and vegetation

4.5.1.3 Remedial Option 3: Removal of Buried Waste

- Excavation of existing cover and removal of buried waste materials
- Segregation of excavated material
- Sampling and characterization of excavated material
- Transportation of hazardous waste to regulated off-site landfill or incinerator
- Transportation of non-hazardous waste to DPG landfill
- Confirmation sampling
- Backfilling of excavations with clean soils

4.5.2 Corrective Measures Alternatives for the Uncharacterized and Unidentified Materials

The nature of contamination, site characteristics, and limitations associated with technologies presented in Section 4.4.2 were considered in the development of the three remedial alternatives (Remedial Options 1, 2, and 3) presented below.

4.5.2.1 Remedial Option 1: Site Controls

- Additional review of site history and available historical documents (including licensing) to obtain more information regarding the types and amounts of radioactive waste in the uncharacterized and unidentified materials
- Site controls including site documentation, access restrictions, fencing, placards, and land-use restrictions to prohibit residential use of the site

4.5.2.2 Remedial Option 2: Landfill Cover

- Additional review of site history and available historical documents (including licensing) to obtain more information regarding the types and amounts of radioactive waste in the uncharacterized and unidentified materials
- Site controls including site documentation, access restrictions, fencing, placards, and land-use restrictions to prohibit residential use of the site
- Installation of an evaporative cover, a protective native soil layer, and vegetation
- Confirmation radiological surveys and/or sampling to demonstrate compliance with the appropriate dose limits

4.5.2.3.1 Remedial Option 3: Removal of Uncharacterized and Unidentified Materials

- Additional review of site history and available historical documents (including licensing) to obtain more information regarding the types and amounts of radioactive waste in the uncharacterized and unidentified materials
- Excavation and removal of uncharacterized and unidentified materials
- Segregation of excavated material
- Sampling and characterization of excavated material
- Transportation of hazardous waste to regulated off-site landfill or incinerator
- Transportation of non-hazardous waste to DPG landfill
- Confirmation sampling (including confirmation radiological surveys and/or sampling to demonstrate compliance with the appropriate dose limits)
- Backfilling of excavations with clean soils

The remedial alternatives proposed for corrective action at SWMU-11 will be evaluated in detail in the CMS Report, which will also include a cost estimate consisting of both the capital and O&M costs and development of the proposed corrective action for this site.

SECTION 5.0

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* Not all references cited here are used in this addendum. This is a comprehensive list of references used in Volume I of the Phase II RFI report and all SWMU addenda.