National Nuclear Security Administration
Sandia Site Office
P.O. Box 5400
Albuquerque, New Mexico 87185-5400

JUN 1 6 2005

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. James Bearzi, Bureau Chief
New Mexico Environment Department
Hazardous Waste Bureau
Permits Management Program
2905 Rodeo Park Road, Building 1
Santa Fe, NM 87505

RECEIVED
JUN 2005
NMED Hazardous Waste Bureau

Dear Mr. Bearzi:

On behalf of the Department of Energy (DOE) and Sandia Corporation, DOE is submitting a copy of the supplemental residential risk screening results for solid waste management units (SWMUs) 4, 5, 52, 233, and 234 identified as SWMUs under the Hazardous and Solid Waste Amendments Module of the Resource Conservation and Recovery Act (RCRA) Permit for Sandia National Laboratories, New Mexico (EPA ID No. NM5890110518).

SWMUs 4, 5 and 52 are part of the Liquid Waste Disposal System (LWDS) Operable Unit in Technical Area III/V. The original No Further Action (NFA) Proposals for SWMUs 4, 5, and 52 were submitted to the New Mexico Environment Department (NMED) as part of the RCRA Field Investigation (RFI) for the LWDS in September 1995. Additionally, a response was submitted to NMED in January 1998 and October 1998 to each of two separate Requests for Supplemental Information (RSIs) for SWMUs 4, 5 and 52. A third response to an RSI request was submitted to NMED in May 2001 for SWMU 52. In December 2002, supplemental RSI information was summarized and provided to NMED for SWMU 5.

SWMUs 233 and 234 are part of the Tijeras Arroyo Operable Unit. The original NFA proposals for SWMUs 233 and 234 were submitted to NMED in June 1995 as part of the Round 2 NFA submittals. Additionally, responses were submitted to NMED in October 1996, December 1999, and December 2000 for three separate RSIs.

The enclosed information updates the residential risk screening results for these five SWMUs to achieve consistency with the methodology currently used by the Sandia ER Project and is provided to the NMED to support a determination of Corrective Action Complete Without Controls for these five sites.

The Compliance Order on Consent (COOC) contains deliverable dates for Investigation Reports related to two of these sites: SWMU 4 by March 31, 2006; and SWMU 52 by September 30, 2004. For each of these sites, the previously submitted NFA proposals and RSI responses (referenced above) satisfy these deliverables as indicated by footnote 1 to Table XI-3 of the COOC. No further site-specific investigations have been undertaken at either of these SWMUs, eliminating the need

SNL1162

for additional investigation reporting. The information included with this submittal is limited to updated residential risk screening results using current methodology.

If you have any questions, please contact John Gould at (505) 845-6089.

Sincerely,

Patty Wagner for
Manager

Enclosures

cc w/enclosures:
W. Moats, NMED-HWB (via Certified Mail)
L. King, EPA, Region 6 (via Certified Mail)
M. Gardipe, NNSA/SC/ERD
J. Volkerding, DOE-NMED-OB
D. Pepe, NMED-OB, Santa Fe

cc w/o enclosures:
J. Estrada, SSO, MS 0184
F. Nimick, SNL, MS 1089
R. E. Fate, SNL, MS 1089
M. J. Davis, SNL, MS 1089
M. Nagy, SNL, MS 1089
D. Stockham, SNL, MS 1087
B. Langkopf, SNL, MS 1087
S. Griffith, SNL, MS 1087
A. Blumberg, SNL, MS 0141

CERTIFICATION STATEMENT FOR APPROVAL AND FINAL RELEASE OF DOCUMENTS

Document title: **Supplemental Risk Document for SWMUs 4, 5, 52, 233 and 234, May 2005**

Document author: **Mike Nagy, 6147 and Stacy Griffith, 6147**

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

Signature: Peter B. Davies 6/13/05

Peter B. Davies
Director
Geoscience & Environment Center
Division 6100
Sandia National Laboratories/New Mexico
Albuquerque, New Mexico 87185
Operator

Date

and

Signature: [illegible] for 6/15/05

Patty Wagner
Manager
U.S. Department of Energy
National Nuclear Security Administration
Sandia Site Office
Owner and Co-Operator

Date

LIBRARY COPY

Sandia National Laboratories/New Mexico Environmental Restoration Project

SUPPLEMENTAL RISK DOCUMENT FOR SWMUs 4, 5, 52, 233, and 234

June 2005

United States Department of Energy
Sandia Site Office

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

SNL1162

INTRODUCTION

The Environmental Restoration Project at Sandia National Laboratories/New Mexico (SNL/NM) is responsible for the investigation and remediation, as necessary, of solid waste management units (SWMUs) identified in the Hazardous and Solid Waste Amendments module of the Resource Conservation and Recovery Act (RCRA) permit. All activities under the RCRA permit, including the investigation and remediation of SWMUs, are regulated by the New Mexico Environment Department (NMED).

This supplemental risk document addresses five SWMUs (4, 5, 52, 233, and 234), which have been proposed for No Further Action (NFA) but are yet to be considered appropriate for NFA by the NMED. A brief site history and residential risk assessment analysis for SWMUs 5, 233 and 234, as well as comprehensive risk assessment reports for SWMUs 4 and 52 are included in this document. The reports for SWMUs 4 and 52 replace earlier risk assessments and provide human health risk assessments for both industrial and residential land-use scenarios as well as ecological risk assessments.

All of the risk assessments in this document were completed using a residential land-use scenario and risk guidance provided by the NMED in the "Technical Background Document for Development of Soil Screening Levels" (NMED December 2000). Appendix 1 in the reports for SWMUs 4 and 52 contains the SNL/NM default exposure pathways and input parameters. For SWMUs that exceeded NMED risk guidance levels, summary statistics (upper confidence limits [UCLs]) were calculated for the constituents that were primary contributors to the overall risk and are included as attachments in the individual reports. Standard U.S. Environmental Protection Agency guidance (EPA 1992) was used to calculate the UCLs.

In April 2003, the NMED requested that SNL/NM change its risk approach to include the dermal pathway for all land-use scenarios and to eliminate the food ingestion pathway for the residential land-use scenario.

In April 2004, the NMED issued the Compliance Order on Consent (Consent Order) (NMED April 2004) that resulted in another change related to the risk assessment process. The Consent Order replaced the "no further action" terminology by establishing two categories of sites for which corrective action is complete: Corrective Action Complete With Controls and Corrective Action Complete Without Controls.

The supplemental risk assessments in this document provide the basis for determining the appropriate category (Corrective Action Complete With Controls or Corrective Action Complete Without Controls) for each of the five SWMUs analyzed. Each of the SWMUs addressed in this document poses an insignificant risk to human health under the residential land-use scenario. Thus a Certificate of Completion is requested from the NMED, designating each of the SWMUs in this document as Corrective Action Complete Without Controls.

Additional information, including detailed descriptions of site location, history, characterization, confirmatory sampling events, and other related data, is contained in the NFA proposal, response to Request for Supplemental Information, or response to Notice of Deficiency documents for each SWMU. Supplemental information for each SWMU is identified in Table 1.

Table 1
Identification of Documents with Supplemental Information for Each
SNL/NM SWMU Proposed for Corrective Action Complete Without Controls

OU Name	OU	SWMU	NFA Date Submitted/Batch No.	Response to NOD or RSI Submittal Date
Liquid Waste Disposal System	1307	4	September 1995/ LWDS RFI Report	January 1998 and October 1998
Liquid Waste Disposal System	1307	5	September 1995/ LWDS RFI Report	January 1998, October 1998, and December 2002
Liquid Waste Disposal System	1307	52	September 1995/ LWDS RFI Report	January 1998, October 1998, and May 2001
Tijeras Arroyo	1309	233	June 1995/2	October 1996, December 1999, and December 2002
Tijeras Arroyo	1309	234	June 1995/2	October 1996, December 1999, and December 2002

LWDS = Liquid Waste Disposal System.
NFA = No Further Action.
NOD = Notice of Deficiency.
OU = Operable Unit.
RCRA = Resource Conservation and Recovery Act.
RFI = RCRA Facility Investigation.
RSI = Request for Supplemental Information.
SNL/NM = Sandia National Laboratories/New Mexico.
SWMU = Solid Waste Management Unit.

REFERENCES

EPA, see U.S. Environmental Protection Agency.

New Mexico Environment Department (NMED), December 2000. "Technical Background Document for Development of Soil Screening Levels," Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program, New Mexico Environment Department, Santa Fe, New Mexico. December 18, 2000.

New Mexico Environment Department (NMED), April 2004. "Compliance Order on Consent Pursuant to New Mexico Hazardous Waste Act § 74-4-10," New Mexico Environment Department, Santa Fe, New Mexico. April 29, 2004.

NMED, see New Mexico Environment Department.

U.S. Environmental Protection Agency (EPA), 1992. "Dermal Exposure Assessment: Principles and Applications," EPA/600/8-91/011B, Office of Research and Development, Washington, D.C.

Sandia National Laboratories/New Mexico Environmental Restoration Project

REVISED RESIDENTIAL RISK ASSESSMENT ANALYSES FOR SWMUs 5, 233, AND 234

June 2005

United States Department of Energy
Sandia Site Office

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

TABLE OF CONTENTS

1.0 SWMU 5: LIQUID WASTE DISPOSAL SYSTEM DRAINFIELD 1
- 1.1 Site Location and Operational History 1
- 1.2 Results of Risk Analysis 5

2.0 SWMU 233: STORM DRAIN SYSTEM OUTFALL 9
- 2.1 Site Location and Operational History 9
- 2.2 Results of Risk Analysis 13

3.0 SWMU 234: STORM DRAIN SYSTEM OUTFALL 16
- 3.1 Site Location and Operational History 17
- 3.2 Results of Risk Analysis 17

4.0 REFERENCES 25

APPENDIX 1 27

This page intentionally left blank.

LIST OF FIGURES

Figure

1 Location of SWMU 5, Boreholes, and Monitoring Well 3

2 Soil Sampling Locations for SWMU 233 11

3 Soil Sampling Locations for SWMU 234 19

LIST OF TABLES

Table

1 Human Health Risk Assessment Values for SWMU 5 Nonradiological COCs 6

2 Human Health Risk Assessment Values for SWMU 233 Nonradiological COCs 14

3 Human Health Risk Assessment Values for SWMU 234 Nonradiological COCs 21

4 Risk Assessment Values for SWMU 234 Nonradiological Background Constituents 23

This page intentionally left blank.

1.0 SWMU 5: LIQUID WASTE DISPOSAL SYSTEM DRAINFIELD

1.1 Site Location and Operational History

Solid Waste Management Unit (SWMU) 5, the Liquid Waste Disposal System (LWDS) drainfield at Sandia National Laboratories/New Mexico (SNL/NM), covers 0.11 acres and is located in Technical Area (TA)-V, operated by SNL/NM. TA-V is a fenced, secured research and testing area located in the northeast corner of TA-III. The site is paved and situated in a flat area west of Building 6580. The ground elevation at SWMU 5 is approximately 5,429 feet above mean sea level (amsl).

The LWDS was designed to receive, monitor, and discharge radioactive effluent from the Sandia Experimental Reactor Facility in TA-V. The LWDS consists of three holding tanks (SWMU 52), a drainfield (SWMU 5), and two surface impoundments (SWMU 4). The drainfield, also known as Tank 3 of the system, constructed of a concrete conduit filled with gravel, is buried approximately 30 feet below grade.

The drainfield was operational from 1963 to 1967. During this time, radioactive discharges were drained into the holding tanks, where they were monitored and then pumped to the drainfield. It is estimated that the drainfield received approximately 6.5 million gallons of discharge water. The discharge water washed away the soil near the drainfield. In 1967, the drainfield collapsed.

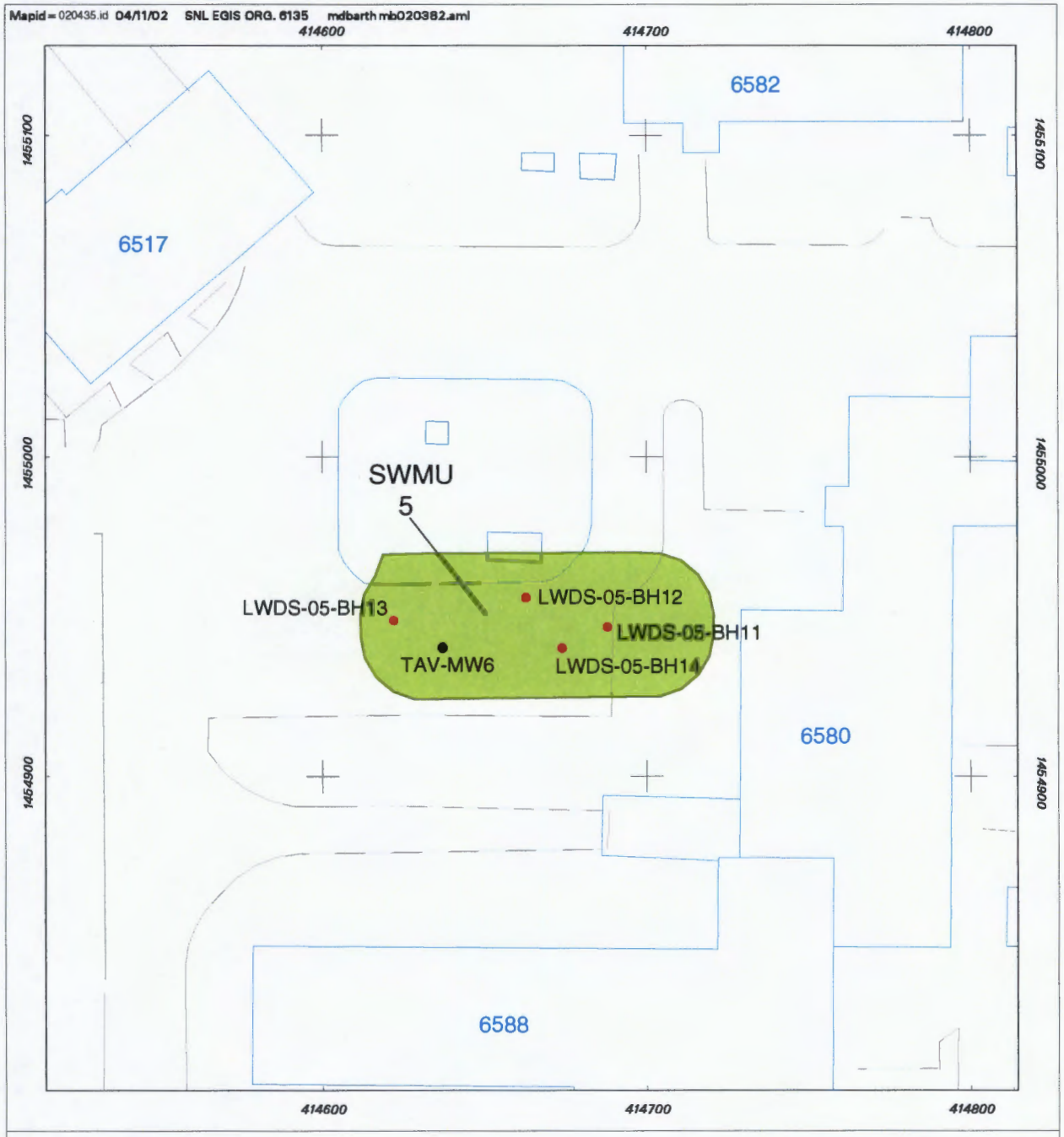
In May 1993, a borehole for monitoring well LWDS-MW1 was drilled to a total depth of 525 feet. LWDS-MW1 was installed to investigate possible effects on groundwater (e.g., mounding and contamination) from the LWDS drainfield. The well was developed in July 1993, and has been sampled on a quarterly basis since then. Trichloroethene (TCE) and nitrate have been detected above the U.S. Environmental Protection Agency Drinking Water Maximum Contaminant Levels in groundwater samples from LWDS-MW1. The maximum TCE and nitrate concentrations in LWDS-MW1 were 24 parts per billion (ppb) and 16.3 ppb, respectively.

Beginning in 1993, four boreholes (LWDS-05-BH11 through LWDS-05-BH14) were installed at the LWDS drainfield. The boreholes were completed in March 1994. Soil core was retrieved, and samples were collected for off-site laboratory analysis. Details of the drilling and sample collection are provided in the "Results of the Liquid Waste Disposal System [Resource Conservation and Recovery Act] RCRA Facility Investigation" (SNL/NM September 1995).

Four additional groundwater monitoring wells (TAV-MW6 through TAV-MW9) were installed in 2001 to further characterize the groundwater contamination in this area. TAV-MW6 was drilled within the boundaries of SWMU 5. Details of the drilling activities, including soil sampling, can be found in the summary of monitoring well drilling activities "TA-V Groundwater Investigation" (SNL/NM November 2001). Because the TA-V Groundwater area of concern is regulated separately under the Compliance Order on Consent (NMED 2004), the SWMU 5 site investigation and risk assessment do not address groundwater issues.

Potential constituents of concern (COCs) at SWMU 5 are metals, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and radiological constituents. Figure 1 shows the location of the four boreholes and the monitoring well at SWMU 5.

This page intentionally left blank.



Legend

- Borehole
- Monitoring well
- Road
- Building/Structure
- SWMU

Figure 1
Location of SWMU 5, Boreholes, and Monitoring Well

0 25 50
Scale in Feet

0 6 12
Scale in Meters

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

840857.04220000 A1

1.2 Results of Risk Analysis

The risk assessment calculation was performed using maximum COC concentrations and the methods specified in "Technical Background Document for Development of Soil Screening Levels" (NMED December 2000). As shown in Table 1, the total human health hazard index (HI) (3.23) is higher than the New Mexico Environment Department (NMED) guidance value of 1 for the residential land-use scenario.

The total estimated excess cancer risk is 1E-5 for the residential land-use scenario. NMED guidance states that cumulative excess lifetime cancer risk must be less than 1E-5 (Bearzi January 2001), thus the excess cancer risk for this site is higher than the suggested acceptable risk value.

The HI and estimated excess cancer risk are both slightly higher than the NMED guidelines for the residential land-use scenario when maximum COC concentrations were used in the risk calculation. However, the site has been adequately characterized and average concentrations are more representative of actual site conditions. The upper confidence limit (UCL) of the mean concentrations used for the main risk drivers at this site are as follows (Appendix 1):

- Antimony (5.34 milligrams [mg]/kilogram [kg])
- Cadmium (9.85 mg/kg)
- Chromium (18.18 mg/kg)
- Thallium (1.09 mg/kg)

In addition, the UCL of the mean concentration for arsenic (3.89 mg/kg), the main contributor to the excess cancer risk (Appendix 1), is lower than the background value of 4.4 mg/kg for the Southwest Area Supergroup; therefore, arsenic is eliminated from the risk calculation. When arsenic is removed from the risk calculation and the risk driver UCLs are evaluated, the excess cancer risk is reduced to 4E-7 and the total HI is 0.73. Thus, by using realistic COC and associated concentrations in the risk calculations that more accurately depict actual site conditions, both the total HI and estimated excess cancer risk are lower than NMED guideline values.

In conclusion, human health risk for SWMU 5 is within the acceptable range according to NMED guidance for a residential land-use scenario.

Table 1
Human Health Risk Assessment Values for SWMU 5 Nonradiological COCs

COC	Maximum/ UCL Concentration (mg/kg)	SNL/NM Background Concentration[a] (mg/kg)	Residential Land-Use Scenario[b] (Maximum Concentrations)		Residential Land-Use Scenario[b] (UCL Concentrations)	
			Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Inorganic						
Antimony	15[c]/**5.34**	3.9	0.49	–	0.17	–
Arsenic	5.39/**3.89**	4.4	0.25	1E-5	Below Background[d]	Below Background[d]
Barium	258	214	0.05	–	0.05	–
Beryllium	0.735	0.65	0.00	7E-10	0.00	7E-10
Cadmium	51.1/**9.85**	0.9	1.31	4E-8	0.25	7E-9
Chromium, total[e]	42.4/**18.18**	1	0.19	2E-7	0.08	8E-8
Cobalt	9.87 J	5.2	0.01	1E-8	0.01	1E-8
Copper	24.2	18.2	0.01	–	0.01	–
Mercury	0.85	<0.1	0.04	–	0.04	–
Nickel	16	11.5	0.01	–	0.01	–
Selenium	1.27	<1	0.00	–	0.00	–
Silver	3.7 J	<1	0.01	–	0.01	–
Thallium	3.89/**1.09**	<1.1	0.77	–	Below Background[d]	Below Background[d]
Vanadium	35.7	21.5	0.07	–	0.07	–
Zinc	67.3	62	0.00	–	0.00	–
Organic						
Acetone	0.0130	–	0.00	–	0.00	–
2-Butanone	0.0107	–	0.00	–	0.00	–
Di-n-butyl phthalate	46 J	–	0.01	–	0.01	–
bis(2-Ethylhexyl) phthalate	1.6	–	0.00	4E-8	0.00	4E-8
Methylene chloride	0.0096	–	0.00	1E-7	0.00	1E-7
4-Methyl-2-pentanone	0.00218	–	0.00	–	0.00	–
Toluene	0.051	–	0.00	–	0.00	–
Trichloroethene	0.0038 J	–	0.00	9E-8	0.00	9E-8
Total			3.23	1E-5	0.73	4E-7

Note: UCLs are calculated only for risk drivers. UCL concentrations are in **bold**.
[a]Dinwiddie September 1997, Southwest Supergroup.
[b]EPA 1989.
[c]Maximum concentration is one-half the detection limit.

Table 1 (Concluded)
Human Health Risk Assessment Values for SWMU 5 Nonradiological COCs

[d]UCL concentration was below background screening level. Therefore risk was not calculated.
[e]Chromium, total is considered to be Chromium VI (most conservative).
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
J = Estimated concentration.
mg/kg = Milligram(s) per kilogram.
SNL/NM = Sandia National Laboratories/New Mexico.
SWMU = Solid Waste Management Unit.
UCL = Upper confidence limit (in **bold**).
– = Information not available.

This page intentionally left blank.

2.0 SWMU 233: STORM DRAIN SYSTEM OUTFALL

2.1 Site Location and Operational History

SWMU 233 at SNL/NM is located about 30 feet southeast of TA-IV on land that is owned by Kirtland Air Force Base (KAFB) and leased to the U.S. Department of Energy (DOE). SWMU 233, a 175-foot-long site with two discharge points, encompasses 0.03 acres of unpaved ground. The first discharge point is located adjacent to the unpaved TA-IV perimeter road. Storm water flows across bare ground at the first discharge point and into a storm-water grate that is connected to another segment of buried piping. This piping terminates at a concrete drop structure from which the storm water discharges onto bare ground a second time and into an earthen ditch. The site occasionally receives storm water from a paved storage yard located on the west side of Building 983. The outfall was built in the early 1980s for the purpose of reducing the amount of soil erosion caused by storm water. The site is situated at the slope break between the steeply sloping, northern rim of Tijeras Arroyo and the nearly flat floodplain below. The vicinity of SWMU 233 is unpaved. Ground elevations at the site range from approximately 5,381 to 5,347 feet amsl.

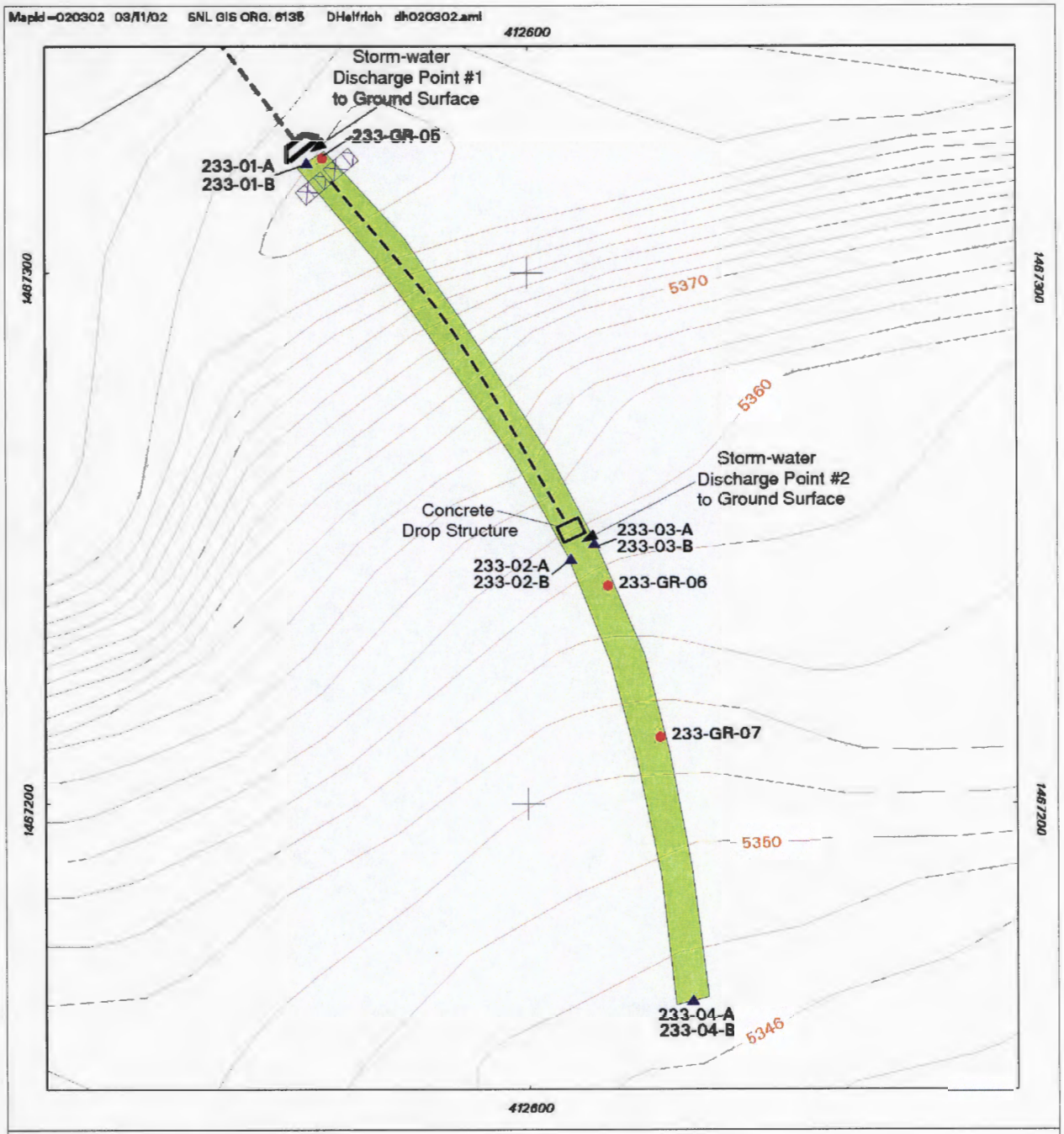
SWMU 233 is one of five storm-water outfalls that have been connected to TA-IV; the other four are SWMUs 230, 231, 232, and 234. The TA-IV storm-water outfalls are managed under two separate regulatory programs (the Environmental Restoration [ER] Project for RCRA Corrective Action, and the Storm Water Program annual reporting for National Pollutant Discharge Elimination System [NPDES] compliance). The outfalls were added to the SWMU list in 1993, even though no chemical releases had been reported for the catchment areas. Similarly, no stained soil was identified at SWMU 233 during inspections conducted between 1993 and 2002. In 1994, the ground surface was surveyed for unexploded ordnance/high explosives and radioactive materials; no anomalies were detected.

In the June 1995 No Further Action (NFA) Proposal for SWMU 233, the potential COCs were considered to be chromates, antifoulants, chromium, sodium hydroxide, hydrochloric acid, diesel fuel, and mineral oil. This list of COCs was conservatively based upon chemicals used at TA-IV. The analytes of VOCs, SVOCs, RCRA metals, and chromium-VI are indicative of the COCs.

The TA-IV outfalls discharge storm water about a dozen days per year in response to significant precipitation, typically resulting from summer thunderstorms. The outfalls do not discharge either industrial waste water or septic waste. The SNL/NM Storm Water Program collects TA-IV storm-water samples from Station 6 and reports the water quality data in the annual SNL/NM Site Environmental Report. Except for a mineral-oil spill at SWMU 232-2 in 1994, no chemical releases have been reported at the TA-IV storm-water outfalls. None of the outfalls have been on the SNL/NM radioactive materials management area list.

Figure 2 shows the boundary of SWMU 233 and the sampling locations.

This page intentionally left blank.



Legend

- Soil Sample Location (1994)
- Soil Sample Location (2001)
- Headwall with Outfall Pipe
- Metal Grate
- Buried Pipe from TA-IV
- 2-foot Contour
- Unpaved Road
- SWMU 233

Figure 2
Soil Sampling Locations for SWMU 233

0 15 30
Scale in Feet

0 2.6 7.2
Scale in Meters

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

840857.04220000 A10

2.2 Results of Risk Analysis

The risk assessment calculation was performed using maximum COC concentrations and the methods specified in NMED's "Technical Background Document for Development of Soil Screening Levels" (NMED December 2000). As shown in Table 2, the total human health HI (0.34) is less than the NMED guidance value of 1 for the residential land-use scenario. The total estimated excess cancer risk is 2E-5 for the residential land-use scenario. NMED guidance states that cumulative excess lifetime cancer risk must be less than 1E-5 (Bearzi January 2001), thus the excess cancer risk for this site is higher than the suggested acceptable risk value.

The estimated excess cancer risk is slightly higher than the NMED guidelines for the residential land-use scenario when maximum COC concentrations were used in the risk calculation. However, the site has been adequately characterized and average concentrations are more representative of actual site conditions. The UCL of the mean concentrations used for the main risk drivers at this site are as follows (Appendix 1):

- Benzo(a)pyrene (0.185 mg/kg)
- Benzo(ghi)perylene (0.178 mg/kg)

In addition, the UCL of the mean concentration for arsenic (3.53 mg/kg), the main contributor to the excess cancer risk (Appendix 1), is lower than the background value of 4.4 mg/kg for the Tijeras Supergroup; therefore, arsenic is eliminated from the risk calculation. When arsenic is removed from the risk calculation and the risk driver UCLs are evaluated, the excess cancer risk is reduced to 9E-6. Thus, by using realistic COC and associated concentrations in the risk calculations that more accurately depict actual site conditions, both the total HI and estimated excess cancer risk are lower than NMED guideline values.

In conclusion, human health risk for SWMU 233 is within the acceptable range according to NMED guidance for a residential land-use scenario.

Table 2
Human Health Risk Assessment Values for SWMU 233 Nonradiological COCs

COC	Maximum/ UCL Concentration (mg/kg)	SNL/NM Background Concentration[a] (mg/kg)	Residential Land-Use Scenario[b] (Maximum Concentrations)		Residential Land-Use Scenario[b] (UCL Concentrations)	
			Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Inorganic						
Arsenic	5.1/**3.53**	4.4	0.24	1E-5	Below Background[c]	Below Background[c]
Barium	210	200	0.04	–	0.04	–
Cadmium	2.3	<1	0.06	2E-9	0.06	2E-9
Chromium VI	0.143 J	NC	0.00	7E-10	0.00	7E-10
Mercury	0.02[d]	<0.1	Below Background	Below Background	Below Background	Below Background
Selenium	0.13[d]	<1	Below Background	Below Background	Below Background	Below Background
Silver	0.228 J	<1	Below Background	Below Background	Below Background	Below Background
Organic						
Anthracene	0.044 J	–	0.00	–	0.00	–
Acenaphthene	0.033 J	–	0.00	–	0.00	–
Benzo(a)anthracene	0.236	–	0.00	4E-7	0.00	4E-7
Benzo(a)pyrene	0.282/**0.185**	–	0.00	5E-6	0.00	3E-6
Benzo(b)fluoranthene	0.291	–	0.00	5E-7	0.00	5E-7
Benzo(ghi)perylene	0.237/**0.178**	–	0.00	4E-6	0.00	3E-6
Benzo(k)fluoranthene	0.251	–	0.00	4E-8	0.00	4E-8
2-Butanone	0.006 J	–	0.00	–	0.00	–
Carbazole	0.0126 J	–	0.00	4E-10	0.00	4E-10
2-Chlorophenol	0.00766 J	–	0.00	–	0.00	–
Chrysene	0.316	–	0.00	5E-9	0.00	5E-9
Di-n-butyl phthalate	0.21	–	0.00	–	0.00	–
Dibenz[a,h]anthracene	0.121	–	0.00	2E-6	0.00	2E-6
Dibenzofuran	0.00494 J	–	0.00	–	0.00	–
bis(2-Ethylhexyl) phthalate	1.0	–	0.00	2E-8	0.00	2E-8
Fluoranthene	0.345	–	0.00	–	0.00	–
Fluorene	0.00732 J	–	0.00	–	0.00	–

Refer to footnotes at end of table.

Table 2 (Concluded)
Human Health Risk Assessment Values for SWMU 233 Nonradiological COCs

COC	Maximum/ UCL Concentration (mg/kg)	SNL/NM Background Concentration[a] (mg/kg)	Residential Land-Use Scenario[b] (Maximum Concentrations)		Residential Land-Use Scenario[b] (UCL Concentrations)	
			Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Indeno(1,2,3-c,d) pyrene	0.206	–	0.00	3E-7	0.00	3E-7
2-Methylnaphthalene	0.0053 J	–	0.00	–	0.00	–
Naphthalene	0.086 J	–	0.00	–	0.00	–
Phenanthrene	0.110	–	0.00	–	0.00	–
Pyrene	0.418	–	0.00	–	0.00	–
Total			0.34	2E-5	0.10	9E-6

Note: UCLs are calculated only for risk drivers. UCL concentrations are in **bold**.
[a]Dinwiddie September 1997, Tijeras Supergroup.
[b]EPA 1989.
[c]UCL concentration was below background screening level. Therefore risk was not calculated.
[d]Maximum concentration is one-half the detection limit.
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
J = Estimated concentration.
mg/kg = Milligram(s) per kilogram.
NC = Not calculated.
SNL/NM = Sandia National Laboratories/New Mexico.
SWMU = Solid Waste Management Unit.
UCL = Upper confidence limit (in **bold**).
– = Information not available.

This page intentionally left blank.

3.0 SWMU 234: STORM DRAIN SYSTEM OUTFALL

3.1 Site Location and Operational History

SWMU 234 at SNL/NM is located about 145 feet south of TA-IV on land that is owned by KAFB and leased to the DOE. SWMU 234 encompasses 0.15 acres of unpaved ground, consisting of a 270-foot-long earthen ditch that previously received storm water from a paved parking lot and storage yards located on the south side of Building 981. Storm water discharged at the site from the early 1980s through the early 1990s and was directed to the site via buried piping. The outfall was built in the early 1980s for the purpose of reducing the amount of soil erosion caused by storm water. The site is situated at the slope break between the steeply sloping, northern rim of Tijeras Arroyo and the nearly flat floodplain below. The vicinity of SWMU 234 is unpaved. Ground elevations at the site range from 5,385 to 5,341 feet amsl.

SWMU 234 is one of five storm-water outfalls that have been connected to TA-IV; the other four are SWMUs 230, 231, 232, and 233. The TA-IV storm-water outfalls are managed under two separate regulatory programs (the ER Project for RCRA Corrective Action, and the Storm Water Program annual reporting for NPDES compliance). The outfalls were added to the SWMU list in 1993, even though no chemical releases had been reported for the catchment areas. Similarly, no stained soil was identified at SWMU 234 during inspections conducted between 1993 and 2002. In 1994, the ground surface was surveyed for unexploded ordnance/high explosives and radioactive materials; no anomalies were detected. In September 2000, a review of historical aerial photography revealed that TA-I waste water from SWMU 46 had discharged into the same area as SWMU 234. This discharge of waste water occurred from 1948 to 1973.

In the June 1995 NFA Proposal for SWMU 233, the potential COCs were considered to be chromates, antifoulants, chromium, sodium hydroxide, hydrochloric acid, diesel fuel, and mineral oil. This list of COCs was conservatively based upon chemicals used at TA-IV. The analytes of VOCs, SVOCs, RCRA metals, and chromium-VI are indicative of the COCs.

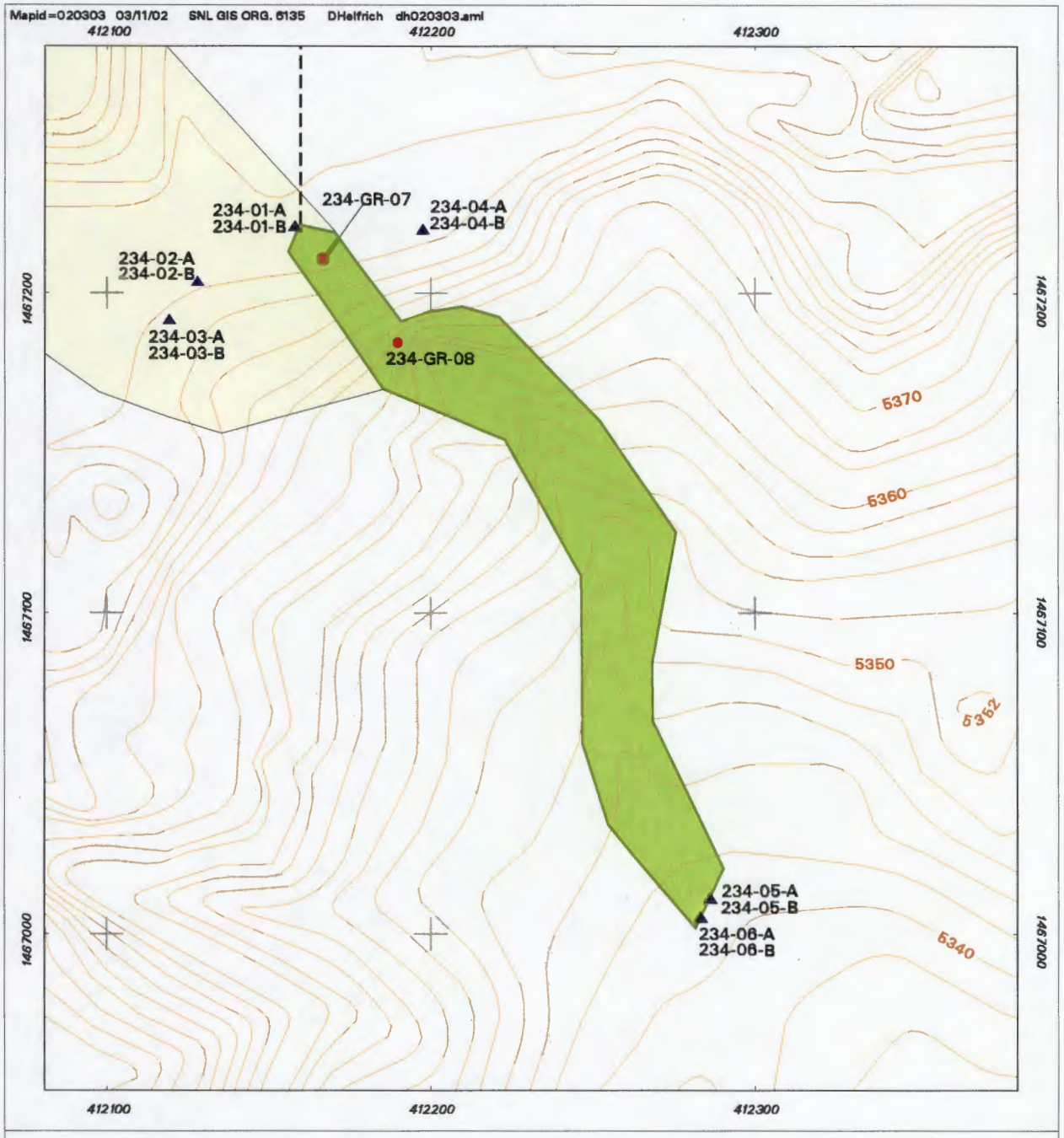
The TA-IV outfalls discharge storm water about a dozen days per year in response to significant precipitation, typically resulting from summer thunderstorms. The outfalls do not discharge industrial waste water or septic waste. The SNL/NM Storm Water Program collects TA-IV storm-water samples from Station 6 and reports the water quality data in the annual SNL/NM Site Environmental Report. Except for a mineral-oil spill at SWMU 232-2 in 1994, no chemical releases have been reported at the TA-IV storm-water outfalls. None of the outfalls have been on the SNL/NM radioactive materials management area list.

Figure 3 shows the boundary of SWMU 234 and the sampling locations.

3.2 Results of Risk Analysis

The risk assessment calculation was performed using maximum COC concentrations and the methods specified in NMED's "Technical Background Document for Development of Soil Screening Levels" (NMED December 2000). As shown in Table 3, the total human health HI (0.46) is less than the NMED guidance value of 1 for the residential land-use scenario. The

This page intentionally left blank.



Legend

- Soil Sample Location (1994)
- Soil Sample Location (2001)
- 2-foot Contour
- Previous location of buried TA-IV Outfall Pipe
- SWMU 234
- SWMU 46

Figure 3
Soil Sampling Locations for SWMU 234

0 25 50
Scale in Feet

0 6 12
Scale in Meters

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

840857.04220000 A9

Table 3
Human Health Risk Assessment Values for SWMU 234 Nonradiological COCs

COC	Maximum/ UCL Concentration (mg/kg)	SNL/NM Background Concentration[a] (mg/kg)	Residential Land-Use Scenario[b] (Maximum Concentrations)		Residential Land-Use Scenario[b] (UCL Concentrations)	
			Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Inorganic						
Arsenic	7/**4.60**	4.4	0.32	2E-5	0.21	1E-5
Barium	240	200	0.05	–	0.05	–
Cadmium	2.9	<1	0.07	2E-9	0.07	2E-9
Chromium, total	17.7	16.2	0.00	–	0.00	–
Chromium VI	2.08	NC	0.01	1E-8	0.01	1E-8
Mercury	0.0603	<0.1	Below Background	Below Background	Below Background	Below Background
Selenium	0.13[c]	<1	Below Background	Below Background	Below Background	Below Background
Silver	1	<1	Below Background	Below Background	Below Background	Below Background
Organic						
Acenaphthene	0.00626 J	–	0.00	–	0.00	–
Acetone	0.015	–	0.00	–	0.00	–
Anthracene	0.0212 J	–	0.00	–	0.00	–
Benzo(a)anthracene	0.258/**0.242**	–	0.00	4E-7	0.00	4E-7
Benzo(a)pyrene	0.435/**0.234**	–	0.00	7E-6	0.00	4E-6
Benzo(b)fluoranthene	0.506/**0.375**	–	0.00	8E-7	0.00	6E-7
Benzo(ghi)perylene	0.309/**0.267**	–	0.00	5E-6	0.00	4E-6
Benzo(k)fluoranthene	0.471	–	0.00	8E-8	0.00	8E-8
Carbazole	0.0182 J	–	0.00	6E-10	0.00	6E-10
Chrysene	0.435	–	0.00	7E-9	0.00	7E-9
Di-n-butyl phthalate	0.0207 J	–	0.00	–	0.00	–
Di-n-octyl phthalate	0.0102 J	–	0.00	–	0.00	–
bis(2-Ethylhexyl) phthalate	0.28 JB	–	0.00	6E-9	0.00	6E-9
Fluoranthene	0.450	–	0.00	–	0.00	–
Fluorene	0.00666 J	–	0.00	–	0.00	–

Refer to footnotes at end of table.

Table 3 (Concluded)
Human Health Risk Assessment Values for SWMU 234 Nonradiological COCs

COC	Maximum/ UCL Concentration (mg/kg)	SNL/NM Background Concentration[a] (mg/kg)	Residential Land-Use Scenario[b] (Maximum Concentrations)		Residential Land-Use Scenario[b] (UCL Concentrations)	
			Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Indeno(1,2,3-c,d) pyrene	0.345 J	–	0.00	6E-7	0.00	6E-7
Phenanthrene	0.139	–	0.00	–	0.00	–
Pyrene	0.603	–	0.00	–	0.00	–
Total			0.46	3E-5	0.35	2E-5

Note: UCLs are calculated only for risk drivers. UCL concentrations are in **bold**.
[a]Dinwiddie September 1997, Tijeras Supergroup.
[b]EPA 1989.
[c]Maximum concentration is one-half the detection limit.
B = Analyte detected in method blank.
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
J = Estimated concentration.
mg/kg = Milligram(s) per kilogram.
NC = Not calculated.
SNL/NM = Sandia National Laboratories/New Mexico.
SWMU = Solid Waste Management Unit.
UCL = Upper confidence limit (in **bold**).
– = Information not available.

total estimated excess cancer risk is 3E-5 for the residential land-use scenario. NMED guidance states that cumulative excess lifetime cancer risk must be less than 1E-5 (Bearzi January 2001), thus the excess cancer risk for this site is higher than the suggested acceptable risk value.

The estimated excess cancer risk is slightly higher than the NMED guidelines for the residential land-use scenario when maximum COC concentrations were used in the risk calculation. However, the site has been adequately characterized and average concentrations are more representative of actual site conditions. The UCL of the mean concentrations used for the main risk drivers at this site are as follows (Appendix 1):

- Arsenic (4.60 mg/kg)
- Benzo(a)anthracene (0.242 mg/kg)
- Benzo(a)pyrene (0.234 mg/kg)
- Benzo(b)fluoranthene (0.375 mg/kg)
- Benzo(ghi)perylene (0.267 mg/kg)

With the UCL of the mean concentrations, the total estimated excess cancer risk is reduced to 2E-5. In addition, Table 4 shows that for the SWMU 234 associated background constituents, an estimated excess cancer risk of 1E-5 for the residential land-use scenario. The estimated incremental cancer risk is 8.4E-6 for the residential land-use scenario. These incremental risk calculations indicate insignificant risk to human health from nonradiological COCs considering the residential land-use scenario. Thus, using realistic concentrations in the risk calculations that more accurately depict actual site conditions and incremental risk, the HI and estimated excess cancer risk are lower than NMED guidelines.

Table 4
Risk Assessment Values for SWMU 234
Nonradiological Background Constituents

COC	Background Concentration[a] (mg/kg)	Residential Land-Use Scenario[b]	
		Hazard Index	Cancer Risk
Arsenic	4.4	0.20	1E-5
Barium	200	0.04	–
Cadmium	<1	–	–
Chromium, total	16.2	0.00	–
Chromium VI	NC	–	–
Mercury	<0.1	–	–
Selenium	<1	–	–
Silver	<1	–	–
Total		**0.24**	**1E-5**

[a]Dinwiddie September 1997, Tijeras Supergroup Soils.
[b]EPA 1989.
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
mg/kg = Milligram(s) per kilogram.
NC = Not calculated.
SWMU = Solid Waste Management Unit.
– = Information not available.

In conclusion, human health risk for SWMU 234 is within the acceptable range according to NMED guidance for a residential land-use scenario.

4.0 REFERENCES

Bearzi, J.P. (New Mexico Environment Department), January 2001. Memorandum to RCRA-Regulated Facilities, "Risk-Based Screening Levels for RCRA Corrective Action Sites in New Mexico," Hazardous Waste Bureau, New Mexico Environment Department, Santa Fe, New Mexico. January 23, 2001.

Dinwiddie, R.S. (New Mexico Environment Department), September 1997. Letter to M.J. Zamorski (U.S. Department of Energy), "Request for Supplemental Information: Background Concentrations Report, SNL/KAFB." September 24, 1997.

EPA, see U.S. Environmental Protection Agency.

New Mexico Environment Department (NMED), December 2000. "Technical Background Document for Development of Soil Screening Levels," Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program, New Mexico Environment Department, Santa Fe, New Mexico. December 18, 2000.

New Mexico Environment Department (NMED), 2004. "Compliance Order on Consent Pursuant to the New Mexico Hazardous Waste Act," § 74-4-10, New Mexico Environment Department. April 2004.

NMED, see New Mexico Environment Department.

Sandia National Laboratories/New Mexico (SNL/NM), September 1995. "Results of the Liquid Waste Disposal System RCRA Facility Investigation, Sandia National Laboratories, Albuquerque, New Mexico," Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), November 2001. "TA-V Groundwater Investigation, Fiscal Years 1999 and 2000," Sandia National Laboratories, Albuquerque, New Mexico.

SNL/NM, see Sandia National Laboratories/New Mexico.

U.S. Environmental Protection Agency (EPA), 1989. "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual," EPA/540-1089/002, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

This page intentionally left blank.

APPENDIX 1
CALCULATION OF THE UPPER CONFIDENCE LIMITS OF MEAN CONCENTRATIONS

For conservatism, Sandia National Laboratories/New Mexico uses the maximum concentration of the constituents of concern (COCs) for initial risk calculation. If the maximum concentrations produce risk above New Mexico Environment Department (NMED) guidelines, conservatism with this approach is evaluated and, if appropriate, a more realistic approach is applied. When the site has been adequately characterized, an estimate of the mean concentration of the COCs is more representative of actual site conditions. The NMED has proposed the use of the upper confidence limit (UCL) of the mean to represent average concentrations at a site (NMED December 2000). The UCL is calculated according to NMED guidance (Tharp June 2002) using the U.S. Environmental Protection Agency ProUCL program (EPA April 2002). Attached are the outputs from that program and the calculated UCLs used in the risk analysis.

References

EPA, see U.S. Environmental Protection Agency.

New Mexico Environment Department (NMED), December 2000. "Technical Background Document for Development of Soil Screening Levels," Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program, New Mexico Environment Department, Santa Fe, New Mexico. December 18, 2000.

NMED, see New Mexico Environment Department.

Tharp, T. (Weston Solutions, Inc.), June 2002. *Personal communication* with K. Olsen (Hazardous Waste Bureau, New Mexico Environment Department). June 12, 2002.

U.S. Environmental Protection Agency (EPA), April 2002. *ProUCL User's Guide*, U.S. Environmental Protection Agency, Washington, D.C.

ATTACHMENT

SWMU 5

SWMU 5				
Summary Statistics for			antimony	
Number of Samples			68	
Minimum			0.119	
Maximum			15	
Mean			2.478	
Median			3.0	
Standard Deviation			2.370	
Variance			5.615	
Coefficient of Variation			0.956	
Skewness			2.376	
Lilliefors Test Statisitic			0.391	
Lilliefors 5% Critical Value			0.107	
Data not Lognormal at 5% Significance Level				
Data not Normal: Try Non-parametric UCL				
99	% UCL (Assuming Normal Data)			
Student's-t			3.163	
99	% UCL (Adjusted for Skewness)			
Adjusted-CLT			3.309	
Modified-t			3.176	
99	% Non-parametric UCL			
CLT			3.146	
Jackknife			3.163	
Standard Bootstrap			3.166	
Bootstrap-t			3.381	
Chebyshev (Mean, Std)			5.337	

SWMU 5							
Summary Statistics for			arsenic		Summary Statistics for	ln(arsenic)	
Number of Samples			68		Minimum	0.1823	
Minimum			1.2		Maximum	1.6845	
Maximum			5.39		Mean	0.8953	
Mean			2.634		Standard Deviation	0.3840	
Median			2.4		Variance	0.1475	
Standard Deviation			1.033				
Variance			1.067		Lilliefors Test Statisitic	0.0836	
Coefficient of Variation			0.392		Lilliefors 5% Critical Value	0.1074	
Skewness			0.750		Data are Lognormal at 5% Significance Level		
97.5	% UCL (Assuming Normal Data)				Estimates Assuming Lognormal Distribution		
Student's-t			2.884		MLE Mean	2.6355	
					MLE Standard Deviation	1.0505	
97.5	% UCL (Adjusted for Skewness)				MLE Coefficient of Variation	0.3986	
Adjusted-CLT			2.896		MLE Skewness	1.2591	
Modified-t			2.886		MLE Median	2.4482	
					MLE 80% Quantile	3.3866	
97.5	% Non-parametric UCL				MLE 90% Quantile	4.0100	
CLT			2.879		MLE 95% Quantile	4.6044	
Jackknife			2.884		MLE 99% Quantile	5.9806	
Standard Bootstrap			2.876				
Bootstrap-t			2.901		MVU Estimate of Median	2.4455	
Chebyshev (Mean, Std)			3.416		MVU Estimate of Mean	2.6324	
					MVU Estimate of Std. Dev.	1.0446	
					MVU Estimate of SE of Mean	0.1265	
					UCL Assuming Lognormal Distribution		
					Confidence Level not supported for H-Statistic		
					Chebyshev 97.5 % (MVUE)	3.4223	
					99% Chebyshev (MVUE) UCL	3.8909	

SWMU 5				
Summary Statistics for			cadmium	
Number of Samples			68	
Minimum			0.007	
Maximum			51.1	
Mean			1.6957	
Median			0.25	
Standard Deviation			6.7606	
Variance			45.7058	
Coefficient of Variation			3.9868	
Skewness			6.4516	
Lilliefors Test Statisitic			0.2497	
Lilliefors 5% Critical Value			0.1074	
Data not Lognormal at 5% Significance Level				
Data not Normal: Try Non-parametric UCL				
99	% UCL (Assuming Normal Data)			
Student's-t			3.6497	
99	% UCL (Adjusted for Skewness)			
Adjusted-CLT			4.8670	
Modified-t			3.7566	
99	% Non-parametric UCL			
CLT			3.6030	
Jackknife			3.6497	
Standard Bootstrap			3.6012	
Bootstrap-t			11.3609	
Chebyshev (Mean, Std)			9.8531	

SWMU 5							
Summary Statistics for			total chrom		Summary Statistics for	ln(total chromium)	
Number of Samples			68		Minimum	0.7885	
Minimum			2.2		Maximum	3.7471	
Maximum			42.4		Mean	2.1227	
Mean			10.082		Standard Deviation	0.6178	
Median			7.700		Variance	0.3817	
Standard Deviation			6.853				
Variance			46.964		Lilliefors Test Statisitic	0.0823	
Coefficient of Variation			0.680		Lilliefors 5% Critical Value	0.1074	
Skewness			2.142		Data are Lognormal at 5% Significance Level		
99	% UCL (Assuming Normal Data)				Estimates Assuming Lognormal Distribution		
Student's-t			12.063		MLE Mean	10.1100	
					MLE Standard Deviation	6.8928	
99	% UCL (Adjusted for Skewness)				MLE Coefficient of Variation	0.6818	
Adjusted-CLT			12.441		MLE Skewness	2.3622	
Modified-t			12.099		MLE Median	8.3533	
					MLE 80% Quantile	14.0798	
99	% Non-parametric UCL				MLE 90% Quantile	18.4782	
CLT			12.016		MLE 95% Quantile	23.0812	
Jackknife			12.063		MLE 99% Quantile	35.1551	
Standard Bootstrap			11.997				
Bootstrap-t			12.664		MVU Estimate of Median	8.3299	
Chebyshev (Mean, Std)			18.351		MVU Estimate of Mean	10.0766	
					MVU Estimate of Std. Dev.	6.7825	
					MVU Estimate of SE of Mean	0.8147	
					UCL Assuming Lognormal Distribution		
					Confidence Level not supported for H-Statistic		
					99% Chebyshev (MVUE) UCL	18.1826	
					99% Chebyshev (MVUE) UCL	18.1826	

SWMU 5				
Summary Statistics for			thallium	
Number of Samples			68	
Minimum			0.14	
Maximum			3.89	
Mean			0.6955	
Median			0.5000	
Standard Deviation			0.7430	
Variance			0.5520	
Coefficient of Variation			1.0683	
Skewness			2.4834	
Lilliefors Test Statisitic			0.3378	
Lilliefors 5% Critical Value			0.1074	
Data not Lognormal at 5% Significance Level				
Data not Normal: Try Non-parametric UCL				
95	% UCL (Assuming Normal Data)			
Student's-t			0.8457	
95	% UCL (Adjusted for Skewness)			
Adjusted-CLT			0.8726	
Modified-t			0.8503	
95	% Non-parametric UCL			
CLT			0.8437	
Jackknife			0.8457	
Standard Bootstrap			0.8421	
Bootstrap-t			0.9033	
Chebyshev (Mean, Std)			1.0882	

SWMU 233

SWMU 233					
Summary Statistics for		arsenic		Summary Statistics for	ln(arsenic)
Number of Samples		14		Minimum	0.2624
Minimum		1.3		Maximum	1.6292
Maximum		5.1		Mean	0.8429
Mean		2.475		Standard Deviation	0.3637
Median		2.4200		Variance	0.1323
Standard Deviation		0.9682			
Variance		0.9373		Shapiro-Wilk Test Statisitic	0.9574
Coefficient of Variation		0.3912		Shapiro-Wilk 5% Critical Value	0.8740
Skewness		1.4511		Data are Lognormal at 5% Significance Level	
95	% UCL (Assuming Normal Data)			Estimates Assuming Lognormal Distribution	
Student's-t		2.9332		MLE Mean	2.4819
				MLE Standard Deviation	0.9334
95	% UCL (Adjusted for Skewness)			MLE Coefficient of Variation	0.3761
Adjusted-CLT		3.0078		MLE Skewness	1.1814
Modified-t		2.9500		MLE Median	2.3231
				MLE 80% Quantile	3.1589
95	% Non-parametric UCL			MLE 90% Quantile	3.7072
CLT		2.9006		MLE 95% Quantile	4.2258
Jackknife		2.9332		MLE 99% Quantile	5.4135
Standard Bootstrap		2.8909			
Bootstrap-t		3.0793		MVU Estimate of Median	2.3121
Chebyshev (Mean, Std)		3.6028635		MVU Estimate of Mean	2.4696
				MVU Estimate of Std. Dev.	0.9129
				MVU Estimate of SE of Mean	0.2438
				UCL Assuming Lognormal Distribution	
				95% H-UCL	3.0224
				95% Chebyshev (MVUE) UCL	3.5323
				99% Chebyshev (MVUE) UCL	4.895374
				Recommended UCL to use:	
					Student's-t or H-UCL

SWMU 233			
Summary Statistics for		benzo(a)pyrene	
Number of Samples		10	
Minimum		0.0010	
Maximum		0.2820	
Mean		0.1239	
Median		0.1290	
Standard Deviation		0.1057	
Variance		0.0112	
Coefficient of Variation		0.8529	
Skewness		0.0976	
Shapiro-Wilk Test Statisitic		0.7194	
Shapiro-Wilk 5% Critical Value		0.8420	
Data not Lognormal at 5% Significance Level			
Data are Normal: Use Student's-t UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.1852	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.1800	
Modified-t		0.1853	
95	% Non-parametric UCL		
CLT		0.1789	
Jackknife		0.1852	
Standard Bootstrap		0.1765	
Bootstrap-t		0.1867	
Chebyshev (Mean, Std)		0.2696	

SWMU 233			
Summary Statistics for		benzo(ghi)perylene	
Number of Samples		10	
Minimum		0.0025	
Maximum		0.2370	
Mean		0.1315	
Median		0.1650	
Standard Deviation		0.0927	
Variance		0.0086	
Coefficient of Variation		0.7051	
Skewness		-0.7145	
Shapiro-Wilk Test Statisitic		0.6447	
Shapiro-Wilk 5% Critical Value		0.8420	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.1852	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.1726	
Modified-t		0.1841	
95	% Non-parametric UCL		
CLT		0.1797	
Jackknife		0.1852	
Standard Bootstrap		0.1775	
Bootstrap-t		0.1770	
Chebyshev (Mean, Std)		0.2592	

SWMU 234

SWMU 234			
Summary Statistics for		arsenic	
Number of Samples		16	
Minimum		0.900	
Maximum		7.000	
Mean		3.261	
Median		2.765	
Standard Deviation		2.057	
Variance		4.231	
Coefficient of Variation		0.631	
Skewness		0.432	
Shapiro-Wilk Test Statisitic		0.912	
Shapiro-Wilk 5% Critical Value		0.887	
Data are Normal: Use Student's-t UCL			
99	% UCL (Assuming Normal Data)		
Student's-t		4.599	
99	% UCL (Adjusted for Skewness)		
Adjusted-CLT		4.567	
Modified-t		4.609	
99	% Non-parametric UCL		
CLT		4.457	
Jackknife		4.599	
Standard Bootstrap		4.420	
Bootstrap-t		4.832	
Chebyshev (Mean, Std)		8.378	

SWMU 234			
Summary Statistics for		benzo(a)anthracene	
Number of Samples		11	
Minimum		0.0005	
Maximum		0.258	
Mean		0.13087	
Median		0.16500	
Standard Deviation		0.08429	
Variance		0.00711	
Coefficient of Variation		0.64408	
Skewness		-0.69832	
Shapiro-Wilk Test Statisitic		0.66877	
Shapiro-Wilk 5% Critical Value		0.85000	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.17694	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.16696	
Modified-t		0.17604	
95	% Non-parametric UCL		
CLT		0.17268	
Jackknife		0.17694	
Standard Bootstrap		0.17118	
Bootstrap-t		0.16966	
Chebyshev (Mean, Std)		0.24165	

SWMU 234			
Summary Statistics for		benzo(a)pyrene	
Number of Samples		10	
Minimum		0.0010	
Maximum		0.4350	
Mean		0.1597	
Median		0.1650	
Standard Deviation		0.1284	
Variance		0.0165	
Coefficient of Variation		0.8041	
Skewness		0.9085	
Shapiro-Wilk Test Statisitic		0.7595	
Shapiro-Wilk 5% Critical Value		0.8420	
Data are Normal: Use Student's-t UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.2341	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.2390	
Modified-t		0.2361	
95	% Non-parametric UCL		
CLT		0.2265	
Jackknife		0.2341	
Standard Bootstrap		0.2205	
Bootstrap-t		0.2491	
Chebyshev (Mean, Std)		0.3367	

SWMU 234			
Summary Statistics for		benzo(b)fluoranthene	
Number of Samples		11	
Minimum		0.00065	
Maximum		0.506	
Mean		0.1624	
Median		0.1650	
Standard Deviation		0.1615	
Variance		0.0261	
Coefficient of Variation		0.9945	
Skewness		1.1590	
Shapiro-Wilk Test Statisitic		0.8008	
Shapiro-Wilk 5% Critical Value		0.8500	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.2507	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.2607	
Modified-t		0.2535	
95	% Non-parametric UCL		
CLT		0.2425	
Jackknife		0.2507	
Standard Bootstrap		0.2405	
Bootstrap-t		0.2964	
Chebyshev (Mean, Std)		0.3747	

SWMU 234			
Summary Statistics for		benzo(ghi)perylen	
Number of Samples		10	
Minimum		0.0025	
Maximum		0.3090	
Mean		0.1307	
Median		0.1650	
Standard Deviation		0.0990	
Variance		0.0098	
Coefficient of Variation		0.7575	
Skewness		-0.0569	
Shapiro-Wilk Test Statisitic		0.6549	
Shapiro-Wilk 5% Critical Value		0.8420	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.1880	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.1815	
Modified-t		0.1879	
95	% Non-parametric UCL		
CLT		0.1821	
Jackknife		0.1880	
Standard Bootstrap		0.1804	
Bootstrap-t		0.1848	
Chebyshev (Mean, Std)		0.2671	

Sandia National Laboratories/New Mexico
Environmental Restoration Project

RISK ASSESSMENT REPORT
SOLID WASTE MANAGEMENT UNIT 4
LIQUID WASTE DISPOSAL SYSTEM
SURFACE IMPOUNDMENTS

June 2005

United States Department of Energy
Sandia Site Office

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

TABLE OF CONTENTS

I. Site Description and History 1
II. Data Quality Objectives 7
III. Determination of Nature, Rate, and Extent of Contamination 8
III.1 Introduction 8
III.2 Nature of Contamination 15
III.3 Rate of Contaminant Migration 15
III.4 Extent of Contamination 15
IV. Comparison of COCs to Background Screening Levels 16
V. Fate and Transport 16
VI. Human Health Risk Assessment 23
VI.1 Introduction 23
VI.2 Step 1. Site Data 24
VI.3 Step 2. Pathway Identification 24
VI.4 Step 3. Background Screening Procedure 24
VI.4.1 Methodology 24
VI.4.2 Results 27
VI.5 Step 4. Identification of Toxicological Parameters 27
VI.6 Step 5. Exposure Assessment and Risk Characterization 30
VI.6.1 Exposure Assessment 31
VI.6.2 Risk Characterization 31
VI.7 Step 6. Comparison of Risk Values to Numerical Guidelines 33
VI.8 Step 7. Uncertainty Discussion 34
VI.9 Summary 37
VII. Ecological Risk Assessment 38
VII.1 Introduction 38
VII.2 Scoping Assessment 38
VII.2.1 Data Assessment 39
VII.2.2 Bioaccumulation 40
VII.2.3 Fate and Transport Potential 40
VII.2.4 Scoping Risk-Management Decision 41
VII.3 Risk Assessment 41
VII.3.1 Problem Formulation 42
VII.3.2 Exposure Estimation 43
VII.3.3 Ecological Effects Evaluation 45
VII.3.4 Risk Characterization 45
VII.3.5 Uncertainty Assessment 52
VII.3.6 Risk Interpretation 56
VII.3.7 Risk Assessment Scientific/Management Decision Point 56
VIII. References 57

Appendix 1 65
Appendix 2 77

This page intentionally left blank.

LIST OF TABLES

Table		Page
1	Summary of Sampling Performed to Meet DQOs	9
2	SWMU 4 Confirmatory Soil Sample Summary and Analytical Suites	10
3	Summary of Data Quality Requirements	13
4	Summary of QA/QC Samples	15
5	Nonradiological COCs for Human Health Risk Assessment at SWMU 4 with Comparison to the Associated SNL/NM Background Screening Value, BCF, and Log K_{ow}	17
6	Nonradiological COCs for Ecological Risk Assessment at SWMU 4 with Comparison to the Associated SNL/NM Background Screening Value, BCF, and Log K_{ow}	19
7	Radiological COCs for Human Health and Ecological Risk Assessments at SWMU 4 with Comparison to the Associated SNL/NM Background Screening Value and BCF	21
8	Summary of Fate and Transport at SWMU 4	23
9	Toxicological Parameter Values for SWMU 4 Nonradiological COCs	28
10	Radiological Toxicological Parameter Values for SWMU 4 COCs Obtained from RESRAD Risk Coefficients	30
11	Risk Assessment Values for SWMU 4 Nonradiological COCs	32
12	Risk Assessment Values for SWMU 4 Nonradiological Background Constituents	33
13	Risk Assessment Values for SWMU 4 Nonradiological COCs with UCL Concentrations for the Major Risk Drivers	36
14	Summation of Radiological and Nonradiological Risks from Site Carcinogens	38
15	Exposure Factors for Ecological Receptors at SWMU 4	44
16	Transfer Factors Used in Exposure Models for COPECs at SWMU 4	46
17	Media Concentrations for COPECs at SWMU 4	47
18	Toxicity Benchmarks for Ecological Receptors at SWMU 4	48

LIST OF TABLES (Concluded)

Table		Page
19	HQs for Ecological Receptors at SWMU 4	50
20	Internal and External Dose Rates for Deer Mouse Exposure to Radionuclides at SWMU 4	53
21	Internal and External Dose Rates for Burrowing Owl Exposure to Radionuclides at SWMU 4	53
22	HQs for Ecological Receptor Exposure to Background Concentrations at SWMU 4	54

LIST OF FIGURES

Figure		Page
1	Location of TA-V and SWMU 4	3
2	Location of SWMUs 4, 5, and 52	5
3	Conceptual Site Model Flow Diagram for SWMU 4	25

SWMU 4: RISK ASSESSMENT REPORT

I. Site Description and History

Solid Waste Management Unit (SWMU) 4, the Liquid Waste Disposal System (LWDS) Surface Impoundments, is located northwest of Sandia National Laboratories/New Mexico (SNL/NM) Technical Area (TA)-V (Figure 1). The LWDS consisted of three individual SWMUs including SWMU 52, the Holding Tanks; SWMU 5, the Drainfield; and SWMU 4, the Surface Impoundments (Figure 2).

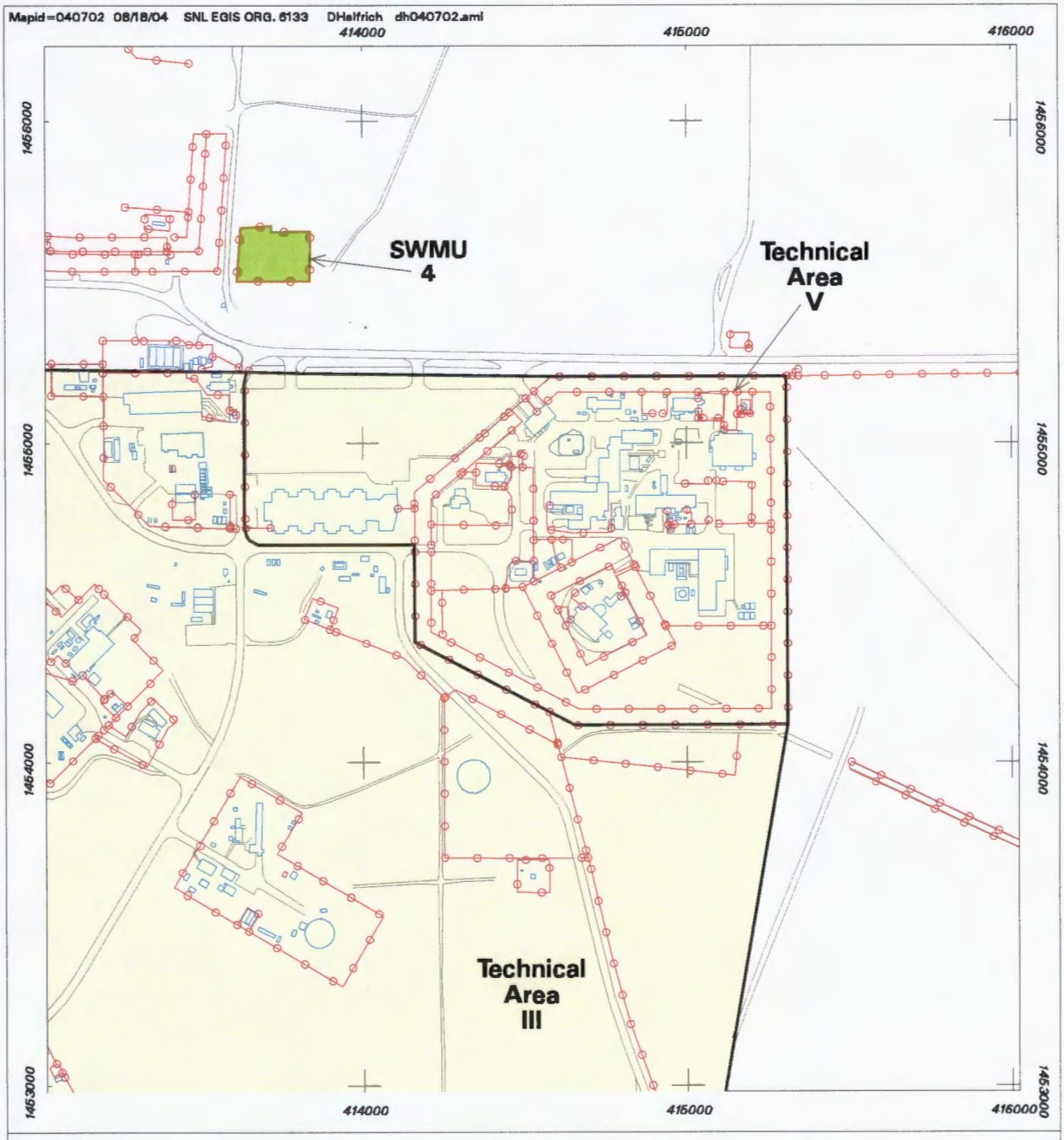
SWMU 4 consists of two unlined surface impoundments constructed to receive coolant water discharges from the Sandia Engineering Reactor Facility (SERF) and possibly contaminated waste water from experiments and operations in the SERF buildings. Beginning in 1963, radioactive discharges drained to the holding tanks, were monitored and then pumped to the drainfield. When the drainfield collapsed in 1967, discharges were directed to the impoundments. Radioactive discharges continued until 1970, and in 1971, the SERF was decommissioned. Nonradioactive discharges continued until 1992. In September 1983, one or both of the impoundments were used by the U.S. Air Force as a "decontamination catch bin" for undocumented purposes. Soil and sludge samples collected in 1984 showed 26.4 parts per million of polychlorinated biphenyls (PCBs) in one of the impoundments. These samples were not collected by SNL/NM's Environmental Restoration (ER) project. The conditions of sample collection are not known and documentation of results cannot be located.

The impoundments were constructed after the collapse of the LWDS drainfield (SWMU 5). Impoundment 1, the eastern impoundment, was constructed in June 1967, encompasses approximately 8,100 square feet, measures 65 by 125 feet, and is 12 feet deep. Impoundment 2 was constructed in June 1970 to the west of Impoundment 1, encompasses approximately 9,400 square feet, measures 102 by 92 feet, and is 20 feet deep. Waste oil and resin beads were disposed in the eastern impoundment on at least one occasion. The volume and radionuclide content of the discharges to the impoundments were monitored and recorded between 1967 and 1971. It is estimated that approximately 12 million gallons of waste water containing approximately 14 curies of measured radioactivity were discharged to the impoundments. After July 1971, reporting requirements were relaxed, and the impoundments continued to receive intermittent waste water discharges from sinks and floor drains in the Hot Cell Facility.

The vicinity of SWMU 4 is unpaved, and no storm sewers are used to direct surface water. Other than the surface impoundments themselves, there is no development on the site. Fencing surrounds the site, and signs are posted that identify the area as an ER site.

The annual precipitation for the area, as measured at Albuquerque International Sunport, is 8.1 inches (NOAA 1990). No springs or perennial surface-water bodies are located within 2 miles of the site. During most rainfall events, rainfall quickly infiltrates the soil at SWMU 4. However, virtually all of the moisture subsequently undergoes evapotranspiration. The estimates of evapotranspiration for the Kirtland Air Force Base (KAFB) area range from 95 to 99 percent of the annual rainfall (SNL/NM March 1996).

This page intentionally left blank.



Legend

- SWMU 4
- Fence
- Paved and Unpaved Road
- Building / Structure
- Technical Area

Figure 1
Location of TA-V and SWMU 4

0 250 500
Scale in Feet

0 60 120
Scale in Meters

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

840857.04220000 A4

Legend

- Road
- Fence
- 10-ft. Contour
- Building / Structure
- SNL Technical Area
- LWDS SWMU

Figure 2
Location of SWMUs 4, 5, and 52

0 150 300
Scale in Feet

0 36 72
Scale in Meters

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

840857.04220000 A5

Groundwater monitoring for the area surrounding SWMU 4 is conducted as part of the TA-V Groundwater Investigation. Thirteen monitoring wells are located within 1 mile of SWMU 4. The regional aquifer is approximately 480 to 500 feet below ground surface (bgs) (SNL/NM March 2003). Both the City of Albuquerque and KAFB use the regional aquifer for water-supply purposes. The nearest water supply well, KAFB-4, is located approximately 2 miles north of SWMU 4, although it is not used on a regular basis. Because the TA-V Groundwater area of concern is regulated separately under the Compliance Order on Consent (NMED 2004), the SWMU 4 site investigation and risk assessment do not address groundwater issues.

In 1992, the ER Project began work on the SWMU 4 LWDS Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) (SNL/NM September 1995) that included surface radiation and organic vapor surveys as well as extensive surface and subsurface soil sampling. A grid system was established, and surface soil samples were collected from the center of each 10- by 10-yard square. Additional samples were collected from both the surface and at a depth of 1 foot at the drainage outfalls. Soil samples were analyzed at an off-site laboratory for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), PCBs, metals, and radionuclides.

The RFI work continued later in 1992 and in 1994 with the advancement of nine soil boreholes in and around the SWMU 4 surface impoundments. In 1992, one groundwater monitoring well (LWDS-MW2) was installed north of the impoundments to a total depth of 531 feet bgs and screened between 506 to 526 feet bgs. This well is part of the TA-V monitoring well network and is sampled on a regular basis. Continuous core was collected from the boreholes, and soil samples were collected at approximately 5-foot intervals and submitted for laboratory analysis.

Analytical results of the LWDS RFI soil samples were compared with the New Mexico Environment Department (NMED)-approved background levels (Dinwiddie September 1997a) and 17 metals were found to be above background levels (antimony, arsenic, barium, beryllium, cadmium, total chromium, chromium VI, cobalt, copper, lead, mercury, nickel, selenium, silver, thallium, vanadium, and zinc). PCBs (Aroclor-1260) were detected in a surface sample at 0.071 milligrams (mg)/kilogram (kg). The U.S. Environmental Protection Agency (EPA) has set a screening level of 1 mg/kg for this site (Title 40, Code of Federal Regulations [CFR], Part 761). Detected organic compounds included acetone, benzene, benzo(a)anthracene, benzo(b)fluoranthene, bis(2-ethylhexyl) phthalate, 2-butanone, chrysene, fluoranthene, 2-hexanone, methylene chloride, PCBs, 4-methyl-2-pentanone, phenanthrene, pyrene, styrene, tetrachloroethene, and toluene. Elevated levels of radionuclides were also detected (Cs-137, Co-60, H-3, Pb-210, Ra-226, Th-232, U-235, and U-238).

A Request for Supplemental Information (RSI) was received from the NMED in 1997 (Dinwiddie September 1997b); this RSI indicated that additional information from the RFI sampling events was required. A response was prepared and submitted (SNL/NM January 1998) that addressed all concerns stated in the request.

II. Data Quality Objectives

The data quality objectives (DQOs) are presented in the LWDS RFI Work Plan (SNL/NM March 1993). The DQOs outline the quality assurance (QA)/quality control (QC) requirements necessary for producing defensible analytical data suitable for risk assessment purposes. The sampling conducted at SWMU 4 was designed to:

- Determine whether a release of constituents of concern (COCs) to the surface soil or subsurface soils beneath the surface impoundments has occurred above the action levels (or applicable approved background values).

- Determine whether a release of COCs above the action levels from SWMU 4 to the groundwater has occurred.

Table 1 summarizes the rationale for designing the sampling plan. Table 2 summarizes the sample collection and analyses performed for SWMU 4. The confirmatory soil samples were collected during two sampling events (in 1992 and 1994). Details of the collection and analytical results can be found in the September 1995 RFI Report (SNL/NM September 1995). The soil samples were analyzed for all COCs, including VOCs, SVOCs, PCBs, metals, and radionuclides.

The samples collected in 1992 were analyzed by Enseco (Quanterra) Laboratory (Enseco); the samples collected from the boreholes in 1994 were analyzed by Enseco, TMA Eberline, and the SNL/NM Radiation Protection Sample Diagnostics Laboratory. Table 3 summarizes the number of samples, the analytical methods, and data quality levels achieved as defined in the LWDS RFI work plan (SNL/NM March 1993).

Thirty-eight QA/QC samples were collected during both sampling events and consisted of 18 soil duplicate, 13 trip blank, and 7 aqueous equipment blank samples (Table 4). No significant QA/QC problems were identified in any of the QA/QC samples.

The 1992 and 1994 soil sample results were verified/validated by SNL/NM according to "Procedure for Validation of Chemical Measurement Data" SNL/NM Environmental Programs Department Procedure QA-11-01, Rev. 0 (SNL/NM October 1991). The reviews confirm that the data from the analytical laboratories are defensible and therefore acceptable for use in the proposal for no further action (NFA), fulfilling the DQO requirements.

III. Determination of Nature, Rate, and Extent of Contamination

III.1 Introduction

The determination of the nature, migration rate, and extent of contamination at SWMU 4 was based upon an initial conceptual model validated with confirmatory sampling at the site. The initial conceptual model was developed from archival research, soil sampling, soil-vapor surveys, aerial photographs, geophysical and radiological surveys. The DQOs contained in the LWDS RFI Work Plan (SNL/NM March 1993) identified the sample locations, sample density, sample depth, and analytical requirements. The quality of the data used to specifically determine the nature, migration rate, and extent of contamination is described in the following sections.

Table 1
Summary of Sampling Performed to Meet DQOs

SWMU 4 Sampling Areas	Potential COC Source	Number of Sampling Locations	Sample Density	Sampling Location Rationale
Surface soil samples in and near the surface impoundments collected in 1992	Discharge water from the LWDS holding tanks and/or KAFB one-time use	Samples collected from 48 points plus 2 sample locations at the drainage outfall	Sampling grid on a 10- by 10-yard spacing	Confirm that no significant levels of COCs exist in the surface and near-surface soil
Soil boreholes LWDS-BH-1 through LWDS-BH-5 drilled in 1992	Discharge water from the LWDS holding tanks and/or KAFB one-time use	Soil samples collected at various depths from 5 boreholes	Samples collected in each borehole at approximately 5-ft intervals	Confirm that no significant levels of COCs exist in the subsurface soil
Soil boreholes LWDS-BH-9, LWDS-BH-10, LWDS-BH-17, and LWDS-BH-18 drilled in 1994	Discharge water from the LWDS holding tanks and/or KAFB one-time use	Soil samples collected at various depths from 4 boreholes	Samples collected in each borehole at approximately 5-ft intervals	Confirm that no significant levels of COCs exist in the subsurface soil

BH = Borehole.
COC = Constituent of concern.
DQO = Data Quality Objective.
ft = Foot (feet).
KAFB = Kirtland Air Force Base.
LWDS = Liquid Waste Disposal System.
SWMU = Solid Waste Management Unit.

Table 2
SWMU 4 Confirmatory Soil Sample Summary and Analytical Suites

Sample Type and Sample Number[a]	Date Sampled	Sample Depth (ft bgs)	TAL Metals (EPA Methods 6010/7060/7196/ 7421/7471/7740/ 7841[b])	VOCs (EPA Method 8240[b])	SVOCs (EPA Method 8270[b])	pH, PAH, Phenols (EPA Method 8010, 8020, 8040[b])	PCBs (EPA Method 8080[b])	H-3 (EPA Method 906.0[b])	Gamma Spectroscopy (EPA Method 901.1[b])
Surface soil from grid area (SNLA010142-SNLA010160; SNLA010164-SNLA010184; SNLA010188-98; SNLA010200; and SNLA010204	07-16-92–07-20-92	48 samples collected at the surface plus 5 duplicate samples.	X	X	X	X	X	X	X
Surface soil from near drainage outfalls (SNLA010185 at Impoundment 2; SNLA010199 and SNLA010205 at Impoundment 1)	07-16-92–07-20-92	2 samples collected at the surface; 1 sample collected at 1 foot.	X	X	X	X	X	X	X
Borehole Sample LWDS-04-BH-1	08-08-92	0, 5, 10, 15, 20, 25, 30, 35, 35D, 40, 45, 50, 55, 60, 75, 80, 85	X	X	X	X	X	X	X
Borehole Sample LWDS-04-BH-2	08-10-92	45, 50, 70, 75, 80, 85, 90, 95, 100	X	X	X	X	X	X	X
Borehole Sample LWDS-04-BH-3	08-12-92	5, 10, 15, 20, 20D, 25, 30, 35, 41, 45, 50, 54, 60, 65, 70, 80, 85	X	X	X	X	X	X	X

Refer to footnotes at end of table.

Table 2 (Continued)
SWMU 4 Confirmatory Soil Sample Summary and Analytical Suites

Sample Type and Sample Number[a]	Date Sampled	Sample Depth (ft bgs)	TAL Metals (EPA Methods 6010/7060/7196/ 7421/7471/7740/ 7841[b])	VOCs (EPA Method 8240[b])	SVOCs (EPA Method 8270[b])	pH, PAH, Phenols (EPA Method 8010, 8020, 8040[b])	PCBs (EPA Method 8080[b])	H-3 (EPA Method 906.0[b])	Gamma Spectroscopy (EPA Method 901.1[b])
Borehole Sample LWDS-04-BH-4	08-18-92	5, 10, 15, 20, 25, 30, 35, 35D, 40, 45, 50, 56, 60, 65, 70, 70D, 74, 80, 84, 90, 95, 100	X	X	X	X	X	X	X
Borehole Sample LWDS-04-BH-5	08-20-92	5, 10, 15, 20, 24, 29, 35, 35D, 40, 45, 50, 55, 59, 65, 69, 75, 80 80D, 86, 90, 90D, 94, 100	X	X	X	X	X	X	X
Borehole Sample LWDS-04-BH-9	03-19-94	5, 10, 15, 20, 25, 30, 35, 40, 40D, 45, 50	X	X	X	X	X	X	X
Borehole Sample LWDS-04-BH-10	03-19-94	5, 10, 15, 15D, 20, 25, 30	X	X	X	X	X	X	X
Borehole Sample LWDS-04-BH-17	11-30-94	0, 5, 10, 15, 20, 25, 42, 49, 54, 59	X	X	X	X	X	X	X
Borehole Sample LWDS-04-BH-18	12-01-94	0, 5, 10, 15, 20, 25, 30	X	X	X	X	X	X	X

[a]Analysis Request/Chain of Custody Forms: 2031, 2032, 2033, 2034, 2035, 2036, 4031, 4032, 4033, 4034, 4035, 4036, 4037, 4038, 4039, 4040, 4041, 4042, 4043, 4044, 4045, 4046, 4047, 4048, 4049, 4050, 4051, 4052, 4053, 4054, 4122, 4123, 4124, 4125, 4126, 4127, 4128, 4129, 4130, 4131, 4132, 4162, 4163, 4164, 4401, 4402, 4403, 4404, 4406, 4407, 4411, 4412, 4413, 4414, 4415, 4416, 4417, 4418, 4419, 4420, 4421, 4422, 4423, 4424, 4425, 4426, 4427, 4428, 4429, 4430, 4491, 4492, 4493, 4494, 4522, 4523, 4525, 4526, 4527, 4528, 4529, 4545, 4546, 4547, 508421, 508424, 508425, 508427, 508601, 508602, 508686, 508688, 508689.
[b]EPA November 1986.

Table 2 (Concluded)
SWMU 4 Confirmatory Soil Sample Summary and Analytical Suites

bgs	= Below ground surface.
BH	= Borehole.
D	= Duplicate soil sample.
EPA	= U.S. Environmental Protection Agency.
ft	= Foot (feet).
LWDS	= Liquid Waste Disposal System.
PAH	= Polyaromatic hydrocarbon.
PCB	= Polychlorinated biphenyl.
SNLA	= Sandia National Laboratories, Albuquerque.
SVOC	=Semivolatile organic compound.
SWMU	= Solid Waste Management Unit.
TAL	= Target Analyte List.
VOC	= Volatile organic compound.
X	= Indicates that sample was collected from interval.

Table 3
Summary of Data Quality Requirements

Data Set	Analytical Method[a]	Data Quality Level	Number of Samples Analyzed			
			Enseco	Quanterra	TMA Eberline	SNL/NM RPSD Laboratory
1992 Surface (0 to 1 ft bgs) Soil Samples	VOCs (EPA Method 8240)	Defensible	51	–	NA	NA
	SVOCs (EPA Method 8270)	Defensible	51	–	NA	NA
	TAL Metals (EPA Method 6010/7010/7421/ 7471/7740/7841)	Defensible	51	–	NA	NA
	PCB (EPA Method 8080)	Defensible	50	–	NA	NA
	H-3 (EPA Method 906.0)	Defensible	49	–	–	–
	Gamma Spectroscopy (EPA Method 901.1)	Defensible	49	–	–	–
1992–Borehole Soil Samples	VOCs (EPA Method 8240)	Defensible	–	72	NA	NA
	SVOCs (EPA Method 8270)	Defensible	–	72	NA	NA
	TAL Metals (EPA Method 6010/7010/7421/ 7471/7740/7841)	Defensible	–	72	NA	NA
	PCB (EPA Method 8080)	Defensible	–	–	NA	NA
	H-3 (EPA Method 906.0)	Defensible	72	–	–	–
	Gamma Spectroscopy (EPA Method 901.1)	Defensible	72	–	–	–
1994–Borehole Soil Samples	VOCs (EPA Method 8240)	Defensible	16	17	NA	NA
	SVOCs (EPA Method 8270)	Defensible	16	17	NA	NA
	TAL Metals (EPA Method 6010/7010/7421/ 7471/7740/7841)	Defensible	16	17	NA	NA
	PCB (EPA Method 8080)	Defensible	3	4	NA	NA
	H-3 (EPA Method 906.0)	Defensible	–	–	34	–
	Gamma Spectroscopy (EPA Method 901.1)	Defensible	–	–	14	22
	Total Uranium (EPA Method 901.1)	Defensible	–	–	2	–

Refer to footnotes at end of table.

Table 3 (Concluded)
Summary of Data Quality Requirements

Total Number of Samples[b]	VOCs	156
	SVOCs	156
	TAL Metals	156
	PCBs	57
	H-3	155
	Gamma Spectroscopy	157
	Total Uranium	2

[a]EPA November 1986.
[b]The number of samples does not include QA/QC samples such as duplicates, trip blanks, and equipment blanks.

bgs = Below ground surface.
EPA = U.S. Environmental Protection Agency.
ft = Foot (feet).
NA = Not applicable.
PCB = Polychlorinated biphenyl.
QA = Quality assurance.
QC = Quality control.
RPSD = Radiation Protection Sample Diagnostics.
SNL/NM = Sandia National Laboratories/New Mexico.
SVOC = Semivolatile organic compound.
TAL = Target Analyte List.
TMA = Thermo Analytical, Inc.
VOC = Volatile organic compound.
– = No samples analyzed.

Table 4
Summary of QA/QC Samples

Data Set	Sample Type	Number of Samples
1992–Surface Soil Samples	Duplicate	5
	Trip Blank	6
1992–Borehole Soil Samples	Duplicate	11
	Trip Blank	5
	Equipment Blank	5
1994–Borehole Soil Samples	Duplicate	2
	Trip Blank	2
	Equipment Blank	2

QA = Quality assurance.
QC = Quality control.

III.2 Nature of Contamination

Both the nature of contamination and the potential for the degradation of COCs at SWMU 4 were evaluated using laboratory analyses of the soil samples. The laboratory requirements included analyses for VOCs, SVOCs, PCBs, metals, and radionuclides, which characterized potential contamination at the site. The analytes and methods listed in Table 2 are appropriate for characterizing the COCs and potential degradation products at SWMU 4.

III.3 Rate of Contaminant Migration

SWMU 4 is an inactive site; therefore, all primary sources of COCs have been eliminated. As a result, only secondary sources of COCs potentially remain in the soil in the form of adsorbed COCs. The rate of COC migration from soil is, therefore, predominantly dependent upon precipitation into the impoundments. Data available from the TA-V Groundwater Investigation (SNL/NM November 2001); numerous SNL/NM monitoring programs for air, water, and radionuclides; and meteorological monitoring are adequate for characterizing the rate of COC migration at SWMU 4.

III.4 Extent of Contamination

Soil samples were collected from the surface and subsurface soil to a maximum depth of 100 feet bgs during the drilling activities at SWMU 4 in order to determine the vertical and horizontal extent of contamination. Extensive soil sampling was conducted within the boundaries of the surface impoundments, both at the surface and in the five boreholes. An additional four boreholes were advanced on each side of the impoundments. These soil samples are representative of the soil directly beneath, and adjacent to, the surface impoundments and are considered to be sufficient to determine the vertical extent, if any, of COCs.

In summary, the design of the confirmatory soil sampling plan was appropriate and adequate to determine the nature, migration rate, and extent of residual COCs in the surface and subsurface soil at SWMU 4.

IV. Comparison of COCs to Background Screening Levels

Site history and characterization activities are used to identify potential COCs. This document describes the identification of COCs and the sampling that was conducted in order to determine the concentration levels of those COCs across the site. Generally, COCs evaluated in this risk assessment include all detected organic and all radiological and inorganic COCs for which samples were analyzed. When the detection limit of an organic compound was too high (i.e., could possibly cause an adverse effect to human health or the environment), the compound was retained. Nondetected organic compounds not included in this assessment were found to have detection limits low enough to ensure protection of human health and the environment. In order to provide conservatism in this risk assessment, the calculation used only the maximum concentration value of each COC found for the entire site. The SNL/NM maximum background concentration (Dinwiddie September 1997a) was selected to provide the background screen listed in Tables 5, 6, and 7.

Nonradiological inorganic constituents that are essential nutrients, such as iron, magnesium, calcium, potassium, and sodium, were not included in this risk assessment (EPA 1989a). Both radiological and nonradiological COCs were evaluated. The nonradiological COCs included both organic and inorganic compounds.

Table 5 lists the nonradiological COCs for the human health risk assessment at SWMU 4. Table 6 lists the nonradiological COCs for the ecological risk assessment. Table 7 lists the radiological COCs for the human health and ecological risk assessments. All tables show the associated SNL/NM maximum background concentration values (Dinwiddie September 1997a). Tables 5 and 7 are discussed in Sections VI.4 (Human Health Risk Assessment), while Tables 6 and 7 are discussed in Sections VII.2 and VII.3 (Ecological Risk Assessment).

V. Fate and Transport

The primary releases of COCs at SWMU 4 occurred in the surface soil as a result of discharges of effluent water from the SERF in TA-V. Wind, water, and biota are natural mechanisms of COC transport from the primary release point. Because the site consists of two excavated and bermed impoundments with surrounding woody vegetation, wind is unlikely to be a significant transport mechanism for COCs at the site.

Effluent discharges to the surface impoundments (from the SERF LWDS Holding Tanks) began around 1967 and were finally discontinued in 1992. Water released to the impoundments was allowed to evaporate or infiltrate into the soil. Infiltration is expected to have carried COCs from the effluent into the subsurface soil. Phreatophytic vegetation (salt cedar trees), established around the margins of the impoundments, provides a mechanism by which subsurface water is transported back to the surface and is lost to the atmosphere though transpiration.

Water at SWMU 4 is received only as precipitation (rain or occasionally snow) that falls directly onto the site. Based upon the average rainfall measured at Albuquerque International Sunport, the site receives approximately 8.1 inches of precipitation per year (NOAA 1990). Because the site consists of excavated impoundments, all surface runoff is contained on the site. Storm-water runoff from off-site areas does not enter the site. On-site runoff will collect in the lowest parts of the impoundments where it will either infiltrate or evaporate. Water that infiltrates into

Table 5
Nonradiological COCs for Human Health Risk Assessment at SWMU 4 with Comparison to the Associated SNL/NM Background Screening Value, BCF, and Log K_{ow}

COC	Maximum Concentration (All Samples) (mg/kg)	SNL/NM Background Concentration (mg/kg)[a]	Is Maximum COC Concentration Less Than or Equal to the Applicable SNL/NM Background Screening Value?	BCF (maximum aquatic)	Log K_{ow} (for organic COCs)	Bioaccumulator?[b] (BCF>40, Log K_{ow}>4)
Inorganic						
Antimony	9.3	3.9	**No**	16,000[c]	NA	**Yes**
Arsenic	7.6	4.4	**No**	44[d]	NA	**Yes**
Barium	849	130	**No**	170[e]	NA	**Yes**
Beryllium	4.9	0.65	**No**	19[d]	NA	No
Cadmium	154	<1	**No**	64[d]	NA	**Yes**
Chromium, total	97.7	15.9	**No**	16[d]	NA	No
Chromium VI	11.2	1	**No**	16[d]	NA	No
Cobalt	42.2	5.2	**No**	10,000[f]	NA	**Yes**
Copper	239	15.4	**No**	6[d]	NA	No
Lead	72.5	11.8	**No**	49[d]	NA	**Yes**
Mercury	0.61	<0.1	**No**	5,500[d]	NA	**Yes**
Nickel	173	11.5	**No**	47[d]	NA	**Yes**
Selenium	10	<1	**No**	800[c]	NA	**Yes**
Silver	90.5	<1	**No**	0.5[d]	NA	No
Thallium	1.2	<1.1	**No**	119[d]	NA	**Yes**
Vanadium	52.7	20.4	**No**	3,000[e]	NA	**Yes**
Zinc	198	62	**No**	47[d]	NA	**Yes**
Organic						
Acetone	4.3	NC	**NA**	0.69[g]	-0.24[g]	No
Benzene	0.01	NC	**NA**	5.2[d]	2.13[d]	No
Benzo(a)anthracene	0.35	NC	**NA**	10,000[h]	5.61[h]	**Yes**
Benzo(b)fluoranthene	0.46	NC	**NA**	–	6.124[h]	**Yes**
bis(2-Ethylhexyl) phthalate	5.9	NC	**NA**	851[i]	7.6[h]	**Yes**
2-Butanone	0.17	NC	**NA**	1[g]	0.29[g]	No
Chrysene	0.36	NC	**NA**	18,000[h]	5.91[h]	**Yes**
Fluoranthene	0.85	NC	**NA**	12,302[h]	4.90[h]	**Yes**

Refer to footnotes at end of table.

Table 5 (Concluded)
Nonradiological COCs for Human Health Risk Assessment at SWMU 4 with Comparison to the Associated SNL/NM Background Screening Value, BCF, and Log K_{ow}

COC	Maximum Concentration (All Samples) (mg/kg)	SNL/NM Background Concentration (mg/kg)[a]	Is Maximum COC Concentration Less Than or Equal to the Applicable SNL/NM Background Screening Value?	BCF (maximum aquatic)	Log K_{ow} (for organic COCs)	Bioaccumulator?[b] (BCF>40, Log K_{ow}>4)
2-Hexanone	0.024	NC	**NA**	6[j]	1.38[j]	No
Methylene chloride	0.046	NC	**NA**	5[g]	1.25[g]	No
4-Methyl-2-pentanone	0.02	NC	**NA**	5[h]	1.19[h]	No
PCBs, total	0.071	NC	**NA**	31,200[d]	6,72[d]	**Yes**
Phenanthrene	0.71	NC	**NA**	23,800[d]	4.63[d]	**Yes**
Pyrene	0.75	NC	**NA**	36,300[c]	5.32[h]	**Yes**
Styrene	0.0025	NC	**NA**	13.5[i]	2.95[i]	No
Tetrachloroethene	0.0085	NC	**NA**	49[g]	2.67[h]	**Yes**
Toluene	0.012	NC	**NA**	10.7[c]	2.69[c]	No

Note: **Bold** indicates the COCs that exceed the background screening value and/or are bioaccumulators.
[a]Dinwiddie September 1997a, Southwest Area Supergroup.
[b]NMED March 1998.
[c]Callahan et al. 1979.
[d]Yanicak March 1997.
[e]Neumann 1976.
[f]Vanderploeg et al. 1975.
[g]Howard 1990.
[h]Micromedex, Inc. 1998.
[i]Howard 1989.
[j]Howard 1993.

BCF = Bioconcentration factor.
COC = Constituent of concern.
K_{ow} = Octanol-water partition coefficient.
Log = Logarithm (base 10).
mg/kg = Milligram(s) per kilogram.
NA = Not applicable.
NC = Not calculated.
NMED = New Mexico Environment Department.
PCB(s) = Polychlorinated biphenyl(s).
SNL/NM = Sandia National Laboratories/New Mexico.
SWMU = Solid Waste Management Unit.
– = Information not available.

Table 6
Nonradiological COCs for Ecological Risk Assessment at SWMU 4 with Comparison to the Associated SNL/NM Background Screening Value, BCF, and Log K_{ow}

COC	Maximum Concentration (0 to 5 ft bgs) (mg/kg)	SNL/NM Background Concentration (mg/kg)[a]	Is Maximum COC Concentration Less Than or Equal to the Applicable SNL/NM Background Screening Value?	BCF (maximum aquatic)	Log K_{ow} (for organic COCs)	Bioaccumulator?[b] (BCF>40, Log K_{ow}>4)
Inorganic						
Antimony	6	3.9	**No**	16,000[c]	NA	**Yes**
Arsenic	7.6	4.4	**No**	44[d]	NA	**Yes**
Barium	232	130	**No**	170[e]	NA	**Yes**
Beryllium	4.9	0.65	**No**	19[d]	NA	No
Cadmium	154	<1	**No**	64[d]	NA	**Yes**
Chromium, total	97.7	15.9	**No**	16[d]	NA	No
Chromium VI	11.2	1	**No**	16[d]	NA	No
Cobalt	42.2	5.2	**No**	10,000[f]	NA	**Yes**
Copper	239	15.4	**No**	6[d]	NA	No
Lead	72.5	11.8	**No**	49[d]	NA	**Yes**
Mercury	0.61	<0.1	**No**	5500[d]	NA	**Yes**
Nickel	173	11.5	**No**	47[d]	NA	**Yes**
Selenium	10	<1	**No**	800[c]	NA	**Yes**
Silver	90.5	<1	**No**	0.5[d]	NA	No
Thallium	0.79 J	<1.1	**No**	119[d]	NA	**Yes**
Vanadium	52.7	20.4	**No**	3,000[e]	NA	**Yes**
Zinc	198	62	**No**	47[d]	NA	**Yes**
Organic						
Acetone	4.3	NC	**NA**	0.69[g]	-0.24[g]	No
Benzo(a)anthracene	0.35	NC	**NA**	10,000[h]	5.61[h]	**Yes**
Benzo(b)fluoranthene	0.46	NC	**NA**	–	6.124[h]	**Yes**
bis(2-Ethylhexyl) phthalate	5.9	NC	**NA**	851[i]	7.6[h]	**Yes**
2-Butanone	0.17	NC	**NA**	1[g]	0.29[g]	No
Chrysene	0.36	NC	**NA**	18,000[h]	5.91[h]	**Yes**
Fluoranthene	0.85	NC	**NA**	12,302[h]	4.90[h]	**Yes**
2-Hexanone	0.024	NC	**NA**	6[j]	1.38[j]	No
4-Methyl-2-pentanone	0.02	NC	**NA**	5[h]	1.19[h]	No
Methylene chloride	0.0075	NC	**NA**	5[g]	1.25[g]	No
PCBs, total	0.071	NC	**NA**	31,200[d]	6.72[d]	**Yes**

Refer to footnotes at end of table.

Table 6 (Concluded)
Nonradiological COCs for Ecological Risk Assessment at SWMU 4 with Comparison to the Associated SNL/NM Background Screening Value, BCF, and Log K_{ow}

COC	Maximum Concentration (0 to 5 ft bgs) (mg/kg)	SNL/NM Background Concentration (mg/kg)[a]	Is Maximum COC Concentration Less Than or Equal to the Applicable SNL/NM Background Screening Value?	BCF (maximum aquatic)	Log K_{ow} (for organic COCs)	Bioaccumulator?[b] (BCF>40, Log K_{ow}>4)
Phenanthrene	0.71	NC	**NA**	23,800[d]	4.63[d]	**Yes**
Pyrene	0.75	NC	**NA**	36,300[c]	5.32[h]	**Yes**
Toluene	0.0094	NC	**NA**	10.7[c]	2.69[c]	No

Note: **Bold** indicates the COCs that exceed the background screening values and/or are bioaccumulators.
[a]Dinwiddie September 1997a, Southwest Area Supergroup.
[b]NMED March 1998.
[c]Callahan et al. 1979.
[d]Yanicak March 1997.
[e]Neumann 1976.
[f]Vanderploeg et al. 1975.
[g]Howard 1990.
[h]Micromedex, Inc. 1998.
[i]Howard 1989.
[j]Howard 1993.
BCF = Bioconcentration factor.
bgs = Below ground surface.
COC = Constituent of concern.
ft = Foot (feet).
K_{ow} = Octanol-water partition coefficient.
J = Estimated value.
Log = Logarithm (base 10).
mg/kg = Milligram(s) per kilogram.
NA = Not applicable.
NC = Not calculated.
NMED = New Mexico Environment Department.
PCB = Polychlorinated biphenyl.
SNL/NM = Sandia National Laboratories/New Mexico.
SWMU = Solid Waste Management Unit.
– = Information not available.

Table 7
Radiological COCs for Human Health and Ecological Risk Assessments at SWMU 4 with Comparison to the Associated SNL/NM Background Screening Value and BCF

COC	Maximum Concentration (pCi/g)	SNL/NM Background Concentration (pCi/g)[a]	Is Maximum COC Concentration Less Than or Equal to the Applicable SNL/NM Background Screening Value?	BCF (maximum aquatic)	Is COC a Bioaccumulator?[b] (BCF>40)
Cs-137	**10.1**	0.664	**No**	3,000[d]	**Yes**
Co-60	**11**	NA	**No**	10,000[c]	**Yes**
H-3	**0.5**	0.021	**No**	No	No
Pb-210	**12.0**	NA	**No**	49[e]	**Yes**
Ra-226	**3.68**	1.76	**No**	No[e]	No
Th-232	**1.18**	1.01	**No**	3,000[f]	**Yes**
U-235	**3.0**	0.16	**No**	900[f]	**Yes**
U-238	**1.4**	1.4	**No**	900[f]	**Yes**

Note: **Bold** indicates COCs that exceed the background screening values and/or are bioaccumulators.
[a]Dinwiddie September 1997a, Southwest Area Supergroup.
[b]NMED March 1998.
[c]Vanderploeg et al. 1975.
[d]Whicker and Schultz 1982.
[e]Yanicak March 1997.
[f]Baker and Soldat 1992.
BCF = Bioconcentration factor.
COC = Constituent of concern.
NA = Not applicable.
NMED = New Mexico Environment Department.
pCi/g = Picocurie(s) per gram.
SNL/NM = Sandia National Laboratories/New Mexico.
SWMU = Solid Waste Management Unit.

the soil can potentially leach COCs deeper into the subsurface soil as it percolates downward. Evaporation from the soil surface may result in capillary rise of soil water, reversing this downward movement and concentrating COCs at or near the surface. Because of the arid environment, evapotranspiration rates are high, with average losses of 95 to 99 percent of precipitation through this process. In addition, the phreatophytic vegetation on the site increases evapotranspiration rates at SWMU 4. Because of the low annual precipitation, high evapotranspiration rates, and depth to groundwater at this site (greater than 480 feet bgs), infiltration and percolation are not sufficient to further leach COCs into the groundwater.

COCs in the soil can enter the food chain via uptake by the plant roots. Herbivores may consume plant tissues that contain these COCs or the COCs may be returned to the soil as plant litter. Aboveground litter is capable of transport by wind until consumed by decomposer organisms in the soil. Constituents in plant tissues that are consumed by herbivores may be absorbed into tissues or may be returned to the soil (at the site or transported from the site by the herbivore). The herbivore may be eaten by a carnivore or scavenger, and the COCs in its tissues will again be either absorbed or excreted by the consumer. The potential for transport of the constituents within the food chain is dependent upon both the mobility of the species that comprise the food chain and the potential for the constituent to accumulate in tissues and be transferred across the links in the food chain. At SWMU 4, the original habitat of the site (grassland) has been highly modified by the construction of the impoundments. With the exception of the salt cedar trees that now occupy the margins of the impoundments, the current vegetative cover is low and primarily consists of ruderal species. Significant transfers of COCs in the food chain are limited by the small size of the site, the low amount of vegetation other than salt cedar trees, and the generally unpalatable nature of salt cedar to most wildlife herbivores. Therefore, food chain uptake is not considered to be a potentially significant transport mechanism at this site.

The COCs at SWMU 4 include both inorganic and organic constituents. The inorganic constituents include both radiological and nonradiological analytes. The inorganic COCs are elemental in form and generally not considered to be degradable. Radiological COCs, however, undergo decay to stable isotopes or radioactive daughter elements. Other transformations of inorganic constituents may include changes in valence (oxidation/reduction reactions) or incorporation into organic forms (e.g., the conversion of selenite or selenate from soil to seleno-amino acids in plants). The rate of such processes will be limited by the arid environment at this site. Organic COCs may be degraded through photolysis, hydrolysis, and biotransformation. Photolysis requires light and therefore takes place in the air, at the ground surface, or in surface water. Hydrolysis includes chemical transformations in water and may occur in the soil solution. Biotransformation (i.e., transformation caused by plants, animals, and microorganisms) may occur; however, biological activity may be limited by the arid environment. Some organic COCs (e.g., VOCs such as acetone, benzene, 2-butanone, and toluene) may be lost through volatilization.

Table 8 summarizes the fate and transport processes that may occur at SWMU 4. Because the site consists of excavated impoundments surrounded by salt cedar trees, the potential for COC transport via wind is low, and no surface-water runoff is expected to leave the site. COCs have leached into the subsurface soil below the impoundments; however, because of the low precipitation and high evapotranspiration rates of this area, further leaching of these COCs into the groundwater is not expected to occur. Although fenced, the site is open to use by wildlife, and some vegetation occurs at the site; therefore, uptake into the food chain is possible, but the

Table 8
Summary of Fate and Transport at SWMU 4

Transport and Fate Mechanism	Existence at Site	Significance
Wind	Yes	Low
Surface runoff	No	None
Migration to groundwater	No	None
Food chain uptake	Yes	Low
Transformation/degradation	Yes	Low

SWMU = Solid Waste Management Unit.

small size and relatively low vegetative cover of the site make this an insignificant transport mechanism for COCs. The potential for significant loss of COCs by degradation and/or transformation is generally low; however, some organic compounds may be lost near the soil surface through volatilization.

VI. Human Health Risk Assessment

VI.1 Introduction

The human health risk assessment of this site includes a number of steps that culminate in a quantitative evaluation of the potential adverse human health effects caused by constituents located at the site. The steps to be discussed include the following:

Step 1.	Site data are described that provide information on the potential COCs, as well as the relevant physical characteristics and properties of the site.
Step 2.	Potential pathways are identified by which a representative population might be exposed to the COCs.
Step 3.	The potential intake of these COCs by the representative population is calculated using a tiered approach. The first component of the tiered approach is a screening procedure that compares the maximum concentration of the COC to an SNL/NM maximum background screening value. COCs that are not eliminated during the first screening procedure are carried forward in the risk assessment process.
Step 4.	Toxicological parameters are identified and referenced for COCs that were not eliminated during the screening procedure.
Step 5.	Potential toxicity effects (specified as a hazard index [HI]) and estimated excess cancer risks are calculated for nonradiological COCs and background. For radiological COCs, the incremental total effective dose equivalent (TEDE) and incremental estimated cancer risk are calculated by subtracting applicable background concentrations directly from maximum on-site contaminant values. This background subtraction applies only when a radiological COC occurs as contamination and exists as a natural background radionuclide.
Step 6.	These values are compared with guidelines established by the EPA, NMED, and the U.S. Department of Energy (DOE) to determine whether further evaluation and potential site cleanup are required. Nonradiological COC risk values also are compared to background risk so that an incremental risk can be calculated.
Step 7.	Uncertainties of the above steps are addressed.

VI.2 Step 1. Site Data

Section I of this risk assessment provides the site description and history for SWMU 4. Section II presents a comparison of results to DQOs. Section III discusses the nature, rate, and extent of contamination.

VI.3 Step 2. Pathway Identification

SWMU 4 has been designated with a future land-use scenario of industrial (DOE et al. September 1995) (see Appendix 1 for default exposure pathways and parameters). However, the residential land-use scenario is also considered in the pathway analysis. Because of the location and characteristics of the potential contaminants, the primary pathway for human exposure is considered to be soil ingestion for the nonradiological COCs and direct gamma exposure for the radiological COCs. The inhalation pathway for both nonradiological and radiological COCs is included because the potential exists to inhale dust and volatiles. Soil ingestion is included for the radiological COCs as well. The dermal pathway is included for the nonradiological COCs because of the potential for the receptor to be exposed to contaminated soil. No water pathways to the groundwater are considered. Depth to groundwater at SWMU 4 is greater than 480 feet bgs. No intake routes through plant, meat, or milk ingestion are considered appropriate for either the industrial or residential land-use scenarios. Figure 3 shows the conceptual model flow diagram for SWMU 4.

Pathway Identification

Nonradiological Constituents	Radiological Constituents
Soil ingestion	Soil ingestion
Inhalation (dust and volatiles)	Inhalation (dust and volatiles)
Dermal contact	Direct gamma

VI.4 Step 3. Background Screening Procedure

This section discusses Step 3, the background screening procedure, which compares the maximum COC concentration to the background screening level. The methodology and results are described in the following sections.

VI.4.1 Methodology

Maximum concentrations of nonradiological COCs were compared to the approved SNL/NM maximum screening levels for this area. The SNL/NM maximum background concentration was selected to provide the background screen in Table 5 and used to calculate risk attributable to background in Section VI.6.2. Only the COCs that were detected above the corresponding SNL/NM maximum background screening levels or do not have either a quantifiable or calculated background screening level were considered in further risk assessment analyses.

For radiological COCs that exceeded the SNL/NM background screening levels, background values were subtracted from the individual maximum radionuclide concentrations. Those that

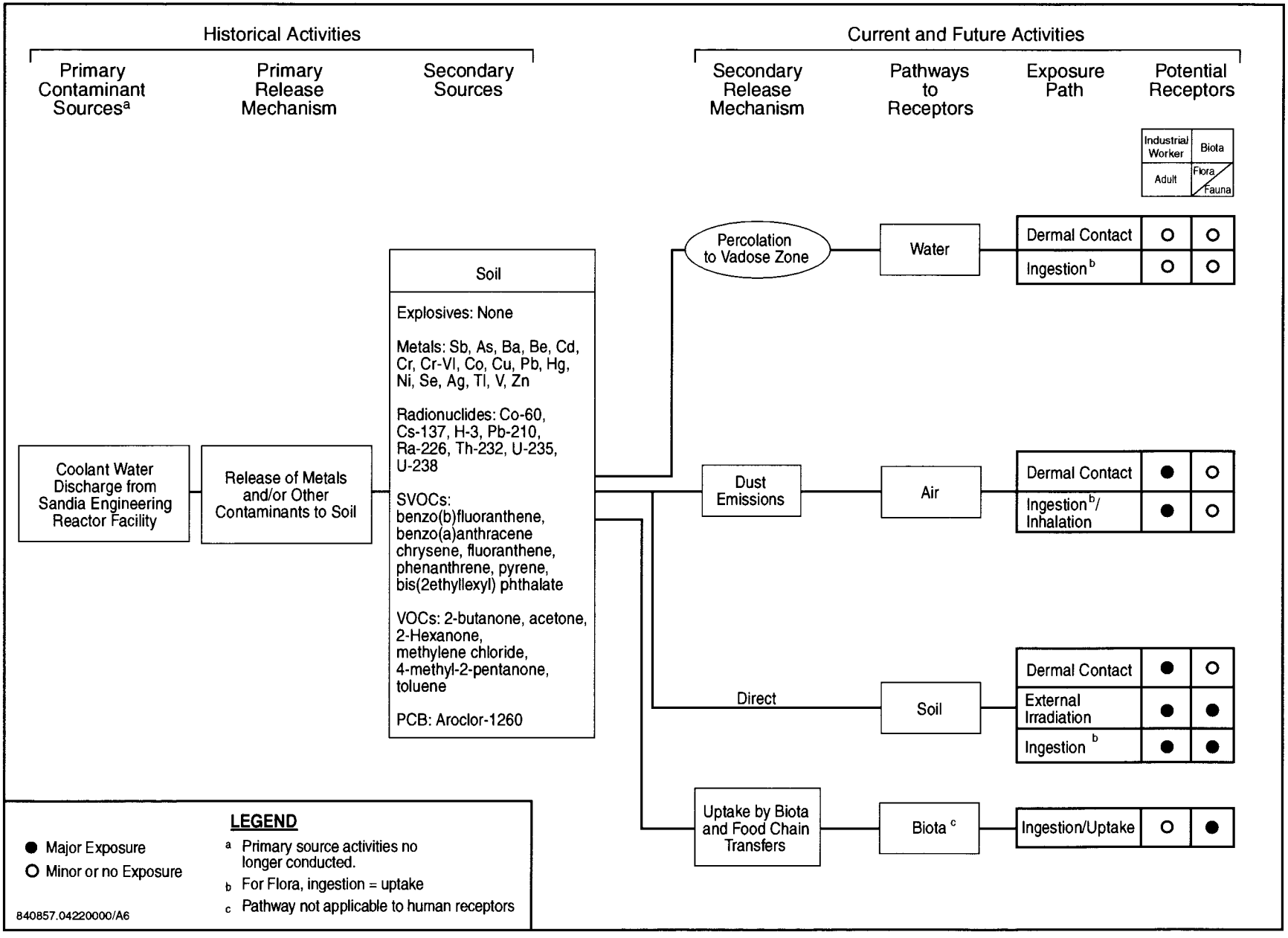


Figure 3

Conceptual Site Model Flow Diagram for SWMU 4

did not exceed these background levels were not carried any further in the risk assessment. This approach is consistent with DOE Order 5400.5, "Radiation Protection of the Public and the Environment" (DOE 1993). Radiological COCs that do not have a background value and were detected above the analytical minimum detectable activity (MDA) were carried through the risk assessment at the maximum levels. The resultant radiological COCs remaining after this step are referred to as background-adjusted radiological COCs.

VI.4.2 Results

Tables 5 and 7 present SWMU 4 maximum COC concentrations that were compared to the SNL/NM maximum background values (Dinwiddie September 1997a) for the human health risk assessment. For the nonradiological COCs, 17 constituents were measured at concentrations greater than the background values. Seventeen COCs were organic compounds that do not have corresponding calculated background concentrations.

The maximum concentration value for lead was 72.5 mg/kg. The EPA intentionally does not provide any human health toxicological data on lead; therefore, no risk parameter values could be calculated. However, the NMED guidance for lead screening concentrations for construction and industrial land-use scenarios are 750 and 1,500 mg/kg, respectively (Olson and Moats March 2000). The EPA screening guidance value for a residential land-use scenario is 400 mg/kg (Laws July 1994). The maximum concentration value for lead at this site was lower than all the screening values; therefore, lead is eliminated from further consideration in the human health risk assessment.

The maximum concentration value for total PCBs was 0.071 mg/kg. The EPA has set a screening level of 1 mg/kg for this site (Title 40, CFR, Part 761). The maximum concentration for PCBs at this site is less than the screening value; therefore, PCBs are eliminated from further consideration in the human health risk assessment.

For the radiological COCs, eight constituents (Cs-137, Co-60, H-3, Pb-210, Ra-226, Th-232, U-235, and U-238) that either exhibited MDA values greater than the corresponding background levels or did not have a corresponding background level are evaluated in this risk assessment.

VI.5 Step 4. Identification of Toxicological Parameters

Tables 9 and 10 list the COCs retained in the risk assessment and the values for the available toxicological information. The toxicological values for the nonradiological COCs presented in Table 9 were obtained from the Integrated Risk Information System (IRIS) (EPA 2003), the Health Effects Assessment Summary Tables (HEAST) (EPA 1997a), the Technical Background Document for Development of Soil Screening Levels (NMED December 2000), the EPA Region 6 (EPA 2002a), and the Risk Assessment Information System (ORNL 2003) electronic databases. Dose conversion factors (DCFs) used in determining the excess TEDE values for radiological COCs for the individual pathways were the default values provided in the RESRAD computer code (Yu et al. 1993a) as developed in the following documents:

- DCFs for ingestion and inhalation are taken from "Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion" (EPA 1988a).

Table 9
Toxicological Parameter Values for SWMU 4 Nonradiological COCs

COC	RfD_o (mg/kg-d)	Confidence[a]	RfD_{inh} (mg/kg-d)	Confidence[a]	SF_o $(mg/kg\text{-}day)^{-1}$	SF_{inh} $(mg/kg\text{-}day)^{-1}$	Cancer Class[b]	ABS
Inorganic								
Antimony	4E-4[c]	L	–	–	–	–	–	0.01[d]
Arsenic	3E-4[c]	M	–	–	1.5E+0[c]	1.5E+1[c]	A	0.03[d]
Barium	7E-2[c]	M	1.4E-4[e]	–	–	–	D	0.01[d]
Beryllium	2E-3[c]	L to M	5.7E-6[c]	M	–	8.4E+0[c]	B1	0.01[d]
Cadmium	5E-4[c]	H	5.7E-5[f]	–	–	6.3E+0[c]	B1	0.001[d]
Chromium, total	1E+0[c]	L	5.7E-7[e]	–	–	–	D	0.01[d]
Chromium VI	3E-3[c]	L	2.3E-6[d]	L	–	4.2E+1[c]	A	0.01[d]
Cobalt	2E-2[g]	–	5.7E-6[e]	–	–	9.8E+0[f]	–	0.01[d]
Copper	3.7E-2[f]	–	–	–	–	–	D	0.01[d]
Mercury	3E-4[e]	–	8.6E-5[c]	M	–	–	D	0.01[d]
Nickel	2E-2[c]	M	–	–	–	–	–	0.01[d]
Selenium	5E-3[c]	H	–	–	–	–	D	0.01[d]
Silver	5E-3[c]	L	–	–	–	–	D	0.01[d]
Thallium	6.6E-5[g]	–	–	–	–	–	–	0.01[d]
Vanadium	7E-3[e]	–	–	–	–	–	–	0.01[d]
Zinc	3E-1[c]	M	–	–	–	–	D	0.01[d]
Organic								
Acetone	1E-1[c]	L	1E-1[f]	–	–	–	D	0.01[h]
Benzene	3E-3[f]	–	1.7E-3[f]	–	5.5E-2[c]	2.7E-2[c]	A	0.01[d]
Benzo(a)anthracene	–	–	–	–	7.3E-1[f]	3.1E-1[f]	–	0.13[d]
Benzo(b)fluoranthene	–	–	–	–	7.3E-1[f]	3.1E-1[f]	B2	0.13[d]
bis(2-Ethylhexyl) phthalate	2E-2[f]	–	2.2E-2[f]	–	1.4E-2[f]	1.4E-2[f]	–	0.01[h]
2-Butanone	6E-1[c]	L	2.9E-1[c]	L	–	–	D	0.1[d]
Chrysene	–	–	–	–	7.3E-3[f]	3.1E-3[f]	B2	0.13[d]
Fluoranthene	4E-2[c]	L	4E-2[f]	–	–	–	D	0.13[d]
2-Hexanone	4E-2[i]	–	1.4E-3[i]	–	–	–	–	0.01[h]
Methylene chloride	6E-2[c]	M	8.6E-1[e]	–	7.5E-3[f]	1.6E-3[c]	B2	0.1[d]
4-Methyl-2-pentanone	8E-2[f]	–	2.3E-2[d]	–	–	–	–	0.1[d]
Phenanthrene[j]	3E-1[c]	L	3E-1[f]	–	–	–	D	0.13[d]
Pyrene	3E-2[c]	L	3E-2[f]	–	–	–	D	0.1[d]
Styrene	2E-1[c]	M	2.9E-1[c]	M	–	–	–	0.01[h]

Refer to footnotes at end of table.

Table 9 (Concluded)
Toxicological Parameter Values for SWMU 4 Nonradiological COCs

COC	RfD_o (mg/kg-d)	Confidence[a]	RfD_{inh} (mg/kg-d)	Confidence[a]	SF_o $(mg/kg\text{-}day)^{-1}$	SF_{inh} $(mg/kg\text{-}day)^{-1}$	Cancer Class[b]	ABS
Tetrachloroethene	1E-2[c]	M	1.1E-2[f]	–	5.2E-2[f]	1.2E-2[f]	–	0.1[d]
Toluene	2E-1[c]	M	1.1E-1[c]	M	–	–	D	0.1[d]

[a]Confidence associated with IRIS (EPA 2003) database values. Confidence: L = low, M = medium, H = high.
[b]EPA weight-of-evidence classification system for carcinogenicity (EPA 1989a) taken from IRIS (EPA 2003) with the exception of carbazole which was taken from HEAST (EPA 1997a):

A = Human carcinogen.
B1 = Probable human carcinogen. Limited human data available.
B2 = Probable human carcinogen. Sufficient evidence in animals and inadequate or no evidence in humans.
D = Not classifiable as to human carcinogenicity.

[c]Toxicological parameter values from IRIS electronic database (EPA 2003).
[d]Toxicological parameter values from NMED December 2000.
[e]Toxicological parameter values from HEAST database (EPA 1997a).
[f]Toxicological parameter values from EPA Region 6 electronic database (EPA 2002a).
[g]Toxicological parameter values from EPA Region 9 electronic database (EPA 2002b).
[h]Toxicological parameter values from ORNL 2003.
[i]Toxicological parameter values from EPA Region 3 electronic database (EPA 2002c).
[j]Phenanthrene does not have toxicological parameter values . Anthracene was used as a surrogate.

ABS = Gastrointestinal absorption coefficient.
COC = Constituent(s) of concern.
EPA = U.S. Environmental Protection Agency.
HEAST = Health Effects Assessment Summary Tables.
IRIS = Integrated Risk Information System.
mg/kg-d = Milligram(s) per kilogram day.
$(mg/kg\text{-}day)^{-1}$ = Per milligram per kilogram day.
RfD_{inh} = Inhalation chronic reference dose.
RfD_o = Oral chronic reference dose.
SF_{inh} = Inhalation slope factor.
SF_o = Oral slope factor.
SWMU = Solid Waste Management Unit.
– = Information not available.

Table 10
Radiological Toxicological Parameter Values for SWMU 4 COCs Obtained from RESRAD Risk Coefficients[a]

COC	SF_o (1/pCi)	SF_{inh} (1/pCi)	SF_{ev} (g/pCi-yr)	Cancer Class[b]
Cs-137	3.20E-11	1.90E-11	2.10E-06	A
Co-60	1.90E-11	6.90E-11	9.80E-06	A
H-3	7.20E-14	9.60E-14	0	A
Pb-210	1.01E-09	2.40E-08	1.43E-10	A
Ra-226	3.00E-10	2.70E-09	6.70 E-06	A
Th-232	4.07E-11	4.07E-08	2.3E-10	A
U-235	4.70E-11	1.30E-08	2.70E-07	A

[a]Yu et al. 1993a.
[b]EPA weight-of-evidence classification system for carcinogenicity (EPA 1989a): A = Human carcinogen for high dose and high dose rate (i.e., greater than 50 rem per year). For low-level environmental exposures, the carcinogenic effect has not been observed and documented.
1/pCi = One per picocurie.
COC = Constituent(s) of concern.
EPA = U.S. Environmental Protection Agency.
g/pCi-yr = Gram(s) per picocurie-year.
SF_{ev} = External volume exposure slope factor.
SF_{inh} = Inhalation slope factor.
SF_o = Oral (ingestion) slope factor.
SWMU = Solid Waste Management Unit.

- DCFs for surface contamination (contamination on the surface of the site) were taken from DOE/EH-0070, "External Dose-Rate Conversion Factors for Calculation of Dose to the Public" (DOE 1988).

- DCFs for volume contamination (exposure to contamination deeper than the immediate surface of the site) were calculated using the methods discussed in "Dose-Rate Conversion Factors for External Exposure to Photon Emitters in Soil" (Kocher 1983) and in ANL/EAIS-8, "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil" (Yu et al. 1993b).

VI.6 Step 5. Exposure Assessment and Risk Characterization

Section VI.6.1 describes the exposure assessment for this risk assessment. Section VI.6.2 provides the risk characterization, including the HI and excess cancer risk for both the potential nonradiological COCs and associated background for industrial and residential land-use scenarios. The incremental TEDE and incremental estimated cancer risk are provided for the background-adjusted radiological COCs for both the industrial and residential land-use scenarios.

VI.6.1 Exposure Assessment

Appendix 1 provides the equations and parameter input values used in calculating intake values and subsequent HI and excess cancer risk values for the individual exposure pathways. The appendix shows parameters for both industrial and residential land-use scenarios. The equations for nonradiological COCs are based upon the Risk Assessment Guidance for Superfund (RAGS) (EPA 1989a). Parameters are based upon information from the RAGS (EPA 1989a), the Technical Background Document for Development of Soil Screening Levels (NMED December 2000), as well as other EPA and NMED guidance documents, and reflect the reasonable maximum exposure (RME) approach advocated by the RAGS (EPA 1989a). For radiological COCs, the coded equations provided in RESRAD computer code are used to estimate the incremental TEDE and cancer risk for individual exposure pathways. Further discussion of this process is provided in the "Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD" (Yu et al. 1993a).

Although the designated land-use scenario for this site is industrial, risk and TEDE values for a residential land-use scenario are also presented.

VI.6.2 Risk Characterization

Table 11 shows an HI of 0.71 for the SWMU 4 nonradiological COCs and an estimated excess cancer risk of 6E-6 for the designated industrial land-use scenario. The numbers presented include exposure from soil ingestion, dermal contact, and dust and volatile inhalation for nonradiological COCs. Table 12 shows an HI of 0.03 and an estimated excess cancer risk of 3E-6 assuming the maximum background concentrations of the SWMU 4 associated background constituents for the designated industrial land-use scenario.

For the radiological COCs, contribution from the direct gamma exposure pathway is included. For the industrial land-use scenario, an incremental TEDE of 1.7E+1 millirem (mrem)/year (yr) was calculated. In accordance with EPA guidance found in Office of Solid Waste and Emergency Response (OSWER) Directive No. 9200.4-18 (EPA 1997b), an incremental TEDE of 15 mrem/yr was used for the probable land-use scenario (industrial in this case); the calculated dose value for SWMU 4 for the industrial land-use scenario is slightly above this guideline. Most of the dose is due to short-lived radionuclides that will quickly decay away. In August 2003, the DOE approved unrestricted radiological release of the site, using 25 mrem/yr as the threshold guidance (Castillo July 2003). The estimated excess cancer risk is 2.3E-4.

For the nonradiological COCs under the residential land-use scenario, the HI is 6.58 and the excess cancer risk is 2E-5 (Table 11). The numbers in the table include exposure from soil ingestion, dermal contact, and dust and volatile inhalation. Although the EPA (1991) generally recommends that inhalation not be included in a residential land-use scenario, this pathway was included because of the potential for soil in Albuquerque, New Mexico, to be eroded and, subsequently, for dust to be present in predominantly residential areas. Because of the nature of the local soil, other exposure pathways were not considered (see Appendix 1). Table 12 shows that for the SWMU 4 associated background constituents, the HI is 0.42 and the calculated excess cancer risk is 1E-5.

Table 11
Risk Assessment Values for SWMU 4 Nonradiological COCs

COC	Maximum Concentration (mg/kg)	Industrial Land-Use Scenario[a]		Residential Land-Use Scenario[a]	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Inorganic					
Antimony	9.3	0.02	–	0.31	–
Arsenic	7.6	0.03	5E-6	0.35	2E-5
Barium	849	0.01	–	0.16	–
Beryllium	4.9	0.00	2E-9	0.03	5E-9
Cadmium	154	0.30	5E-8	3.95	1E-7
Chromium, total	97.7	0.00	–	0.00	–
Chromium VI	11.2	0.00	2E-8	0.05	5E-8
Cobalt	42.2	0.00	2E-8	0.03	5E-8
Copper	239	0.01	–	0.08	–
Mercury	0.61	0.00	–	0.03	–
Nickel	173	0.01	–	0.11	–
Selenium	10	0.00	–	0.03	–
Silver	90.5	0.02	–	0.24	–
Thallium	1.2	0.02	–	0.24	–
Vanadium	52.7	0.01	–	0.10	–
Zinc	198	0.00	–	0.01	–
Organic					
Acetone	4.3	0.00	–	0.00	–
Benzene	0.01	0.00	7E-9	0.00	2E-8
Benzo(a)anthracene	0.35	0.00	2E-7	0.00	6E-7
Benzo(b)fluoranthene	0.46	0.00	2E-7	0.00	7E-7
bis(2-Ethylhexyl) phthalate	5.9	0.00	3E-8	0.00	1E-7
2-Butanone	0.17	0.00	–	0.00	–
Chrysene	0.36	0.00	2E-9	0.00	6E-9
Fluoranthene	0.85	0.00	–	0.00	–
2-Hexanone	0.024	0.00	–	0.00	–
Methylene chloride	0.046	0.00	3E-7	0.00	6E-7
4-Methyl-2-pentanone	0.02	0.00	–	0.00	–
Phenanthrene	0.71	0.26	–	0.84	–
Pyrene	0.75	0.00	–	0.00	–
Styrene	0.0025	0.00	–	0.00	–
Tetrachloroethene	0.0085	0.00	2E-9	0.00	6E-9
Toluene	0.012	0.00	–	0.00	–
Total		**0.71**	**6E-6**	**6.58**	**2E-5**

[a]EPA 1989a.
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
mg/kg = Milligram(s) per kilogram.
SWMU = Solid Waste Management Unit.
– = Information not available.

Table 12
Risk Assessment Values for SWMU 4 Nonradiological Background Constituents

COC	Background Concentration[a] (mg/kg)	Industrial Land-Use Scenario[b]		Residential Land-Use Scenario[b]	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Antimony	3.9	0.00	–	0.13	–
Arsenic	4.4	0.02	3E-6	0.20	1E-5
Barium	130	0.00	–	0.02	–
Beryllium	0.65	0.00	3E-10	0.00	6E-10
Cadmium	<1	–	–	–	–
Chromium, total	15.9	0.00	–	0.00	–
Chromium VI	1	0.00	2E-9	0.00	5E-9
Cobalt	5.2	0.00	3E-9	0.00	6E-9
Copper	15.4	0.00	–	0.01	–
Mercury	<0.1	–	–	–	–
Nickel	11.5	0.00	–	0.01	–
Selenium	<1	–	–	–	–
Silver	<1	–	–	–	–
Thallium	<1.1	–	–	–	–
Vanadium	20.4	0.00	–	0.04	–
Zinc	62	0.00	–	0.00	–
Total		**0.03**	**3E-6**	**0.42**	**1E-5**

[a]Dinwiddie September 1997a, Southwest Area Supergroup.
[b]EPA 1989a.
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
mg/kg = Milligram(s) per kilogram.
SWMU = Solid Waste Management Unit.
– = Information not available.

For the radiological COCs, the incremental TEDE for the residential land-use scenario is 74 mrem/yr. The guideline being used is an excess TEDE of 75 mrem/yr (SNL/NM February 1998) for a complete loss of institutional controls (residential land use in this case); the calculated dose value for SWMU 4 for the residential land-use scenario is below this guideline. Consequently, SWMU 4 is eligible for unrestricted radiological release because the residential land-use scenario resulted in an incremental TEDE of less than 75 mrem/yr to the on-site receptor. The estimated excess cancer risk is 9.1E-4. The excess cancer risk from the nonradiological and radiological COCs should be summed to provide risk estimates for persons exposed to both types of carcinogenic contaminants, as noted in OSWER Directive No. 9200.4-18 (EPA 1997b). This summation is tabulated in Section VI.9, Summary.

VI.7 Step 6. Comparison of Risk Values to Numerical Guidelines

The human health risk assessment analysis evaluated the potential for adverse health effects for both the industrial (the designated land-use scenario for this site) and residential land-use scenarios.

For the nonradiological COCs under the industrial land-use scenario, the HI is 0.71 (lower than the numerical guideline of 1 suggested in the RAGS [EPA 1989a]). The estimated excess cancer risk is 6E-6. NMED guidance states that cumulative excess lifetime cancer risk must be less than 1E-5 (Bearzi January 2001); thus, the excess cancer risk for this site is below the suggested acceptable risk value. This assessment also determined risks considering background concentrations of the potential nonradiological COCs for both the industrial and residential land-use scenarios. Assuming the industrial land-use scenario, the associated background risk calculated for the nonradiological COCs resulted in an HI of 0.03 with an excess cancer risk of 3E-6. The incremental risk is determined by subtracting risk associated with background from potential COC risk. These numbers are not rounded before the difference is determined and, therefore, may appear to be inconsistent with numbers presented in tables and within the text. For conservatism, the background constituents that do not have quantified background concentrations are assumed to have a hazard quotient (HQ) of 0.00. The incremental HI is 0.67 and estimated incremental cancer risk is 2.83E-6 for the industrial land-use scenario. Both the incremental HI and excess cancer risk to human health from nonradiological COCs are below proposed guidelines considering an industrial land-use scenario.

For the radiological COCs under the industrial land-use scenario, the incremental TEDE is 1.7E+1 mrem/yr, which is slightly higher than the EPA's numerical guideline of 15 mrem/yr but less than the DOE's guideline of 25 mrem/yr. The incremental estimated excess cancer risk is 2.3E-4.

For the nonradiological COCs under the residential land-use scenario, the calculated HI is 6.85, which is above the numerical guidance. The estimated excess cancer risk is 2E-5. NMED guidance states that cumulative excess lifetime cancer risk must be less than 1E-5 (Bearzi January 2001); thus, the excess cancer risk for this site is above the suggested acceptable risk value. The HI for the associated background constituents for the residential land-use scenario is 0.42; the estimated excess cancer risk is 1E-5. The incremental HI is 6.15 and the estimated incremental cancer risk is 1.05E-5 for the residential land-use scenario. Both the incremental HI and excess cancer risk to human health from nonradiological COCs are above proposed guidelines considering a residential land-use scenario.

The incremental TEDE for a residential land-use scenario from the radiological components is 74 mrem/yr, which is lower than the numerical guideline of 75 mrem/yr suggested in the SNL/NM "RESRAD Input Parameter Assumptions and Justification" (SNL/NM February 1998). The estimated excess cancer risk is 9.1E-4.

VI.8 Step 7. Uncertainty Discussion

The determination of the nature, rate, and extent of contamination at SWMU 4 was based upon an initial conceptual model that was validated with confirmatory sampling conducted across the site. The confirmatory sampling was implemented in accordance with the LWDS RFI work plan (SNL/NM March 1993). The DQOs contained in the work plan are appropriate for use in risk assessments. The data collected, based upon sample location, density, and depth, are representative of the site. The analytical requirements and results satisfy the DQOs. Data quality was verified/validated in accordance with SNL/NM procedures (SNL/NM October 1991). Therefore, there is no uncertainty associated with the quality of the data used to perform the risk assessment at SWMU 4.

Because of the location, history of the site, and future land use (DOE et al. September 1995), there is low uncertainty in the land-use scenario and the potentially affected populations that were considered in performing the risk assessment analysis. Because the COCs are found in surface and near-surface soil and because of the location and physical characteristics of the site, there is little uncertainty in the exposure pathways relevant to the analysis.

An RME approach was used to calculate the risk assessment values. This means that the parameter values in the calculations are conservative and that calculated intakes are probably overestimated. Maximum measured values of COC concentrations are used to provide conservative results.

Table 9 shows the uncertainties (confidence level) in nonradiological toxicological parameter values. There is a mixture of estimated values and values from the IRIS (EPA 2003), HEAST (EPA 1997a), Technical Background Document for Development of Soil Screening Levels (NMED December 2000), and the Risk Assessment Information System (ORNL 2003), the EPA Region 6 (EPA 2002a), and Region 9 (EPA 2002b) electronic databases. Where values are not provided, information is not available from the HEAST (EPA 1997a), IRIS (EPA 2003), Technical Background Document for Development of Soil Screening Levels (NMED December 2000), the Risk Assessment Information System (ORNL 2003) or the EPA regions (EPA 2002a, EPA 2002b, EPA 2002c). Because of the conservative nature of the RME approach, uncertainties in toxicological values are not expected to change the conclusion from the risk assessment analysis.

Risk assessment values for nonradiological COCs are within the acceptable range for human health under the industrial land-use scenario compared to established numerical guidance.

Although both the HI and estimated excess cancer risk are above the NMED guideline for the residential land-use scenario, maximum concentrations were used in the risk calculation. Because the site has been adequately characterized, average concentrations are more representative of actual site conditions. Using the upper confidence limit (UCL) of the mean concentrations for the main contributors to excess cancer risk and hazards (summarized in Appendix 2), including arsenic (2.7 mg/kg), cadmium (11.1 mg/kg), and phenanthrene (0.34 mg/kg), the total HI and estimated excess cancer risk are reduced to 2.10 and 2E-6, respectively (Table 13). Because the UCL of the mean concentration for arsenic is below background level, arsenic is eliminated from further evaluation in the risk analysis. The incremental HI and excess cancer risk are reduced to 1.89 and 2.20E-6, respectively. Thus, by using realistic concentrations in the risk calculations that more accurately depict actual site conditions, both the total and incremental estimated excess cancer risks are reduced to values below NMED guidelines. In addition, none of the individual HQs for noncarcinogens exceed 1.0 under these conditions.

For the radiological COCs, the conclusion of the risk assessment is that potential effects on human health for both the industrial and residential land-use scenarios are within guidelines and represent only a small fraction of the estimated 360 mrem/yr received by the average U.S. population (NCRP 1987).

The overall uncertainty in all of the steps in the risk assessment process is not considered to be significant with respect to the conclusion reached.

Table 13
Risk Assessment Values for SWMU 4 Nonradiological COCs with UCL Concentrations for the Major Risk Drivers

COC	Maximum Concentration/ UCL[a] (mg/kg)	Residential Land-Use Scenario[b]	
		Hazard Index	Cancer Risk
Inorganic			
Antimony	9.3	0.31	–
Arsenic	**2.7**	Below Background	Below Background
Barium	849	0.16	–
Beryllium	4.9	0.03	5E-9
Cadmium	**11.1**	**0.28**	**8E-9**
Chromium, total	97.7	0.00	–
Chromium VI	11.2	0.05	5E-8
Cobalt	42.2	0.03	5E-8
Copper	239	0.08	–
Mercury	0.61	0.03	–
Nickel	173	0.11	–
Selenium	10	0.03	–
Silver	90.5	0.24	–
Thallium	1.2	0.24	–
Vanadium	52.7	0.10	–
Zinc	198	0.01	–
Organic			
Acetone	4.3	0.00	–
Benzene	0.01	0.00	2E-8
Benzo(a)anthracene	0.35	0.00	6E-7
Benzo(b)fluoranthene	0.46	0.00	7E-7
bis(2-Ethylhexyl) phthalate	5.9	0.00	1E-7
2-Butanone	0.17	0.00	–
Chrysene	0.36	0.00	6E-9
Fluoranthene	0.85	0.00	–
2-Hexanone	0.024	0.00	–
Methylene chloride	0.046	0.00	6E-7
4-Methyl-2-pentanone	0.02	0.00	–
Phenanthrene	**0.34**	**0.39**	–
Pyrene	0.75	0.00	–
Styrene	0.0025	0.00	–
Tetrachloroethene	0.0085	0.00	6E-9
Toluene	0.012	0.00	–
Total		**2.10**	**2E-6**

[a]UCL concentrations and risks in **bold**.
[b]EPA 1989a.
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
mg/kg = Milligram(s) per kilogram.
SWMU = Solid Waste Management Unit.
UCL = Upper confidence limit.
– = Information not available.

VI.9 Summary

SWMU 4 contains identified COCs consisting of some inorganic, organic, and radiological compounds. Because of the location of the site, the designated industrial land-use scenario, and the nature of contamination, potential exposure pathways identified for this site included soil ingestion, dermal contact, and dust and volatile inhalation for chemical COCs and soil ingestion, dust inhalation, and direct gamma exposure for radionuclides. The same exposure pathways were applied to the residential land-use scenario.

Using conservative assumptions and an RME approach to risk assessment, calculations for nonradiological COCs show that for the industrial land-use scenario, the HI (0.71) is lower than the accepted numerical guidance from the EPA. The estimated excess cancer risk is 6E-6. Thus, excess cancer risk is also below the acceptable risk value provided by the NMED for an industrial land-use scenario (Bearzi January 2001). The incremental HI is 0.67 and the incremental excess cancer risk is 2.83E-6 for the industrial land-use scenario. The incremental risk calculations indicate insignificant risk to human health for the industrial land-use scenario.

Using conservative assumptions and an RME approach to risk assessment, calculations for nonradiological COCs show that for the residential land-use scenario, the HI (6.58) is above the accepted numerical guidance from the EPA. Estimated excess cancer risk is 2E-5. Thus, excess cancer risk is above the acceptable risk value provided by the NMED for a residential land-use scenario (Bearzi January 2001). The incremental HI is 6.15 and the incremental excess cancer risk is 1.05E-5 for the residential land-use scenario.

Although both the HI and estimated excess cancer risk are above the NMED guideline for the residential land-use scenario, maximum concentrations were used in the risk calculation. Because the site has been adequately characterized, average concentrations are more representative of actual site conditions. Using the UCL of the mean concentrations for the main contributors to excess cancer risk and hazards (summarized in Appendix 2), including arsenic (2.7 mg/kg), cadmium (11.1 mg/kg), and phenanthrene (0.34 mg/kg), the total HI and estimated excess cancer risk are reduced to 2.10 and 2E-6, respectively (Table 13). Because the UCL of the mean concentration for arsenic is below the background level, arsenic is eliminated from further evaluation in the risk analysis. The incremental HI and excess cancer risk are reduced to 1.89 and 2.20E-6, respectively. Thus, by using realistic concentrations in the risk calculations that more accurately depict actual site conditions, both the total and incremental estimated excess cancer risks are reduced to values below NMED guidelines. In addition, none of the individual HQs for noncarcinogens exceed 1.0 under these conditions.

The incremental TEDE and corresponding estimated cancer risk from radiological COCs are much lower than EPA guidance values; the estimated TEDE is 1.7E+1 mrem/yr for the industrial land-use scenario, which is slightly above the EPA's numerical guidance of 15 mrem/yr (EPA 1997b) but less than the DOE's guideline of 25 mrem/yr. The corresponding incremental estimated cancer risk value is 2.3E-4 for the industrial land-use scenario. Furthermore, the incremental TEDE for the residential land-use scenario that results from a complete loss of institutional control is 74 mrem/yr with an associated risk of 9.1E-4. The guideline for this scenario is 75 mrem/yr (SNL/NM February 1998). Therefore, SWMU 4 is eligible for unrestricted radiological release.

The summation of the nonradiological and radiological incremental excess carcinogenic risks is tabulated in Table 14.

Table 14
Summation of Radiological and Nonradiological Risks from Site Carcinogens

Scenario	Nonradiological Risk	Radiological Risk	Total Risk
Industrial	2.83E-6	2.3E-4	2.3E-4
Residential	2.20E-6	9.1E-4	9.1E-4

Uncertainties associated with the calculations are considered small relative to the conservatism of the risk assessment analysis. Therefore, it is concluded that this site poses insignificant risk to human health under both the industrial and residential land-use scenarios.

VII. Ecological Risk Assessment

VII.1 Introduction

This section addresses the ecological risks associated with exposure to constituents of potential ecological concern (COPECs) in the soil at SWMU 4. A component of the NMED Risk-Based Decision Tree (NMED March 1998) is to conduct an ecological risk assessment that corresponds with that presented in EPA's Ecological RAGS (EPA 1997c). The current methodology is tiered and contains an initial scoping assessment followed by a more detailed screening assessment. Initial components of NMED's decision tree (a discussion of DQOs, data assessment, and evaluations of bioaccumulation as well as fate and transport potential) are addressed in previous sections of this report. Following the completion of the scoping assessment, a determination is made as to whether a more detailed examination of potential ecological risk is necessary. If deemed necessary, the scoping assessment proceeds to a screening assessment whereby a more quantitative estimate of ecological risk is conducted. Although this assessment incorporates conservatisms in the estimation of ecological risks, ecological relevance and professional judgment also are used as recommended by the EPA (1998) to ensure that predicted exposures of selected ecological receptors reflect those reasonably expected to occur at the site.

VII.2 Scoping Assessment

The scoping assessment focuses primarily on the likelihood of exposure of biota at, or adjacent to, the site to be exposed to constituents associated with site activities. Included in this section are an evaluation of existing data and a comparison of maximum detected concentrations to background concentrations, examination of bioaccumulation potential, and fate and transport potential. A scoping risk-management decision (Section VII.2.4) involves summarizing the scoping results and determining whether further examination of potential ecological impacts is necessary.

VII.2.1 Data Assessment

As indicated in Section IV (Tables 6 and 7), inorganic constituents in the soil within the 0- to 5-foot depth interval that exceed background concentrations are as follows:

- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Chromium, total
- Chromium VI
- Cobalt
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Thallium
- Vanadium
- Zinc
- Cs-137
- Co-60
- H-3
- Pb-210
- Ra-226
- Th-232
- U-235
- U-238

Organic analytes detected in the soil are as follows:

- Acetone
- Benzo(a)anthracene
- Benzo(b)fluoranthene
- Bis(2-ethylhexyl) phthalate
- 2-Butanone
- Chrysene
- Fluoranthene
- 2-Hexanone
- 4-Methyl-2-pentanone
- Methylene chloride
- PCBs (total)
- Phenanthrene

- Pyrene
- Toluene

VII.2.2 Bioaccumulation

Among the COPECs listed in Section VII.2.1, the following are considered to have bioaccumulation potential in aquatic environments (Section IV, Tables 6 and 7):

- Antimony
- Arsenic
- Barium
- Cadmium
- Cobalt
- Lead
- Mercury
- Nickel
- Selenium
- Thallium
- Vanadium
- Zinc
- Cs-137
- Co-60
- Pb-210
- Th-232
- U-235
- U-238
- Benzo(a)anthracene
- Benzo(b)fluoranthene
- Chrysene
- bis(2-Ethylhexyl) phthalate
- Fluoranthene
- PCBs (total)
- Phenanthrene
- Pyrene

It should be noted, however, that as directed by the NMED (March 1998), bioaccumulation for inorganic constituents is assessed exclusively based upon maximum reported bioconcentration factors (BCFs) for aquatic species. Because only aquatic BCFs are used to evaluate the bioaccumulation potential for metals, bioaccumulation in terrestrial species is likely to be overpredicted.

VII.2.3 Fate and Transport Potential

The potential for the COPECs to migrate from the source of contamination to other media or biota is discussed in Section V. As noted in Table 8 (Section V), wind is expected to be of low

significance as a transport mechanism for COPECs at this site. Because the site consists of excavated impoundments, surface-water runoff will be contained on the site, and no runoff will enter or leave the site. Migration to groundwater is not anticipated due to the arid environment and high evapotranspiration rates. Food chain uptake is expected to be of low significance. Degradation (decay) and transformation for the inorganic COPECs and radionuclides is expected to be of low significance, but volatilization may account for the loss of some organic COPECs from this site.

VII.2.4 Scoping Risk-Management Decision

Based upon information gathered through the scoping assessment, it was concluded that complete ecological pathways may be associated with SWMU 4 and that COPECs also exist at the site. As a consequence, a risk assessment was deemed necessary to predict the potential level of ecological risk associated with the site.

VII.3 Risk Assessment

As concluded in Section VII.2.4, both complete ecological pathways and COPECs are associated with this SWMU. The risk assessment performed for the site involves a quantitative estimate of current ecological risks using exposure models in association with exposure parameters and toxicity information obtained from the literature. The estimation of potential ecological risks is conservative to ensure that ecological risks are not underpredicted.

Components within the risk assessment include the following:

- Problem Formulation—sets the stage for the evaluation of potential exposure and risk.
- Exposure Estimation—provides a quantitative estimate of potential exposure.
- Ecological Effects Evaluation—presents benchmarks used to gauge the toxicity of COPECs to specific receptors.
- Risk Characterization—characterizes the ecological risk associated with exposure of the receptors to environmental media at the site.
- Uncertainty Assessment—discusses uncertainties associated with the estimation of exposure and risk.
- Risk Interpretation—evaluates ecological risk in terms of HQs and ecological significance.
- Risk Assessment Scientific/Management Decision Point—presents the decision to risk managers based upon the results of the risk assessment.

VII.3.1 Problem Formulation

Problem formulation is the initial stage of the ecological risk assessment that provides the introduction to the risk evaluation process. Components that are addressed in this section include a discussion of ecological pathways and the ecological setting, identification of COPECs, and selection of ecological receptors. The conceptual model, ecological food webs, and ecological endpoints (other components commonly addressed in a risk assessment) are presented in the "Predictive Ecological Risk Assessment Methodology, Environmental Restoration Program, Sandia National Laboratories, New Mexico" (IT July 1998) and are not duplicated here.

VII.3.1.1 Ecological Pathways and Setting

SWMU 4 is approximately 0.8 acre in size and is located in an area dominated by grassland habitat. The original habitat of the site is highly disturbed by the construction of the impoundments that now comprise the site. Vegetative cover is generally low over most of the site. Most of the vegetative growth consists of salt cedar trees that have become established around the margins of the impoundments. Salt cedar is generally unpalatable to wildlife herbivores. Although the site is fenced to control human access, it is generally open to use by wildlife. It does not contain perennial surface water. No threatened, endangered, or other sensitive species are known to occur within SWMU 4.

Complete ecological pathways may exist at this site through the exposure of plants and wildlife to COPECs in soil at this site. It was assumed that direct uptake of COPECs from soil is the major route of exposure for plants and that exposure of plants to wind-blown soil is minor. Exposure modeling for the wildlife receptors was limited to the food and soil ingestion pathways and external radiation. Because of the lack of surface water at this site, exposure to COPECs through the ingestion of surface water was considered insignificant. Inhalation and dermal contact were also considered insignificant pathways with respect to ingestion (Sample and Suter 1994). Groundwater is not expected to be affected by COCs at this site.

VII.3.1.2 COPECs

Discharges of effluent water from the SERF at TA-V are the potential sources of the COPECs associated with the soil at SWMU 4. Inorganic and organic COPECs identified for SWMU 4 are listed in Section VII.2.1. The inorganic COPECs include both radiological and nonradiological analytes. The inorganic analytes were screened against background concentrations and those that exceed the approved SNL/NM background screening levels (Dinwiddie September 1997a) for the area are considered to be COPECs. Nonradiological inorganic constituents that are essential nutrients, such as iron, magnesium, calcium, potassium, and sodium, are not included in this risk assessment as set forth by the EPA (1989a). All organic analytes detected in the upper 5 feet of the soil are considered to be COPECs for the site. In order to provide conservatism, this ecological risk assessment was based upon the maximum soil concentrations of the COPECs measured in the surface soil at this site. Tables 6 and 7 present the maximum concentrations for the COPECs.

VII.3.1.3 Ecological Receptors

A nonspecific perennial plant was selected as the receptor to represent plant species at the site (IT July 1998). Vascular plants are the principal primary producers at the site and are key to the diversity and productivity of the wildlife community associated with the site. The deer mouse (*Peromyscus maniculatus*) and the burrowing owl (*Speotyto cunicularia*) were used to represent wildlife use. Because of its opportunistic food habits, the deer mouse was used to represent a mammalian herbivore, omnivore, and insectivore. The burrowing owl was selected to represent a top predator at this site. The burrowing owl is present at SNL/NM and is designated a species of management concern by the U.S. Fish and Wildlife Service in Region 2, which includes the state of New Mexico (USFWS September 1995).

VII.3.2 Exposure Estimation

For nonradiological COPECs, direct uptake from the soil was considered the only significant route of exposure for terrestrial plants. Exposure modeling for the wildlife receptors was limited to food and soil ingestion pathways. Inhalation and dermal contact were considered insignificant pathways with respect to ingestion (Sample and Suter 1994). Drinking water was also considered an insignificant pathway because of the lack of surface water at this site. The deer mouse was modeled under three dietary regimes: as an herbivore (100 percent of its diet as plant material), as an omnivore (50 percent of its diet as plants and 50 percent as soil invertebrates), and as an insectivore (100 percent of its diet as soil invertebrates). The burrowing owl was modeled as a strict predator on small mammals (100 percent of its diet as deer mice). Because the exposure in the burrowing owl from a diet consisting of equal parts of herbivorous, omnivorous, and insectivorous mice would be equivalent to the exposure consisting of only omnivorous mice, the diet of the burrowing owl was modeled with intake of omnivorous mice only. Both species were modeled with soil ingestion comprising 2 percent of the total dietary intake. Table 15 presents the species-specific factors used in modeling exposures in the wildlife receptors. Justification for use of the factors presented in this table is described in the ecological risk assessment methodology document (IT July 1998).

Although home range is also included in this table, exposures for this risk assessment were modeled using an area use factor of 1.0, implying that all food items and soil ingested come from the site being investigated. The maximum COPEC concentrations measured in surface soil samples were used to conservatively estimate potential exposures and risks to plants and wildlife at this site.

For the radiological dose-rate calculations, the deer mouse was modeled as an herbivore (100 percent of its diet as plants), and the burrowing owl was modeled as a strict predator on small mammals (100 percent of its diet as deer mice). Both were modeled with soil ingestion comprising 2 percent of the total dietary intake. Receptors are exposed to radiation both internally and externally from Cs-137, Co-60, H-3, Pb-210, Ra-226, Th-232, U-235, and U-238. Internal and external dose rates to the deer mouse and the burrowing owl are approximated using modified dose-rate models from DOE (1995) as presented in the ecological risk assessment methodology document (IT July 1998). Radionuclide-dependent data for the dose-rate calculations were obtained from Baker and Soldat (1992). The external dose-rate model examines the total-body dose rate to a receptor residing in soil exposed to radionuclides. The soil surrounding the receptor is assumed to be an infinite medium uniformly contaminated with gamma-emitting radionuclides. The external dose-rate model is the same for both the deer

Table 15
Exposure Factors for Ecological Receptors at SWMU 4

Receptor Species	Class/Order	Trophic Level	Body Weight (kg)[a]	Food Intake Rate (kg/day)[b]	Dietary Composition[c]	Home Range (acres)
Deer Mouse (*Peromyscus maniculatus*)	Mammalia/ Rodentia	Herbivore	2.39E-2[d]	3.72E-3	Plants: 100% (+ Soil at 2% of intake)	2.7E-1[e]
Deer Mouse (*Peromyscus maniculatus*)	Mammalia/ Rodentia	Omnivore	2.39E-2[d]	3.72E-3	Plants: 50% Invertebrates: 50% (+ Soil at 2% of intake)	2.7E-1[e]
Deer Mouse (*Peromyscus maniculatus*)	Mammalia/ Rodentia	Insectivore	2.39E-2[d]	3.72E-3	Invertebrates: 100% (+ Soil at 2% of intake)	2.7E-1[e]
Burrowing owl (*Speotyto cunicularia*)	Aves/ Strigiformes	Carnivore	1.55E-1[f]	1.73E-2	Rodents: 100% (+ Soil at 2% of intake)	3.5E+1[g]

[a]Body weights are in kg wet weight.
[b]Food intake rates are estimated from the allometric equations presented in Nagy (1987). Units are kg dry weight per day.
[c]Dietary compositions are generalized for modeling purposes. Default soil intake value of 2% of food intake.
[d]Silva and Downing 1995.
[e]EPA 1993, based upon the average home range measured in semiarid shrubland in Idaho.
[f]Dunning 1993.
[g]Haug et al. 1993.
EPA = U.S. Environmental Protection Agency.
kg = Kilogram(s).
SWMU = Solid Waste Management Unit.

mouse and the burrowing owl. The internal total-body dose-rate model assumes that a fraction of the radionuclide concentration ingested by a receptor is absorbed by the body and concentrated at the center of a spherical body shape. This provides for a conservative estimate for absorbed dose. This concentrated radiation source at the center of the body of the receptor is assumed to be a "point" source. Radiation emitted from this point source is absorbed by the body tissues to contribute to the absorbed dose. Alpha and beta emitters are assumed to transfer 100 percent of their energy to the receptor as they pass through tissues. Gamma-emitting radionuclides transfer only a fraction of their energy to the tissues because gamma rays interact less with matter than do beta or alpha emitters. The external and internal dose-rate results are summed to calculate a total dose rate from exposure to Cs-137, Co-60, H-3, Pb-210, Ra-226, Th-232, U-235, and U-238 in soil.

Table 16 provides the transfer factors used in modeling the concentrations of COPECs through the food chain. Table 17 presents maximum concentrations in soil and derived concentrations in tissues of the various food chain elements that are used to model dietary exposures for each of the wildlife receptors. Total PCBs were evaluated as Aroclor-1254.

VII.3.3 Ecological Effects Evaluation

Table 18 shows benchmark toxicity values for the plant and wildlife receptors. For plants, the benchmark soil concentrations are based upon the lowest-observed-adverse-effect level (LOAEL). For wildlife, the toxicity benchmarks are based upon the no-observed-adverse-effect level (NOAEL) for chronic oral exposure in a taxonomically similar test species. As noted above, total PCBs were evaluated as Aroclor-1254. Sufficient toxicity information was not available to estimate the LOAELs or NOAELs for some COPECs.

The benchmark used for exposure of terrestrial receptors to radiation was 0.1 rad/day. This value has been recommended by the International Atomic Energy Agency (IAEA 1992) for the protection of terrestrial populations. Because plants and insects are less sensitive to radiation than vertebrates (Whicker and Schultz 1982), the dose of 0.1 rad/day should also protect other groups within the terrestrial habitat of SWMU 4.

VII.3.4 Risk Characterization

Maximum concentrations in soil and estimated dietary exposures were compared to plant and wildlife benchmark values, respectively. Table 19 presents the results of these comparisons. HQs are used to quantify the comparison with benchmarks for plant and wildlife exposure.

The HQs for plants exceed unity for antimony, cadmium, total chromium, chromium VI, cobalt, copper, lead, mercury, nickel, selenium, silver, vanadium, and zinc. The HQs exceed unity for all three dietary regimes in the deer mouse for antimony, cadmium, and selenium, as well as for mercury when it is assumed to be entirely in organic form. In addition, the HQs exceed unity for the omnivorous and insectivorous deer mouse from exposures to arsenic, barium, thallium, vanadium, total PCBs (evaluated as Aroclor-1254), and phenanthrene, and for the insectivorous deer mouse from exposures to benzo(a)anthracene, benzo(b)fluoranthene, chrysene, and bis(2-ethylhexyl) phthalate. The HQs also exceed unity for the herbivorous and omnivorous deer mice from exposures to acetone. For the burrowing owl, the HQ exceeds unity from

Table 16
Transfer Factors Used in Exposure Models for COPECs at SWMU 4

COPEC	Soil-to-Plant Transfer Factor	Soil-to-Invertebrate Transfer Factor	Food-to-Muscle Transfer Factor
Inorganic			
Arsenic	4.0E-2[a]	1.0E+0[b]	2.0E-3[a]
Barium	1.5E-1[a]	1.0E+0[b]	2.0E-4[c]
Beryllium	1.0E-2[a]	1.0E+0[b]	1.0E-3[a]
Cadmium	5.5E-1[a]	6.0E-1[d]	5.5E-4[a]
Chromium, total	4.0E-2[c]	1.3E-1[e]	3.0E-2[c]
Chromium VI	4.0E-2[c]	1.3E-1[e]	3.0E-2[c]
Cobalt	4.0E-1[c]	1.0E+0[b]	3.0E-2[c]
Copper	8.0E-1[f]	2.5E-1[d]	1.0E-2[a]
Lead	9.0E-2[c]	4.0E-2[d]	8.0E-4[c]
Mercury	1.0E+0[c]	1.0E+0[b]	2.5E-1[a]
Selenium	5.0E-1[c]	1.0E+0[b]	1.0E-1[c]
Silver	1.0E+0[c]	2.5E-1[d]	5.0E-3[c]
Organic[g]			
Acetone	5.3E+1	1.3E+1	1.0E-8
Benzo(a)anthracene	2.2E-2	2.5E+1	1.1E-2
Benzo(b)fluoranthene	6.2E-3	2.8E+1	1.1E-1
2-Butanone	2.6E+1	1.4E+1	3.7E-8
Chrysene	1.5E-2	2.6E+1	2.3E-2
bis(2-Ethylhexyl) phthalate	1.6E-3	3.2E+1	1.3E+0
Fluoranthene	5.7E-2	2.3E+1	2.1E-3
2-Hexanone	6.2E+0	1.5E+1	4.9E-7
4-Methyl-2-pentanone	7.9E+0	1.5E+1	3.1E-7
Methylene chloride	7.3E+0	1.5E+1	3.6E-7
PCBs (as Aroclor-1254)	1.3E-2	2.6E+1	3.2E-2
Phenanthrene	8.9E-2	2.2E+1	9.6E-4
Pyrene	3.3E-2	2.4E+1	5.8E-3
Toluene	1.0E+0	1.8E+1	1.3E-5

[a]Baes et al. 1984.
[b]Default value.
[c]NCRP January 1989.
[d]Stafford et al. 1991.
[e]Ma 1982.
[f]IAEA 1994.
[g]Soil-to-plant and food-to-muscle transfer factors from equations developed in Travis and Arms (1988). Soil-to-invertebrate transfer factors from equations developed in Connell and Markwell (1990). All three equations are based upon the relationship of the transfer factor to the Log K_{ow} value of the compound.
COPEC = Constituent of potential ecological concern.
IAEA = International Atomic Energy Agency.
K_{ow} = Octanol-water partition coefficient.
Log = Logarithm (base 10).
NCRP = National Council on Radiation Protection and Measurements.
PCB = Polychlorinated biphenyl.
SWMU = Solid Waste Management Unit.

Table 17
Media Concentrations[a] for COPECs at SWMU 4

COPEC	Soil (maximum)[a]	Plant Foliage[b]	Soil Invertebrate[b]	Deer Mouse Tissues[c]
Inorganic				
Arsenic	7.6E+0	3.0E-1	7.6E+0	2.6E-2
Barium	2.3E+2	3.5E+1	2.3E+2	8.6E-2
Beryllium	4.9E+0	4.9E-2	4.9E+0	8.0E-3
Cadmium	1.5E+2	8.5E+1	9.2E+1	1.6E-1
Chromium, total	9.8E+1	3.9E+0	1.3E+1	9.6E-1
Chromium VI	1.1E+1	4.5E-1	1.5E+0	1.1E-1
Cobalt	4.2E+1	1.7E+1	4.2E+1	2.8E+0
Copper	2.4E+2	1.9E+2	6.0E+1	4.1E+0
Lead	7.3E+1	6.5E+0	2.9E+0	1.5E-2
Mercury	6.1E-1	6.1E-1	6.1E-1	4.9E-1
Selenium	1.0E+1	5.0E+0	1.0E+1	2.4E+0
Silver	9.1E+1	9.1E+1	2.3E+1	9.1E-1
Organic				
Acetone	4.3E+0	2.3E+2	5.5E+1	4.6E-6
Benzo(a)anthracene	3.5E-1	7.8E-3	8.8E+0	1.6E-1
Benzo(b)fluoranthene	4.6E-1	2.8E-3	1.3E+1	2.3E+0
2-Butanone	1.7E-1	4.5E+0	2.3E+0	3.9E-7
Chrysene	3.6E-1	5.3E-3	9.4E+0	3.4E-1
bis(2-Ethylhexyl) phthalate	5.9E+0	9.2E-3	1.9E+2	3.8E+2
Fluoranthene	8.5E-1	4.8E-2	2.0E+1	6.5E-2
2-Hexanone	2.4E-2	1.5E-1	3.7E-1	4.0E-7
4-Methyl-2-pentanone	2.0E-2	1.6E-1	3.0E-1	2.3E-7
Methylene chloride	7.5E-3	5.5E-2	1.1E-1	9.5E-8
PCBs (as Aroclor-1254)	7.1E-2	8.9E-4	1.9E+0	9.4E-2
Phenanthrene	7.1E-1	6.3E-2	1.6E+1	2.4E-2
Pyrene	7.5E-1	2.4E-2	1.8E+1	1.6E-1
Toluene	9.4E-3	9.4E-3	1.7E-1	3.6E-6

[a]In milligrams per kilogram. All biotic media are based upon dry weight of the media. Soil concentration measurements are assumed to have been based upon dry weight. Values have been rounded to two significant digits after calculation.
[b]Product of the soil concentration and the corresponding transfer factor.
[c]Based upon the deer mouse with an omnivorous diet. Product of the average concentration ingested in food and soil times the food-to-muscle transfer factor times a wet weight-dry weight conversion factor of 3.125 (EPA 1993).
COPEC = Constituent of potential ecological concern.
PCB = Polychlorinated biphenyl.
SWMU = Solid Waste Management Unit.

Table 18
Toxicity Benchmarks for Ecological Receptors at SWMU 4

COPEC	Plant Benchmark[a,b]	Mammalian NOAELs			Avian NOAELs		
		Mammalian Test Species[c,d]	Test Species NOAEL[d,e]	Deer Mouse NOAEL[e,f]	Avian Test Species[d]	Test Species NOAEL[d,e]	Burrowing Owl NOAEL[e,g]
Inorganics							
Antimony	5	mouse	0.125	0.132	–	–	–
Arsenic	10	mouse	0.126	0.133	mallard	5.14	5.14
Barium	500	rat[h]	5.1	10.5	chicken	20.8	20.8
Beryllium	10	rat	0.66	1.29	–	–	–
Cadmium	3	rat[i]	1	1.9	mallard	1.45	1.45
Chromium, total	1	rat	2,737	5,354	black duck	1.0	1.0
Chromium VI	1	rat	3.28	6.42	–	–	–
Cobalt	20	–	–	–	–	–	–
Copper	100	mink	11.7	29.8	chicken	47	47
Lead	50	rat	8.0	15.7	American kestrel	3.85	3.85
Mercury (organic)	0.3	rat	0.032	0.063	mallard	0.0064	0.0064
Mercury (inorganic)	0.3	mouse	13.2	14.0	Japanese quail	0.45	0.45
Nickel	30	rat	40	78.2	mallard	77.4	77.4
Selenium	1	rat	0.20	0.39	screech owl	0.44	0.44
Silver	2	rat	17.8[j]	34.8	–	–	–
Thallium	1	rat	0.0074	0.015	–	–	–
Vanadium	2	rat	0.21	0.38	mallard	11.4	11.4
Zinc	50	rat	160	313	chicken	14.5	14.5
Organic							
Acetone	–	rat	10	19.6	–	–	–
Benzo(a)anthracene	18[k]	mouse	1.0[l]	1.1	–	–	–
Benzo(b)fluoranthene	18[k]	mouse	1.0[l]	1.1	–	–	–
2-Butanone	–	rat	1,771	3,464	–	–	–
Chrysene	18[k]	mouse	1.0[l]	1.1	–	–	–
bis(2-Ethylhexyl) phthalate	–	mouse	18.3	19.4	ringed dove	1.1	1.1
Fluoranthene	18[k]	mouse	12.5[m]	13.2	–	–	–
2-Hexanone	–	rat	1,676[n]	3279	–	–	–
4-Methyl-2-pentanone	–	rat	1,346[n]	2,633	–	–	–
Methylene chloride	–	rat	5.85	11.4	–	–	–

Refer to footnotes at end of table.

Table 18 (Concluded)
Toxicity Benchmarks for Ecological Receptors at SWMU 4

COPEC	Plant Benchmark[a,b]	Mammalian NOAELs			Avian NOAELs		
		Mammalian Test Species[c,d]	Test Species NOAEL[d,e]	Deer Mouse NOAEL[e,f]	Avian Test Species[d]	Test Species NOAEL[d,e]	Burrowing Owl NOAEL[e,g]
PCBs (as Aroclor-1254)	40	oldfield mouse	0.068	0.059	ring-necked pheasant	0.18	0.18
Phenanthrene	18[k]	mouse	1.0[l]	1.1	–	–	–
Pyrene	18[k]	mouse	7.5[o]	7.9	–	–	–
Toluene	200	mouse	26	27.5	–	–	–

[a]In milligrams per kilogram soil dry weight.
[b]Efroymson et al. 1997.
[c]Body weights (in kilograms) for NOAEL conversion are as follows: lab mouse, 0.030; lab rat, 0.350; mink, 1.0; oldfield mouse, 0.014 (except where noted).
[d]Sample et al. 1996, except where noted.
[e]In milligrams per kilogram body weight per day.
[f]Based upon NOAEL conversion methodology presented in Sample et al. (1996), using a deer mouse body weight of 0.0239 kilogram and a mammalian scaling factor of 0.25.
[g]Based upon NOAEL conversion methodology presented in Sample et al. (1996). The avian scaling factor of 0.0 was used, making the NOAEL independent of body weight.
[h]Body weight: 0.435 kilogram.
[i]Body weight: 0.303 kilogram.
[j]Based upon a rat LOAEL of 89 mg/kg/d (EPA 2003) and an uncertainty factor of 0.2.
[k]Sims and Overcash 1983.
[l]Insufficient toxicity data available for this compound. The NOAEL for benzo(a)pyrene is used as a default value.
[m]Based upon subchronic NOAEL of 125 mg/kg/d (EPA 1988b) and an uncertainty factor of 0.1.
[n]Test species NOAEL based upon NOAEL for 2-butanone and ratio of LD_{50} values (RTECS 1997).
[o]Based upon subchronic NOAEL of 75 mg/kg/d (EPA 1989b) and an uncertainty factor of 0.1.

COPEC = Constituent of potential ecological concern.
LD_{50} = Acute lethal dose to 50 percent of the test population.
LOAEL = Lowest-observed-adverse-effect level.
mg/kg/d = Milligrams per kilogram per day.
NOAEL = No-observed-adverse-effect level.
PCB = Polychlorinated biphenyl.
SWMU = Solid Waste Management Unit.
– = Insufficient toxicity data.

Table 19
HQs for Ecological Receptors at SWMU 4

COPEC	Plant HQ[a]	Deer Mouse HQ (Herbivorous)[a]	Deer Mouse HQ (Omnivorous)[a]	Deer Mouse HQ (Insectivorous)[a]	Burrowing Owl HQ[a]
Inorganic					
Antimony	**1.2E+0**	**1.6E+0**	**4.4E+0**	**7.2E+0**	–
Arsenic	7.6E-1	5.3E-1	**4.8E+0**	**9.0E+0**	3.9E-3
Barium	4.6E-1	5.8E-1	**2.0E+0**	**3.5E+0**	2.5E-2
Beryllium	4.9E-1	1.8E-2	3.1E-1	6.0E-1	–
Cadmium	**5.1E+1**	**7.2E+0**	**7.6E+0**	**7.9E+0**	2.5E-1
Chromium, total	**9.8E+1**	1.7E-4	3.0E-4	4.3E-4	3.3E-1
Chromium VI	**1.1E+1**	1.6E-2	2.9E-2	4.1E-2	–
Cobalt	**2.1E+0**	–	–	–	–
Copper	**2.4E+0**	1.0E+0	6.8E-1	3.4E-1	2.1E-2
Lead	**1.5E+0**	7.9E-2	6.1E-2	4.3E-2	4.2E-2
Mercury (organic)	**2.0E+0**	**1.5E+0**	**1.5E+0**	**1.5E+0**	**8.7E+0**
Mercury (inorganic)	**2.0E+0**	6.9E-3	6.9E-3	6.9E-3	1.2E-1
Nickel	**5.8E+0**	7.6E-2	1.1E-1	1.4E-1	6.4E-3
Selenium	**1.0E+1**	**2.1E+0**	**3.1E+0**	**4.1E+0**	6.6E-1
Silver	**4.5E+1**	4.1E-1	2.6E-1	1.1E-1	–
Thallium	7.9E-1	2.0E-1	**4.4E+0**	**8.6E+0**	–
Vanadium	**2.6E+1**	5.5E-1	**1.1E+1**	**2.2E+1**	1.2E-2
Zinc	**4.0E+0**	1.5E-1	9.1E-2	3.2E-2	4.7E-1
Organic					
Acetone	–	**1.8E+0**	**1.1E+0**	4.4E-1	–
Benzo(a)anthracene	1.9E-2	2.2E-3	6.5E-1	**1.3E+0**	–
Benzo(b)fluoranthene	2.6E-2	1.8E-3	9.5E-1	**1.9E+0**	–
2-Butanone	–	2.0E-4	1.5E-4	1.0E-4	–
Chrysene	2.0E-2	1.8E-3	6.9E-1	**1.4E+0**	–
bis(2-Ethylhexyl) phthalate	–	1.0E-3	7.5E-1	**1.5E+0**	**3.9E+1**
Fluoranthene	4.7E-2	7.7E-4	1.2E-1	2.3E-1	–
2-Hexanone	–	7.1E-6	1.2E-5	1.8E-5	–
4-Methyl-2-pentanone	–	9.4E-6	1.4E-5	1.8E-5	–
Methylene chloride	–	7.5E-4	1.2E-3	1.6E-3	–

Refer to footnotes at end of table.

Table 19 (Concluded)
HQs for Ecological Receptors at SWMU 4

PCBs (as Aroclor-1254)	1.8E-3	6.0E-3	**2.5E+0**	**4.9E+0**	5.9E-2
Phenanthrene	3.9E-2	1.1E-2	**1.2E+0**	**2.3E+0**	–
Pyrene	4.2E-2	7.7E-4	1.8E-1	3.6E-1	–
Toluene	4.7E-5	5.4E-5	5.1E-4	9.6E-4	–
HI[b]	**2.7E+2**	**1.8E+1**	**4.9E+1**	**7.9E+1**	**4.9E+1**

[a]**Bold** values indicate the HQ or HI exceeds unity.
[b]The HI is the sum of individual HQs.
COPEC = Constituent of potential ecological concern.
HI = Hazard index.
HQ = Hazard quotient.
PCB = Polychlorinated biphenyl.
SWMU = Solid Waste Management Unit.
– = Insufficient toxicity data available for risk estimation purposes.

exposure to both bis(2-ethylhexyl) phthalate and mercury when the mercury is assumed to be entirely in organic form. Because of a lack of sufficient toxicity information, HQs could not be determined for plants for 6 of the 14 organic COPECs, for the deer mouse for cobalt, and for the burrowing owl for antimony, beryllium, chromium VI, cobalt, silver, thallium, and all organic compounds except bis(2-ethylhexyl) phthalate and PCBs (evaluated as Aroclor-1254). As directed by the NMED, HIs were calculated for each of the receptors (the HI is the sum of chemical-specific HQs for all pathways for a given receptor). All receptors had total HIs greater than unity, with a maximum HI of approximately 270 for plants.

Tables 20 and 21 summarize the internal and external dose-rate model results for Cs-137, Co-60, Pb-210, Ra-226, Th-232, H-3, U-235, and U-238 for the deer mouse and burrowing owl, respectively. The total radiation dose rate to the deer mouse was predicted to be 8.2E-3 rad/day and that for the burrowing owl was 9.1E-3 rad/day. The dose rates for the deer mouse and the burrowing owl are lower than the benchmark of 0.1 rad/day.

VII.3.5 Uncertainty Assessment

Many uncertainties are associated with the characterization of ecological risks at SWMU 4, resulting from assumptions used in calculating risk that could overestimate or underestimate true risk presented at the site. For this risk assessment, assumptions are made that are more likely to overestimate exposures and risk rather than to underestimate them. These conservative assumptions are used to be more protective of the ecological resources potentially affected by the site. Conservatisms incorporated into this risk assessment include the use of maximum analyte concentrations measured in soil samples to evaluate risk, the use of wildlife toxicity benchmarks based upon NOAEL values, the incorporation of strict herbivorous and strict insectivorous diets for predicting the extreme HQ values for the deer mouse, and the assumption that all food and soil ingested by the wildlife receptors comes from the site. Each of these uncertainties, which are consistent among each of the SWMU-specific ecological risk assessments, is discussed in greater detail in the uncertainty section of the ecological risk assessment methodology document (IT July 1998).

Uncertainties associated with the estimation of risk to ecological receptors following exposure to Co-60, Cs-137, H-3, Pb-210, Ra-226, Th-232, U-235, and U-238 are primarily related to those inherent in the radionuclide-specific data. Radionuclide-dependent data are measured values that have their associated errors. The dose-rate models used for these calculations are based upon conservative estimates of receptor shape, radiation absorption by body tissues, and intake parameters. The goal is to provide a realistic but conservative estimate of a receptor's internal and external exposure to radionuclides in soil.

In the estimation of ecological risk, background concentrations are included as a component of maximum on-site concentrations. Conservatisms in the modeling of exposure and risk can result in the prediction of risk to ecological receptors when exposed at background concentrations. As shown in Table 22, the HQs associated with exposures to background are greater than 1.0 for antimony, arsenic, barium, total chromium, vanadium, and zinc. It is therefore likely that the actual risks from antimony, arsenic, barium, total chromium, vanadium, and zinc at SWMU 4 are overestimated by the HQs calculated in this risk assessment because of conservatisms incorporated into both the exposure assessment and toxicity benchmarks for these COPECs. In the cases of antimony, arsenic, and barium, exposure to background

Table 20
Internal and External Dose Rates for
Deer Mouse Exposure to Radionuclides at SWMU 4

Radionuclide	Maximum Concentration (pCi/g)	Internal Dose (rad/day)	External Dose (rad/day)	Total Dose (rad/day)
Cs-137	10.1	3.2E-4	4.6E-4	7.8E-4
Co-60	11.0	3.3E-5	2.1E-3	2.1E-3
Pb-210	12.0	4.0E-3	4.1E-6	4.0E-3
Ra-226	3.7	8.1E-4	1.9E-6	8.2E-4
Th-232	1.18	4.7E-7	2.2E-4	2.2E-4
H-3	0.5	1.6E-6	0.0E+0	1.6E-6
U-235	3.0	3.3E-5	4.9E-5	8.2E-5
U-238	1.4	1.4E-5	2.1E-4	2.2E-4
Total		5.2E-3	3.1E-3	8.3E-3

pCi/g = Picocurie(s) per gram.
SWMU = Solid Waste Management Unit.

Table 21
Internal and External Dose Rates for
Burrowing Owl Exposure to Radionuclides at SWMU 4

Radionuclide	Maximum Concentration (pCi/g)	Internal Dose (rad/day)	External Dose (rad/day)	Total Dose (rad/day)
Cs-137	10.1	2.1E-4	4.6E-4	6.7E-4
Co-60	11.0	8.4E-6	2.1E-3	1.9E-3
Pb-210	12.0	3.3E-3	4.1E-6	3.3E-3
Ra-226	3.7	2.5E-3	1.9E-6	2.5E-3
Th-232	1.18	6.9E-7	2.2E-4	2.2E-4
H-3	0.5	5.6E-7	0.0E+0	5.6E-7
U-235	3.0	1.3E-5	4.9E-5	6.2E-5
U-238	1.4	5.7E-6	2.1E-4	2.2E-4
Total		6.0E-3	3.1E-3	9.1E-3

pCi/g = Picocurie(s) per gram.
SWMU = Solid Waste Management Unit.

Table 22
HQs for Ecological Receptor Exposure to Background Concentrations at SWMU 4

COPEC	Plant HQ[a]	Deer Mouse HQ (Herbivorous)[a]	Deer Mouse HQ (Omnivorous)[a]	Deer Mouse HQ (Insectivorous)[a]	Burrowing Owl HQ[a]
Inorganic					
Antimony	7.8E-1	**1.0E+0**	**2.8E+0**	**4.7E+0**	–
Arsenic	4.4E-1	3.1E-1	**2.8E+0**	**5.2E+0**	2.2E-3
Barium	2.6E-1	3.3E-1	**1.1E+0**	**2.0E+0**	1.4E-2
Beryllium	6.5E-2	2.4E-3	4.1E-2	8.0E-2	–
Cadmium	1.7E-1	2.4E-2	2.5E-2	2.6E-2	8.1E-4
Chromium, total	**1.6E+1**	2.8E-5	4.9E-5	6.9E-5	5.3E-2
Chromium VI	1.0E+0	1.5E-3	2.5E-3	3.6E-3	–
Cobalt	2.6E-1	–	–	–	–
Copper	1.5E-1	6.6E-2	4.4E-2	2.2E-2	1.4E-3
Lead	2.4E-1	1.3E-2	1.0E-2	7.0E-3	6.9E-3
Mercury (organic)	1.7E-1	1.3E-1	1.3E-1	1.3E-1	7.1E-1
Mercury (inorganic)	1.7E-1	5.7E-4	5.7E-4	5.7E-4	1.0E-2
Nickel	3.8E-1	5.0E-3	7.1E-3	9.1E-3	4.3E-4
Selenium	5.0E-1	1.0E-1	1.5E-1	2.0E-1	3.3E-2
Silver	2.5E-1	2.3E-3	1.4E-3	6.0E-4	–
Thallium	–	–	–	–	–
Vanadium	**1.0E+1**	2.1E-1	**4.4E+0**	**8.5E+0**	4.8E-3
Zinc	**1.2E+0**	4.7E-2	2.8E-2	9.9E-3	1.5E-1
HI[b]	**2.0E+1**	9.7E-1	**4.3E+0**	**7.7E+0**	8.3E-1

[a]**Bold** values indicate the HQ or HI exceeds unity.
[b]The HI is the sum of individual HQs.
COPEC = Constituent of potential ecological concern.
HI = Hazard index.
HQ = Hazard quotient.
SWMU = Solid Waste Management Unit.
– = Insufficient toxicity data available for risk estimation purposes.

concentrations may account for more than half (63, 58, and 56 percent, respectively) of the HQ values shown in Table 19.

The assumption of an area use factor of 1.0 for all ecological receptors is a source of uncertainty for the burrowing owl. Because SWMU 4 is 0.8 acre in size, an area use factor of approximately 0.023 would be justified for the burrowing owl based upon a probable home range for this species of approximately 35 acres (see Table 15). Application of this area use factor to the HQs shown in Table 19 would reduce all of the HQs for this receptor to values less unity (the maximum being 0.89 for exposure to bis[2-ethylhexyl] phthalate). Therefore, when more realistic assumptions of exposure to COPECs at this site are considered, the potential risks to the burrowing owl are very low.

A significant source of uncertainty associated with the prediction of ecological risk at this site is the use of the maximum measured concentrations to evaluate exposure and risk. This results in a conservative exposure scenario that does not necessarily reflect actual site conditions. To assess the potential degree of overestimation caused by using the maximum measured soil concentrations in the exposure assessment, the UCLs of the average soil concentrations were calculated (Appendix 2). For the COPECs with HQs greater than unity, these HQs can be accounted for by the magnitude of the extreme measurement. The UCLs of antimony, arsenic, barium, and vanadium (3.3, 3.1, 87, and 16.0 mg/kg, respectively) are lower than the corresponding background screening values. Therefore, risks from exposures to these COPECs at SWMU 4 are likely to be within the background levels shown in Table 22. Furthermore, all HQs for cobalt, copper, lead, and acetone are reduced to values less than unity when based upon the UCL concentrations (10, 89, 28, and 0.33 mg/kg, respectively).

In the case of cadmium, exposures to the UCL concentration (29 mg/kg) reduces the HQs for the three dietary regimes of the deer mouse to values of 1.5 or less and the HQ for plants to 9.6. For total chromium, chromium VI, nickel, silver, and zinc, the UCL concentrations (28.0, 1.9, 32.8, 19.3, and 64.1 mg/kg, respectively) reduce the HQs for plants to 28, 1.9, 1.1, 9.7, and 1.3, respectively. For total chromium, it should be noted that the plant toxicity benchmark is based upon chromium VI (Efroymson et al. 1997), which may be more toxic to plants than the more common chromium III. The data from SWMU 4 show that chromium VI accounts for less than 7 percent of total chromium (based upon the UCLs). For this reason, it is uncertain whether the calculated HQ for total chromium accurately predicts the potential risk to plants, although the plant HQ for chromium VI indicates a low potential for risk to plants from exposure to this COPEC. The plant benchmarks for cadmium, chromium, nickel, and zinc are conservatively based upon laboratory tests using soil amendments with a highly available form of these elements (Efroymson et al. 1997). It is likely that only a small fraction of the cadmium and chromium in the soil at SWMU 4 is in a form that is highly available for plant uptake. Therefore, the plant toxicity benchmarks for these metals probably overestimate risk to plants to a significant degree.

For selenium, exposures to the UCL (1.5 mg/kg) reduces the HQs for all three dietary regimes of the deer mouse to values less than unity, and the HQ for plants to 1.5, indicating a low potential for risk from this COPEC. For silver, the UCL (19.3 mg/kg) reduces the plant HQ to 9.7, indicating a low potential for risk. For thallium, exposure to the UCL concentration (0.38 mg/kg) reduces the HQ for the three dietary regimes of the deer mouse to values of 4.1 or less. In the case of mercury, the UCL (0.15 mg/kg) reduces all HQs for both plants and the deer mouse (all dietary regimes) to values less than unity regardless of whether the mercury is

assumed to be organic or inorganic in form. The HQ for the burrowing owl is reduced to 2.1 for mercury assumed to be in organic form, which is further reduced to 0.048 with the application of the area use factor of 0.023.

Use of the UCL concentration of bis(2-ethylhexyl) phthalate (0.90 mg/kg) reduces the HQ for the insectivorous deer mouse to less than unity; however, the HQ (5.8) for the burrowing owl is still above unity for this COPEC. Based upon the application of the area use factor of 0.023, however, no risk is predicted for this receptor from this COPEC.

The HQs for total PCBs exceed unity for both the omnivorous and insectivorous deer mouse when based upon the maximum detected value for PCBs. These HQs also were conservatively based upon an assumption that these PCBs were Aroclor-1254. However, at SWMU 4, only Aroclor-1260 was detected, the UCL concentration of which is 0.022 mg/kg. Based upon this UCL, and incorporating toxicity data specific to Aroclor-1260, the HQs for these two receptors (the omnivorous and insectivorous deer mouse) are reduced to 0.59 and 1.2, respectively, indicating a low potential risk from exposure to PCBs at this site.

Because only one data point is available for each of the four remaining COPECs (benzo[a]anthracene, benzo[b]fluoranthene, chrysene, and phenanthrene), evaluation of potential risk based upon the UCL is not meaningful; however, because all HQs associated with these COPECs are less than 2.3, risk is therefore considered to be low.

Based upon this uncertainty analysis, ecological risks at SWMU 4 are generally expected to be low. HQs greater than unity were initially predicted, with some HQs being significantly greater than 10; however, closer examination of the exposure assumptions revealed an overestimation of risk primarily attributed to exposure concentration and the contribution of background risk.

VII.3.6 Risk Interpretation

Ecological risks associated with SWMU 4 were estimated through a risk assessment that incorporated site-specific information when available. Overall, risks to ecological receptors are expected to be low because predicted risks associated with exposure to COPECs are based upon calculations using maximum detected values and (for the burrowing owl) the assumed area use factor of 1.0. Application of the area use factor of 0.023 reduces all HQs for the burrowing owl to values less than 1. The UCL concentrations of arsenic and barium are within the background range. HQs based upon the UCLs of cobalt, copper, lead, and acetone result in no HQs greater than unity. All other HQs (based upon UCL concentrations) are less than 10 with the exception of total chromium (HQ of 28 for plants) based upon a chromium VI plant benchmark, and all HQs greater than 2.6 are limited to plants. Based upon this final analysis, ecological risks associated with SWMU 4 are expected to be low.

VII.3.7 Risk Assessment Scientific/Management Decision Point

After potential ecological risks associated with the site have been assessed, a decision is made regarding whether the site should be recommended for NFA or whether additional data should be collected to assess actual ecological risk at the site more thoroughly. With respect to this

site, ecological risks are predicted to be low. The scientific/management decision is to recommend this site for NFA.

VIII. References

Baes, III, C.F., R.D. Sharp, A.L. Sjoreen, and R.W. Shor, 1984. "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture," ORNL-5786, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Baker, D.A., and J.K. Soldat, 1992. "Methods for Estimating Doses to Organisms from Radioactive Materials Released into the Aquatic Environment," PNL-8150, Pacific Northwest Laboratory, Richland, Washington.

Bearzi, J.P. (New Mexico Environment Department), January 2001. Memorandum to RCRA-Regulated Facilities, "Risk-Based Screening Levels for RCRA Corrective Action Sites in New Mexico," Hazardous Waste Bureau, New Mexico Environment Department, Santa Fe, New Mexico. January 23, 2001.

Callahan, M.A., M.W. Slimak, N.W. Gabel, I.P. May, C.F. Fowler, J.R. Freed, P. Jennings, R.L. Durfee, F.C. Whitmore, B. Maestri, W.R. Mabey, B.R. Holt, and C. Gould, 1979. "Water-Related Environmental Fate of 129 Priority Pollutants," EPA-440/4-79-029, Office of Water and Waste Management, Office of Water Planning and Standards, U.S. Environmental Protection Agency, Washington, D.C.

Castillo, D. (Sandia National Laboratories/New Mexico), July 2003. Memorandum to B. Langkopf (Sandia National Laboratories/New Mexico), "Abolishment of RMMA (ER-4)," Environmental Restoration Project, Albuquerque, New Mexico. July 24, 2003.

Connell, D.W., and R.D. Markwell, 1990. "Bioaccumulation in the Soil to Earthworm System," *Chemosphere*, Vol. 20, Nos. 1-2, pp. 91-100.

Dinwiddie, R.S. (New Mexico Environment Department), September 1997a. Letter to M.J. Zamorski (U.S. Department of Energy), "Request for Supplemental Information: Background Concentrations Report, SNL/KAFB." September 24, 1997.

Dinwiddie, R.S. (New Mexico Environment Department), September 1997b. "Request for Supplemental Information: Liquid Waste Disposal System RFI Report, Sandia National Laboratories." September 30, 1997.

DOE, see U.S. Department of Energy.

Dunning, J.B., 1993. *CRC Handbook of Avian Body Masses*, CRC Press, Boca Raton, Florida.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997. "Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1997 Revision," ES/ER/TM-85/R3, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

EPA, see U.S. Environmental Protection Agency.

Haug, E.A., B.A. Millsap, and M.S. Martell, 1993. "*Speotyto cunicularia* Burrowing Owl," *in* A. Poole and F. Gill (eds.), *The Birds of North America*, No. 61, The Academy of Natural Sciences of Philadelphia.

Howard, P.H., 1989. "Volume I: Large Production and Priority Pollutants," *Handbook of Environmental Fate and Exposure Data for Organic Chemicals*, Lewis Publishers, Inc., Chelsea, Michigan.

Howard, P.H., 1990. "Volume II: Solvents," *Handbook of Environmental Fate and Exposure Data for Organic Chemicals*, Lewis Publishers, Inc., Chelsea, Michigan.

Howard, P.H., 1993. "Volume IV: Solvents 2," *Handbook of Environmental Fate and Exposure Data for Organic Chemicals*, Lewis Publishers, Inc., Chelsea, Michigan.

IAEA, see International Atomic Energy Agency.

International Atomic Energy Agency (IAEA), 1992. "Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards," *Technical Report Series* No. 332, International Atomic Energy Agency, Vienna, Austria.

International Atomic Energy Agency (IAEA), 1994. "Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments," *Technical Reports Series No. 364*, International Atomic Energy Agency, Vienna, Austria.

IT, see IT Corporation.

IT Corporation (IT), July 1998. "Predictive Ecological Risk Assessment Methodology, Environmental Restoration Program, Sandia National Laboratories, New Mexico," IT Corporation, Albuquerque, New Mexico.

Kocher, D.C. 1983. "Dose-Rate Conversion Factors for External Exposure to Photon Emitters in Soil," *Health Physics,* Vol. 28, pp. 193–205.

Laws, E. (U.S. Environmental Protection Agency), July 1994. Memorandum to Region Administrators I-X, "Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities," U.S. Environmental Protection Agency, Washington, D.C. July 14, 1994.

Ma, W.C. 1982. "The Influence of Soil Properties and Worm-Related Factors on the Concentration of Heavy Metals in Earthworms," *Pedobiologia*, Vol. 24, pp. 109-119.

Micromedex, Inc., 1998. "Registry of Toxic Effects of Chemical Substances (RTECS)," Hazardous Substances Databank.

Nagy, K.A., 1987. "Field Metabolic Rate and Food Requirement Scaling in Mammals and Birds," *Ecological Monographs*, Vol. 57, No. 2, pp. 111–128.

National Council on Radiation Protection and Measurements (NCRP), 1987. "Exposure of the Population in the United States and Canada from Natural Background Radiation," *NCRP Report* No. 94, National Council on Radiation Protection and Measurements, Bethesda, Maryland.

National Council on Radiation Protection and Measurements (NCRP), January 1989. "Screening Techniques for Determining Compliance with Environmental Standards: Releases of Radionuclides to the Atmosphere," *NCRP Commentary* No. 3, Rev., National Council on Radiation Protection and Measurements, Bethesda, Maryland.

National Oceanographic and Atmospheric Administration (NOAA), 1990. Local Climatological Data, Annual Summary with Comparative Data, Albuquerque, New Mexico.

NCRP, see National Council on Radiation Protection and Measurements.

Neumann, G., 1976. "Concentration Factors for Stable Metals and Radionuclides in Fish, Mussels and Crustaceans—A Literature Survey," Report 85-04-24, National Swedish Environmental Protection Board.

New Mexico Environment Department (NMED), March 1998. "Risk-Based Decision Tree Description," *in* New Mexico Environment Department, "RPMP Document Requirement Guide," RCRA Permits Management Program, Hazardous and Radioactive Materials Bureau, New Mexico Environment Department, Santa Fe, New Mexico.

New Mexico Environment Department (NMED), December 2000. "Technical Background Document for Development of Soil Screening Levels," Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program, New Mexico Environment Department, Santa Fe, New Mexico. December 18, 2000.

New Mexico Environment Department (NMED), 2004. "Compliance Order on Consent Pursuant to the New Mexico Hazardous Waste Act," § 74-4-10, New Mexico Environment Department. April 2004.

NMED, see New Mexico Environment Department.

NOAA, see National Oceanographic and Atmospheric Administration.

Oak Ridge National Laboratory (ORNL), 2003. "Risk Assessment Information System," electronic database maintained by Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Olson, K., and W. Moats (New Mexico Environment Department), March 2000. Memorandum to File, "Proposed ER Site 8 Cleanup Levels," Hazardous and Radioactive Materials Bureau, New Mexico Environment Department, Santa Fe, New Mexico.

ORNL, see Oak Ridge National Laboratory.

Registry of Toxic Effects of Chemical Substances (RTECS), 1997. Produced by Micromedex.

RTECS, see Registry of Toxic Effects of Chemical Substances.

Sample, B.E., and G.W. Suter II, 1994. "Estimating Exposure of Terrestrial Wildlife to Contaminants," ES/ER/TM-125, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Sample, B.E., D.M. Opresko, and G.W. Suter II, 1996. "Toxicological Benchmarks for Wildlife: 1996 Revision," ES/ER/TM-86/R3, Risk Assessment Program, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Sandia National Laboratories/New Mexico (SNL/NM), October 1991. "Procedure for Validation of Chemical Measurement Data," Environmental Programs Department, 7720, Procedure QA-11-01, Rev. 0, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), March 1993. "RCRA Facility Investigation Work Plan for the Liquid Waste Disposal System (LWDS) ER Program Sites 4, 5, and 52," Environmental Impact and Restoration Division, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), September 1995. "Results of the Liquid Waste Disposal System RCRA Facility Investigation, Sandia National Laboratories, Albuquerque, New Mexico," Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), March 1996. "Site-Wide Hydrogeologic Characterization Project, Calendar Year 1995 Annual Report," Environmental Restoration Project, Sandia National Laboratories Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), January 1998. "Response to Request for Supplemental Information, Liquid Waste Disposal System RFI Report," Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), February 1998. "RESRAD Input Parameter Assumptions and Justification," Environmental Restoration Project, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), November 2001. "TA-V Groundwater Investigation, Fiscal Years 1999 and 2000," Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), March 2003. "Annual Groundwater Monitoring Report, Fiscal Year 2002, Sandia National Laboratories, Albuquerque, New Mexico," Sandia National Laboratories/New Mexico, Albuquerque, New Mexico.

Silva, M., and J.A. Downing, 1995. *CRC Handbook of Mammalian Body Masses*, CRC Press, Boca Raton, Florida.

Sims, R.C., and R.M. Overcash, 1983. "Fate of Polynuclear Aromatic Compounds (PNAs) in Soil-Plant Systems," *Residue Reviews*, Vol. 88, pp. 1-67.

SNL/NM, See Sandia National Laboratories, New Mexico.

Stafford, E.A., J.W. Simmers, R.G. Rhett, and C.P. Brown, 1991. "Interim Report: Collation and Interpretation of Data for Times Beach Confined Disposal Facility, Buffalo, New York," *Miscellaneous Paper* D-91-17, U.S. Army Corps of Engineers, Buffalo, New York.

Travis, C.C., and A.D. Arms, 1988. "Bioconcentration of Organics in Beef, Milk, and Vegetation," *Environmental Science and Technology*, Vol. 22, No. 3, pp. 271-274.

U.S. Department of Energy (DOE), 1988. "External Dose-Rate Conversion Factors for Calculation of Dose to the Public," DOE/EH-0070, Assistant Secretary for Environment, Safety and Health, U.S. Department of Energy, Washington, D.C.

U.S. Department of Energy (DOE), 1993. "Radiation Protection of the Public and the Environment," DOE Order 5400.5, U.S. Department of Energy, Washington, D.C.

U.S. Department of Energy (DOE), 1995. "Hanford Site Risk Assessment Methodology," DOE/RL-91-45 (Rev. 3), U.S. Department of Energy, Richland, Washington.

U.S. Department of Energy, U.S. Air Force, and U.S. Forest Service, September 1995. "Workbook: Future Use Management Area 2, Sectors 2E and 2G, Areas I–V," prepared by Future Use Logistics and Support Working Group in cooperation with U.S. Department of Energy Affiliates, the U.S. Air Force, and the U.S. Forest Service.

U.S. Environmental Protection Agency (EPA), November 1986. "Test Methods for Evaluating Solid Waste," 3rd ed., Update 3, SW-846, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1988a. "Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1988b. "13-week Mouse Oral Subchronic Toxicity Study," Toxicity Research Laboratories, Ltd. for the Office of Solid Waste Management, U.S. Environmental Protection Agency, Washington D.C.

U.S. Environmental Protection Agency (EPA), 1989a. "Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual," EPA/540-1089/002, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1989b. "13-week Mouse Oral Subchronic Toxicity Study with Pyrene," Toxicity Research Laboratory, Study #042-012 for the Office of Solid Waste Management, U.S. Environmental Protection Agency, Washington D.C.

U.S. Environmental Protection Agency (EPA), 1991. "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part B)," Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1993. "Wildlife Exposure Factors Handbook, Volume I of II," EPA/600/R-93/187a, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1997a. "Health Effects Assessment Summary Tables (HEAST), FY 1997 Update," EPA-540-R-97-036, Office of Research and Development and Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1997b. "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination," OSWER Directive No. 9200.4-18, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1997c. "Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risks," Interim Final, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1998. "Guidelines for Ecological Risk Assessment," EPA/630/R-95/002F, Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 2002a. "Region 6 Preliminary Remediation Goals (PRGs) 2002," electronic database maintained by Region 6, U.S. Environmental Protection Agency, Dallas, Texas.

U.S. Environmental Protection Agency (EPA), 2002b. "Region 9 Preliminary Remediation Goals (PRGs) 2002," electronic database maintained by Region 9, U.S. Environmental Protection Agency, San Francisco, California.

U.S. Environmental Protection Agency (EPA), 2002c. "Risk-Based Concentration Table," electronic database maintained by Region 3, U.S. Environmental Protection Agency, Philadelphia, Pennsylvania.

U.S. Environmental Protection Agency (EPA), 2003. Integrated Risk Information System (IRIS) electronic database, maintained by the U.S. Environmental Protection Agency, Washington, D.C.

U.S. Fish and Wildlife Service (USFWS), September 1995. "Migratory Nongame Birds of Management Concern in the United States: The 1995 List," Office of Migratory Bird Management, U.S. Fish and Wildlife Service, Washington, D.C.

USFWS, see U.S. Fish and Wildlife Service.

Vanderploeg, H.A., D.C. Parzyck, W.H. Wilcox, J.R. Kercher, and S.V. Kaye, 1975. "Bioaccumulation Factors for Radionuclides in Freshwater Biota," ORNL-5002, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Whicker, F.W., and V. Schultz, 1982. *Radioecology: Nuclear Energy and the Environment*, Vol. 2, CRC Press, Boca Raton, Florida.

Yanicak, S. (Oversight Bureau, Department of Energy, New Mexico Environment Department), March 1997. Letter to M. Johansen (DOE/AIP/POC Los Alamos National Laboratory), "(Tentative) list of constituents of potential ecological concern (COPECs) which are considered to be bioconcentrators and/or biomagnifiers." March 3, 1997.

Yu, C., A.J. Zielen, J.-J. Cheng, Y.C. Yuan, L.G. Jones, D.J. LePoire, Y.Y. Wang, C.O. Loureiro, E. Gnanapragasam, E. Faillace, A. Wallo III, W.A. Williams, and H. Peterson, 1993a. "Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD," Version 5.0. Environmental Assessment Division, Argonne National Laboratory, Argonne, Illinois.

Yu, C., C. Loureiro, J.-J. Cheng, L.G. Jones, Y.Y. Wang, Y.P. Chia, and E. Faillace, 1993b. "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil," ANL/EAIS-8, Argonne National Laboratory, Argonne, Illinois.

This page intentionally left blank.

APPENDIX 1
EXPOSURE PATHWAY DISCUSSION FOR CHEMICAL AND RADIONUCLIDE CONTAMINATION

Introduction

Sandia National Laboratories/New Mexico (SNL/NM) uses a default set of exposure routes and associated default parameter values developed for each future land-use designation being considered for SNL/NM Environmental Restoration (ER) Project sites. This default set of exposure scenarios and parameter values are invoked for risk assessments unless site-specific information suggests other parameter values. Because many SNL/NM solid waste management units (SWMUs) have similar types of contamination and physical settings, SNL/NM believes that the risk assessment analyses at these sites can be similar. A default set of exposure scenarios and parameter values facilitates the risk assessments and subsequent review.

The default exposure routes and parameter values used are those that SNL/NM views as resulting in a Reasonable Maximum Exposure (RME) value. Subject to comments and recommendations by the U.S. Environmental Protection Agency (EPA) Region VI and New Mexico Environment Department (NMED), SNL/NM will use these default exposure routes and parameter values in future risk assessments.

At SNL/NM, all SWMUs exist within the boundaries of the Kirtland Air Force Base. Approximately 240 potential waste and release sites have been identified where hazardous, radiological, or mixed materials may have been released to the environment. Evaluation and characterization activities have occurred at all of these sites to varying degrees. Among other documents, the SNL/NM ER draft Environmental Assessment (DOE 1996) presents a summary of the hydrogeology of the sites and the biological resources present. When evaluating potential human health risk the current or reasonably foreseeable land use negotiated and approved for the specific SWMU/AOC, aggregate, or watershed will be used. The following references generally document these land uses: *Workbook: Future Use Management Area 2 (DOE et al. September 1995); Workbook: Future Use Management Area 1 (DOE et al. October 1995); Workbook: Future Use Management Areas 3, 4, 5, and 6 (DOE and USAF January 1996); Workbook: Future Use Management Area 7 (DOE and USAF March 1996)*. At this time, all SNL/NM SWMUs have been tentatively designated for either industrial or recreational future land use. The NMED has also requested that risk calculations be performed based upon a residential land-use scenario. Therefore, all three land-use scenarios will be addressed in this document.

The SNL/NM ER Project has screened the potential exposure routes and identified default parameter values to be used for calculating potential intake and subsequent hazard index (HI), excess cancer risk and dose values. The EPA (EPA 1989) provides a summary of exposure routes that could potentially be of significance at a specific waste site. These potential exposure routes consist of:

- Ingestion of contaminated drinking water
- Ingestion of contaminated soil

- Ingestion of contaminated fish and shellfish
- Ingestion of contaminated fruits and vegetables
- Ingestion of contaminated meat, eggs, and dairy products
- Ingestion of contaminated surface water while swimming
- Dermal contact with chemicals in water
- Dermal contact with chemicals in soil
- Inhalation of airborne compounds (vapor phase or particulate)
- External exposure to penetrating radiation (immersion in contaminated air; immersion in contaminated water; and exposure from ground surfaces with photon-emitting radionuclides)

Based upon the location of the SNL/NM SWMUs and the characteristics of the surface and subsurface at the sites, we have evaluated these potential exposure routes for different land-use scenarios to determine which should be considered in risk assessment analyses (the last exposure route is pertinent to radionuclides only). At SNL/NM SWMUs, there is currently no consumption of fish, shellfish, fruits, vegetables, meat, eggs, or dairy products that originate on site. Additionally, no potential for swimming in surface water is present due to the high-desert environmental conditions. As documented in the RESRAD computer code manual (ANL 1993), risks resulting from immersion in contaminated air or water are not significant compared to risks from other radiation exposure routes.

For the industrial and recreational land-use scenarios, SNL/NM ER has, therefore, excluded the following five potential exposure routes from further risk assessment evaluations at any SNL/NM SWMU:

- Ingestion of contaminated fish and shellfish
- Ingestion of contaminated fruits and vegetables
- Ingestion of contaminated meat, eggs, and dairy products
- Ingestion of contaminated surface water while swimming
- Dermal contact with chemicals in water

That part of the exposure pathway for radionuclides related to immersion in contaminated air or water is also eliminated.

Based upon this evaluation, for future risk assessments the exposure routes that will be considered are shown in Table 1.

Table 1
Exposure Pathways Considered for Various Land-Use scenarios

Industrial	Recreational	Residential
Ingestion of contaminated drinking water	Ingestion of contaminated drinking water	Ingestion of contaminated drinking water
Ingestion of contaminated soil	Ingestion of contaminated soil	Ingestion of contaminated soil
Inhalation of airborne compounds (vapor phase or particulate)	Inhalation of airborne compounds (vapor phase or particulate)	Inhalation of airborne compounds (vapor phase or particulate)
Dermal contact (nonradiological constituents only) soil only	Dermal contact (nonradiological constituents only) soil only	Dermal contact (nonradiological constituents only) soil only
External exposure to penetrating radiation from ground surfaces	External exposure to penetrating radiation from ground surfaces	External exposure to penetrating radiation from ground surfaces

Equations and Default Parameter Values for Identified Exposure Routes

In general, SNL/NM expects that ingestion of compounds in drinking water and soil will be the more significant exposure routes for chemicals; external exposure to radiation may also be significant for radionuclides. All of the above routes will, however, be considered for their appropriate land-use scenarios. The general equation for calculating potential intakes via these routes is shown below. The equations are taken from "Assessing Human Health Risks Posed by Chemicals: Screening-Level Risk Assessment" (NMED March 2000) and "Technical Background Document for Development of Soil Screening Levels" (NMED December 2000). Equations from both documents are based upon the "Risk Assessment Guidance for Superfund" (RAGS): Volume 1 (EPA 1989, 1991). These general equations also apply to calculating potential intakes for radionuclides. A more in-depth discussion of the equations used in performing radiological pathway analyses with the RESRAD code may be found in the RESRAD Manual (ANL 1993). RESRAD is the only code designated by the U.S. Department of Energy (DOE) in DOE Order 5400.5 for the evaluation of radioactively contaminated sites (DOE 1993). The Nuclear Regulatory Commission (NRC) has approved the use of RESRAD for dose evaluation by licensees involved in decommissioning, NRC staff evaluation of waste disposal requests, and dose evaluation of sites being reviewed by NRC staff. EPA Science Advisory Board reviewed the RESRAD model. EPA used RESRAD in their rulemaking on radiation site cleanup regulations. RESRAD code has been verified, undergone several benchmarking analyses, and been included in the International Atomic Energy Agency's VAMP and BIOMOVS II projects to compare environmental transport models.

Also shown are the default values SNL/NM ER will use in RME risk assessment calculations for industrial, recreational, and residential land-use scenarios, based upon EPA and other governmental agency guidance. The pathways and values for chemical contaminants are discussed first, followed by those for radionuclide contaminants. RESRAD input parameters that are left as the default values provided with the code are not discussed. Further information relating to these parameters may be found in the RESRAD Manual (ANL 1993) or by directly accessing the RESRAD websites at: http://web.ead.anl.gov/resrad/home2/ or http://web.ead.anl.gov/resrad/documents/.

Generic Equation for Calculation of Risk Parameter Values

The equation used to calculate the risk parameter values (i.e., hazard quotients/HI, excess cancer risk, or radiation total effective dose equivalent [TEDE] [dose]) is similar for all exposure pathways and is given by:

Risk (or Dose) = Intake x Toxicity Effect (either carcinogenic, noncarcinogenic, or radiological)

$$= C \times (CR \times EFD/BW/AT) \times \text{Toxicity Effect} \qquad (1)$$

where;

C = contaminant concentration (site specific)
CR = contact rate for the exposure pathway
EFD= exposure frequency and duration
BW = body weight of average exposure individual
AT = time over which exposure is averaged.

For nonradiological constituents of concern (COCs), the total risk/dose (either cancer risk or HI) is the sum of the risks/doses for all of the site-specific exposure pathways and contaminants. For radionuclides, the calculated radiation exposure, expressed as TEDE is compared directly to the exposure guidelines of 15 millirem per year (mrem/year) for industrial and recreational future use and 75 mrem/year for the unlikely event that institutional control of the site is lost and the site is used for residential purposes (EPA 1997).

The evaluation of the carcinogenic health hazard produces a quantitative estimate for excess cancer risk resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of the quantitative estimate with the potentially acceptable risk of 1E-5 for nonradiological carcinogens. The evaluation of the noncarcinogenic health hazard produces a quantitative estimate (i.e., the HI) for the toxicity resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of this quantitative estimate with the EPA standard HI of unity (1). The evaluation of the health hazard from radioactive compounds produces a quantitative estimate of doses resulting from the COCs present at the site. This estimated dose is used to calculate an assumed risk. However, this calculated risk is presented for illustration purposes only, not to determine compliance with regulations.

The specific equations used for the individual exposure pathways can be found in RAGS (EPA 1989) and are outlined below. The RESRAD Manual (ANL 1993) describes similar equations for the calculation of radiological exposures.

Soil Ingestion

A receptor can ingest soil or dust directly by working in the contaminated soil. Indirect ingestion can occur from sources such as unwashed hands introducing contaminated soil to food that is then eaten. An estimate of intake from ingesting soil will be calculated as follows:

$$I_s = \frac{C_s * IR * CF * EF * ED}{BW * AT}$$

where:

I_s = Intake of contaminant from soil ingestion (milligrams [mg]/kilogram [kg]-day)
C_s = Chemical concentration in soil (mg/kg)
IR = Ingestion rate (mg soil/day)
CF = Conversion factor (1E-6 kg/mg)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged) (days)

It should be noted that it is conservatively assumed that the receptor only ingests soil from the contaminated source.

Soil Inhalation

A receptor can inhale soil or dust directly by working in the contaminated soil. An estimate of intake from inhaling soil will be calculated as follows (EPA August 1997):

$$I_s = \frac{C_s * IR * EF * ED * \left(1/VF \text{ or } 1/PEF\right)}{BW * AT}$$

where:

I_s = Intake of contaminant from soil inhalation (mg/kg-day)
C_s = Chemical concentration in soil (mg/kg)
IR = Inhalation rate (cubic meters [m^3]/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
VF = soil-to-air volatilization factor (m^3/kg)
PEF = particulate emission factor (m^3/kg)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged) (days)

Soil Dermal Contact

$$D_a = \frac{C_s * CF * SA * AF * ABS * EF * ED}{BW * AT}$$

where:

D_a = Absorbed dose (mg/kg-day)
C_s = Chemical concentration in soil (mg/kg)
CF = Conversion factor (1E-6 kg/mg)
SA = Skin surface area available for contact (cm^2/event)
AF = Soil to skin adherence factor (mg/cm^2)
ABS = Absorption factor (unitless)
EF = Exposure frequency (events/year)

ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged) (days)

Groundwater Ingestion

A receptor can ingest water by drinking it or through using household water for cooking. An estimate of intake from ingesting water will be calculated as follows (EPA August 1997):

$$I_w = \frac{C_w * IR * EF * ED}{BW * AT}$$

where:

I_w = Intake of contaminant from water ingestion (mg/kg/day)
C_w = Chemical concentration in water (mg/liter [L])
IR = Ingestion rate (L/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged) (days)

Groundwater Inhalation

The amount of a constituent taken into the body via exposure to volatilization from showering or other household water uses will be evaluated using the concentration of the constituent in the water source (EPA 1991 and 1992). An estimate of intake from volatile inhalation from groundwater will be calculated as follows (EPA 1991):

$$I_w = \frac{C_w * K * IR_i * EF * ED}{BW * AT}$$

where:

I_w = Intake of volatile in water from inhalation (mg/kg/day)
C_w = Chemical concentration in water (mg/L)
K = volatilization factor (0.5 L/m^3)
IR_i = Inhalation rate (m^3/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged—days)

For volatile compounds, volatilization from groundwater can be an important exposure pathway from showering and other household uses of groundwater. This exposure pathway will only be evaluated for organic chemicals with a Henry's Law constant greater than $1x10^{-5}$ and with a molecular weight of 200 grams/mole or less (EPA 1991).

Tables 2 and 3 show the default parameter values suggested for use by SNL/NM at SWMUs, based upon the selected land-use scenarios for nonradiological and radiological COCs,

respectively. References are given at the end of the table indicating the source for the chosen parameter values. SNL/NM uses default values that are consistent with both regulatory guidance and the RME approach. Therefore, the values chosen will, in general, provide a conservative estimate of the actual risk parameter. These parameter values are suggested for use for the various exposure pathways, based upon the assumption that a particular site has no unusual characteristics that contradict the default assumptions. For sites for which the assumptions are not valid, the parameter values will be modified and documented.

Summary

SNL/NM will use the described default exposure routes and parameter values in risk assessments at sites that have an industrial, recreational, or residential future land-use scenario. There are no current residential land-use designations at SNL/NM ER sites, but NMED has requested this scenario to be considered to provide perspective of the risk under the more restrictive land-use scenario. For sites designated as industrial or recreational land use, SNL/NM will provide risk parameter values based upon a residential land-use scenario to indicate the effects of data uncertainty on risk value calculations or in order to potentially mitigate the need for institutional controls or restrictions on SNL/NM ER sites. The parameter values are based upon EPA guidance and supplemented by information from other government sources. If these exposure routes and parameters are acceptable, SNL/NM will use them in risk assessments for all sites where the assumptions are consistent with site-specific conditions. All deviations will be documented.

Table 2
Default Nonradiological Exposure Parameter Values for Various Land-Use scenarios

Parameter	Industrial	Recreational	Residential
General Exposure Parameters			
Exposure Frequency (day/yr)	250[a,b]	8.7 (4 hr/wk for 52 wk/yr)[a,b]	350[a,b]
Exposure Duration (yr)	25[a,b,c]	30[a,b,c]	30[a,b,c]
Body Weight (kg)	70[a,b,c]	70 Adult[a,b,c] 15 Child[a,b,c]	70 Adult[a,b,c] 15 Child[a,b,c]
Averaging Time (days) for Carcinogenic Compounds (= 70 yr x 365 day/yr) for Noncarcinogenic Compounds (= ED x 365 day/yr)	25,550[a,b] 9,125 [a,b]	25,550[a,b] 10,950[a,b]	25,550 [a,b] 10,950 [a,b]
Soil Ingestion Pathway			
Ingestion Rate (mg/day)	100[a,b]	200 Child[a,b] 100 Adult[a,b]	200 Child [a,b] 100 Adult [a,b]
Inhalation Pathway			
Inhalation Rate (m^3/day)	20[a,b]	15 Child[a] 30 Adult[a]	10 Child[a] 20 Adult[a]
Volatilization Factor (m^3/kg)	Chemical Specific	Chemical Specific	Chemical Specific
Particulate Emission Factor (m^3/kg)	1.36E9[a]	1.36E9[a]	1.36E9[a]
Water Ingestion Pathway			
Ingestion Rate (liter/day)	2.4[a]	2.4[a]	2.4[a]
Dermal Pathway			
Skin Adherence Factor (mg/cm^2)	0.2[a]	0.2 Child[a] 0.07 Adult[a]	0.2 Child[a] 0.07 Adult[a]
Exposed Surface Area for Soil/Dust (cm^2/day)	3,300[a]	2,800 Child[a] 5,700 Adult[a]	2,800 Child[a] 5,700 Adult[a]
Skin Adsorption Factor	Chemical Specific	Chemical Specific	Chemical Specific

[a]Technical Background Document for Development of Soil Screening Levels (NMED December 2000).
[b]Risk Assessment Guidance for Superfund, Vol. 1, Part B (EPA 1991).
[c]Exposure Factors Handbook (EPA August 1997).
ED = Exposure duration.
EPA = U.S. Environmental Protection Agency.
hr = Hour(s).
kg = Kilogram(s).
m = Meter(s).
mg = Milligram(s).
NA = Not available.
wk = Week(s).
yr = Year(s).

Table 3
Default Radiological Exposure Parameter Values for Various Land-Use scenarios

Parameter	Industrial	Recreational	Residential
General Exposure Parameters			
Exposure Frequency	8 hr/day for 250 day/yr	4 hr/wk for 52 wk/yr	365 day/yr
Exposure Duration (yr)	25[a,b]	30[a,b]	30[a,b]
Body Weight (kg)	70 Adult[a,b]	70 Adult[a,b]	70 Adult[a,b]
Soil Ingestion Pathway			
Ingestion Rate	100 mg/day[c]	100 mg/day[c]	100 mg/day[c]
Averaging Time (days) (= 30 yr x 365 day/yr)	10,950[d]	10,950[d]	10,950[d]
Inhalation Pathway			
Inhalation Rate (m^3/yr)	7,300[d,e]	10,950[e]	7,300[d,e]
Mass Loading for Inhalation g/m^3	1.36 E-5[d]	1.36 E-5 [d]	1.36 E-5 [d]
Food Ingestion Pathway			
Ingestion Rate, Leafy Vegetables (kg/yr)	NA	NA	16.5[c]
Ingestion Rate, Fruits, Non-Leafy Vegetables & Grain (kg/yr)	NA	NA	101.8[b]
Fraction Ingested	NA	NA	0.25[b,d]

[a]Risk Assessment Guidance for Superfund, Vol. 1, Part B (EPA 1991).
[b]Exposure Factors Handbook (EPA August 1997).
[c]EPA Region VI guidance (EPA 1996).
[d]For radionuclides, RESRAD (ANL 1993).
[e]SNL/NM (February 1998).
EPA = U.S. Environmental Protection Agency.
g = Gram(s)
hr = Hour(s).
kg = Kilogram(s).
m = Meter(s).
mg = Milligram(s).
NA = Not applicable.
wk = Week(s).
yr = Year(s).

References

ANL, see Argonne National Laboratory.

Argonne National Laboratory (ANL), 1993. *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD*, Version 5.0, ANL/EAD/LD-2, Argonne National Laboratory, Argonne, IL.

DOE, see U.S. Department of Energy.

DOE and USAF, see U.S. Department of Energy and U.S. Air Force.

EPA, see U.S. Environmental Protection Agency.

New Mexico Environment Department (NMED), March 2000. "Assessing Human Health Risks Posed by Chemical: Screening-level Risk Assessment," Hazardous and Radioactive Materials Bureau, NMED, March 6, 2000.

New Mexico Environment Department (NMED), December 2000. "Technical Background Document for Development of Soil Screening Levels," Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program, December 18, 2000.

Sandia National Laboratories/New Mexico (SNL/NM), February 1998. "RESRAD Input Parameter Assumptions and Justification," Sandia National Laboratories/New Mexico Environmental Restoration Project, Albuquerque, New Mexico.

U.S. Department of Energy (DOE), 1993. DOE Order 5400.5, "Radiation Protection of the Public and the Environment," U.S. Department of Energy, Washington, D.C.

U.S. Department of Energy (DOE), 1996. "Environmental Assessment of the Environmental Restoration Project at Sandia National Laboratories/New Mexico," U.S. Department of Energy, Kirtland Area Office.

U.S. Department of Energy, U.S. Air Force, and U.S. Forest Service, September 1995. "Workbook: Future Use Management Area 2," prepared by the Future Use Logistics and Support Working Group in cooperation with U.S. Department of Energy Affiliates, the U.S. Air Force, and the U.S. Forest Service.

U.S. Department of Energy, U.S. Air Force, and U.S. Forest Service, October 1995. "Workbook: Future Use Management Area 1," prepared by the Future Use Logistics and Support Working Group in cooperation with U.S. Department of Energy Affiliates, the U.S. Air Force, and the U.S. Forest Service.

U.S. Department of Energy and U.S. Air Force (DOE and USAF), January 1996. "Workbook: Future Use Management Areas 3,4,5,and 6," prepared by the Future Use Logistics and Support Working Group in cooperation with U.S. Department of Energy Affiliates, and the U.S. Air Force.

U.S. Department of Energy and U.S. Air Force (DOE and USAF), March 1996. "Workbook: Future Use Management Area 7," prepared by the Future Use Logistics and Support Working Group in cooperation with U.S. Department of Energy Affiliates and the U.S. Air Force.

U.S. Environmental Protection Agency (EPA), 1989. "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual," EPA/540-1089/002, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1991. "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part B)," EPA/540/R-92/003, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1992. "Dermal Exposure Assessment: Principles and Applications," EPA/600/8-91/011B, Office of Research and Development, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1996. "Soil Screening Guidance: Technical Background Document," EPA/540/1295/128, Office of Solid Waste and Emergency Response, Washington, D.C.

U.S. Environmental Protection Agency (EPA), August 1997. *Exposure Factors Handbook*, EPA/600/8-89/043, U.S. Environmental Protection Agency, Office of Health and Environmental Assessment, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1997. (OSWER No. 9200.4-18) *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*, U.S. EPA Office of Radiation and Indoor Air, Washington D.C, August 1997.

This page intentionally left blank.

APPENDIX 2
CALCULATION OF THE UPPER CONFIDENCE LIMITS OF MEAN CONCENTRATIONS

For conservatism, Sandia National Laboratories/New Mexico uses the maximum concentration of the constituents of concern (COCs) for initial risk calculation. If the maximum concentrations produce risk above New Mexico Environment Department (NMED) guidelines, conservatism with this approach is evaluated and, if appropriate, a more realistic approach is applied. When the site has been adequately characterized, an estimate of the mean concentration of the COCs is more representative of actual site conditions. The NMED has proposed the use of the upper confidence limit (UCL) of the mean to represent average concentrations at a site (NMED December 2000). The UCL is calculated according to NMED guidance (Tharp June 2002) using the U.S. Environmental Protection Agency ProUCL program (EPA April 2002). Attached are the outputs from that program and the calculated UCLs used in the risk analysis.

References

EPA, see U.S. Environmental Protection Agency.

New Mexico Environment Department (NMED), December 2000. "Technical Background Document for Development of Soil Screening Levels," Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program, New Mexico Environment Department, Santa Fe, New Mexico. December 18, 2000.

NMED, see New Mexico Environment Department.

Tharp, T. (Weston Solutions, Inc.), June 2002. *Personal communication* with K. Olsen (Hazardous Waste Bureau, New Mexico Environment Department). June 12, 2002.

U.S. Environmental Protection Agency (EPA), April 2002. *ProUCL User's Guide*, U.S. Environmental Protection Agency, Washington, D.C.

This page intentionally left blank.

ATTACHMENT

General Statistics

SWMU 4 HH			
Summary Statistics for		Arsenic	
Number of Samples		185	
Minimum		0.5	
Maximum		7.6	
Mean		2.192703	
Median		2	
Standard Deviation		1.111601	
Variance		1.235658	
Coefficient of Variation		0.506955	
Skewness		1.487008	
Lilliefors Test Statisitic		0.066108	
Lilliefors 5% Critical Value		0.06514	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
97.5	% UCL (Assuming Normal Data)		
97.5	% UCL (Adjusted for Skewness)		
Adjusted-CLT		2.365814	
Modified-t		2.355433	
97.5	% Non-parametric UCL		
CLT		2.352884	
Jackknife		2.353944	
Standard Bootstrap		2.352796	
Bootstrap-t		2.371465	
Chebyshev (Mean, Std)		2.703085	

General Statistics

SWMU 4 HH			
Summary Statistics for		Cadmium	
Number of Samples		185	
Minimum		0.25	
Maximum		154	
Mean		2.097243	
Median		0.25	
Standard Deviation		12.30025	
Variance		151.2962	
Coefficient of Variation		5.864363	
Skewness		10.71909	
Lilliefors Test Statisitic		0.444697	
Lilliefors 5% Critical Value		0.06514	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
99	% UCL (Assuming Normal Data)		
Student's-t		4.219517	
99	% UCL (Adjusted for Skewness)		
Adjusted-CLT		5.605484	
Modified-t		4.338298	
99	% Non-parametric UCL		
CLT		4.201036	
Jackknife		4.219517	
Standard Bootstrap		4.175432	
Bootstrap-t		8.991117	
Chebyshev (Mean, Std)		11.09524	

General Statistics

SWMU 4 HH			
Summary Statistics for		Phenanthrene	
Number of Samples		192	
Minimum		0.165	
Maximum		3.3	
Mean		0.225442708	
Median		0.165	
Standard Deviation		0.359204964	
Variance		0.129028206	
Coefficient of Variation		1.593331479	
Skewness		7.351098891	
Lilliefors Test Statisitic		0.53436438	
Lilliefors 5% Critical Value		0.063941542	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.268290699	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.282778025	
Modified-t		0.270582844	
95	% Non-parametric UCL		
CLT		0.268082883	
Jackknife		0.268290699	
Standard Bootstrap		0.268863154	
Bootstrap-t		0.318263215	
Chebyshev (Mean, Std)		0.338440125	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Antimony	
Number of Samples		86	
Minimum		3	
Maximum		6	
Mean		3.069767	
Median		3	
Standard Deviation		0.454797	
Variance		0.20684	
Coefficient of Variation		0.148153	
Skewness		6.439299	
Lilliefors Test Statisitic		0.537704	
Lilliefors 5% Critical Value		0.09554	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		3.151323	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		3.186821	
Modified-t		3.156999	
95	% Non-parametric UCL		
CLT		3.150434	
Jackknife		3.151323	
Standard Bootstrap		3.150241	
Bootstrap-t		1.#INF	
Chebyshev (Mean, Std)		3.283536	

General Statistics

SWMU 4 ECO				
Summary Statistics for	Arsenic		Summary Statistics for	ln(Arsenic)
Number of Samples	69		Minimum	0
Minimum	1		Maximum	2.028148
Maximum	7.6		Mean	0.946754
Mean	2.824638		Standard Deviation	0.430649
Median	2.6		Variance	0.185459
Standard Deviation	1.279178			
Variance	1.636296		Lilliefors Test Statisitic	0.079253
Coefficient of Variation	0.452864		Lilliefors 5% Critical Value	0.106662
Skewness	1.412845		Data are Lognormal at 5% Significance Level	
95 % UCL (Assuming Normal Data)			Estimates Assuming Lognormal Distribution	
Student's-t	3.081435		MLE Mean	2.827756
			MLE Standard Deviation	1.276476
95 % UCL (Adjusted for Skewness)			MLE Coefficient of Variation	0.45141
Adjusted-CLT	3.105924		MLE Skewness	1.446213
Modified-t	3.085801		MLE Median	2.57733
			MLE 80% Quantile	3.708593
95 % Non-parametric UCL			MLE 90% Quantile	4.482309
CLT	3.077937		MLE 95% Quantile	5.23398
Jackknife	3.081435		MLE 99% Quantile	7.017761
Standard Bootstrap	3.080981			
Bootstrap-t	3.125292		MVU Estimate of Median	2.573868
Chebyshev (Mean, Std)	3.495886		MVU Estimate of Mean	2.823622
			MVU Estimate of Std. Dev.	1.267399
			MVU Estimate of SE of Mean	0.152214
			UCL Assuming Lognormal Distribution	
			95% H-UCL	3.108467
			95% Chebyshev (MVUE) UCL	3.487107
			99% Chebyshev (MVUE) UCL	4.338131
			Recommended UCL to use:	
			Student's-t or H-UCL	

General Statistics

SWMU 4 ECO				
Summary Statistics for	Barium		Summary Statistics for	ln(Barium)
Number of Samples	69		Minimum	3.517498
Minimum	33.7		Maximum	5.446737
Maximum	232		Mean	4.321604
Mean	80.95942		Standard Deviation	0.363486
Median	71.3		Variance	0.132122
Standard Deviation	35.99037			
Variance	1295.307		Lilliefors Test Statisitic	0.101478
Coefficient of Variation	0.444548		Lilliefors 5% Critical Value	0.106662
Skewness	2.290841		Data are Lognormal at 5% Significance Level	
95 % UCL (Assuming Normal Data)			Estimates Assuming Lognormal Distribution	
Student's-t	88.18456		MLE Mean	80.45236
			MLE Standard Deviation	30.23631
95 % UCL (Adjusted for Skewness)			MLE Coefficient of Variation	0.375829
Adjusted-CLT	89.3629		MLE Skewness	1.180571
Modified-t	88.38371		MLE Median	75.30935
			MLE 80% Quantile	102.386
95 % Non-parametric UCL			MLE 90% Quantile	120.1431
CLT	88.08613		MLE 95% Quantile	136.9393
Jackknife	88.18456		MLE 99% Quantile	175.4005
Standard Bootstrap	88.16923			
Bootstrap-t	89.89016		MVU Estimate of Median	75.23728
Chebyshev (Mean, Std)	99.84536		MVU Estimate of Mean	80.37052
			MVU Estimate of Std. Dev.	30.08639
			MVU Estimate of SE of Mean	3.617532
			UCL Assuming Lognormal Distribution	
			95% H-UCL	87.00553
			95% Chebyshev (MVUE) UCL	96.13897
			99% Chebyshev (MVUE) UCL	116.3645
			Recommended UCL to use:	
			Student's-t or H-UCL	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Cadmium	
Number of Samples		69	
Minimum		0.25	
Maximum		154	
Mean		5.114348	
Median		0.25	
Standard Deviation		19.86382	
Variance		394.5714	
Coefficient of Variation		3.88394	
Skewness		6.544162	
Lilliefors Test Statisitic		0.320334	
Lilliefors 5% Critical Value		0.106662	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
99	% UCL (Assuming Normal Data)		
Student's-t		10.81155	
99	% UCL (Adjusted for Skewness)		
Adjusted-CLT		14.38995	
Modified-t		11.12554	
99	% Non-parametric UCL		
CLT		10.6774	
Jackknife		10.81155	
Standard Bootstrap		10.79731	
Bootstrap-t		22.737	
Chebyshev (Mean, Std)		28.90771	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Total Chromium	
Number of Samples		69	
Minimum		3.1	
Maximum		97.7	
Mean		11.21449275	
Median		7.5	
Standard Deviation		14.0229253	
Variance		196.6424339	
Coefficient of Variation		1.250428852	
Skewness		4.518774388	
Lilliefors Test Statisitic		0.16140647	
Lilliefors 5% Critical Value		0.106661866	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
99	% UCL (Assuming Normal Data)		
Student's-t		15.23644637	
99	% UCL (Adjusted for Skewness)		
Adjusted-CLT		16.95148201	
Modified-t		15.38950539	
99	% Non-parametric UCL		
CLT		15.14174443	
Jackknife		15.23644637	
Standard Bootstrap		15.03047889	
Bootstrap-t		21.89504241	
Chebyshev (Mean, Std)		28.01149083	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Chromium IV	
Number of Samples		56	
Minimum		0.05	
Maximum		11.2	
Mean		0.518035714	
Median		0.1	
Standard Deviation		1.610095897	
Variance		2.592408799	
Coefficient of Variation		3.108078947	
Skewness		5.90311285	
Lilliefors Test Statisitic		0.219161217	
Lilliefors 5% Critical Value		0.11839673	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
97.5	% UCL (Assuming Normal Data)		
Student's-t		0.949222069	
97.5	% UCL (Adjusted for Skewness)		
Adjusted-CLT		1.185355327	
Modified-t		0.977509503	
97.5	% Non-parametric UCL		
CLT		0.939737869	
Jackknife		0.949222069	
Standard Bootstrap		0.936735215	
Bootstrap-t		2.697128534	
Chebyshev (Mean, Std)		1.861697709	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Cobalt	
Number of Samples		69	
Minimum		1.6	
Maximum		42.2	
Mean		4.275362	
Median		3.5	
Standard Deviation		4.793268	
Variance		22.97541	
Coefficient of Variation		1.121137	
Skewness		7.493575	
Lilliefors Test Statisitic		0.129684	
Lilliefors 5% Critical Value		0.106662	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
99	% UCL (Assuming Normal Data)		
Student's-t		5.650133	
99	% UCL (Adjusted for Skewness)		
Adjusted-CLT		6.643596	
Modified-t		5.736893	
99	% Non-parametric UCL		
CLT		5.617762	
Jackknife		5.650133	
Standard Bootstrap		5.6224	
Bootstrap-t		8.146879	
Chebyshev (Mean, Std)		10.01685	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Copper	
Number of Samples		69	
Minimum		4	
Maximum		239	
Mean		29.12319	
Median		9	
Standard Deviation		49.67635	
Variance		2467.74	
Coefficient of Variation		1.705732	
Skewness		2.833041	
Lilliefors Test Statisitic		0.235789	
Lilliefors 5% Critical Value		0.106662	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
99	% UCL (Assuming Normal Data)		
Student's-t		43.371	
99	% UCL (Adjusted for Skewness)		
Adjusted-CLT		47.0549	
Modified-t		43.71094	
99	% Non-parametric UCL		
CLT		43.03552	
Jackknife		43.371	
Standard Bootstrap		42.39937	
Bootstrap-t		49.85886	
Chebyshev (Mean, Std)		88.62672	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Lead	
Number of Samples		69	
Minimum		2.5	
Maximum		72.5	
Mean		11.90725	
Median		7.1	
Standard Deviation		13.41408	
Variance		179.9374	
Coefficient of Variation		1.126547	
Skewness		3.369679	
Lilliefors Test Statisitic		0.170598	
Lilliefors 5% Critical Value		0.106662	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
99	% UCL (Assuming Normal Data)		
Student's-t		15.75457	
99	% UCL (Adjusted for Skewness)		
Adjusted-CLT		16.95492	
Modified-t		15.86376	
99	% Non-parametric UCL		
CLT		15.66398	
Jackknife		15.75457	
Standard Bootstrap		15.6081	
Bootstrap-t		18.99196	
Chebyshev (Mean, Std)		27.97495	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Mercury	
Number of Samples		69	
Minimum		0.05	
Maximum		0.61	
Mean		0.090638	
Median		0.05	
Standard Deviation		0.109673	
Variance		0.012028	
Coefficient of Variation		1.21001	
Skewness		3.068887	
Lilliefors Test Statisitic		0.489354	
Lilliefors 5% Critical Value		0.106662	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.112655	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.117567	
Modified-t		0.113468	
95	% Non-parametric UCL		
CLT		0.112355	
Jackknife		0.112655	
Standard Bootstrap		0.112303	
Bootstrap-t		0.122934	
Chebyshev (Mean, Std)		0.148188	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Nickel	
Number of Samples		86	
Minimum		2	
Maximum		173	
Mean		10.95349	
Median		6.1	
Standard Deviation		20.34097	
Variance		413.7552	
Coefficient of Variation		1.857032	
Skewness		6.517619	
Lilliefors Test Statisitic		0.390653	
Lilliefors 5% Critical Value		0.09554	
Data not Normal at 5% Significance Level			
Data not Lognormal: Try Non-parametric UCL			
99	% UCL (Assuming Normal Data)		
Student's-t		16.15414	
99	% UCL (Adjusted for Skewness)		
Adjusted-CLT		19.09401	
Modified-t		16.41107	
99	% Non-parametric UCL		
CLT		16.05615	
Jackknife		16.15414	
Standard Bootstrap		15.95735	
Bootstrap-t		25.50402	
Chebyshev (Mean, Std)		32.77778	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Selenium	
Number of Samples		69	
Minimum		0.25	
Maximum		10	
Mean		0.619565	
Median		0.5	
Standard Deviation		1.176711	
Variance		1.384648	
Coefficient of Variation		1.899253	
Skewness		7.668453	
Lilliefors Test Statisitic		0.263245	
Lilliefors 5% Critical Value		0.106662	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
97.5	% UCL (Assuming Normal Data)		
Student's-t		0.902242	
97.5	% UCL (Adjusted for Skewness)		
Adjusted-CLT		1.086465	
Modified-t		0.924038	
97.5	% Non-parametric UCL		
CLT		0.897212	
Jackknife		0.902242	
Standard Bootstrap		0.899227	
Bootstrap-t		1.583984	
Chebyshev (Mean, Std)		1.504227	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Silver	
Number of Samples		69	
Minimum		0.5	
Maximum		90.5	
Mean		3.42029	
Median		0.5	
Standard Deviation		13.22684	
Variance		174.9493	
Coefficient of Variation		3.867169	
Skewness		5.835375	
Lilliefors Test Statisitic		0.469595	
Lilliefors 5% Critical Value		0.106662	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
99	% UCL (Assuming Normal Data)		
Student's-t		7.213916	
99	% UCL (Adjusted for Skewness)		
Adjusted-CLT		9.328943	
Modified-t		7.40035	
99	% Non-parametric UCL		
CLT		7.12459	
Jackknife		7.213916	
Standard Bootstrap		7.208532	
Bootstrap-t		30.68584	
Chebyshev (Mean, Std)		19.26372	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Thallium	
Number of Samples		86	
Minimum		0.25	
Maximum		0.79	
Mean		0.324419	
Median		0.25	
Standard Deviation		0.124613	
Variance		0.015528	
Coefficient of Variation		0.384113	
Skewness		1.355367	
Lilliefors Test Statisitic		0.450246	
Lilliefors 5% Critical Value		0.09554	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.346765	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.34862	
Modified-t		0.347092	
95	% Non-parametric UCL		
CLT		0.346521	
Jackknife		0.346765	
Standard Bootstrap		0.346147	
Bootstrap-t		0.348645	
Chebyshev (Mean, Std)		0.382991	

General Statistics

SWMU 4 ECO					
Summary Statistics for		Vanadium		Summary Statistics for	ln(Vanadium)
Number of Samples		86		Minimum	2.014903
Minimum		7.5		Maximum	3.964615
Maximum		52.7		Mean	2.670776
Mean		15.1814		Standard Deviation	0.300533
Median		14.25		Variance	0.09032
Standard Deviation		5.66067			
Variance		32.04318		Lilliefors Test Statisitic	0.059899
Coefficient of Variation		0.372869		Lilliefors 5% Critical Value	0.09554
Skewness		3.543737		Data are Lognormal at 5% Significance Level	
95	% UCL (Assuming Normal Data)			Estimates Assuming Lognormal Distribution	
Student's-t		16.19649		MLE Mean	15.11875
				MLE Standard Deviation	4.648236
95	% UCL (Adjusted for Skewness)			MLE Coefficient of Variation	0.307448
Adjusted-CLT		16.43466		MLE Skewness	0.951407
Modified-t		16.23536		MLE Median	14.45117
				MLE 80% Quantile	18.62912
95	% Non-parametric UCL			MLE 90% Quantile	21.26283
CLT		16.18542		MLE 95% Quantile	23.69235
Jackknife		16.19649		MLE 99% Quantile	29.07316
Standard Bootstrap		16.17016			
Bootstrap-t		16.4829		MVU Estimate of Median	14.44359
Chebyshev (Mean, Std)		17.84209		MVU Estimate of Mean	15.11047
				MVU Estimate of Std. Dev.	4.635746
				MVU Estimate of SE of Mean	0.499587
				UCL Assuming Lognormal Distribution	
				95% H-UCL	16.00026
				95% Chebyshev (MVUE) UCL	17.28812
				99% Chebyshev (MVUE) UCL	20.0813
				Recommended UCL to use:	
				Student's-t or H-UCL	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Zinc	
Number of Samples		86	
Minimum		15.9	
Maximum		198	
Mean		33.4407	
Median		24.85	
Standard Deviation		28.62008	
Variance		819.109	
Coefficient of Variation		0.855846	
Skewness		3.96203	
Lilliefors Test Statisitic		0.194931	
Lilliefors 5% Critical Value		0.09554	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
99	% UCL (Assuming Normal Data)		
Student's-t		40.7581	
99	% UCL (Adjusted for Skewness)		
Adjusted-CLT		43.21857	
Modified-t		40.97786	
99	% Non-parametric UCL		
CLT		40.62023	
Jackknife		40.7581	
Standard Bootstrap		40.5958	
Bootstrap-t		47.27989	
Chebyshev (Mean, Std)		64.14783	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Acetone	
Number of Samples		72	
Minimum		0.0044	
Maximum		4.3	
Mean		0.066228	
Median		0.005	
Standard Deviation		0.505999	
Variance		0.256035	
Coefficient of Variation		7.640284	
Skewness		8.484422	
Lilliefors Test Statisitic		0.437139	
Lilliefors 5% Critical Value		0.104416	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.165611	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.228026	
Modified-t		0.175549	
95	% Non-parametric UCL		
CLT		0.164315	
Jackknife		0.165611	
Standard Bootstrap		0.160266	
Bootstrap-t		10.1258	
Chebyshev (Mean, Std)		0.32616	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Benzo(a)anthracene	
Number of Samples		69	
Minimum		0.165	
Maximum		3.3	
Mean		0.327971015	
Median		0.165	
Standard Deviation		0.584737447	
Variance		0.341917882	
Coefficient of Variation		1.782893673	
Skewness		4.324293558	
Lilliefors Test Statisitic		0.504827521	
Lilliefors 5% Critical Value		0.106661866	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.445358272	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.482915851	
Modified-t		0.451465945	
95	% Non-parametric UCL		
CLT		0.443759032	
Jackknife		0.445358272	
Standard Bootstrap		0.441672891	
Bootstrap-t		0.561058648	
Chebyshev (Mean, Std)		0.634811854	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Benzo(b)fluoranthene	
Number of Samples		69	
Minimum		0.165	
Maximum		3.3	
Mean		0.329565217	
Median		0.165	
Standard Deviation		0.5849483	
Variance		0.342164514	
Coefficient of Variation		1.774909091	
Skewness		4.311372101	
Lilliefors Test Statisitic		0.506268551	
Lilliefors 5% Critical Value		0.106661866	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.446994804	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.484448879	
Modified-t		0.453086422	
95	% Non-parametric UCL		
CLT		0.445394988	
Jackknife		0.446994804	
Standard Bootstrap		0.445254536	
Bootstrap-t		0.581874306	
Chebyshev (Mean, Std)		0.636516702	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Bis(2-ethylhexyl)phthalate	
Number of Samples		69	
Minimum		0.046	
Maximum		5.9	
Mean		0.389217391	
Median		0.165	
Standard Deviation		0.964480535	
Variance		0.930222702	
Coefficient of Variation		2.477999587	
Skewness		5.135872704	
Lilliefors Test Statisitic		0.485799686	
Lilliefors 5% Critical Value		0.106661866	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.582838863	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.656908751	
Modified-t		0.594803716	
95	% Non-parametric UCL		
CLT		0.580201037	
Jackknife		0.582838863	
Standard Bootstrap		0.574787188	
Bootstrap-t		1.024653745	
Chebyshev (Mean, Std)		0.895328328	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Chrysene	
Number of Samples		69	
Minimum		0.165	
Maximum		3.3	
Mean		0.328116	
Median		0.165	
Standard Deviation		0.584744	
Variance		0.341926	
Coefficient of Variation		1.782127	
Skewness		4.323379	
Lilliefors Test Statisitic		0.50499	
Lilliefors 5% Critical Value		0.106662	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.445505	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.483054	
Modified-t		0.451611	
95	% Non-parametric UCL		
CLT		0.443905	
Jackknife		0.445505	
Standard Bootstrap		0.442877	
Bootstrap-t		0.601455	
Chebyshev (Mean, Std)		0.63496	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Phenanthrene	
Number of Samples		69	
Minimum		0.165	
Maximum		3.3	
Mean		0.333188406	
Median		0.165	
Standard Deviation		0.586540187	
Variance		0.344029391	
Coefficient of Variation		1.760385945	
Skewness		4.261244591	
Lilliefors Test Statisitic		0.507923487	
Lilliefors 5% Critical Value		0.106661866	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.450937567	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.488038262	
Modified-t		0.456974744	
95	% Non-parametric UCL		
CLT		0.449333397	
Jackknife		0.450937567	
Standard Bootstrap		0.449673261	
Bootstrap-t		0.566657326	
Chebyshev (Mean, Std)		0.640975233	

General Statistics

SWMU 4 ECO			
Summary Statistics for		Aroclor 1260	
Number of Samples		63	
Minimum		0.0165	
Maximum		0.071	
Mean		0.018015873	
Median		0.0165	
Standard Deviation		0.007697909	
Variance		5.93E-05	
Coefficient of Variation		0.427284837	
Skewness		5.940425929	
Lilliefors Test Statisitic		0.536248203	
Lilliefors 5% Critical Value		0.111625508	
Data not Lognormal at 5% Significance Level			
Data not Normal: Try Non-parametric UCL			
95	% UCL (Assuming Normal Data)		
Student's-t		0.019635325	
95	% UCL (Adjusted for Skewness)		
Adjusted-CLT		0.020386713	
Modified-t		0.0197563	
95	% Non-parametric UCL		
CLT		0.019611127	
Jackknife		0.019635325	
Standard Bootstrap		0.019605958	
Bootstrap-t		0.022052527	
Chebyshev (Mean, Std)		0.022243331	

Sandia National Laboratories/New Mexico Environmental Restoration Project

RISK ASSESSMENT REPORT SOLID WASTE MANAGEMENT UNIT 52 LIQUID WASTE DISPOSAL SYSTEM HOLDING TANKS

June 2005

United States Department of Energy
Sandia Site Office

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

TABLE OF CONTENTS

I. Site Description and History 1
II. Data Quality Objectives 7
III. Determination of Nature, Rate, and Extent of Contamination 10
- III.1 Introduction 10
- III.2 Nature of Contamination 10
- III.3 Rate of Contaminant Migration 11
- III.4 Extent of Contamination 11

IV. Comparison of COCs to Background Screening Levels 11
V. Fate and Transport 12
VI. Human Health Risk Assessment 16
- VI.1 Introduction 16
- VI.2 Step 1. Site Data 17
- VI.3 Step 2. Pathway Identification 17
- VI.4 Step 3. Background Screening Procedure 21
  - VI.4.1 Methodology 21
  - VI.4.2 Results 21
- VI.5 Step 4. Identification of Toxicological Parameters 21
- VI.6 Step 5. Exposure Assessment and Risk Characterization 24
  - VI.6.1 Exposure Assessment 25
  - VI.6.2 Risk Characterization 25
- VI.7 Step 6. Comparison of Risk Values to Numerical Guidelines 27
- VI.8 Step 7. Uncertainty Discussion 28
- VI.9 Summary 29

VII. Ecological Risk Assessment 32
- VII.1 Introduction 32
- VII.2 Scoping Assessment 32
  - VII.2.1 Data Assessment 32
  - VII.2.2 Bioaccumulation 32
  - VII.2.3 Fate and Transport Potential 32
  - VII.2.4 Scoping Risk-Management Decision 33

VIII. References 33

Appendix 1 39
Appendix 2 51

This page intentionally left blank.

LIST OF TABLES

Table		Page
1	Summary of Sampling Performed to Meet DQOs	8
2	Summary of Data Quality Requirements	9
3	Summary of QA/QC Samples	10
4	Nonradiological COCs for Human Health Risk Assessment at SWMU 52 with Comparison to the Associated SNL/NM Background Screening Value, BCF, and Log K_{ow}	13
5	Radiological COCs for Human Health Risk Assessment at SWMU 52 with Comparison to the Associated SNL/NM Background Screening Value and BCF	15
6	Summary of Fate and Transport at SWMU 52	16
7	Toxicological Parameter Values for SWMU 52 Nonradiological COCs	22
8	Radiological Toxicological Parameter Values for SWMU 52 COCs Obtained from RESRAD Risk Coefficients	24
9	Risk Assessment Values for SWMU 52 Nonradiological COCs	26
10	Risk Assessment Values for SWMU 52 Nonradiological Background Constituents	27
11	Risk Assessment Values for SWMU 52 Nonradiological COCs with UCL Concentrations for the Major Risk Drivers	30
12	Summation of Radiological and Nonradiological Risks from Site Carcinogens	31

LIST OF FIGURES

Figure		Page
1	Location of TA-V and SWMU 52	3
2	Location of SWMU 52, LWDS Holding Tanks	5
3	Conceptual Site Model Flow Diagram for SWMU 52	19

This page intentionally left blank.

SWMU 52: RISK ASSESSMENT REPORT

I. Site Description and History

Solid Waste Management Unit (SWMU) 52, the Liquid Waste Disposal System (LWDS) Holding Tanks at Sandia National Laboratories/New Mexico (SNL/NM), encompasses approximately 0.6 acre in Technical Area (TA)-V, operated by SNL/NM. TA-V is a fenced, secured, research and testing area located in the northeast corner of TA-III (Figure 1). The holding tank portion of the site is paved and situated in a flat area west of Building 6580. The piping portion of the site extends out of TA-V to the surface impoundments. The ground elevation at SWMU 52 is approximately 5,429 feet above mean sea level.

The LWDS was designed to receive, monitor, and discharge radioactive effluent from the Sandia Experimental Reactor Facility (SERF) in TA-V. The LWDS consists of the holding tanks and piping (SWMU 52), a drainfield (SWMU 5), and two surface impoundments (SWMU 4). The three holding tanks, a series of two concrete tanks (Tanks 1 and 2) and one steel tank (Tank 4), were designed to allow short-lived radionuclides to decay before discharging to the LWDS drainfield (referred to as Tank 3) (Figure 2). The two concrete tanks (Tanks 1 and 2) have capacities of 2,000 and 6,000 gallons, respectively. The steel tank (Tank 4) has a capacity of approximately 29,860 gallons.

The SERF reactor operated from 1962 to 1971. The tanks received liquid wastes from the SERF during this entire period. Since the decommissioning of the SERF in 1971, nonradioactive discharges from various buildings in TA-V have continued to drain to the holding tanks. The tanks were periodically pumped to the LWDS drainfield until its collapse in 1967 and later pumped to surface impoundments until October 1992, when the U.S. Department of Energy (DOE) ordered that all discharges to the impoundments be stopped. During this time, no logs were maintained to record the frequency of operation and activity measurement. In 1994, a Liquid Effluent Control System (LECS) was constructed to manage all future TA-V liquid discharges. The LECS receives all process water from TA-V, including liquids previously discharged to the holding tanks. This system allows for the water to be held and sampled prior to discharging it to the City of Albuquerque (COA) publicly-owned treatment works (POTW).

In May 1993, a borehole for Monitoring Well LWDS-MW1 was drilled to a total depth of 525 feet below ground surface (bgs). LWDS-MW1 was installed primarily to investigate possible effects on groundwater (e.g., mounding and contamination) from the LWDS drainfield. The well was developed in July 1993 and has been sampled on a quarterly basis since then. Trichloroethene (TCE) and nitrate have been detected above the U.S. Environmental Protection Agency (EPA) Drinking Water Maximum Contaminant Levels in groundwater samples from LWDS-MW1. The maximum TCE and nitrate concentrations in LWDS-MW1 were 24 parts per billion (ppb) and 16.3 parts per million (ppm), respectively. Constituents of concern (COCs) at SWMU 52 are organic compounds, heavy metals, and radionuclides.

In September 1992, three angled boreholes (LWDS-52-BH06 through LWDS-52-BH08; Figure 2) were installed at the LWDS drainfield. In 1994, another two angled boreholes were completed (LWDS-52-BH15 and LWDS-52-BH16). Soil core was retrieved, and samples were collected for off-site laboratory analysis. Details of the drilling and sample collection are provided in the results of the LWDS Resource Conservation and Recovery Act (RCRA) Facility

This page intentionally left blank.

Legend

- SWMU 52
- Fence
- Paved and Unpaved Road
- Building / Structure
- Technical Area

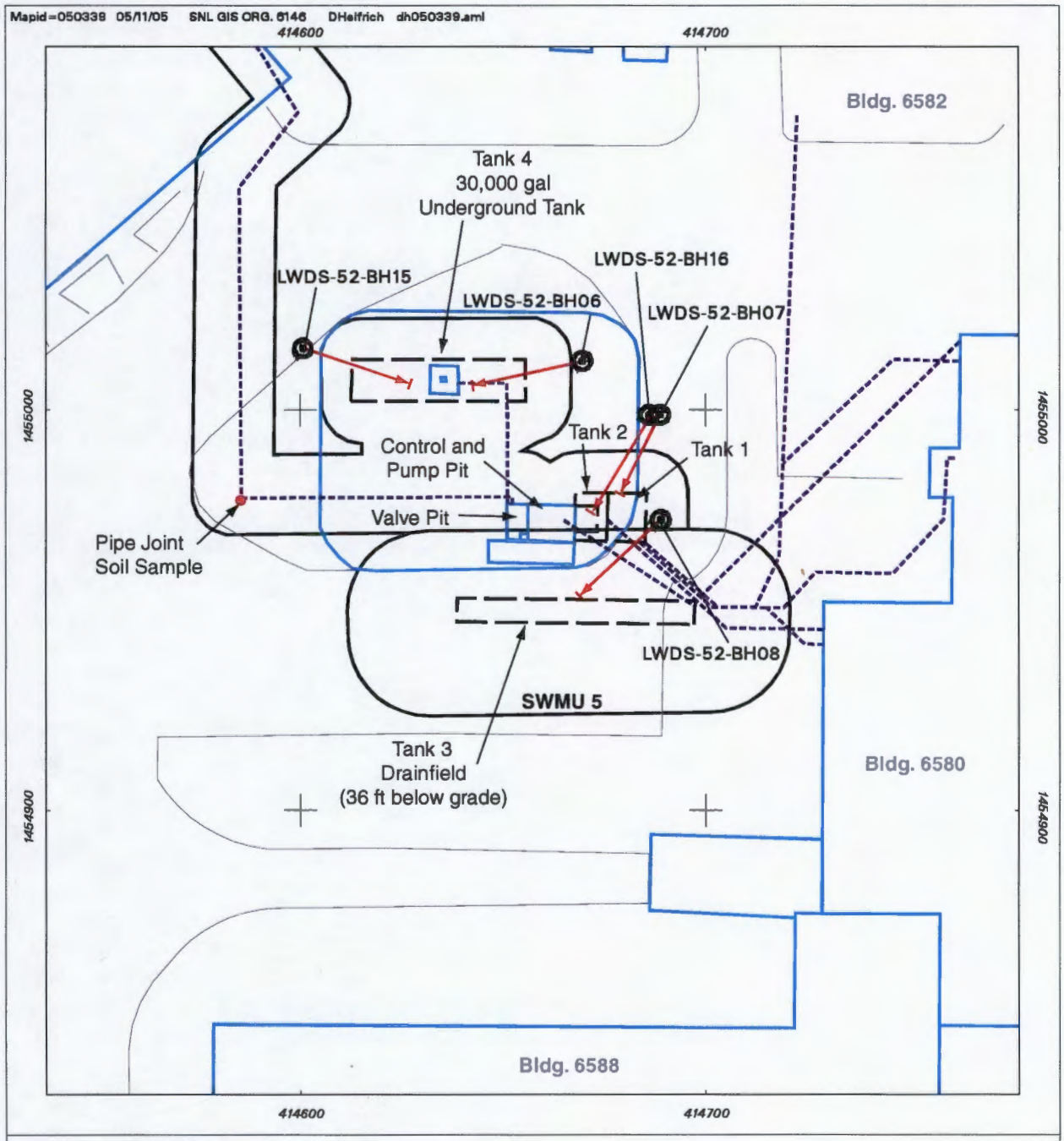
Figure 1
Location of TA-V and SWMU 52

0 250 500
Scale in Feet

0 60 120
Scale in Meters

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

840857.04220000 A3



Legend

- 30 Angled Borehole (arrow shows drilling direction and projected horizontal reach at depth)
- Pipe Joint Soil Sample Location
- Solid Waste Management Unit (SWMU)
- Building/Structure
- Underground Tank/Drainfield
- Road
- Drain Line

Figure 2
Location of SWMU 52, LWDS Holding Tanks

0 20 40
Scale in Feet

0 4.8 9.6
Scale in Meters

N

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

840857.04220000 A8

Investigation (RFI) (SNL/NM September 1995) and in Response to Request for Supplemental Information (SNL/NM May 2001).

Four additional groundwater monitoring wells (TAV-MW6 through TAV-MW9) were installed in 2001 to further characterize the groundwater contamination in this area. Details of the drilling activities, including soil sampling, can be found in "Summary of Monitoring Well Drilling Activities, TA-V Groundwater Investigation" (SNL/NM October 2001).

Groundwater monitoring for the area surrounding SWMU 52 is conducted as part of the TA-V Groundwater Investigation (SNL/NM March 2000). Thirteen monitoring wells are located within 1 mile of SWMU 52. The depth to the regional aquifer is approximately 480 to 500 feet bgs (SNL/NM March 2000). Both the COA and Kirtland Air Force Base (KAFB) use the regional aquifer for water supply purposes. The nearest water-supply well is KAFB-4, which is located approximately 2 miles north of SWMU 52; this well is not used on a regular basis. Because the TA-V Groundwater area of concern is regulated separately under the Compliance Order on Consent (NMED 2004), the SWMU 52 site investigation and risk assessment do not address groundwater issues.

II. Data Quality Objectives

The Data Quality Objectives (DQOs) are presented in the LWDS RFI Work Plan (SNL/NM March 1993). The DQOs outline the Quality Assurance (QA)/Quality Control (QC) requirements necessary for producing defensible analytical data suitable for risk assessment purposes. The sampling conducted at SWMU 52 was designed to:

- Characterize the tank contents as a potential source for spreading contamination to the surrounding soil in the future.
- Aid in determining the acceptability of leaving the tanks in service.
- Provide sufficient quality analytical data to support risk assessment.

Table 1 summarizes the rationale for designing the sampling plan.

Details of the collection and analytical results of the swipe and soil samples can be found in the September 1995 RFI report (SNL/NM September 1995). The soil samples were analyzed for all COCs, including volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), RCRA metals, and radionuclides.

The SWMU 52 soil samples were analyzed by Enseco and TMA Eberline Laboratories for RCRA metals, VOCs, SVOCs, radionuclides, and H-3. The swipe samples collected during the drilling in 1992 were analyzed on site at the TA-V Dosimetry Laboratory. Table 2 summarizes the analytical methods and data quality requirements from the LWDS Work Plan (SNL/NM March 1993).

Fourteen QA/QC samples were collected during both sampling efforts. The QA/QC samples consisted of four duplicates, four trip blanks, and six equipment blanks (Table 3). During the 1992 sampling, two duplicate soil samples each were collected from Boreholes 6 and 8, one

Table 1
Summary of Sampling Performed to Meet DQOs

SWMU 52 Sampling Areas	Potential COC Source	Number of Sampling Locations	Sample Density	Sampling Location Rationale
One swipe sample and one soil sample (completed in 1992) LWDS Pipe Joint	Internal pipe contaminatio n and possible pipe leakage	One swipe sample and one soil sample immediately beneath joint	NA	Determine the nature and extent of internal pipe contamination and possible pipe leaking
Three Soil Boreholes (completed in 1992) LWDS-52-BH06 through LWDS-52-BH08	Leaking from the LWDS Holding Tanks	Three boreholes (Each adjacent to a holding tank)	Soil samples collected every 5 ft up to 43 ft	Determine the nature and extent of contamination
Two Soil Boreholes (completed in 1994) LWDS-52-BH15 and LWDS-52-BH16	Leaking from the LWDS Holding Tanks	Two boreholes (One west of Tank 4 and one in the same location as LWDS-52-BH07)	Soil samples collected every 5 ft up to 50 ft	Further determine the nature and extent of contamination

BH = Borehole.
COC = Constituent of concern.
DQO = Data Quality Objective.
ft = Foot (feet).
LWDS = Liquid Waste Disposal System.
NA = Not applicable.
SWMU = Solid Waste Management Unit.

Table 2
Summary of Data Quality Requirements

Data Set	Analytical Requirement[a]	Data Quality Level	Enseco	TMA Eberline Laboratories	TA-V Dosimetry Laboratory
1992	VOCs (EPA Method 8240)	Defensible	26	–	–
	SVOCs (EPA Method 8270)	Defensible	26	–	–
	TAL Metals (EPA Method 6010/7010/7421/7471/7740/7841)	Defensible	26	–	–
	H-3 (EPA Method 906.0)	Defensible	26	–	–
	Gamma Spectroscopy (EPA Method 901.1)	Defensible	26	–	–
1994	VOCs (EPA Method 8260)	Defensible	12	–	–
	SVOCs (EPA Method 8270)	Defensible	12	–	–
	TAL Metals (EPA Method 6010/7010/7421/7471/7740/7841)	Defensible	12	–	–
	H-3 (EPA Method 906.0)	Defensible	–	12	1
	Gamma Spectroscopy (EPA Method 901.1)	Defensible	–	12	1
Total Number of Samples	VOCs		38		
	SVOCs		38		
	TAL Metals		38		
	H-3		39		
	Gamma Spectroscopy		39		

[a]EPA November 1986.
Note: The number of samples does not include QA/QC samples such as duplicates, trip blanks, and equipment blanks.
EPA = U.S. Environmental Protection Agency.
QA = Quality assurance.
QC = Quality control.
SVOC = Semivolatile organic compound.
TA = Technical area.
TAL = Target Analyte List.
TMA = Thermo Analytical Inc.
VOC = Volatile organic compound.
– = No samples analyzed.

Table 3
Summary of QA/QC Samples

Data Set	Sample Type	Number of Samples
1992	Duplicate	3
	Trip Blank	3
	Equipment Blank	4
1994	Duplicate	1
	Trip Blank	1
	Equipment Blank	2

QA = Quality assurance.
QC = Quality control.

duplicate soil sample was taken from Borehole 7, and three trip blanks and four equipment blanks were collected. During the 1994 sampling, one duplicate soil sample, one trip blank, and two equipment blanks were collected. No significant QA/QC problems were identified in any of the QA/QC samples.

All soil sample results were verified/validated by SNL/NM according to "Procedure for Validation of Chemical Measurement Data" (SNL/NM October 1991). Reviews confirmed that the analytical data from the analytical laboratories are defensible and therefore acceptable for use in the proposal for no further action (NFA), fulfilling the DQO requirements.

III. Determination of Nature, Rate, and Extent of Contamination

III.1 Introduction

The determination of the nature, migration rate, and extent of contamination at SWMU 52 was based upon a conceptual model validated with confirmatory sampling at the site. The conceptual model was presented in the LWDS Work Plan (SNL/NM March 1993) and the Summary Report of Groundwater Investigations at TA-V, Operable Units 1306 and 1307. The conceptual model was developed from archival research and soil sampling conducted during two drilling events. The DQOs contained in the LWDS Work Plan (SNL/NM March 1993) identified the sample locations, sample depth, and analytical requirements. The nature, migration rate, and extent of contamination are described below.

III.2 Nature of Contamination

The nature of contamination at SWMU 52 was evaluated through laboratory analyses of the soil samples. The analytical requirements included analyses for VOCs, metals, and radionuclides. These analyses characterized any contamination at the site. The analytes and methods listed in Table 2 are appropriate for characterizing the COCs and potential degradation products at SWMU 52.

III.3 Rate of Contaminant Migration

SWMU 52 is an active site; however, all analytical results indicate a lack of contamination of potential COCs, with the exception of the sample collected at a depth of 15 feet bgs from Borehole 15. This sample contained slightly elevated levels of four metals. This grouping, although suspicious, does not necessarily indicate tank leakage. These metals were not detected at high levels in the holding tanks and no increased soil moisture was detected in Borehole 15 at any depth. Elevated concentrations of these metals were not noted in samples from deeper intervals. The common grouping may indicate corrosion products of the Tank 4 metal. This sample location is also very close to the tank bottom, which is located at approximately 16 feet bgs.

The internal tank sampling results identified the presence of several solvents and radionuclides slightly above the detection limit (IT 1992). Although soil action levels were exceeded, these contaminant levels were measured inside the tanks; there is no evidence of gross leakage to the soil. Industrial waste water containing these levels of RCRA-regulated constituents are acceptable for discharge to the COA POTW. These data are representative of future discharges to the holding tanks. As a result, allowing for the possibility of future leakage, the tanks pose no significant threat of contaminating the surrounding soil. Data available from the TA-V Groundwater Investigation (SNL/NM November 2001); numerous SNL/NM monitoring programs for air, water, and radionuclides; and meteorological monitoring are adequate for characterizing the rate of any future COC migration at SWMU 52.

III.4 Extent of Contamination

Soil samples were collected from five angled boreholes adjacent to the LWDS Holding Tanks in order to determine the nature and extent of possible vertical contamination. Soil samples were collected from the surface to a maximum depth of 50 feet bgs during the drilling activities in 1992 and 1994. The five boreholes drilled and sampled were located as closely as possible and adjacent to the three holding tanks. Therefore, these soil samples are considered to be representative of the potentially contaminated soil directly adjacent to and below the holding tanks and sufficient to determine the vertical extent, if any, of COCs.

In summary, the design of the confirmatory sampling was appropriate and adequate to determine the nature, migration rate, and extent of residual COCs in the subsurface soil at SWMU 52.

IV. Comparison of COCs to Background Screening Levels

Site history and characterization activities are used to identify potential COCs. The SWMU 52 NFA proposal describes the identification of COCs and the sampling that was conducted in order to determine the concentration levels of those COCs across the site. Generally, COCs that were evaluated in this risk assessment included all detected organic compounds and all inorganic and radiological COCs for which samples were analyzed. When the detection limit of an organic compound was too high (i.e., could possibly cause an adverse effect to human health or the environment), the compound was retained. Nondetected organic constituents not included in this assessment were determined to have detection limits low enough to ensure protection of human health and the environment. In order to provide conservatism in this risk

assessment, the calculation used only the maximum concentration value of each COC found for the entire site. The SNL/NM maximum background concentration (Dinwiddie September 1997) was selected to provide the background screen listed in Tables 4 and 5.

Nonradiological inorganic compounds that are essential nutrients, such as iron, magnesium, calcium, potassium, and sodium, were not included in this risk assessment (EPA 1989). Both radiological and nonradiological COCs were evaluated. The nonradiological COCs evaluated included both inorganic and organic compounds.

Table 4 lists the nonradiological COCs for the human health risk assessment at SWMU 52. Table 5 lists radiological COCs for the human health risk assessment. The point of release (the bottom of the holding tanks) is greater than 5 feet bgs and all samples were collected below 5 feet bgs; therefore, evaluation of ecological risk was not performed. All tables show the associated SNL/NM maximum background concentration values (Dinwiddie September 1997). Section VI.4 provides discussion of Tables 4 and 5.

V. Fate and Transport

The releases of COCs at SWMU 52 would have been to the subsurface soil resulting from the discharges of waste water from the LWDS Holding Tanks to the adjacent soil. Wind, water, and biota are natural mechanisms of COC transport from the primary release point. Because COCs at this site are in the subsurface (greater than 5 feet bgs), wind and surface water are considered to be of low significance as transport mechanisms at this site.

Water at SWMU 52 is received as precipitation (approximately 8.1 inches annually [NOAA 1990]) that will either evaporate at or near the point of contact, infiltrate into the soil, or form runoff. Runoff at the site is collected in storm sewers and directed into the holding tanks. Water that infiltrates into the soil can leach COCs deeper into the subsurface soil; however, because of the high evapotranspiration rate in this area (estimated to be 95 to 99 percent of the annual precipitation) the potential for significant downward movement of water from the surface to the soil that contains COCs is very limited. Because depth to groundwater at the site is approximately 480 to 500 feet bgs, the potential for COCs to reach groundwater through the unsaturated zone above the water table is extremely low.

COCs can enter the food chain through uptake by plant roots. COCs taken up by plant roots can be transported to aboveground tissues where they can be consumed by herbivores, which can in turn be eaten by predators. Once in the food web, COCs can be transported from the site by the movements of the organisms that contain them or other surficial transport mechanisms. However, because SWMU 52 occupies only a very small area (0.22 acre) with very limited vegetation cover, food chain transport is expected to be of low significance at this site.

The COCs at SWMU 52 include both inorganic and organic analytes. The nonradiological inorganic COCs are elemental in form and are not considered to be degradable. Transformations of these inorganic COCs could include changes in valence (oxidation/reduction reactions) or incorporation into organic forms (e.g., the conversion of selenite or selenate from soil to seleno-amino acids in plants). Radiological COCs will undergo decay to stable isotopes or radioactive daughter elements. However, because of the long half-lives of the radionuclides,

Table 4
Nonradiological COCs for Human Health Risk Assessment at SWMU 52 with Comparison to the Associated SNL/NM Background Screening Value, BCF, and Log K_{ow}

COC	Maximum Concentration (mg/kg)	SNL/NM Background Concentration (mg/kg)[a]	Is Maximum COC Concentration Less Than or Equal to the Applicable SNL/NM Background Screening Value?	BCF (maximum aquatic)	Log K_{ow} (for organic COCs)	Bioaccumulator?[b] (BCF>40, Log K_{ow}>4)
Inorganic						
Arsenic	6.7	4.4	**No**	44[c]	–	**Yes**
Barium	412	214	**No**	170[d]	–	**Yes**
Beryllium	1.2	0.65	**No**	19[c]	–	No
Cadmium	1.3	0.9	**No**	64[c]	–	**Yes**
Chromium, total	28.2	15.9	**No**	16[c]	–	No
Copper	18.4	18.2	**No**	6[c]	–	No
Lead	10.2	11.8	Yes	49[c]	–	**Yes**
Mercury	0.05[e]	<0.1	**Unknown**	5,500[c]	–	**Yes**
Nickel	15.5	11.5	**No**	47[c]	–	**Yes**
Selenium	0.57	<1	**Unknown**	800[f]	–	**Yes**
Silver	0.76 J	<1	**Unknown**	0.5[c]	–	No
Vanadium	28.2	21.5	**No**	3,000[d]	–	**Yes**
Zinc	47.3	62	Yes	47[c]	–	**Yes**
Organic						
Acetone	0.15	NA	**NA**	0.69[g]	-0.24[g]	No
2-Butanone	0.016	NA	**NA**	1[g]	0.29[g]	No
bis(2-Ethylhexyl) phthalate	1.3	NA	**NA**	851[h]	7.6[i]	**Yes**
Di-n-butyl phthalate	0.051 J	NA	**NA**	6,761[h]	4.61[i]	**Yes**
Methylene chloride	0.024	NA	**NA**	5[g]	1.25[g]	No

Note: **Bold** indicates the COCs that exceed background screening values and/or are bioaccumulators.
[a]Dinwiddie September 1997, Southwest Area Supergroup.
[b]NMED March 1998.
[c]Yanicak March 1997.
[d]Neumann 1976.

Table 4 (Concluded)
Nonradiological COCs for Human Health Risk Assessment at SWMU 52 with Comparison to the Associated SNL/NM Background Screening Value, BCF, and Log K_{ow}

[e]Parameter was not detected. Concentration is one-half the detection limit.
[f]Callahan et al. 1979.
[g]Howard 1990.
[h]Howard 1989.
[i]Micromedex 1998.

B	= Parameter was found in associated blank.
BCF	= Bioconcentration factor.
COC	= Constituent of concern.
J	= Estimated concentration.
K_{ow}	= Octanol-water partition coefficient.
Log	= Logarithm (base 10).
mg/kg	= Milligram(s) per kilogram.
NA	= Not applicable.
NMED	= New Mexico Environment Department.
SNL/NM	= Sandia National Laboratories/New Mexico.
SWMU	= Solid Waste Management Unit.
–	= Information not available.

Table 5
Radiological COCs for Human Health Risk Assessment at SWMU 52 with Comparison to the Associated SNL/NM Background Screening Value and BCF

COC	Maximum Activity (pCi/g)	SNL/NM Background Activity (pCi/g)[a]	Is Maximum COC Activity Less Than or Equal to the Applicable SNL/NM Background Screening Value?	BCF (maximum aquatic)	Is COC a Bioaccumulator?[b] (BCF >40)
H-3	**0.041**	0.021	**No**	NA	No
Th-232	**1.3**	1.01	**No**	3,000[c]	No[d]

Note: **Bold** indicates COCs that exceed background screening values and/or are bioaccumulators.
[a]Dinwiddie September 1997, North Supergroup.
[b]NMED March 1998.
[c]Baker and Soldat 1992.
[d]Yanicak March 1997.
BCF = Bioconcentration factor.
COC = Constituent of concern.
NA = Not Applicable
NMED = New Mexico Environment Department.
pCi/g = Picocurie(s) per gram.
SNL/NM = Sandia National Laboratories/New Mexico.
SWMU = Solid Waste Management Unit.

the aridity of the environment at this site, and the lack of potential contact with biota, none of these mechanisms is expected to result in significant losses or transformations of the inorganic COCs.

The organic COCs at SWMU 52 may be degraded through photolysis, hydrolysis, and biotransformation. Photolysis requires light, and therefore takes place in the air, at the ground surface, or in surface water. Hydrolysis includes chemical transformations in water, and may occur in the soil solution. Biotransformation (i.e., transformation caused by plants, animals, and microorganisms) may occur; however, biological activity may be limited by the arid environment at this site. Some organic COCs (e.g., 2-butanone, acetone, and methylene chloride) may be lost through volatilization, with subsequent degradation in the air.

Table 6 summarizes the fate and transport processes that can occur at SWMU 52. COCs at this site include organic analytes and radiological and nonradiological inorganic analytes. For the reasons detailed above, wind, surface water, and biota are considered to be of low significance as potential transport mechanisms at this site. Significant leaching in the subsurface soil is unlikely and leaching into the groundwater at this site is highly unlikely. The potential for transformation of inorganic compounds is low and loss through decay of radiological COCs is insignificant because of their long half-lives. For some organic compounds, loss through volatilization and eventual degradation may be of moderate significance.

Table 6
Summary of Fate and Transport at SWMU 52

Transport and Fate Mechanism	Existence at Site	Significance
Wind	Yes	Low
Surface runoff	Yes	Low
Migration to groundwater	No	None
Food chain uptake	Yes	Low
Transformation/degradation	Yes	Moderate to low

SWMU = Solid Waste Management Unit.

VI. Human Health Risk Assessment

VI.1 Introduction

The human health risk assessment of this site includes a number of steps that culminate in a quantitative evaluation of the potential adverse human health effects caused by constituents located at the site. The steps to be discussed include the following:

Step 1.	Site data are described that provide information on the potential COCs, as well as the relevant physical characteristics and properties of the site.
Step 2.	Potential pathways are identified by which a representative population might be exposed to the COCs.

Step 3.	The potential intake of these COCs by the representative population is calculated using a tiered approach. The first component of the tiered approach is a screening procedure that compares the maximum concentration of the COC to an SNL/NM maximum background screening value. COCs that are not eliminated during the first screening procedure are carried forward in the risk assessment process.
Step 4.	Toxicological parameters are identified and referenced for COCs that were not eliminated during the screening procedure.
Step 5.	Potential toxicity effects (specified as a hazard index [HI]) and estimated excess cancer risks are calculated for nonradiological COCs and background. For radiological COCs, the incremental total effective dose equivalent (TEDE) and incremental estimated cancer risk are calculated by subtracting applicable background concentrations directly from maximum on-site contaminant values. This background subtraction applies only when a radiological COC occurs as contamination and exists as a natural background radionuclide.
Step 6.	These values are compared with guidelines established by the EPA, New Mexico Environment Department (NMED), and the DOE to determine whether further evaluation and potential site cleanup are required. Nonradiological COC risk values also are compared to background risk so that an incremental risk can be calculated.
Step 7.	Uncertainties of the above steps are addressed.

VI.2 Step 1. Site Data

Section I of this risk assessment provides the site description and history for SWMU 52. Section II presents a comparison of results to DQOs. Section III discusses the nature, rate, and extent of contamination.

VI.3 Step 2. Pathway Identification

SWMU 52 has been designated with a future land use scenario of industrial (DOE et al. September 1995) (see Appendix 1 for default exposure pathways and parameters). However, the residential land use scenario is also considered within the pathway analysis. Because of the location and characteristics of the potential contaminants, the primary pathway for human exposure is considered to be soil ingestion for the nonradiological COCs and direct gamma exposure for the radiological COCs. The inhalation pathway for both nonradiological and radiological COCs is included because the potential exists to inhale dust and volatiles. Soil ingestion is included for the radiological COCs as well. The dermal pathway is included for the nonradiological COCs because of the potential for the receptor to be exposed to contaminated soil. No water pathways to groundwater are considered. Depth to groundwater at SWMU 52 is approximately 480 to 500 feet bgs. No intake routes through plant, meat, or milk ingestion are considered appropriate for either the industrial or residential land use scenarios. Figure 3 shows the conceptual site model flow diagram for SWMU 52.

Pathway Identification

Nonradiological Constituents	Radiological Constituents
Soil ingestion	Soil ingestion
Inhalation (dust and volatiles)	Inhalation (dust and volatiles)
Dermal contact	Direct gamma

This page intentionally left blank.

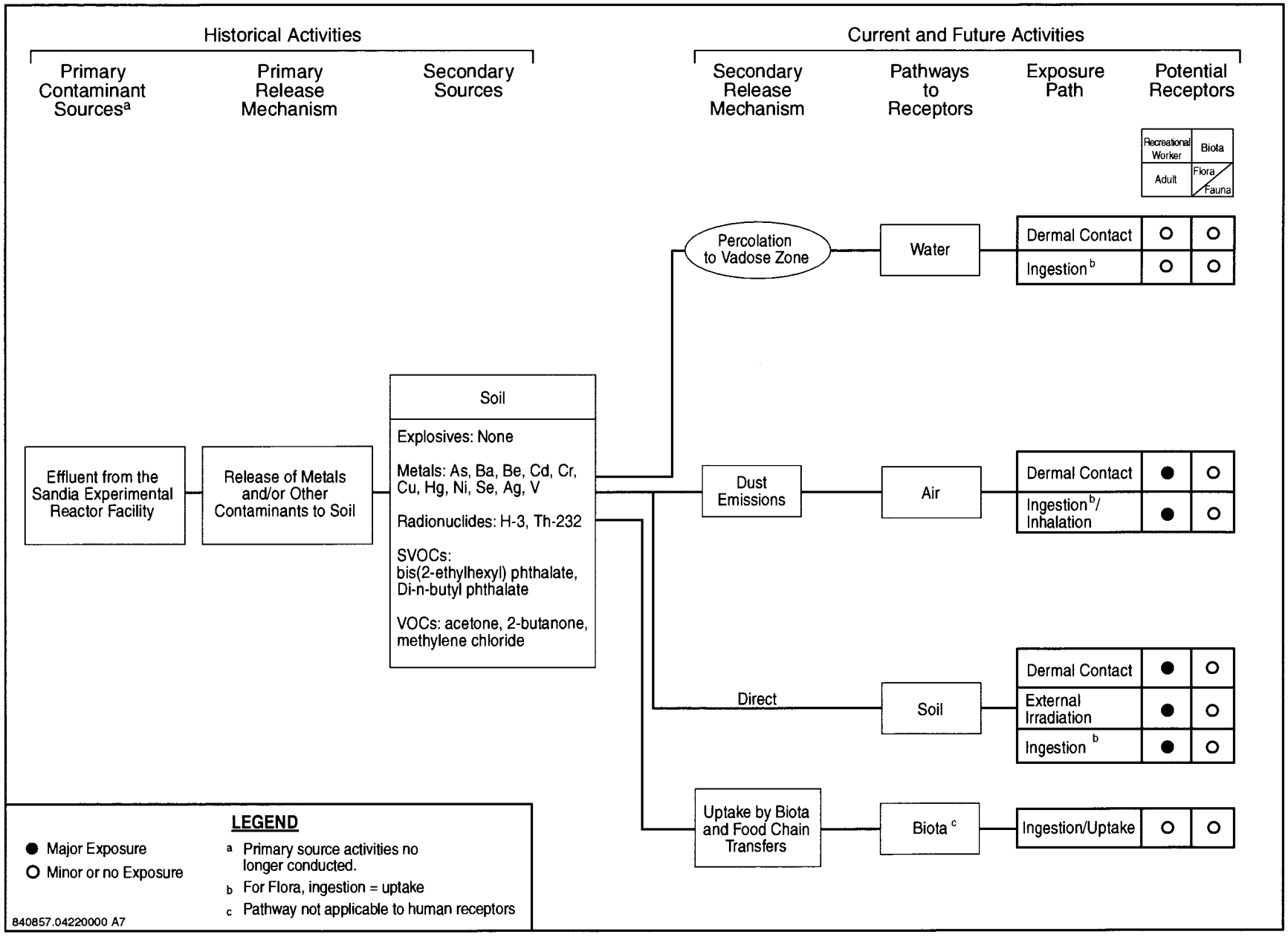


Figure 3
Conceptual Site Model Flow Diagram for SWMU 52

VI.4 Step 3. Background Screening Procedure

This section discusses Step 3, the background screening procedure, which compares the maximum COC concentrations to the background screening levels. The methodology and results are described below.

VI.4.1 Methodology

Maximum concentrations of nonradiological COCs were compared to the approved SNL/NM maximum screening level for this area (Dinwiddie September 1997). The SNL/NM maximum background concentration was selected to provide the background screen in Table 4 and was used to calculate risk attributable to background in Section VI.6.2. Only the COCs that were detected above the corresponding SNL/NM maximum background screening levels or did not have either a quantifiable or a calculated background screening level were considered in further risk assessment analyses.

For radiological COCs that exceeded the SNL/NM background screening levels, background values were subtracted from the individual maximum radionuclide concentrations. Those that did not exceed these background levels were not carried any further in the risk assessment. This approach is consistent with DOE Order 5400.5, "Radiation Protection of the Public and the Environment" (DOE 1993). Radiological COCs that do not have a background value and were detected above the analytical minimum detectable activity were carried through the risk assessment at their maximum levels. The resultant radiological COCs remaining after this step are referred to as background-adjusted radiological COCs.

VI.4.2 Results

Tables 4 and 5 show SWMU 52 maximum COC concentrations that were compared to the SNL/NM maximum background values (Dinwiddie September 1997) for the human health risk assessment. For the nonradiological COCs, seven constituents were measured at concentrations greater than their respective background screening values. Three constituents do not have quantified background screening concentrations. Five nonradiological COCs were organic compounds that do not have corresponding background values.

For the radiological COCs, two constituents (H-3 and Th-232) exhibited measured activity greater than the corresponding background values.

VI.5 Step 4. Identification of Toxicological Parameters

Tables 7 and 8 list the COCs retained in the risk assessment and the values for the available toxicological information. The toxicological values used for nonradiological COCs in Table 7 were obtained from the Integrated Risk Information System (IRIS) (EPA 2003), the Health Effects Assessment Summary Tables (HEAST) (EPA 1997a), the Technical Background Document for Development of Soil Screening Levels (NMED December 2000), the EPA Region 6 (EPA 2002a), and the Risk Assessment Information System (ORNL 2003) electronic databases.

Table 7
Toxicological Parameter Values for SWMU 52 Nonradiological COCs

COC	RfD_o (mg/kg-d)	Confidence[a]	RfD_{inh} (mg/kg-d)	Confidence[a]	SF_o $(mg/kg\text{-}day)^{-1}$	SF_{inh} $(mg/kg\text{-}day)^{-1}$	Cancer Class[b]	ABS
Inorganic								
Arsenic	3E-4[c]	M	–	–	1.5E+0[c]	1.5E+1[c]	A	0.03[d]
Barium	7E-2[c]	M	1.4E-4[e]	–	–	–	D	0.01[d]
Beryllium	2E-3[c]	L to M	5.7E-6[c]	M	–	8.4E+0[c]	B1	0.01[d]
Cadmium	5E-4[c]	H	5.7E-5[f]	–	–	6.3E+0[c]	B1	0.001[d]
Chromium, total	1.5E+0[c]	L	–	–	–	–	D	0.01[d]
Chromium VI	3E-3[c]	L	2.3E-6[c]	L	–	4.2E+1[c]	A	0.01[d]
Copper	3.7E-2[f]	–	–	–	–	–	D	0.01[d]
Mercury	3E-4[e]	–	8.6E-5[c]	M	–	–	D	0.01[d]
Nickel	2E-2[c]	M	–	–	–	–	–	0.01[d]
Selenium	5E-3[c]	H	–	–	–	–	D	0.01[d]
Silver	5E-3[c]	L	–	–	–	–	D	0.01[d]
Vanadium	7E-3[e]	–	–	–	–	–	–	0.01[d]
Organic								
Acetone	1E-1[c]	L	1E-1[f]	–	–	–	D	0.01[g]
2-Butanone	6E-1[c]	L	2.9E-1[c]	L	–	–	D	0.1[d]
bis(2-Ethylhexyl) phthalate	2E-2[f]	–	2E-2[f]	–	1.4E-2[f]	1.4E-2[f]	–	0.01[g]
Di-n-butyl phthalate	1E-1[c]	L	1E-1[f]	–	–	–	D	0.1[d]
Methylene chloride	6E-2[c]	M	8.6E-1[e]	–	7.15E-3[c]	1.6E-3[c]	B2	0.1[d]

[a]Confidence associated with IRIS (EPA 2003) database values. Confidence: L = low, M = medium, H = high.
[b]EPA weight-of-evidence classification system for carcinogenicity (EPA 1989) taken from IRIS (EPA 2003):
- A = Human carcinogen
- B1 = Probable human carcinogen. Limited human data are available
- B2 = Probable human carcinogen. Sufficient evidence in animals and inadequate or no evidence in humans.
- D = Not classifiable as to human carcinogenicity.

[c]Toxicological parameter values from IRIS electronic database (EPA 2003).
[d]Toxicological parameter values from NMED December 2000.
[e]Toxicological parameter values from HEAST (EPA 1997a).
[f]Toxicological parameter values from EPA Region 6 electronic database (EPA 2002a).
[g]Toxicological parameter values from ORNL 2003.

ABS = Gastrointestinal adsorption coefficient.
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
HEAST = Health Effects Assessment Summary Tables.

Table 7 (Concluded)
Toxicological Parameter Values for SWMU 52 Nonradiological COCs

IRIS	= Integrated Risk Information System.
mg/kg-d	= Milligram(s) per kilogram per day.
$(mg/kg\text{-}day)^{-1}$	= Per milligram per kilogram per day.
NMED	= New Mexico Environment Department.
ORNL	= Oak Ridge National Laboratory.
RfD_{inh}	= Inhalation chronic reference dose.
RfD_o	= Oral chronic reference dose.
SF_{inh}	= Inhalation slope factor.
SF_o	= Oral slope factor.
SWMU	= Solid Waste Management Unit.
–	= Information not available.

Table 8
Radiological Toxicological Parameter Values for SWMU 52 COCs Obtained from RESRAD Risk Coefficients[a]

COC	SF_o (1/pCi)	SF_{inh} (1/pCi)	SF_{ev} (g/pCi-yr)	Cancer Class[b]
H-3	7.20E-14	9.60E-14	0.0	A
Th-232	3.30E-11	1.90E-08	2.00E-11	A

[a]Yu et al. 1993a.
[b]EPA weight-of-evidence classification system for carcinogenicity (EPA 1989): A = Human carcinogen for high dose and high dose rate (i.e., greater than 50 rem per year). For low-level environmental exposures, the carcinogenic effect has not been observed and documented.
1/pCi = One per picocurie.
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
g/pCi-yr = Gram(s) per picocurie-year.
SF_{ev} = External volume exposure slope factor.
SF_{inh} = Inhalation slope factor.
SF_o = Oral (ingestion) slope factor.
SWMU = Solid Waste Management Unit.

Dose conversion factors (DCF) used in determining the excess TEDE values for radiological COCs for the individual pathways were the default values provided in the RESRAD computer code (Yu et al. 1993a) as developed in the following documents:

- DCFs for ingestion and inhalation were taken from "Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion" (EPA 1988).
- DCFs for surface contamination were taken from DOE/EH-0070, "External Dose-Rate Conversion Factors for Calculation of Dose to the Public" (DOE 1988).
- DCFs for volume contamination (exposure to contamination deeper than the immediate surface of the site) were calculated using the methods discussed in "Dose-Rate Conversion Factors for External Exposure to Photon Emitters in Soil" (Kocher 1983) and in ANL/EAIS-8, "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil" (Yu et al. 1993b).

VI.6 Step 5. Exposure Assessment and Risk Characterization

Section VI.6.1 describes the exposure assessment for this risk assessment. Section VI.6.2 provides the risk characterization, including the HI and excess cancer risk for both the potential nonradiological COCs and associated background for industrial and residential land use scenarios. The incremental TEDE and incremental estimated cancer risk are provided for the background-adjusted radiological COCs for both industrial and residential land uses.

VI.6.1 Exposure Assessment

Appendix 1 provides the equations and parameter input values used in calculating intake values and subsequent HI and excess cancer risk values for the individual exposure pathways. The appendix shows parameters for both industrial and residential land use scenarios. The equations for nonradiological COCs are based upon the Risk Assessment Guidance for Superfund (RAGS) (EPA 1989). Parameters are based upon information from the RAGS (EPA 1989), the Technical Background Document for Development of Soil Screening Levels (NMED December 2000), as well as other EPA and NMED guidance documents, and reflect the reasonable maximum exposure (RME) approach advocated by the RAGS (EPA 1989). For radiological COCs, the coded equations provided in RESRAD computer code are used to estimate the incremental TEDE and cancer risk for individual exposure pathways. Further discussion of this process is provided in the "Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD" (Yu et al. 1993a).

Although the designated land use scenario for this site is industrial, risk and TEDE values for a residential land use scenario are also presented.

VI.6.2 Risk Characterization

Table 9 shows an HI of 0.05 for the SWMU 52 nonradiological COCs and an estimated excess cancer risk of 4E-6 for the designated industrial land use scenario. The numbers presented include exposure from soil ingestion, dermal contact, and dust and volatile inhalation for nonradiological COCs. Table 10 shows an HI of 0.02 and an estimated excess cancer risk of 3E-6 for background constituents in the designated industrial land use scenario.

For the radiological COCs, contribution from the direct gamma exposure pathway is included. For the industrial land use scenario, a TEDE was calculated that resulted in an incremental TEDE of 6.8E-1 millirem (mrem)/year (yr). In accordance with EPA guidance found in Office of Solid Waste and Emergency Response (OSWER) Directive No. 9200.4-18 (EPA 1997b), an incremental TEDE of 15 mrem/yr is used for the probable land use scenario (industrial in this case); the calculated dose value for SWMU 52 for the industrial land use is well below this guideline. The estimated excess cancer risk is 9.8E-6.

For the residential land use scenario nonradiological COCs, the HI is 0.63 and the estimated excess cancer risk is 2E-5 (Table 9). The numbers in the table include exposure from soil ingestion, dermal contact, and dust and volatile inhalation. Although the EPA (1991) generally recommends that inhalation not be included in a residential land use scenario, this pathway is included because of the potential for soil in Albuquerque, New Mexico, to be eroded and, subsequently, for dust to be present in predominantly residential areas. Because of the nature of the local soil, other exposure pathways are not considered (see Appendix 1). Table 10 shows that for the SWMU 52 associated background constituents, the HI is 0.32 and the estimated excess cancer risk is 1E-5.

For the radiological COCs, the incremental TEDE for the residential land use scenario is 1.7 mrem/yr. The guideline being used is an excess TEDE of 75 mrem/yr (SNL/NM February 1998) for a complete loss of institutional controls (residential land use in this case); the calculated dose value for SWMU 52 for the residential land use scenario is well below this guideline. Consequently, SWMU 52 is eligible for unrestricted radiological release as the

Table 9
Risk Assessment Values for SWMU 52 Nonradiological COCs

COC	Maximum Concentration (mg/kg)	Industrial Land Use Scenario[a]		Residential Land Use Scenario[a]	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Inorganic					
Arsenic	6.7	0.03	4E-6	0.31	2E-5
Barium	412	0.01	–	0.08	–
Beryllium	1.2	0.00	5E-10	0.01	1E-9
Cadmium	1.3	0.00	4E-10	0.03	9E-10
Chromium, total[b]	28.2	0.01	6E-8	0.13	1E-7
Copper	18.4	0.00	–	0.01	–
Mercury	0.05[c]	0.00	–	0.00	–
Nickel	15.5	0.00	–	0.01	–
Selenium	0.57	0.00	–	0.00	–
Silver	0.76 J	0.00	–	0.00	–
Vanadium	28.2	0.00	–	0.05	–
Organic					
Acetone	0.15	0.00	–	0.00	–
2-Butanone	0.016	0.00	–	0.00	–
bis(2-Ethylhexyl) phthalate	1.3	0.00	7E-9	0.00	3E-8
Di-n-butyl phthalate	0.051 J	0.00	–	0.00	–
Methylene chloride	0.024	0.00	2E-7	0.00	3E-7
Total		**0.05**	**4E-6**	**0.63**	**2E-5**

[a]EPA 1989.
[b]Chromium, total assumed to be chromium VI (most conservative).
[c]Parameter was not detected. Concentration is one-half the detection limit.
B = Parameter was found in associated blank.
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
J = Estimated concentration.
mg/kg = Milligram(s) per kilogram.
SWMU = Solid Waste Management Unit.
– = Information not available.

Table 10
Risk Assessment Values for SWMU 52 Nonradiological Background Constituents

COC	Background Concentration[a] (mg/kg)	Industrial Land Use Scenario[b]		Residential Land Use Scenario[b]	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Arsenic	4.4	0.02	3E-6	0.20	1E-5
Barium	214	0.00	–	0.04	–
Beryllium	0.65	0.00	3E-10	0.00	6E-10
Cadmium	0.9	0.00	3E-10	0.02	6E-10
Chromium, total[c]	15.9	0.00	–	0.00	–
Copper	18.2	0.00	–	0.01	–
Mercury	<0.1	–	–	–	–
Nickel	11.5	0.00	–	0.01	–
Selenium	<1	–	–	–	–
Silver	<1	–	–	–	–
Vanadium	21.5	0.00	–	0.04	–
Total		**0.02**	**3E-6**	**0.32**	**1E-5**

[a]Dinwiddie September 1997, North Supergroup.
[b]EPA 1989.
[c]Chromium, total assumed to be chromium III (most conservative)
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
mg/kg = Milligram(s) per kilogram.
SWMU = Solid Waste Management Unit.
– = Information not available.

residential land use scenario resulted in an incremental TEDE of less than 75 mrem/yr to the on-site receptor. The estimated excess cancer risk is 2.9E-5. The excess cancer risk from the nonradiological COCs and the radiological COCs should be summed to provide risk estimates for persons exposed to both types of carcinogenic contaminants, as noted in OSWER Directive No. 9200.4-18 "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination" (EPA 1997b). This summation is tabulated in Section VI.9, Summary.

VI.7 Step 6. Comparison of Risk Values to Numerical Guidelines

The human health risk assessment analysis evaluated the potential for adverse health effects for both the industrial land use scenario (the designated land use scenario for this site) and the residential land use scenario.

For the nonradiological COCs under the industrial land use scenario, the HI is 0.05, which is less than the numerical guideline of 1 suggested in the RAGS (EPA 1989). Excess cancer risk is estimated at 4E-6. NMED guidance states that cumulative excess lifetime cancer risk must be less than 1E-5 (Bearzi January 2001); thus, the excess cancer risk for this site is below the suggested acceptable risk value. This assessment also determined risks considering background concentrations of the potential nonradiological COCs for both the industrial and residential land use scenarios. Assuming the industrial land use scenario, for nonradiological

COCs the HI is 0.02 and the estimated excess cancer risk is 3E-6. Incremental risk is determined by subtracting risk associated with background from potential COC risk. These numbers are not rounded before the difference is determined and, therefore, may appear to be inconsistent with numbers presented in tables and within the text. The incremental HI is 0.03 and the estimated incremental cancer risk is 1.27E-6 for the industrial land use scenario. These incremental risk calculations indicate insignificant risk to human health from nonradiological COCs considering an industrial land use scenario.

For radiological COCs under the industrial land use scenario, the incremental TEDE is 6.8E-1 mrem/yr, which is significantly lower than the EPA's numerical guideline of 15 mrem/yr. The incremental estimated excess cancer risk is 9.8E-6.

The calculated HI for the nonradiological COCs under the residential land use scenario is 0.63, which is below the numerical guidance. The excess cancer risk was estimated to be 2E-5. NMED guidance states that cumulative excess lifetime cancer risk must be less than 1E-5 (Bearzi January 2001); thus, the excess cancer risk for this site is above the suggested acceptable risk value. The HI for associated background for the residential land use scenario is 0.32; the estimated excess cancer risk is 1E-5. The incremental HI is 0.31 and the estimated incremental cancer risk is 1.04E-5 for the residential land use scenario. The incremental estimated excess cancer risk slightly exceeds guidelines considering a residential land use scenario.

The incremental TEDE for a residential land use scenario from the radiological components is 1.7 mrem/yr, which is significantly less than the numerical guideline of 75 mrem/yr suggested in "RESRAD Input Parameter Assumptions and Justification" (SNL/NM February 1998). The estimated excess cancer risk is 2.9E-5.

VI.8 Step 7. Uncertainty Discussion

The determination of the nature, rate, and extent of contamination at SWMU 52 was based upon an initial conceptual model that was validated with confirmatory sampling conducted across the site during the two drilling events. The confirmatory sampling was implemented in accordance with the LWDS RFI Work Plan (SNL/NM March 1993). The DQOs contained in the work plan are appropriate for use in risk assessments. The data collected, based upon sample location, density, and depth, are representative of the site. The analytical requirements and results satisfy the DQOs. Data quality was verified/validated in accordance with SNL/NM procedures (SNL/NM January 2000, SNL/NM October 1991). Therefore, there is no uncertainty associated with the data quality used to perform the risk assessment at SWMU 52.

Because of the location, history of the site, and future land use (DOE et al. September 1995), there is low uncertainty in the land use scenario and the potentially affected populations that were considered in performing the risk assessment analysis. Because the COCs are found in near-surface soil and because of the location and physical characteristics of the site, there is little uncertainty in the exposure pathways relevant to the analysis.

An RME approach was used to calculate the risk assessment values. This means that the parameter values in the calculations are conservative and that calculated intakes are probably overestimated. Maximum measured values of COC concentrations are used to provide conservative results.

Table 9 shows the uncertainties in nonradiological toxicological parameter values. There is a mixture of estimated values and values from the IRIS (EPA 2003), HEAST (EPA 1997a), Technical Background Document for Development of Soil Screening Levels (NMED December 2000), the Risk Assessment Information System (ORNL 2003), and EPA Region 6 (EPA 2002a) electronic databases. Where values are not provided, information is not available from the HEAST (EPA 1997a), IRIS (EPA 2003), Technical Background Document for Development of Soil Screening Levels (NMED December 2000), the Risk Assessment Information System (ORNL 2003) or the EPA regions (EPA 2002a, EPA 2002b, EPA 2002c). Because of the conservative nature of the RME approach, uncertainties in toxicological values are not expected to change the conclusion from the risk assessment analysis.

Risk assessment values for nonradiological COCs are within the acceptable range for human health for the industrial land use scenario compared to established numerical guidance.

The HI for the nonradiological COCs is within the acceptable range for the residential land use scenario compared to established numerical guidance. Although the estimated excess cancer risk is slightly above the NMED guideline for the residential land use scenario, maximum concentrations were used in the risk calculation. Because the site has been adequately characterized, average concentrations are more representative of actual site conditions. The upper confidence limit (UCL) of the average concentrations for arsenic, the main contributor to excess cancer risk (3.2 milligrams [mg]/kilogram [kg]) (Appendix 2), is below background (4.4 mg/kg), which eliminates arsenic from the risk calculation. With the removal of arsenic, the total estimated excess cancer risk is reduced to 4E-7, and the incremental excess cancer risk is reduced to 4.31E-7 (Table 11). Thus, using realistic concentrations in the risk calculations that more accurately depict actual site conditions, the total and incremental estimated excess cancer risks are below NMED guidelines.

For radiological COCs, the conclusion of the risk assessment is that potential effects on human health for both industrial and residential land use scenarios are within guidelines and represent only a small fraction of the estimated 360 mrem/yr received by the average U.S. population (NCRP 1987).

The overall uncertainty in all of the steps in the risk assessment process is not considered to be significant with respect to the conclusion reached.

VI.9 Summary

SWMU 52 contains identified COCs consisting of some inorganic, organic, and radiological compounds. Because of the location of the site, the designated industrial land use scenario, and the nature of contamination, potential exposure pathways identified for this site included soil ingestion, dermal contact, and dust and volatile inhalation for chemical COCs and soil ingestion, dust inhalation, and direct gamma exposure for radionuclides. The same exposure pathways were applied to the residential land use scenario.

Using conservative assumptions and an RME approach to risk assessment, calculations for nonradiological COCs show that for the industrial land use scenario the HI (0.05) is significantly lower than the accepted numerical guidance from the EPA. Estimated excess cancer risk is 4E-6; thus, excess cancer risk is also below the acceptable risk value provided by the NMED for an industrial land use scenario (Bearzi January 2001). The incremental HI is 0.03, and the

Table 11
Risk Assessment Values for SWMU 52 Nonradiological COCs with UCL Concentrations for the Major Risk Drivers

COC	Maximum Concentration/ UCL[a] (mg/kg)	Residential Land Use Scenario[b]	
		Hazard Index	Cancer Risk
Inorganic			
Arsenic	**3.2**	Below Background	Below Background
Barium	412	0.08	–
Beryllium	1.2	0.01	1E-9
Cadmium	1.3	0.03	9E-10
Chromium, total[c]	28.2	0.13	1E-7
Copper	18.4	0.01	–
Mercury	0.05[d]	0.00	–
Nickel	15.5	0.01	–
Selenium	0.57	0.00	–
Silver	0.76 J	0.00	–
Vanadium	28.2	0.05	–
Organic			
Acetone	0.15	0.00	–
2-Butanone	0.016	0.00	–
bis(2-Ethylhexyl) phthalate	1.3	0.00	3E-8
Di-n-butyl phthalate	0.051 J	0.00	–
Methylene chloride	0.024	0.00	3E-7
Total		**0.32**	**4E-7**

[a]UCL concentrations and risks in **bold**.
[b]EPA 1989.
[c]Chromium, total assumed to be chromium VI (most conservative).
[d]Parameter was not detected. Concentration is one-half the detection limit.
B = Parameter was found in associated blank.
COC = Constituent of concern.
EPA = U.S. Environmental Protection Agency.
J = Estimated concentration.
mg/kg = Milligram(s) per kilogram.
SWMU = Solid Waste Management Unit.
– = Information not available.

incremental excess cancer risk is 1.27E-6 for the industrial land use scenario. Incremental risk calculations indicate insignificant risk to human health for the industrial land use scenario.

Using conservative assumptions and an RME approach to risk assessment, calculations for nonradiological COCs show that for the residential land use scenario the HI (0.63) is below the accepted numerical guidance from the EPA. Estimated excess cancer risk is 2E-5. Thus, excess cancer risk is above the acceptable risk value provided by the NMED for a residential land use scenario (Bearzi January 2001). The incremental HI is 0.31, and the incremental excess cancer risk is 1.04E-5 for the residential land use scenario. Incremental excess cancer risk calculations slightly exceed guidelines considering the residential land use scenario.

The HI for the nonradiological COCs is within the acceptable range for human health for the residential land use scenario compared to established numerical guidance. Although the estimated excess cancer risk is slightly above the NMED guideline for the residential land use scenario, maximum concentrations were used in the risk calculation. Because the site has been adequately characterized, average concentrations are more representative of actual site conditions. The UCL of the average concentrations for arsenic, the main contributor to excess cancer risk (3.2 mg/kg) (Appendix 2), is below background (4.4 mg/kg), which eliminates arsenic from the risk calculation. With the removal of arsenic, the total estimated excess cancer risk is reduced to 4E-7 and the incremental excess cancer risk is reduced to 4.31E-7 (Table 11). Thus, using realistic concentrations in the risk calculations that more accurately depict actual site conditions, the total and incremental estimated excess cancer risk is below NMED guidelines.

Incremental TEDE and corresponding estimated cancer risk from radiological COCs are much lower than EPA guidance values; the estimated TEDE is 6.8E-1 mrem/yr for the industrial land use scenario. This value is much lower than the EPA's numerical guidance of 15 mrem/yr (EPA 1997b). The corresponding incremental estimated cancer risk value is 9.8E-6 for the industrial land use scenario. Furthermore, the incremental TEDE for the residential land use scenario that results from a complete loss of institutional control is 1.7 mrem/yr with an associated risk of 2.9E-5. The guideline for this scenario is 75 mrem/yr (SNL/NM February 1998). Therefore, SWMU 52 is eligible for unrestricted radiological release.

The summation of the nonradiological and radiological carcinogenic risks are tabulated in Table 12.

Table 12
Summation of Radiological and Nonradiological Risks from Site Carcinogens

Scenario	Nonradiological Risk	Radiological Risk	Total Risk
Industrial	1.2E-6	9.8E-6	1.1E-5
Residential	4.1E-7	2.9E-5	2.9E-5

Uncertainties associated with the calculations are considered small relative to the conservatism of risk assessment analysis. It is therefore concluded that this site poses insignificant risk to human health under both the industrial and residential land use scenarios.

VII. Ecological Risk Assessment

VII.1 Introduction

This section addresses the ecological risks associated with exposure to constituents of potential ecological concern (COPEC) in the soil at SWMU 52. A component of the NMED Risk-Based Decision Tree (NMED March 1998) is to conduct an ecological risk assessment that corresponds with that presented in the EPA's Ecological RAGS (EPA 1997c). The current methodology is tiered and contains an initial scoping assessment which is followed by a more detailed risk assessment, if warranted by the results of the scoping assessment. Initial components of the NMED's decision tree (a discussion of DQOs, data assessment, and evaluations of bioaccumulation as well as fate and transport potential) are addressed in previous sections of this report. At the end of the scoping assessment, a determination is made as to whether a more detailed examination of potential ecological risk is necessary.

VII.2 Scoping Assessment

The scoping assessment focuses primarily on the likelihood of exposure of biota at, or adjacent to, the site to constituents associated with site activities. Included in this section are an evaluation of existing data with respect to the existence of complete ecological exposure pathways, an evaluation of bioaccumulation potential, and a summary of fate and transport potential. A scoping risk-management decision (Section VII.2.4) involves summarizing the scoping results and determining whether further examination of potential ecological impacts is necessary.

VII.2.1 Data Assessment

As indicated in Section IV, all COCs at SWMU 52 are from greater than 5 feet bgs. Therefore, no complete ecological exposure pathways exist at this site and no COCs are considered to be COPECs.

VII.2.2 Bioaccumulation

Because no COPECs are associated with this site, bioacccumulation potential is not evaluated.

VII.2.3 Fate and Transport Potential

The potential for the COCs to move from the source of contamination to other media or biota is discussed in Section V. As noted in Table 6 (Section V), wind, surface water, and biota (food chain uptake) are expected to be of low significance as transport mechanisms for COCs at this site. Degradation, transformation, and radiological decay of the COCs are also expected to be of low significance.

VII.2.4 Scoping Risk-Management Decision

Based upon information gathered through the scoping assessment, it was concluded that no complete ecological pathways are associated with COCs at this site; therefore, no COPECs exist at the site. As a consequence, a more detailed risk assessment was not deemed necessary to predict the potential level of ecological risk associated with the site.

VIII. References

Baker, D.A., and J.K. Soldat, 1992. "Methods for Estimating Doses to Organisms from Radioactive Materials Released into the Aquatic Environment," PNL-8150, Pacific Northwest Laboratory, Richland, Washington.

Bearzi, J.P. (New Mexico Environment Department), January 2001. Memorandum to RCRA-Regulated Facilities, "Risk-Based Screening Levels for RCRA Corrective Action Sites in New Mexico," Hazardous Waste Bureau, New Mexico Environment Department, Santa Fe, New Mexico. January 23, 2001.

Callahan, M.A., M.W. Slimak, N.W. Gabel, I.P. May, C.F. Fowler, J.R. Freed, P. Jennings, R.L. Durfee, F.C. Whitmore, B. Maestri, W.R. Mabey, B.R. Holt, and C. Gould, 1979. "Water-Related Environmental Fate of 129 Priority Pollutants," EPA-440/4-79-029, Office of Water and Waste Management, Office of Water Planning and Standards, U.S. Environmental Protection Agency, Washington, D.C.

Dinwiddie, R.S. (New Mexico Environment Department), September 1997. Letter to M.J. Zamorski (U.S. Department of Energy), "Request for Supplemental Information: Background Concentrations Report, SNL/KAFB." September 24, 1997.

DOE, see U.S. Department of Energy.

EPA, see U.S. Environmental Protection Agency.

Howard, P.H., 1989. "Volume I: Large Production and Priority Pollutants," *Handbook of Environmental Fate and Exposure Data for Organic Chemicals*, Lewis Publishers, Inc., Chelsea, Michigan.

Howard, P.H., 1990. "Volume II Solvents," *Handbook of Environmental Fate and Exposure Data for Organic Chemicals*, Lewis Publishers, Inc. Chelsea, Michigan.

IT, see IT Corporation.

IT Corporation (IT), 1992. "Results of Analyses on Samples SNLA010118, SNLA010120, and SNLA010121 Collected from Liquid Waste Disposal System Tanks at Technical Area V on July 29, 1992," IT Corporation, Albuquerque, New Mexico. November 3, 1992.

Kocher, D.C. 1983. "Dose-Rate Conversion Factors for External Exposure to Photon Emitters in Soil," *Health Physics,* Vol. 28, pp. 193–205.

Micromedex, Inc., 1998. "Registry of Toxic Effects of Chemical Substances (RTECS)," Hazardous Substances Databank.

National Council on Radiation Protection and Measurements (NCRP), 1987. "Exposure of the Population in the United States and Canada from Natural Background Radiation," *NCRP Report* No. 94, National Council on Radiation Protection and Measurements, Bethesda, Maryland.

National Oceanographic and Atmospheric Administration (NOAA), 1990. "Local Climatological Data, Annual Summary with Comparative Data," Albuquerque, New Mexico.

NCRP, see National Council on Radiation Protection and Measurements.

Neumann, G., 1976. "Concentration Factors for Stable Metals and Radionuclides in Fish, Mussels and Crustaceans—A Literature Survey," Report 85-04-24, National Swedish Environmental Protection Board.

New Mexico Environment Department (NMED), March 1998. "Risk-Based Decision Tree Description," *in* New Mexico Environment Department, "RPMP Document Requirement Guide," RCRA Permits Management Program, Hazardous and Radioactive Materials Bureau, New Mexico Environment Department, Santa Fe, New Mexico.

New Mexico Environment Department (NMED), December 2000. Technical Background Document for Development of Soil Screening Levels," Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program, New Mexico Environment Department, Santa Fe, New Mexico.

New Mexico Environment Department (NMED), 2004. "Compliance Order on Consent Pursuant to the New Mexico Hazardous Waste Act," § 74-4-10, New Mexico Environment Department. April 2004.

NMED, see New Mexico Environment Department.

NOAA, see National Oceanographic and Atmospheric Administration.

Oak Ridge National Laboratory (ORNL), 2003. "Risk Assessment Information System," electronic database maintained by Oak Ridge National Laboratory, Oak Ridge, Tennessee.

ORNL, see Oak Ridge National Laboratory.

Sandia National Laboratories/New Mexico (SNL/NM), October 1991. "Procedure for Validation of Chemical Measurement Data," Procedure QA-11-01, Rev. 0, Environmental Programs Department, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), March 1993. "RCRA Facility Investigation Work Plan for the Liquid Waste Disposal System (LWDS) ER Program Sites 4, 5, and 52," Environmental Impact and Restoration Division, Sandia National Laboratories/New Mexico, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), September 1995. "Results for the Liquid Waste Disposal System (LWDS) RCRA Facility Investigation," Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), February 1998. "RESRAD Input Parameter Assumptions and Justification," Environmental Restoration Project, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), January 2000. "Data Validation Procedure for Chemical and Radiochemical Data, Sandia National Laboratories/New Mexico Environmental Restoration Project, AOP 00-03," Rev. 0, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), March 2000. "Annual Groundwater Protection Monitoring Report, Fiscal Year 1999," Groundwater Protection Program, Sandia National Laboratories/New Mexico, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), May 2001. "Response to NMED's Request for Supplemental Information (RSI) on the Liquid Waste Disposal System RCRA Facility Investigation (RFI) and No Further Action (NFA) Proposal for Solid Waste Management Unit (SWMU) 52," Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), October 2001. "Summary of Monitoring Well Drilling Activities, TA-V Groundwater Investigation," Sandia National Laboratories/New Mexico, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), November 2001. "TA-V Groundwater Investigation, Fiscal Years 1999 and 2000," Sandia National Laboratories/New Mexico, Albuquerque, New Mexico.

SNL/NM, See Sandia National Laboratories, New Mexico.

U.S. Department of Energy (DOE), 1988. "External Dose-Rate Conversion Factors for Calculation of Dose to the Public," DOE/EH-0070, Assistant Secretary for Environment, Safety and Health, U.S. Department of Energy, Washington, D.C.

U.S. Department of Energy (DOE), 1993. "Radiation Protection of the Public and the Environment," DOE Order 5400.5, U.S. Department of Energy, Washington, D.C.

U.S. Department of Energy (DOE), U.S. Air Force, and U.S. Forest Service, September 1995. "Workbook: Future Use Management Area 2," prepared by the Future Use Logistics and Support Working Group in cooperation with U.S. Department of Energy Affiliates, the U.S. Air Force, and the U.S. Forest Service.

U.S. Environmental Protection Agency (EPA), November 1986. "Test Methods for Evaluating Solid Waste," 3rd ed., Update 3, SW-846, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1988. "Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1989. "Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual," EPA/540-1089/002, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1991. "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part B)," Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1997a. "Health Effects Assessment Summary Tables (HEAST), FY 1997 Update," EPA-540-R-97-036, Office of Research and Development and Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1997b. "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination," OSWER Directive No. 9200.4-18, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1997c. "Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risks," Interim Final, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 2002a. "Region 6 Preliminary Remediation Goals (PRGs) 2002," electronic database maintained by Region 6, U.S. Environmental Protection Agency, Dallas, Texas.

U.S. Environmental Protection Agency (EPA), 2002b. "Region 9 Preliminary Remediation Goals (PRGs) 2002," electronic database maintained by Region 9, U.S. Environmental Protection Agency, San Francisco, California.

U.S. Environmental Protection Agency (EPA), 2002c. "Risk-Based Concentration Table," electronic database maintained by Region 3, U.S. Environmental Protection Agency, Philadelphia, Pennsylvania.

U.S. Environmental Protection Agency (EPA), 2003. Integrated Risk Information System (IRIS) electronic database, maintained by the U.S. Environmental Protection Agency, Washington, D.C.

Yanicak, S. (Oversight Bureau, Department of Energy, New Mexico Environment Department). Letter to M. Johansen (DOE/AIP/POC Los Alamos National Laboratory), March 1997. "(Tentative) list of constituents of potential ecological concern (COPECs) which are considered to be bioconcentrators and/or biomagnifiers." March 3, 1997.

Yu, C., A.J. Zielen, J.J. Cheng, Y.C. Yuan, L.G. Jones, D.J. LePoire, Y.Y. Wang, C.O. Loureiro, E. Gnanapragasam, E. Faillace, A. Wallo III, W.A. Williams, and H. Peterson, 1993a. "Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD," Version 5.0. Environmental Assessment Division, Argonne National Laboratory, Argonne, Illinois.

Yu, C., C. Loureiro, J.J. Cheng, L.G. Jones, Y.Y. Wang, Y.P. Chia, and E. Faillace, 1993b. "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil," ANL/EAIS-8, Argonne National Laboratory, Argonne, Illinois.

This page intentionally left blank.

APPENDIX 1
EXPOSURE PATHWAY DISCUSSION FOR CHEMICAL AND RADIONUCLIDE CONTAMINATION

Introduction

Sandia National Laboratories/New Mexico (SNL/NM) uses a default set of exposure routes and associated default parameter values developed for each future land-use designation being considered for SNL/NM Environmental Restoration (ER) Project sites. This default set of exposure scenarios and parameter values are invoked for risk assessments unless site-specific information suggests other parameter values. Because many SNL/NM solid waste management units (SWMUs) have similar types of contamination and physical settings, SNL/NM believes that the risk assessment analyses at these sites can be similar. A default set of exposure scenarios and parameter values facilitates the risk assessments and subsequent review.

The default exposure routes and parameter values used are those that SNL/NM views as resulting in a Reasonable Maximum Exposure (RME) value. Subject to comments and recommendations by the U.S. Environmental Protection Agency (EPA) Region VI and New Mexico Environment Department (NMED), SNL/NM will use these default exposure routes and parameter values in future risk assessments.

At SNL/NM, all SWMUs exist within the boundaries of the Kirtland Air Force Base. Approximately 240 potential waste and release sites have been identified where hazardous, radiological, or mixed materials may have been released to the environment. Evaluation and characterization activities have occurred at all of these sites to varying degrees. Among other documents, the SNL/NM ER draft Environmental Assessment (DOE 1996) presents a summary of the hydrogeology of the sites and the biological resources present. When evaluating potential human health risk the current or reasonably foreseeable land use negotiated and approved for the specific SWMU/AOC, aggregate, or watershed will be used. The following references generally document these land uses: *Workbook: Future Use Management Area 2 (DOE et al. September 1995); Workbook: Future Use Management Area 1 (DOE et al. October 1995); Workbook: Future Use Management Areas 3, 4, 5, and 6 (DOE and USAF January 1996); Workbook: Future Use Management Area 7 (DOE and USAF March 1996)*. At this time, all SNL/NM SWMUs have been tentatively designated for either industrial or recreational future land use. The NMED has also requested that risk calculations be performed based upon a residential land-use scenario. Therefore, all three land-use scenarios will be addressed in this document.

The SNL/NM ER Project has screened the potential exposure routes and identified default parameter values to be used for calculating potential intake and subsequent hazard index (HI), excess cancer risk and dose values. The EPA (EPA 1989) provides a summary of exposure routes that could potentially be of significance at a specific waste site. These potential exposure routes consist of:

- Ingestion of contaminated drinking water
- Ingestion of contaminated soil

- Ingestion of contaminated fish and shellfish
- Ingestion of contaminated fruits and vegetables
- Ingestion of contaminated meat, eggs, and dairy products
- Ingestion of contaminated surface water while swimming
- Dermal contact with chemicals in water
- Dermal contact with chemicals in soil
- Inhalation of airborne compounds (vapor phase or particulate)
- External exposure to penetrating radiation (immersion in contaminated air; immersion in contaminated water; and exposure from ground surfaces with photon-emitting radionuclides)

Based upon the location of the SNL/NM SWMUs and the characteristics of the surface and subsurface at the sites, we have evaluated these potential exposure routes for different land-use scenarios to determine which should be considered in risk assessment analyses (the last exposure route is pertinent to radionuclides only). At SNL/NM SWMUs, there is currently no consumption of fish, shellfish, fruits, vegetables, meat, eggs, or dairy products that originate on site. Additionally, no potential for swimming in surface water is present due to the high-desert environmental conditions. As documented in the RESRAD computer code manual (ANL 1993), risks resulting from immersion in contaminated air or water are not significant compared to risks from other radiation exposure routes.

For the industrial and recreational land-use scenarios, SNL/NM ER has, therefore, excluded the following five potential exposure routes from further risk assessment evaluations at any SNL/NM SWMU:

- Ingestion of contaminated fish and shellfish
- Ingestion of contaminated fruits and vegetables
- Ingestion of contaminated meat, eggs, and dairy products
- Ingestion of contaminated surface water while swimming
- Dermal contact with chemicals in water

That part of the exposure pathway for radionuclides related to immersion in contaminated air or water is also eliminated.

Based upon this evaluation, for future risk assessments the exposure routes that will be considered are shown in Table 1.

Table 1
Exposure Pathways Considered for Various Land-Use Scenarios

Industrial	Recreational	Residential
Ingestion of contaminated drinking water	Ingestion of contaminated drinking water	Ingestion of contaminated drinking water
Ingestion of contaminated soil	Ingestion of contaminated soil	Ingestion of contaminated soil
Inhalation of airborne compounds (vapor phase or particulate)	Inhalation of airborne compounds (vapor phase or particulate)	Inhalation of airborne compounds (vapor phase or particulate)
Dermal contact (nonradiological constituents only) soil only	Dermal contact (nonradiological constituents only) soil only	Dermal contact (nonradiological constituents only) soil only
External exposure to penetrating radiation from ground surfaces	External exposure to penetrating radiation from ground surfaces	External exposure to penetrating radiation from ground surfaces

Equations and Default Parameter Values for Identified Exposure Routes

In general, SNL/NM expects that ingestion of compounds in drinking water and soil will be the more significant exposure routes for chemicals; external exposure to radiation may also be significant for radionuclides. All of the above routes will, however, be considered for their appropriate land-use scenarios. The general equation for calculating potential intakes via these routes is shown below. The equations are taken from "Assessing Human Health Risks Posed by Chemicals: Screening-Level Risk Assessment" (NMED March 2000) and "Technical Background Document for Development of Soil Screening Levels" (NMED December 2000). Equations from both documents are based upon the "Risk Assessment Guidance for Superfund" (RAGS): Volume 1 (EPA 1989, 1991). These general equations also apply to calculating potential intakes for radionuclides. A more in-depth discussion of the equations used in performing radiological pathway analyses with the RESRAD code may be found in the RESRAD Manual (ANL 1993). RESRAD is the only code designated by the U.S. Department of Energy (DOE) in DOE Order 5400.5 for the evaluation of radioactively contaminated sites (DOE 1993). The Nuclear Regulatory Commission (NRC) has approved the use of RESRAD for dose evaluation by licensees involved in decommissioning, NRC staff evaluation of waste disposal requests, and dose evaluation of sites being reviewed by NRC staff. EPA Science Advisory Board reviewed the RESRAD model. EPA used RESRAD in their rulemaking on radiation site cleanup regulations. RESRAD code has been verified, undergone several benchmarking analyses, and been included in the International Atomic Energy Agency's VAMP and BIOMOVS II projects to compare environmental transport models.

Also shown are the default values SNL/NM ER will use in RME risk assessment calculations for industrial, recreational, and residential land-use scenarios, based upon EPA and other governmental agency guidance. The pathways and values for chemical contaminants are discussed first, followed by those for radionuclide contaminants. RESRAD input parameters that are left as the default values provided with the code are not discussed. Further information relating to these parameters may be found in the RESRAD Manual (ANL 1993) or by directly accessing the RESRAD websites at: http://web.ead.anl.gov/resrad/home2/ or http://web.ead.anl.gov/resrad/documents/.

Generic Equation for Calculation of Risk Parameter Values

The equation used to calculate the risk parameter values (i.e., hazard quotients/HI, excess cancer risk, or radiation total effective dose equivalent [TEDE] [dose]) is similar for all exposure pathways and is given by:

Risk (or Dose) = Intake x Toxicity Effect (either carcinogenic, noncarcinogenic, or radiological)

$$= C \times (CR \times EFD/BW/AT) \times \text{Toxicity Effect} \qquad (1)$$

where;

C = contaminant concentration (site specific)
CR = contact rate for the exposure pathway
EFD= exposure frequency and duration
BW = body weight of average exposure individual
AT = time over which exposure is averaged.

For nonradiological constituents of concern (COCs), the total risk/dose (either cancer risk or HI) is the sum of the risks/doses for all of the site-specific exposure pathways and contaminants. For radionuclides, the calculated radiation exposure, expressed as TEDE is compared directly to the exposure guidelines of 15 millirem per year (mrem/year) for industrial and recreational future use and 75 mrem/year for the unlikely event that institutional control of the site is lost and the site is used for residential purposes (EPA 1997).

The evaluation of the carcinogenic health hazard produces a quantitative estimate for excess cancer risk resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of the quantitative estimate with the potentially acceptable risk of 1E-5 for nonradiological carcinogens. The evaluation of the noncarcinogenic health hazard produces a quantitative estimate (i.e., the HI) for the toxicity resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of this quantitative estimate with the EPA standard HI of unity (1). The evaluation of the health hazard from radioactive compounds produces a quantitative estimate of doses resulting from the COCs present at the site. This estimated dose is used to calculate an assumed risk. However, this calculated risk is presented for illustration purposes only, not to determine compliance with regulations.

The specific equations used for the individual exposure pathways can be found in RAGS (EPA 1989) and are outlined below. The RESRAD Manual (ANL 1993) describes similar equations for the calculation of radiological exposures.

Soil Ingestion

A receptor can ingest soil or dust directly by working in the contaminated soil. Indirect ingestion can occur from sources such as unwashed hands introducing contaminated soil to food that is then eaten. An estimate of intake from ingesting soil will be calculated as follows:

$$I_s = \frac{C_s * IR * CF * EF * ED}{BW * AT}$$

where:

I_s = Intake of contaminant from soil ingestion (milligrams [mg]/kilogram [kg]-day)
C_s = Chemical concentration in soil (mg/kg)
IR = Ingestion rate (mg soil/day)
CF = Conversion factor (1E-6 kg/mg)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged) (days)

It should be noted that it is conservatively assumed that the receptor only ingests soil from the contaminated source.

Soil Inhalation

A receptor can inhale soil or dust directly by working in the contaminated soil. An estimate of intake from inhaling soil will be calculated as follows (EPA August 1997):

$$I_s = \frac{C_s * IR * EF * ED * \left(1/VF \text{ or } 1/PEF\right)}{BW * AT}$$

where:

I_s = Intake of contaminant from soil inhalation (mg/kg-day)
C_s = Chemical concentration in soil (mg/kg)
IR = Inhalation rate (cubic meters [m^3]/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
VF = soil-to-air volatilization factor (m^3/kg)
PEF = particulate emission factor (m^3/kg)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged) (days)

Soil Dermal Contact

$$D_a = \frac{C_s * CF * SA * AF * ABS * EF * ED}{BW * AT}$$

where:

D_a = Absorbed dose (mg/kg-day)
C_s = Chemical concentration in soil (mg/kg)
CF = Conversion factor (1E-6 kg/mg)
SA = Skin surface area available for contact (cm^2/event)
AF = Soil to skin adherence factor (mg/cm^2)
ABS = Absorption factor (unitless)
EF = Exposure frequency (events/year)

ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged) (days)

Groundwater Ingestion

A receptor can ingest water by drinking it or through using household water for cooking. An estimate of intake from ingesting water will be calculated as follows (EPA August 1997):

$$I_w = \frac{C_w * IR * EF * ED}{BW * AT}$$

where:

I_w = Intake of contaminant from water ingestion (mg/kg/day)
C_w = Chemical concentration in water (mg/liter [L])
IR = Ingestion rate (L/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged) (days)

Groundwater Inhalation

The amount of a constituent taken into the body via exposure to volatilization from showering or other household water uses will be evaluated using the concentration of the constituent in the water source (EPA 1991 and 1992). An estimate of intake from volatile inhalation from groundwater will be calculated as follows (EPA 1991):

$$I_w = \frac{C_w * K * IR_i * EF * ED}{BW * AT}$$

where:

I_w = Intake of volatile in water from inhalation (mg/kg/day)
C_w = Chemical concentration in water (mg/L)
K = volatilization factor (0.5 L/m^3)
IR_i = Inhalation rate (m^3/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged—days)

For volatile compounds, volatilization from groundwater can be an important exposure pathway from showering and other household uses of groundwater. This exposure pathway will only be evaluated for organic chemicals with a Henry's Law constant greater than $1x10^{-5}$ and with a molecular weight of 200 grams/mole or less (EPA 1991).

Tables 2 and 3 show the default parameter values suggested for use by SNL/NM at SWMUs, based upon the selected land-use scenarios for nonradiological and radiological COCs,

respectively. References are given at the end of the table indicating the source for the chosen parameter values. SNL/NM uses default values that are consistent with both regulatory guidance and the RME approach. Therefore, the values chosen will, in general, provide a conservative estimate of the actual risk parameter. These parameter values are suggested for use for the various exposure pathways, based upon the assumption that a particular site has no unusual characteristics that contradict the default assumptions. For sites for which the assumptions are not valid, the parameter values will be modified and documented.

Summary

SNL/NM will use the described default exposure routes and parameter values in risk assessments at sites that have an industrial, recreational, or residential future land-use scenario. There are no current residential land-use designations at SNL/NM ER sites, but NMED has requested this scenario to be considered to provide perspective of the risk under the more restrictive land-use scenario. For sites designated as industrial or recreational land use, SNL/NM will provide risk parameter values based upon a residential land-use scenario to indicate the effects of data uncertainty on risk value calculations or in order to potentially mitigate the need for institutional controls or restrictions on SNL/NM ER sites. The parameter values are based upon EPA guidance and supplemented by information from other government sources. If these exposure routes and parameters are acceptable, SNL/NM will use them in risk assessments for all sites where the assumptions are consistent with site-specific conditions. All deviations will be documented.

Table 2
Default Nonradiological Exposure Parameter Values for Various Land-Use Scenarios

Parameter	Industrial	Recreational	Residential
General Exposure Parameters			
Exposure Frequency (day/yr)	250[a,b]	8.7 (4 hr/wk for 52 wk/yr)[a,b]	350[a,b]
Exposure Duration (yr)	25[a,b,c]	30[a,b,c]	30[a,b,c]
Body Weight (kg)	70[a,b,c]	70 Adult[a,b,c] 15 Child[a,b,c]	70 Adult[a,b,c] 15 Child[a,b,c]
Averaging Time (days) for Carcinogenic Compounds (= 70 yr x 365 day/yr) for Noncarcinogenic Compounds (= ED x 365 day/yr)	25,550[a,b] 9,125[a,b]	25,550[a,b] 10,950[a,b]	25,550[a,b] 10,950[a,b]
Soil Ingestion Pathway			
Ingestion Rate (mg/day)	100[a,b]	200 Child[a,b] 100 Adult[a,b]	200 Child[a,b] 100 Adult[a,b]
Inhalation Pathway			
Inhalation Rate (m^3/day)	20[a,b]	15 Child[a] 30 Adult[a]	10 Child[a] 20 Adult[a]
Volatilization Factor (m^3/kg)	Chemical Specific	Chemical Specific	Chemical Specific
Particulate Emission Factor (m^3/kg)	1.36E9[a]	1.36E9[a]	1.36E9[a]
Water Ingestion Pathway			
Ingestion Rate (liter/day)	2.4[a]	2.4[a]	2.4[a]
Dermal Pathway			
Skin Adherence Factor (mg/cm^2)	0.2[a]	0.2 Child[a] 0.07 Adult[a]	0.2 Child[a] 0.07 Adult[a]
Exposed Surface Area for Soil/Dust (cm^2/day)	3,300[a]	2,800 Child[a] 5,700 Adult[a]	2,800 Child[a] 5,700 Adult[a]
Skin Adsorption Factor	Chemical Specific	Chemical Specific	Chemical Specific

[a]Technical Background Document for Development of Soil Screening Levels (NMED 2000).
[b]Risk Assessment Guidance for Superfund, Vol. 1, Part B (EPA 1991).
[c]Exposure Factors Handbook (EPA August 1997).
ED = Exposure duration.
EPA = U.S. Environmental Protection Agency.
hr = Hour(s).
kg = Kilogram(s).
m = Meter(s).
mg = Milligram(s).
NA = Not available.
wk = Week(s).
yr = Year(s).

Table 3
Default Radiological Exposure Parameter Values for Various Land-Use Scenarios

Parameter	Industrial	Recreational	Residential
General Exposure Parameters			
Exposure Frequency	8 hr/day for 250 day/yr	4 hr/wk for 52 wk/yr	365 day/yr
Exposure Duration (yr)	25[a,b]	30[a,b]	30[a,b]
Body Weight (kg)	70 Adult[a,b]	70 Adult[a,b]	70 Adult[a,b]
Soil Ingestion Pathway			
Ingestion Rate	100 mg/day[c]	100 mg/day[c]	100 mg/day[c]
Averaging Time (days) (= 30 yr x 365 day/yr)	10,950[d]	10,950[d]	10,950[d]
Inhalation Pathway			
Inhalation Rate (m^3/yr)	7,300[d,e]	10,950[e]	7,300[d,e]
Mass Loading for Inhalation g/m^3	1.36 E-5[d]	1.36 E-5 [d]	1.36 E-5 [d]
Food Ingestion Pathway			
Ingestion Rate, Leafy Vegetables (kg/yr)	NA	NA	16.5[c]
Ingestion Rate, Fruits, Non-Leafy Vegetables & Grain (kg/yr)	NA	NA	101.8[b]
Fraction Ingested	NA	NA	0.25[b,d]

[a]Risk Assessment Guidance for Superfund, Vol. 1, Part B (EPA 1991).
[b]Exposure Factors Handbook (EPA August 1997).
[c]EPA Region VI guidance (EPA 1996).
[d]For radionuclides, RESRAD (ANL 1993).
[e]SNL/NM (February 1998).
EPA = U.S. Environmental Protection Agency.
g = Gram(s)
hr = Hour(s).
kg = Kilogram(s).
m = Meter(s).
mg = Milligram(s).
NA = Not applicable.
wk = Week(s).
yr = Year(s).

References

ANL, see Argonne National Laboratory.

Argonne National Laboratory (ANL), 1993. *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD*, Version 5.0, ANL/EAD/LD-2, Argonne National Laboratory, Argonne, IL.

DOE, see U.S. Department of Energy.

DOE and USAF, see U.S. Department of Energy and U.S. Air Force.

EPA, see U.S. Environmental Protection Agency.

New Mexico Environment Department (NMED), March 2000. "Assessing Human Health Risks Posed by Chemical: Screening-level Risk Assessment," Hazardous and Radioactive Materials Bureau, NMED, March 6, 2000.

New Mexico Environment Department (NMED), December 2000. "Technical Background Document for Development of Soil Screening Levels," Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program, December 18, 2000.

Sandia National Laboratories/New Mexico (SNL/NM), February 1998. "RESRAD Input Parameter Assumptions and Justification," Sandia National Laboratories/New Mexico Environmental Restoration Project, Albuquerque, New Mexico.

U.S. Department of Energy (DOE), 1993. DOE Order 5400.5, "Radiation Protection of the Public and the Environment," U.S. Department of Energy, Washington, D.C.

U.S. Department of Energy (DOE), 1996. "Environmental Assessment of the Environmental Restoration Project at Sandia National Laboratories/New Mexico," U.S. Department of Energy, Kirtland Area Office.

U.S. Department of Energy, U.S. Air Force, and U.S. Forest Service, September 1995. "Workbook: Future Use Management Area 2," prepared by the Future Use Logistics and Support Working Group in cooperation with U.S. Department of Energy Affiliates, the U.S. Air Force, and the U.S. Forest Service.

U.S. Department of Energy, U.S. Air Force, and U.S. Forest Service, October 1995. "Workbook: Future Use Management Area 1," prepared by the Future Use Logistics and Support Working Group in cooperation with U.S. Department of Energy Affiliates, the U.S. Air Force, and the U.S. Forest Service.

U.S. Department of Energy and U.S. Air Force (DOE and USAF), January 1996. "Workbook: Future Use Management Areas 3,4,5,and 6," prepared by the Future Use Logistics and Support Working Group in cooperation with U.S. Department of Energy Affiliates, and the U.S. Air Force.

U.S. Department of Energy and U.S. Air Force (DOE and USAF), March 1996. "Workbook: Future Use Management Area 7," prepared by the Future Use Logistics and Support Working Group in cooperation with U.S. Department of Energy Affiliates and the U.S. Air Force.

U.S. Environmental Protection Agency (EPA), 1989. "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual," EPA/540-1089/002, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1991. "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part B)," EPA/540/R-92/003, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1992. "Dermal Exposure Assessment: Principles and Applications," EPA/600/8-91/011B, Office of Research and Development, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1996. "Soil Screening Guidance: Technical Background Document," EPA/540/1295/128, Office of Solid Waste and Emergency Response, Washington, D.C.

U.S. Environmental Protection Agency (EPA), August 1997. *Exposure Factors Handbook*, EPA/600/8-89/043, U.S. Environmental Protection Agency, Office of Health and Environmental Assessment, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1997. (OSWER No. 9200.4-18) *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*, U.S. EPA Office of Radiation and Indoor Air, Washington D.C, August 1997.

This page intentionally left blank.

APPENDIX 2
CALCULATION OF THE UPPER CONFIDENCE LIMITS OF MEAN CONCENTRATIONS

For conservatism, Sandia National Laboratories/New Mexico uses the maximum concentration of the constituents of concern (COCs) for initial risk calculation. If the maximum concentrations produce risk above New Mexico Environment Department (NMED) guidelines, conservatism with this approach is evaluated and, if appropriate, a more realistic approach is applied. When the site has been adequately characterized, an estimate of the mean concentration of the COCs is more representative of actual site conditions. The NMED has proposed the use of the upper confidence limit (UCL) of the mean to represent average concentrations at a site (NMED December 2000). The UCL is calculated according to NMED guidance (Tharp June 2002) using the U.S. Environmental Protection Agency ProUCL program (EPA April 2002). Attached are the outputs from that program and the calculated UCLs used in the risk analysis.

References

EPA, see U.S. Environmental Protection Agency.

New Mexico Environment Department (NMED), December 2000. "Technical Background Document for Development of Soil Screening Levels," Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program, New Mexico Environment Department, Santa Fe, New Mexico. December 18, 2000.

NMED, see New Mexico Environment Department.

Tharp, T. (Weston Solutions, Inc.), June 2002. *Personal communication* with K. Olsen (Hazardous Waste Bureau, New Mexico Environment Department). June 12, 2002.

U.S. Environmental Protection Agency (EPA), April 2002. *ProUCL User's Guide*, U.S. Environmental Protection Agency, Washington, D.C.

ATTACHMENT

SWMU 52	
Summary Statistics for	Arsenic
Number of Samples	42
Minimum	0.82
Maximum	6.7
Mean	2.138571
Median	1.85
Standard Deviation	1.089259
Variance	1.186486
Coefficient of Variation	0.50934
Skewness	2.247318
Shapiro-Wilk Test Statisitic	0.781698
Shapiro-Wilk 5% Critical Value	0.942
Data not Normal at 5% Significance Level	
Data not Lognormal: Try Non-parametric UCL	
97.5 % UCL (Assuming Normal Data)	
Student's-t	2.478008
97.5 % UCL (Adjusted for Skewness)	
Adjusted-CLT	2.55234
Modified-t	2.487722
97.5 % Non-parametric UCL	
CLT	2.467995
Jackknife	2.478008
Standard Bootstrap	2.459517
Bootstrap-t	2.621169
Chebyshev (Mean, Std)	3.188208