DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DIVISION, GREAT LAKES AND OHIO RIVER
CORPS OF ENGINEERS
P.O. BOX 1159
CINCINNATI, OH 45201-1159

REPLY TO
ATTENTION OF

CELRD-PDM-M

MAR

MEMORANDUM FOR COMMANDER, PITTSBURGH DISTRICT

SUBJECT: Remedial Investigation Report, Parks Township, Shallow Land Disposal Area

1. Reference:

a. CECW-BA Memorandum, 19 Nov 2001, Subject: Revised Delegation of Authorities under the Formerly Utilized Sites Remedial Action Program.

b. CELRP-BR-P Memorandum, 7 March 2005, Subject: Shallow Land Disposal Area (SLDA) site Remedial Investigation Report, FUSRAP Program.

2. I approve distribution of the Parks Township, Shallow Land Disposal Area, Remedial Investigation Report.

3. The POC for CELRD is Mr. Ron Church, CELRD-PDM-M, (513) 684-3077.

Encls

William E. Ryan III, COL, EN
for BRUCE A. BERWICK
Brigadier General, U.S. Army
Commander

CF:
Commander, Buffalo District

DEPARTMENT OF THE ARMY
PITTSBURGH DISTRICT, CORPS OF ENGINEERS
WILLIAM S. MOORHEAD FEDERAL BUILDING
1000 LIBERTY AVENUE
PITTSBURGH, PA 15222-4186

REPLY TO
ATTENTION OF

CELRP-BR-P 7 March 2005

MEMORANDUM FOR Commander, Ohio River and Great Lakes Division (CELRD-PDM-M/ Ron Church), P. O. Box 1159, Cincinnati, Ohio 45201

SUBJECT: Shallow Land Disposal Area (SLDA) site Remedial Investigation Report, FUSRAP Program

1. Reference CECW-BA Memorandum, 19 Nov 01, subject: Revised Delegation of Authorities under the Formerly Utilized Sites Remedial Action Program.

2. Request approval to distribute the SLDA site Remedial Investigation Report (Encl. 1) for regulatory agency and property owner review, in accordance with the referenced memorandum.

3. The Remedial Investigation Report was certified as legally sufficient by LRB Office of Counsel on 10 February 2005(Encl. 2).

4. My point of contact pertaining to this matter is Mr. William J. Lenart who can be reached at (412) 395-7377.

2 Encls
1. Remedial Investigation Report
2. Legal certification

STEPHEN L. HILL
Colonel, Corps of Engineers
Commanding

CELRB-OC

10 February 2005

MEMORANDUM FOR David Frothingham

SUBJECT: Remedial Investigation for the Shallow Landfill Disposal Area (SLDA)

1. I reviewed the subject document and found it to be legally sufficient. Therefore, I recommend that it be forwarded on to higher headquarters for approval.

2. If you have any questions please contact me at 4183.

Michelle F. Barczak
District Counsel

SHALLOW LAND DISPOSAL AREA

REMEDIAL INVESTIGATION REPORT

FINAL

DEPARTMENT OF THE ARMY

OCTOBER 2005

G3624L

URS

CERTIFICATION

By affixing my seal to this document, Shallow Land Disposal Area Remedial Investigation Report, I am certifying that I have reviewed this document and to the extent of my professional knowledge find the information is true and correct. I further certify I am licensed to practice in the Commonwealth of Pennsylvania and that it is within my professional expertise to verify the correctness of the information.

Sheldon S. Nozik, P.G., CHMM
License No. PG-002383-G

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
SHELDON S. NOZIK
GEOLOGIST
No. PG 2383G

URS Corporation
77 Goodell Street
Buffalo, NY 14203
Tel: 716.856.5636
Fax: 716.856.2545

FINAL

REMEDIAL INVESTIGATION REPORT

SHALLOW LAND DISPOSAL AREA SITE

PARKS TOWNSHIP, ARMSTRONG COUNTY, PENNSYLVANIA

USACE CONTRACT NO. DACW49-01-D-0001

DELIVERY ORDER NO. 0010

PREPARED FOR:

DEPARTMENT OF THE ARMY

UNITED STATES ARMY CORPS OF ENGINEERS

1000 LIBERTY AVENUE

PITTSBURGH, PENNSYLVANIA 15222

OCTOBER 2005

ACKNOWLEDGEMENTS

The United States Army Corps of Engineers (USACE) would like to acknowledge the following organizations and/or individuals for their contributions in the preparation of this document: URS Corporation, Argonne National Laboratory, the Pennsylvania Department of Environmental Protection, the Nuclear Regulatory Commission, Atlantic Richfield Company, BWXT Services, Inc., Parks Township, Congressman John Murtha (PA-12th) and his staff, and various citizens who contributed valuable historical information and institutional knowledge.

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FIGURES (continued)

FIGURES (continued)

APPENDICES

ACRONYMS, FORMULAS, AND SYMBOLS

1SB	First Shallow Bedrock
2SB	Second Shallow Bedrock
ACS	American Cancer Society
AEC	United States Atomic Energy Commission
AIB	Allegheny Series Soils
ALARA	As Low As Reasonably Achievable
ANL	Argonne National Laboratory
ARAR	Applicable or Relevant and Appropriate Requirements
ARCO	Atlantic Richfield Company
ASTM	American Society for Testing and Materials
BCG	Biota Concentration Guideline
bgs	Below Ground Surface
BOD	Biochemical Oxygen Demand
BRA	Baseline Risk Assessment
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
B&W	Babcock and Wilcox
BWXT	BWX Technologies
BZA	Breathing Zone Apparatus
C&D	Construction and Demolition
CADD	Computer-Aided Drafting and Design
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
cfs	Cubic Feet per Second
CFR	Code of Federal Regulations
CGI	Combustible Gas Indicator
CHP	Certified Health Physicist
cm	Centimeter
CNSC-ACRP	Canadian Nuclear Safety Commission, Advisory Committee on Radiological Protection
COD	Chemical Oxygen Demand
CPEC	Constituent of Potential Environmental Concern

cpm	counts per minute
CQC	Chemical Quality Control
CSM	Conceptual Site Model
DAC	Derived Air Concentration
DAW	Dry Active Waste
DB	Deep Bedrock
DCA	Dichloroethane
DCE	Dichloroethene
DCF	Dose Conversion Factor
DEIS	Draft Environmental Impact Statement
DO	Dissolved Oxygen
DOE	United States Department of Energy
DQCR	Daily Quality Control Report
DQI	Data Quality Indicator
DQO	Data Quality Objective
EDE	Effective Dose Equivalent
EDR	Environmental Data Resources, Inc.
EDTA	Ethylenediaminetetraacetic Acid
EIS	Environmental Impact Statement
EML	Environmental Measurements Laboratory
EPA	United States Environmental Protection Agency
EPC	Exposure Point Concentration
ERDA	Energy Research and Development Administration
EU	Exposure Unit
eV	Electron Volt
FGR	Federal Guidance Report
FIDLER	Field Instrument for Detecting Low Level Radiation
FLUTe	Flexible Liner Underground Technology
FS	Feasibility Study

ACRONYMS, FORMULAS, AND SYMBOLS (Con't)

FSS	Final Status Survey
FUSRAP	Formerly Utilized Sites Remedial Action Program
GEL	General Engineering Laboratories, Inc.
GIS	Geographic Information System
GPR	Ground Penetrating Radar
GPS	Global Positioning System
HASL	Health and Safety Laboratory
HEAST	Health Effects Assessment Summary Tables
HEPA	High-Efficiency Particulate Air
HI	Hazard Index
HSA	Hollow Stem Auger
IAEA	International Atomic Energy Agency
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
ICRP	International Commission on Radiological Protection
ID	Internal Diameter
IDW	Investigation-Derived Waste
IRIS	Integrated Risk Information System
ITRC	Interstate Technology and Regulatory Council
K_d	Distribution Coefficient
Kg	Kilogram
LDPE	Low-Density Polyethylene
LET	Linear-Energy Transfer
LOAEL	Lowest-Observed-Adverse-Effect Level
lpm	Liters per Minute
MAG	Magnetometry
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	Maximum Contaminant Level
MED	Manhattan Engineer District
mg	Milligram
mg/m^3	Milligram per Cubic Meter

ACRONYMS, FORMULAS, AND SYMBOLS (Con't)

mL	Milliliter
mrem/yr	Millirem per Year
MOU	Memorandum of Understanding
MSC	Medium-Specific Concentration
MSL	Mean Sea Level
MW	Monitoring Well
NaI	Sodium Iodide
NESI	Nuclear Environmental Services, Inc.
NCP	National Oil and Hazardous Substances Pollution Control Plan
NCRP	National Council on Radiation Protection and Measurements
NEL	(B&W Nuclear Environmental Services, Inc.) Nuclear Environmental Laboratory
NMDR	Nuclear Material Discard Report
NOAA	National Oceanographic and Atmospheric Agency
NOAEL	No-Observed-Adverse-Effect Level
NPDES	National Pollutant Discharge Elimination System
NRC	United States Nuclear Regulatory Commission
NTU	Nephelometric Turbidity Unit
NUMEC	Nuclear Materials and Equipment Corporation
NWI	(U.S. Fish and Wildlife Service) National Wetlands Inventory
NWS	Nested Well Set
OD	Outside Diameter
OH	Hydroxyquinoline
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORP	Oxidation Reduction Potential
PADEP	Pennsylvania Department of Environmental Protection
PCB	Polychlorinated Biphenyl
pCi/g	picoCuries per gram
pCi/L	picoCuries per liter
PID	Photoionization Detector

ACRONYMS, FORMULAS, AND SYMBOLS (Con't)

PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goal
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RaA/RaB	Rainsboro Series Soils
rad/d	Radiation Absorbed Dose per Day
RAGS	Risk Assessment Guidance for Superfund
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
RESRAD	RESidual RADioactivity (Computer Code)
RI	Remedial Investigation
RIR	Remedial Investigation Report
RMA	Radioactive Materials Area
ROC	Radionuclide of Concern
ROPC	Radionuclide of Potential Concern
RQD	Rock Quality Designation
RSO	Radiation Safety Officer
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SCFM	Standard Cubic Feet per Minute
SJB	SJB Drilling, Inc.
SLDA	Shallow Land Disposal Area
SLERA	Screening Level Ecological Risk Assessment
SOR	Sum of Ratios
SS	Subsoil

ACRONYMS, FORMULAS, AND SYMBOLS (Con't)

SSHP	Site Safety and Health Plan
SVOC	Semivolatile Organic Compound
TAL	Target Analyte List
TB	Test Boring
TBP	Tributyl Phosphate
TC	Terrain Conductivity
TCA	Trichloroethane
TCE	Trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TEC	United States Army Topographic Engineering Center
TEDE	Total Effective Dose Equivalent
TLD	Thermoluminescent Dosimeter
TOC	Total Organic Carbon
TOX	Total Organic Halogens
TPH	Total Petroleum Hydrocarbons
TPP	Technical Project Planning
TWSP	Temporary Waste Sampling Point
UCL	Upper Confidence Limit
UF	Upper Freeport
UNSCLEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
URS	URS Corporation
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USDOT	United States Department of Transportation
USGS	United States Geological Survey
UTL	Upper Tolerance Limit
VOC	Volatile Organic Compound
µCi	microCurie
µg	microgram

ACRONYMS, FORMULAS, AND SYMBOLS (Con't)

$\mu g/m^3$	microgram per cubic meter
μm	micrometer
μR/h	microRoentgens per hour
μrad/hr	micro rad per hour

Shallow Land Disposal Area

Remedial Investigation Report

EXECUTIVE SUMMARY

INTRODUCTION

The Shallow Land Disposal Area (SLDA) site is located in Parks Township, Armstrong County, Pennsylvania, about 23 miles (37 kilometers) east-northeast of Pittsburgh, Pennsylvania. The 44-acre site (18 hectares) includes ten trenches containing an estimated 23,500 to 36,700 cubic yards (18,000 to 28,000 cubic meters) of potentially contaminated waste and soil.

The SLDA was created for the disposal of uranium-contaminated waste generated by Nuclear Materials and Equipment Company (NUMEC), between 1961 and 1970. NUMEC's mission was to convert enriched uranium to naval reactor fuel. NUMEC operated the nearby Apollo nuclear fuel fabrication facility in the late 1950s. The waste from this facility was disposed of in trenches at the SLDA in accordance with the United States Atomic Energy Commission (AEC) regulation in effect at the time, 10 CFR 20.304 (this regulation was rescinded in 1981).

In 1967, the Atlantic Richfield Company (ARCO) bought NUMEC stock. In 1970, NUMEC discontinued use of the SLDA for radioactive waste disposal. In 1971, ARCO sold the stock of NUMEC to the Babcock & Wilcox Company. BWX Technologies, Inc. (BWXT) became the owner of the site in 1997. Until 1995, the SLDA site was included under a license issued by the United States Nuclear Regulatory Commission (NRC) for the adjacent Parks nuclear fuel fabrication facility (SNM-414). In 1995, to facilitate the decommissioning of the Parks facility, the SLDA site was issued a separate license (SNM-2001). BWXT is the current licensee for the site and is responsible for compliance with the terms and conditions of NRC License SNM-2001.

AUTHORITY

The RI for the SLDA site is issued pursuant to authority established in §8143 of the Fiscal Year 2002 Defense Appropriations Act, Public Law 107-117, which directs the Secretary of the Army, acting through the Chief of Engineers, to clean up radioactive waste at the SLDA site, consistent with a 2001 Memorandum of Understanding (MOU) between the United States Army Corps of Engineers (USACE, the Corps) and NRC.

In July of 2001, the USACE and the NRC signed the MOU between the agencies to minimize dual regulation and duplication of regulatory requirements at Formerly Utilized Sites Remedial Action Program (FUSRAP) sites with NRC-licensed facilities, such as the SLDA. The MOU applies to USACE response actions that meet the decommissioning requirements of 10 CFR 20.1402, "Radiological Criteria for Unrestricted Use." These decommissioning requirements specify that the annual radiation dose to an average member of the critical group of the general public not exceed 25 millirem per year (mrem/year), and that the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA).

Based on the 2002 legislation cited above and in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process, this RI has been performed at the SLDA site, to investigate radiological contamination at the site associated with the Nation's early atomic energy program.

SITE DESCRIPTION

The trenches located on the SLDA site are actually a series of disposal pits located close to each other, giving the general appearance of trenches. The area covered by these trenches is approximately 1.2 acres (0.49 hectares). The term "trench" is used in this report to describe these disposal pits for consistency with previously reported information for the site. The waste disposal area is separated into two general areas; one area containing Trenches 1 through 9 (referred to as the upper trench area) and a second area comprised of Trench 10. The land slopes downward from the southeast (Trenches 1 through 9) toward the northwest (Trench 10), describing a change in elevation of approximately 115 feet (35 meters) over a distance of approximately 1,000 feet (310 meters, see Figure 1-2).

The SLDA is predominantly an open field, with wooded vegetation along most of the northeastern boundary and in the southeastern and southern corners. A small, intermittent stream, identified as Dry Run, collects surface runoff from the site and from several groundwater seeps located along the hillside. A portion of the flow in Dry Run infiltrates through the coal mine spoils in the vicinity of Trench 10 and into the abandoned coal mines that underlie the majority of the site. The balance of Dry Run flow continues off site, northwest to the Kiskiminetas River.

Land use surrounding the SLDA site is mixed, consisting of medium-sized residential communities and individual rural residences, small farms with croplands and pastures, idle farmland, forestlands, and light industrial areas. The closest community is Kiskimere, which is adjacent to and to the south of the SLDA. Some residences within this community are located within several hundred feet of the SLDA.

INVESTIGATIVE LIMITATIONS

The trench locations described in this document are defined by outlines created during geophysical investigations conducted by the site owners in the 1980s and 1990s. However, the limiting physical characteristics of subsurface soils and the lack of a detailed and complete historical disposal record create significant uncertainty in the exact locations, size and shape of each trench. Trench outlines shown in Figure 1-2 are the best available estimates of the shapes and locations, and were used as guides for this investigation.

INVESTIGATIVE METHODS, TOOLS AND ACTIVITIES

The Corps conducted its RI field investigations at the site from August 2003 to January 2004. Prior to this field work, in-depth historical records searches and analyses were conducted as well as detailed interviews with individuals familiar with disposal operations at the SLDA. To conduct the RI, and to more accurately determine the current nature and extent of radiological contamination on the site, the Corps evaluated historical data from previous investigations, conducted extensive field sampling, and completed a baseline risk assessment which identified the risks to human health and the environment regarding the historical radiological AEC-related contamination at the site.

A wide variety of wastes were placed in the trenches, in a highly heterogeneous manner. It also appears that the individual pits were separated by about 6 feet (1.8 meters), and following placement in the pits, the waste materials were covered with about 4 feet (1.2 meters) of clean soil, as specified in 10 CFR 20.304 (the AEC regulation in effect at the time).

As part of the RI field investigations, the Corps sampled surface and subsurface soils, trench waste, five groundwater-bearing geologic units, sediment, surface water, and groundwater seeps. In addition, the air in the work zone and at the site perimeter was monitored. Follow-up field efforts were performed in May and June 2004 to collect further groundwater, surface water, sediment, and seep data. The execution and results of these activities to date are presented and evaluated in this comprehensive RI report.

FIELD SAMPLING RESULTS

Field sampling conducted during the RI shows that the primary radioactive contaminants at the site are uranium and thorium. Uranium is the radioactive element of most concern at the SLDA and the uranium-contaminated materials present in the trenches exhibit a wide range of enrichments, ranging from less than 0.2 percent (by weight) U-235 to greater than 45 percent U-235. The uranium isotopes of concern at the site are those associated with natural uranium, i.e., U-234, U-235, and U-238.

The information developed for the RI report indicates that the radioactive contaminants at the site are generally confined to the immediate vicinity of the trenches. While isolated pockets of radiological surface and subsurface soil contamination are present at the site, sampling of air, surface water, sediment, and groundwater show no elevated levels of radionuclides migrating from the site.

Soil Sampling – Surface and Subsurface

During the RI, the Corps found little evidence of radiological soil contamination outside the general area of the trenches. The only exceptions are localized areas of contaminated soil in the vicinity of Trench 10. The concentrations of radioactive contaminants in most soil samples outside the trenches were generally comparable to background levels.

The localized radiological soil contamination near Trench 10 is reportedly due to contaminated equipment, from the former Parks nuclear fuel fabrication facility, which was temporarily stored near Trench 10. These localized areas of surface soil nearby Trench 10 contain elevated concentrations of plutonium (Pu-239 and Pu-241) and americium-241 (Am-241); however, these transuranic radionuclides were not found at depth during the recent field investigations.

> **Soil Contamination**
>
> U-234 was generally the radionuclide that had the highest concentrations in soil, which is indicative of enriched uranium. There were also isolated areas near Trench 10, which show elevated concentrations of americium and plutonium isotopes in surface soil.
>
> - The maximum surface soil concentrations measured at the SLDA site were for Am-241 (320 pCi/g), Pu-239 (325 pCi/g), and Pu-241 (628 pCi/g) by Trench 10;
> - The maximum subsurface soil concentration was for U-234 (508 pCi/g) in the upper trench area, and the maximum sediment concentration in Dry Run was 29 pCi/g for U-234, and is located within the site boundaries.

Waste materials were detected in trench borings at depths from 4 to 14 feet (1.2 to 4.3 meters) below ground surface. Analyses of these wastes showed the presence of U-234, U-235, and U-238 in concentrations exceeding background levels and preliminary remediation goals (PRGs) developed for the site. The PRGs are the concentrations of radionuclides in soil that would result in an annual radiation dose of 25 mrem/year under a conservative (Subsistence Farmer) scenario. Based on waste disposal records, elevated concentrations of Th-232 and Ra-228 are also expected to be present in these wastes.

Surface Water, Sediment, and Groundwater Sampling

Surface water in Carnahan Run (off-site) was determined to be uncontaminated, while low levels of radioactive contamination were identified in surface water in Dry Run and in groundwater seeps within the upper trench area. This indicates that the radioactive wastes in the trenches (or previous site activities) may be impacting on-site surface water and sediment in Dry Run. Such impacts were not observed at off-site sampling locations. Groundwater at the site, outside of perched areas within the trenches, does not appear to be contaminated, other than a localized area in the upper water-bearing zone downgradient of Trenches 1 and 2. Some low levels of radioactive contamination were identified at this location, which may be associated with the radioactive wastes in these two trenches.

These current conditions are not expected to remain indefinitely, and over time radionuclides present in the trenches would be expected to gradually leach to percolating water and reach groundwater. The upper shallow bedrock water-bearing zone in the upper trench area is the groundwater system of most concern, and potential contamination of this zone was considered in development of the PRGs. Due to the complex hydrogeology at this area, groundwater monitoring is the only accurate means of determining groundwater conditions at the site.

Human Health Baseline Risk Assessment (BRA)

A human health baseline risk assessment (BRA) was performed consistent with United States Environmental Protection Agency (EPA) risk assessment guidance to support the determination of appropriate actions for the site. The assessment was limited to the radioactive contaminants at the SLDA, consistent with the authorizing legislation for the site. The chemical toxic effects of these radioactive contaminants were considered in this assessment, specifically for uranium, which is chemically toxic to the kidney.

The SLDA site was divided into three exposure units (EUs) to support the risk assessment process. These EUs were based on environmental conditions, historical uses of specific areas, reasonableness of size in terms of representing receptor behavior, geographical similarity, and contamination potential. These three EUs address the upper trench area, the lower trench area, and an area near the fence, southeast of the upper trench area.

The first step in the risk assessment process, was to identify preliminary Radionuclides of Potential Concern (ROPCs) for the SLDA based on historical uses of the site (specifically the radiological characteristics of the wastes buried in the trenches) and previous characterization activities. The Corps divided these preliminary ROPCs into primary ROPCs and secondary ROPCs, and this designation was used to focus site characterization activities and develop the Sampling and Analysis Plan (SAP) for the site.

The primary ROPCs are those radionuclides expected to be present at the site in concentrations posing a potential risk concern. The primary ROPCs for the SLDA site were: Am-241, Pu-239, Pu-241, Ra-228, Th-232, U-234, U-235, and U-238. The secondary ROPCs are those radionuclides not expected to be present at concentrations posing a potential risk concern, but may be present at the site based on historical information and activities conducted at the adjacent Parks facility. These secondary ROPCs were addressed for completeness in the RI conducted for the site and were determined to be: Co-60, Cs-137, Pu-238, Pu-240, Pu-242, Ra-226, and Th-230.

Elevated concentrations of the secondary ROPCs were detected infrequently during site characterization activities, and the detections that did exceed background were not significantly elevated (all of the values were less than twice background). The secondary ROPCs were eliminated from quantitative assessment in the BRA based on the low frequency of detection and the reported low concentrations. Therefore, the quantitative evaluation of risks in the BRA was limited to the eight primary ROPCs.

The results of the human health BRA indicate that the SLDA site presents very little risk to human health under current conditions. The site is currently vacant and surrounded by a security fence that is actively maintained. However, these conditions cannot be guaranteed in perpetuity, and over time the radionuclides in the trenches would be expected to gradually leach to groundwater. The SLDA is also susceptible to subsidence from collapse of the abandoned mine workings beneath the site.

Current information indicates that there is little radiological soil contamination outside the footprints of the ten trenches, and the radionuclides that are present at those isolated areas pose very little current or future risk. However, the previously disposed of wastes within the trenches contain significant concentrations of radioactive contaminants (in excess of the PRGs developed for soil), and these materials could pose a potential risk to human health in the future. A screening-level calculation of the risks associated with these materials was included in the BRA, and the carcinogenic risk to the Subsistence Farmer was calculated to be 3×10^{-3} using the results of the samples obtained from the trenches in the recent characterization program. This risk increases to 1×10^{-2} if the results are limited to the 13 samples that had field-screening evidence of waste. The hazard index (HI) exceeds one for both situations, and the corresponding annual doses are approximately 300 and 900 mrem/year, well in excess of the annual dose limit identified for release of this site, i.e., 25 mrem/year. These results confirm that the concentrations of radionuclides in the buried wastes are high enough to present a potential future risk to human health, and remedial action alternatives for these materials should be developed and evaluated.

Screening-Level Ecological Risk Assessment (SLERA)

A screening-level ecological risk assessment (SLERA) was performed in order to determine the potential for adverse ecological effects to occur from exposures to radionuclides at the SLDA in the absence of remedial actions. The SLERA was performed using the United States Department of Energy's (DOE's) graded approach for ecological risk assessments, utilizing established biota dose limits. The dose limits used in the SLERA are 1 radiation absorbed dose per day (rad/d) for aquatic animals, 1 rad/d for terrestrial plants, and 0.1 rad/d for terrestrial animals. These biota dose limits were developed by the National Council on Radiation Protection and Measurements (NCRP) and International Atomic Energy Agency (IAEA).

The maximum detected concentrations of radionuclides in soil, sediment, and surface water were used to calculate the sum of ratios (SORs) for the three ecological EUs considered for the site (one terrestrial and two aquatic). The SORs ranged from 0.3 to 0.5 for the three EUs, meaning that the biota dose limits are not exceeded. It was also determined that there is little potential for unacceptable risk to ecological receptors due to the chemical toxic effects of uranium at the site. Since the results of this conservative assessment indicate that the radionuclides at the SLDA do not pose a potential risk to ecological receptors, the SLERA was completed at the first, screening stage, and no further evaluation of the potential risks to ecological receptors is warranted. Potential environmental impacts from implementing various remedial action alternatives will be addressed during preparation of the Feasibility Study (FS).

MAJOR CONCLUSIONS

The Radionuclides of Concern (ROCs) for the SLDA are the eight primary ROPCs, i.e., Am-241, Pu-239, Pu-241, Ra-228, Th-232, U-234, U-235, and U-238. Elevated concentrations of secondary ROPCs were present in only a small percentage of the samples, and these concentrations did not exceed background by a significant amount (all of the values were less than twice background). In addition, the elevated levels reported for the secondary ROPCs appear to be generally collocated with elevated levels of the primary ROPCs (which would be expected based on the operating history of the site), so remediating the SLDA for the primary ROPCs would also result in cleanup of any secondary ROPCs that may be present.

Most of the radioactive contamination is associated with the upper trench area (in the wastes disposed of in Trenches 1 through 9), and the major radionuclides in this portion of the site are the three uranium isotopes (U-234, U-235, and U-238), Ra-228, and Th-232. Of the three uranium isotopes, U-234 has the highest concentration, which is indicative of enriched uranium. Very little radioactive contamination is associated with Trench 10, and this is the only area of the site that appears to be significantly contaminated with Am-241, Pu-239, and Pu-241. While the sampling results provide evidence to support the contention that some radionuclides may only be present at specific areas of the site, all eight of the primary ROPCs are being retained as ROCs for all portions of the site. This will ensure that cleanup of the SLDA is conducted in a thorough manner and will result in conditions that are fully protective of human health and the environment. Efforts will continue during preparation of the FS to determine if it is possible to further focus individual ROCs to specific portions of the site.

NEXT STEPS

Based on the findings identified in this RI report, the Corps is initiating the preparation of an FS and will be evaluating alternatives to address radioactive contamination at the site to ensure safe future use of the site and that the site complies with the 25 mrem/year annual dose limit for unrestricted use identified in 10 CFR 20.1402. Additional remedial action objectives include complying with other applicable laws and regulations and conducting remedial actions in a manner that would minimize public and worker exposures to site-related radiological contaminants. The Corps will also address potential impacts to environmental receptors and other resources in the FS.

FINAL

REMEDIAL INVESTIGATION REPORT
SHALLOW LAND DISPOSAL AREA SITE
PARKS TOWNSHIP, ARMSTRONG COUNTY, PENNSYLVANIA

1.0 INTRODUCTION

The Shallow Land Disposal Area (SLDA) site is located in Parks Township, Armstrong County, Pennsylvania, about 23 miles (37 kilometers) east-northeast of Pittsburgh, Pennsylvania (Figure 1). The 44-acre site (18 hectares) includes nine trenches and a backfilled settling pond (referred to as Trench 3) containing between an estimated 23,500 and 36,700 cubic yards (18,000 to 28,000 cubic meters) of potentially contaminated waste and soil. The total trench surface area is approximately 1.2 acres (0.49 hectares). The trenches are separated into two general areas: one area containing Trenches 1 through 9 and a second area containing Trench 10. The land slopes downward from the southeast (Trenches 1 through 9) toward the northwest (Trench 10), with a change in elevation of approximately 115 feet (35 meters) over a distance of approximately 1,000 feet (310 meters). Figure 1-2 presents the Site Plan illustrating site characteristics.

The SLDA is predominantly an open field, with wooded vegetation along most of the northeastern boundary and in the southeastern and southern corners. A small, intermittent stream, identified as Dry Run, collects surface runoff from the site and from several groundwater seeps along the hillside. A portion of the flow in Dry Run infiltrates through the coal mine spoils in the Trench 10 area and into the abandoned coal mines that underlie the majority of the site, including Trenches 1 through 9. The balance of Dry Run flow continues off site, northwest to the Kiskiminetas River.

Land use surrounding the SLDA site is mixed, consisting of medium-sized residential communities and individual rural residences, small farms with croplands and pastures, idle farmland, forest lands, and light industrial areas. The closest community is Kiskimere, which is adjacent to and to the south of the SLDA. Some residences within this community are located within several hundred feet of the SLDA.

Uranium-contaminated wastes were disposed of at the SLDA by the Nuclear Materials and Equipment Company (NUMEC) between 1961 and 1970. The disposal of that waste was done in accordance with the United States Atomic Energy Commission (AEC) regulation in effect at the time, 10 CFR 20.304. Contaminated waste originated from the nearby Apollo nuclear fuel fabrication facility, which began operations under NUMEC in the late 1950s and converted enriched uranium to naval reactor fuel. In 1967, the Atlantic Richfield Company (ARCO) bought the stock of NUMEC. In 1970, NUMEC discontinued use of the SLDA for radioactive waste disposal. In 1971, ARCO sold the stock of NUMEC to the Babcock & Wilcox Company. BWX Technologies, Inc. (BWXT) became the owner of the site in 1997. BWXT is the current licensee for the site and is responsible for compliance with the terms and conditions of the United States Nuclear Regulatory Commission (NRC) License SNM-2001.

In the Energy and Water Development Appropriations Act, 1998 (Title I, Public Law 105-62, 111 Stat. 1320, 1326), Congress transferred the responsibility for the administration and execution of cleanup at eligible Formerly Utilized Sites Remedial Action Program (FUSRAP) sites to USACE. In the Energy and Water Development Appropriations Act, 2000 (Title VI, Public Law 106-60, 113 Stat. 483, 502), Congress indicated that any response action taken under the FUSRAP program by the Secretary of the Army, Acting through the Chief of Engineers, shall be subject to the process outlined in Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

In March of 1999, USACE and DOE signed a Memorandum of Understanding (MOU) between the agencies for the purpose of delineating the administration and execution of responsibilities of each party for the FUSRAP. Pursuant to that MOU, when a new site is considered for inclusion in the FUSRAP, DOE is responsible for performing historical research to determine if the site was used for activities that supported the Nation's early atomic energy program. If DOE concludes that the site was used for that purpose, the agency will provide USACE with that determination.

On May 25, 2000, after performing historical research regarding the SLDA, the DOE provided USACE with a determination that the site contains wastes resulting from activities that supported the Nation's early atomic energy program. In November 2000, as a result of DOE's determination and Congress' direction, USACE included the SLDA in the FUSRAP and referred the site to the Great Lakes and Ohio Rivers Division for action. In accordance with the CERCLA process, a Preliminary Assessment was performed and released in March 2002. This Preliminary Assessment recommended no further action at the site under FUSRAP, due to the absence of an unpermitted release, as defined by CERCLA. However, this recommendation was superceded by Section 8143, Department of Defense Appropriations Act, 2002, P. L. 107-117, which states:

"(a) ACTIVITIES UNDER FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM. – Subject to subsections (b) through (e) of section 611 of Public Law 106-60 (113 Stat. 502; 10 U.S.C. 2701 note), the Secretary of the Army, acting through the Chief of Engineers, under the Formerly Utilized Sites Remedial Action Program shall undertake the functions and activities specified in subsection (a) of such section in order to –

(1) clean up radioactive contamination at the Shpack Landfill site located in Norton and Attlebor, Massachusetts; and
(2) clean up radioactive waste at the Shallow Land Disposal Area located in Parks Township, Armstrong County, Pennsylvania, consistent with the Memorandum of Understanding Between the United States Nuclear Regulatory Commission and the United States Army Corps of Engineers for Coordination on Cleanup and Decommissioning of the Formerly Utilized Sites Remedial Action Program (FUSRAP) Sites with NRC-Licensed Facilities, dated July 5, 2001.

(b) SPECIAL RULES REGARDING SHALLOW LAND DISPOSAL AREA – The Secretary of the Army shall seek to recover response costs incurred by the Army Corps of Engineers for cleanup of the Shallow Land Disposal Area from appropriate responsible parties in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 U.S.C. 9601 et seq.). The Secretary of the Army and the Corps of Engineers shall not, by virtue of this cleanup, become liable for the actions or omissions of past, current, or future licensees, owners, or operators of the Shallow Land Disposal Area.

(c) FUNDING SOURCES – Amounts appropriated to the Army Corps of Engineers for fiscal year 2001 and subsequent fiscal years and available for the Formerly Utilized Sites Remedial Action Program shall be available to carry out this section."

In July of 2001, the USACE and the NRC signed a Memorandum of Understanding (MOU) between the agencies to minimize dual regulation and duplication of regulatory requirements at FUSRAP sites with NRC-licensed facilities, such as the SLDA. The MOU applies to USACE response actions that meet the decommissioning requirements of 10 CFR 20.1402, "Radiological Criteria for Unrestricted Use."

Based on the 2002 legislation cited above and in accordance with the CERCLA process, a remedial investigation (RI) has been performed at the SLDA site, to investigate radiological contamination associated with the Nation's early atomic energy program. This RI will be followed by a feasibility study (FS), which will describe and evaluate remedial alternatives, and a proposed plan, which will present the recommended alternative.

1.1 Purpose of the Remedial Investigation Report

The RI was conducted to investigate radiological contamination at the SLDA site associated with the Nation's early atomic energy program. The primary purpose of the RI report is to document the data collection and analysis activities and report the results of the site Baseline Risk Assessment. Results of these activities and the site assessment will be used to assess the need for remediation at the site and to determine whether or not data are sufficient to support the evaluation of remedial alternatives in a Feasibility Study. This RI report will be included in the project Administrative Record.

1.2 Remedial Investigation Overview and Scope

The primary objective of the comprehensive RI was to collect data of sufficient quantity and quality to define the nature and extent of on-site contamination and evaluate the risk posed by current and future site conditions to human health and the environment.

Initial planning for the RI at the SLDA began in 2002 with a historical records search and a Data Gap analysis. A surficial gamma radiation walkover survey and a historical aerial photograph analysis were subsequently completed in June 2003. These activities were performed in support of the development of the final Sampling and Analysis Plan (SAP) for the site (USACE 2003a and 2003b). The overall goals of the RI were developed and stated in site-specific project goals and data quality objectives, which were included in the SAP.

Intrusive field investigations were performed between August 2003 and January 2004 and are described in Section 3.0 of this document. These investigations included the sampling of surface and subsurface soils, trench waste, five groundwater-bearing geologic units, sediment, surface water, groundwater seeps, and work zone and perimeter ambient air.

Follow-up field efforts were performed in May and June 2004 to collect further groundwater, surface water, sediment, and groundwater seep data and to address technical problems associated with the Flexible Liner Underground Technology (FLUTe) multi-port, groundwater monitoring systems. Data from these sampling events were analyzed and validated following guidance cited in Section 3.0 of this document.

The execution and results of these activities are presented and evaluated in this comprehensive RI report. Historical data from previous investigations at the site are also evaluated to convey more accurately the current nature and extent of contamination on the site.

1.3 Report Organization

This RI report was prepared in accordance with United States Environmental Protection Agency (EPA) guidance and the recommended format (EPA 1998), with further guidance from work plans developed by the USACE, Buffalo District. The report consists of Sections 1.0 through 9.0 and associated tables, figures, and appendices. Section 1.0 describes the purpose and organization of this report.

Section 2.0 describes the history of the SLDA site, including an overview of previous investigations and remediation efforts. The objective of Section 2.0 is to provide a backdrop against which human health and environmental impacts may be evaluated. The historical summary was compiled from a search of records and photographs associated with the site. Section 2.0 also describes the physical characteristics of the SLDA site, including geography, geology, hydrology, and ecology of the site, surrounding areas, and region, where appropriate.

Section 3.0 summarizes the RI activities completed between August 2003 and June 2004 under direction of the USACE. Specific data objectives, methodology used for data collection and analysis, and the approach to data management are presented in this section as well as methodology used to calculate background activity levels.

The data gathered during the RI, as well as historical data from previous investigations at the site, are used in Section 4.0 as the basis for a discussion of the nature and extent of radiological contamination at the SLDA site. Nature and extent of contamination in soil is evaluated using site-specific background concentrations developed during the RI process and in relation to preliminary remediation goals (PRGs) developed in Section 6.0, Baseline Human Health Risk Assessment.

Section 5.0 includes a fate and transport analysis for on-site contaminants.

Sections 6.0 and 7.0 include the radiological risk assessments for human health and ecological receptors, respectively. Data and evaluations supporting the risk assessments and the uncertainties associated with the risk assessments are also presented in this section.

Section 8.0 summarizes the results and conclusions drawn from the RI and other data relevant to the SLDA site. General recommendations are presented, as well as any data gaps that may need to be addressed. This section also identifies preliminary remedial action objectives.

References used in the preparation of this report are listed in Section 9.0.

The appendices contain data relevant to the RI, including boring and well construction logs, analytical data tables, radiological risk assessment calculations, and RESRAD scenario documentation.

For ease of review and/or use, this document is divided into five volumes:

1. Remedial Investigation Report, Tables, and Figures
2. Appendices A and B (Radiological and Chemical Analytical Data)
3. Appendices C through Q (Current RI Information)

4. Appendices R through AA (Historical RI Information)
5. Appendix BB (Analytical Data Validation Reports).

2.0 SITE BACKGROUND

This section describes the historical activities at the SLDA site, including past disposal operations and environmental investigations, as well as the physical characteristics pertinent to the RI. A brief overview of past license activities is also given. Historical disposal and environmental information was gleaned from documents and statements provided by the site owner, regulatory agencies, and concerned citizens. Environmental and physical site information was confirmed and/or updated with information obtained during the RI.

2.1 Site History

In 1957, the Apollo Nuclear Fabrication Facility began operations in Apollo, Pennsylvania, under AEC license No. SNM-145. From 1957 to 1962, the Apollo Facility was used for small-scale production of high and low enriched uranium and thorium fuel. By 1963, the majority of the Apollo Facility was dedicated to continuous production of uranium fuel. Throughout its operation, the Facility converted low enriched uranium hexafluoride to uranium dioxide, which was used as fuel in commercial nuclear power plants. In 1963, a second product line was added to produce highly enriched uranium fuel for United States Navy propulsion reactors. Other operations included analytical laboratories, scrap recovery, uranium storage, and research and development (DOE 1997).

Between 1961 and 1970, NUMEC, who owned both the Apollo Facility and the SLDA, buried process and other wastes from the Apollo facility in trenches at the SLDA site. These wastes were buried in accordance with 10 CFR 20.304, Disposal by Burial in Soil, which was subsequently rescinded in 1981. In 1967, ARCO bought the stock of NUMEC, who subsequently discontinued use of the SLDA for radioactive waste disposal in 1970. In 1971, ARCO sold the stock of NUMEC to the Babcock & Wilcox Company. BWX Technologies, Inc. (BWXT) became the owner of the site in 1997. Although BWXT is the current owner, ARCO retains environmental liability for the SLDA site.

2.1.1 Waste Characteristics

Uranium-and thorium-contaminated wastes consisting of process wastes, equipment, scrap, and trash from the nearby Apollo nuclear fuel fabrication facility were disposed of in the SLDA between 1961 and 1970. The uranium in the trenches is present at various levels of enrichment, from depleted to high enriched. Activity percentages indicate levels of enrichment from less than 0.2 percent U-235 to greater than 45 percent U-235, by weight. Americium (Am-241) and plutonium (Pu-239 and Pu-241), whose presence is attributed to the storage of equipment used at the Parks Facility, have been detected in soils in the Trench 10 area.

The disposals were conducted according to AEC regulations, 10 CFR 20.304, by NUMEC, which began fabricating nuclear fuel at the Apollo facility in 1957. The Apollo Facility processed uranium and, to a lesser extent, thorium. Processing operations included the conversion of uranium hexafluoride (UF_6) to uranium dioxide (UO_2) by the ammonium diuranate process and subsequent metallurgical and ceramic processes to produce uranium products and fuel components. Typical products included uranium (U) metal, UO_2, UC, UC_2, ThO_2, ThO_2-UO_2, and UC-ThC produced as sintered pellets, powder, and other particulate forms. Process wastes, including off-specification products and incinerated high-efficiency particulate air (HEPA) filters and rags, were recycled in a nitric acid solvent extraction scrap recovery process to recover usable uranium. The Apollo plant processed uranium at a capacity of 350 to 450 metric tons per year (ARCO, 1995).

The waste types consisted of process wastes (slag, crucibles, spent solvent, unrecoverable sludges, organic liquids, debris, etc.), laboratory wastes (sample vials, reagent vials, etc.), old or broken equipment, building materials, protective clothing, general maintenance materials (paint, oil, pipe, used lubricants, solvents [trichloroethene, methylene chloride], etc.), and trash (shipping containers, paper, wipes, etc.). Beryllium wastes were also present as beryllium-uranium scrap solutions and zirconium-beryllium waste. Some of the wastes were stored in cardboard and metal drums, some were bagged, and some, particularly pieces of equipment and building materials, were placed in trenches with no special packaging or containers (ARCO, 1995). The waste volume in the trenches has been estimated to be between 23,500 and 36,700 cubic yards (18,000 to 28,000 cubic meters, ARCO, 1995, 2002). Table 2-1 presents a description of materials placed into the disposal trenches based on information provided by ARCO.

Preliminary Radionuclides of Potential Concern (ROPCs) were developed for the SLDA based on historical uses (specifically the radiological characteristics of the wastes buried in the trenches) and the previous characterization activities discussed in Section 2.2. These preliminary ROPCs were divided into primary ROPCs and secondary ROPCs, and this designation was used to focus site characterization activities and develop the Sampling and Analysis Plan (SAP).

The primary ROPCs are those radionuclides expected to be present at the site in concentrations posing a potential risk concern. Uranium isotopes and Th-232 were present in wastes generated at the Apollo facility, disposed of at SLDA, and detected in historical soil samples collected from SLDA. Am-241, Pu-239, and Pu-241 were present in materials processed at the adjacent Parks nuclear fuel fabrication facility and were also reported in soil samples previously collected from SLDA. Ra-228 is present due to radionuclide ingrowth (from Th-232) and was detected in previous SLDA soil samples. Therefore, the primary ROPCs for the SLDA site are: Am-241, Pu-239, Pu-241, Ra-228, Th-232, U-234, U-235, and U-238.

The secondary ROPC list included those radionuclides considered likely to be present based on historical information, previous SLDA sampling, and activities conducted at the adjacent Parks facility. These radionuclides are not expected to be present at concentrations posing a potential risk concern, but were addressed for completeness. These secondary ROPCs were determined to be: Co-60, Cs-137, Pu-238, Pu-240, Pu-242, Ra-226, and Th-230.

2.1.2 License Activities

BWXT held a NRC license (SNM-414) for their Parks Township Operations Facilities, which, until 1995, included the area now defined as the SLDA. In 1995, the SLDA was given a separate license (SNM-2001), in order to expedite decommissioning activities at the Parks Facility. Following findings of SLDA-related contamination on Parks Facility property during a confirmatory survey, BWXT was granted an amendment to SNM-2001 in March 2002. This amendment added an approximately 12-acre area (4.9 hectares), formerly part of the SNM-414 license, to the southeastern edge of the SLDA (SNM-2001).

2.2 Previous Investigations

This section provides a description of past studies completed at the SLDA site and the types of data collected. Much of the information presented is organized by media. A summary of how the data were collected and the testing completed on each type of media is presented in Appendices S through Y. Evaluation of the data, including a discussion of nature and extent of contamination, is presented in Section 4.0, Nature and Extent of Contamination.

A limited amount of information on chemical contaminants was obtained during previous site investigations. Statistical summary tables of sampling data collected during previous investigations and the RI program are presented in Appendix B. Since Public Law 107-117, Section 8143 directs the USACE to clean up radioactive wastes at SLDA, only radiological testing results are discussed in this RI report. The purpose of the chemical testing data is to support disposal decisions for IDW; therefore, these data are included for information purposes only.

2.2.1 Summary of Previous Investigations and Remediation Work

The NRC docket for the SLDA site was reviewed to identify existing documents and reports potentially relevant to the RI requirements. These documents, including reports associated with previous field investigations and soil remediation projects, were provided by ARCO/Babcock & Wilcox (B&W), USACE, Pennsylvania Department of Environmental Protection (PADEP), NRC, and local residents/former employees. The information presented in this section reflects the total of all identified relevant information related to previous investigations and remediation work completed prior to the RI.

Numerous field investigations have been completed at SLDA over the past two decades. These investigations focused on radiological and chemical contamination potentially impacting the environment from past site operations with special emphasis on the ten disposal trenches. The following is a chronological listing of the major field investigation reports completed for the SLDA site:

- *Radiological Assessment of the Parks Township Burial Site (Babcock & Wilcox) Leechburg, Pennsylvania*, Oak Ridge Associated Universities (ORAU), 1982.
- *Survey of Remediated Areas – Babcock and Wilcox Parks Township Burial Site*, *Leechburg, Pennsylvania,* Oak Ridge Associated Universities, 1987.
- *Survey of Remediated Areas – Babcock and Wilcox Parks Township Burial Site, Leechburg, Pennsylvania*, Oak Ridge Associated Universities, 1990.
- *Parks Shallow Land Disposal Facility Site Characterization Report*, ARCO/B&W, 1995.
- *1995 Field Work Report,* ARCO/B&W, 1996.
- *Inspections 07000364/2000002 and 07003085/2001001, BWXT Services, Inc., Parks Township Facility, and Shallow Land Disposal Area, Vandergrift, Pennsylvania*, NRC, 2001 (field investigations completed by Oak Ridge Institute for Science and Education [ORISE]).

Table 2-2 summarizes the various site investigations completed at the SLDA site with an indication of the sample analyses performed on the various media (soil, groundwater, etc.) both on-site and off-site. Data gathered during these investigations were reviewed by the project team to evaluate whether these data were appropriate for identification of data gaps, determining the nature and extent of contamination, or for risk assessment. Historical data were generally deemed appropriate for data gap analysis and determining nature and extent of contamination; however, were not used for risk assessment purposes. A very limited amount of historical data was not usable for either purpose due to a variety of reasons including absence of locational data and samples collected of soils that were subsequently removed from the site through surface soil remediation.

Historical data considered usable for nature and extent purposes and data generated during the RI were entered into a geographic information system (GIS) database in accordance with the USACE document, “Policies, Guidance, and Requirements for Geospacial Data Systems”, ER 1110-1-8156 (USACE, 1996b). In addition, these data are presented in figures generated using Environmental Systems Research Institute, Inc. (ESRI) software. These figures are found in Sections 2.0, 3.0, and 4.0 of this report. Radiological and chemical analytical data generated during previous investigations are presented in tabular form in Appendices A and B, respectively.

The reports and data associated with major field investigations were reviewed and the following summaries were prepared to document sample collection activities and historical data:

- Summary of Historical Surface Soils Sampling (Appendix S)
- Summary of Historical Subsurface Soils Sampling (Appendix T)
- Summary of Historical Groundwater Sampling (Appendix U)
- Summary of Historical Surface Water, Sediment, and Groundwater Seep Sampling (Appendix V)
- Summary of Historical Trench Contents Sampling (Appendix W)
- Summary of Historical Biota Sampling (Appendix X)
- Summary of Historical Background Sampling (Appendix Y)

Each summary discusses the details of sample collection and analytical results. Section 4.0 of this report, Nature and Extent of Contamination, provides all site data (both historical and RI data) on figures and tables as well as a discussion of the nature and extent of radionuclides in site media.

2.2.2 Gamma Survey Results

External gamma radiation levels were measured at the ground surface during a gamma walkover survey completed by Oak Ridge Associated Universities in 1981 (ORAU, 1982). Large portions of the upper trench and lower trench areas were gridded and gamma radiation measurements were taken by traversing the site in a straight-line fashion with 4.9 foot (1.5 meter) spacing between measurements. In addition, external gamma radiation levels were measured at 50 foot (15 meter) spacing within the gridded areas at elevations of 0.39 inches (1 centimeter) and 3.3 feet (1 meter) above ground surface. Figure 2-1 illustrates the two areas where the gamma survey was conducted.

The exposure rates measured systematically 3.3 feet (1 meter) above ground surface at grid points located in the lower trench area ranged from 9 to 14 microRoentgens per hour (μR/h); the average exposure rate was 11 μR/h. Exposure rates measured systematically on contact with the ground surface at grid points located in the lower trench area ranged from 8 to 15 μR/h with an average of 11 μR/h. The walkover surface scan identified several locations with contact exposure rates greater than 20 μR/h with a maximum level of 670 μR/h.

The lower trench beta-gamma surface dose rates at grid points ranged from 11 to 51 microrads per hour (μrad/hr) with an average of 29 μrad/hr. There was a lack of any significant difference between the open and closed-shield measurements, which indicated a negligible beta component.

In the upper trench area, the exposure rate measured systematically one meter above ground surface at grid points ranged from 6 to 19 μR/h with an average exposure rate of 11 μR/h. Exposure rates measured systematically on contact with the ground surface at grid points located in the upper trench area ranged from 6 to 32 μR/h with an average of 11 μR/h. The walkover surface scan identified numerous locations, primarily south of the upper trenches, with elevated contact exposure rates and a maximum exposure rate of 1,300 μR/h. However, it should be noted that the vast majority of the surface soils where these elevated exposures were measured were removed during the remediation work completed in 1986 and 1989.

The upper trench area beta-gamma surface dose rates at grid points ranged from 8 to 54 μrad/hr with an average of 27 μrad/hr. There was a lack of any significant difference between the open and closed-shield measurements, which indicates a negligible beta component.

2.2.3 Soil Remediation Work Completed by B&W

In 1986 and 1989, B&W completed surface soil remediation in areas where elevated uranium concentrations were detected during the radiological assessment completed in 1981 (ORAU, 1987, 1990). Figure 2-2 illustrates the approximate limits of surface soil remediation completed by B&W. There was no documentation available summarizing the actual site remediation; however, the results of confirmation soil sampling programs were included in the reports and the remediated areas were inferred. As a result, surface soil data collected within these remediated areas prior to 1986 are no longer representative of site conditions, as the soil has been removed. Therefore, these sample results are not included in the data set used in this report describing the distribution of radionuclides in soils (refer to Section 4.0, Nature and Extent of Contamination). Specific sample locations removed from the database are discussed in Section 2.2.5.

2.2.4 Geophysical Survey Results

2.2.4.1 Surface Geophysical Survey Results

Geophysical surveys were conducted at the SLDA site in 1981 during the radiological assessment completed by ORAU and in 1992 and 1993 during the Site Characterization completed by ARCO/B&W.

In 1981, ORAU subcontracted the services of Geo-Centers, Inc. (Geo-Centers) to complete a ground penetrating radar (GPR) survey to delineate the location of the disposal trenches and to identify the locations and depths of subsurface objects (ORAU, 1982). The survey area was limited to the areas designated by ORAU in the upper and lower trench areas (illustrated in Figure 2-1). In addition to the radar measurements, selected bulk soil resistivity measurements were made to aid in the selection of the best GPR system parameters and estimate the depth of penetration into the site geology. The results of the GPR survey identified areas that appear to be disturbed or showed distinct boundaries that are indicated on the report figures as the probable trench locations. In addition to the probable trench locations, numerous individual targets were clearly discernible. These targets were primarily located south of the trenches in the area where the trench exhumation stockpiling reportedly occurred; this area was subsequently remediated in 1986 and 1989. However, since there are no reports available documenting the actual remediation activities (such as the extent and nature of materials removed), it is unclear whether these targets were removed during the remediation programs.

In 1992 and 1993, geophysical surveys were performed by Hager-Richter Geoscience, Inc. (Hager-Richter) and Geo-Centers as part of site characterization work. The purpose of the geophysical surveys was to define the locations and depths of the trenches and determine the presence of subsurface metal objects (ARCO/B&W, 1995). The geophysical surveys consisted of three complementary techniques: GPR, magnetometry (MAG), and terrain conductivity (TC). The geophysical survey areas evaluated in 1992 and 1993 are shown in Figure 2-3.

Hager-Richter was retained in 1992 by ARCO/B&W to conduct a GPR survey in the vicinity of the disposal trenches. Both the 300 and 120 megahertz antennas used in this survey produced generally poor penetration and the trench boundaries could not be identified. As a result, after one day of field work, the GPR survey was terminated.

There was no text in the Site Characterization report describing any details of the TC and MAG surveys (ARCO/B&W, 1995). The only information provided for the TC survey was presented in two figures illustrating the results corresponding to the north-south and east-west orientations. Similarly, the only information provided for the MAG survey was in two figures illustrating the results corresponding to the total magnetic field and magnetic gradient. As reported in the Site Characterization report, ARCO/B&W combined the information gathered during the GPR survey completed by Geo-Centers with the results of the TC and MAG surveys to ascertain the trench boundaries.

Multiview Geoservices, Inc. was also retained by ARCO/B&W in 1993 to conduct a GPR survey to delineate the limits of the disposal trenches at SLDA. They conducted a phased geophysical work program, which permitted an incremental evaluation regarding the effectiveness of the pulseEKKO IV radar system at the SLDA site. Several antenna systems were evaluated and calibration measurements were made to tailor the radar system for the SLDA site. Data taken with the 10 megahertz (MHz) antenna indicate a maximum depth of penetration of 15 to 20 feet (4.6 to 6.1 meters). Resolution at this frequency was approximately 12 feet (3.7 meters) and precluded the detection of smaller objects. The 80 MHz antenna offered penetration depths up to 10 to 13 feet (3.1 to 4.0 meters) with an average resolution of 1 to 2 feet (0.31 to 0.62 meters).

According to the findings of the final report prepared by Multiview Geoservices, the radar survey successfully delineated changes in subsurface conditions, which were interpreted as debris filled trenches within the natural soils. Penetration depths of 15 to 20 feet (4.6 to 6.1 meters) were achieved with a resolution of 12 feet (3.7 meters) using the 10 MHz antenna. The spatial position of these inferred trenches generally agreed with the previous interpretations. However, there were aspects of the various interpretations that did not always agree, most notably the interpretations of some of the trench limits. The significance of these notable exceptions is that there is some degree of uncertainty regarding the trench locations and limits at the site.

2.2.4.2 Down-Hole Gamma Survey Results

As part of the Site Characterization program conducted by ARCO/B&W, a down-hole gamma logging program was completed in 36 temporary waste sampling points (TWSPs) installed within the trenches to measure in-situ gamma radiation activity (ARCO/B&W, 1996). The TWSPs were constructed of two-inch internal-diameter (ID) polyvinyl chloride (PVC) screens and risers with the screens wrapped in filter fabric. The TWSPs were installed in the trenches by first driving a steel casing through the trench cover and wastes to bedrock. Although it is not stated in the Site Characterization Report, it is assumed that the driller used a sacrificial point on the end of the casing. The TWSPs were then installed inside the steel casing, which was subsequently removed, exposing the screen to the waste material. This installation method allowed leachate sampling and down-hole gamma measurements in the trenches, but minimized waste generation and the potential for personnel exposure. The locations of trench TWSPs installed in 1993 are shown in Figure 2-4.

The 1993 down-hole gamma survey involved utilizing a small-diameter sodium iodide (NaI) detector inserted into the two-inch-diameter PVC TWSPs to measure subsurface gamma radiation in the trenches. Results of this survey detected gamma activity, but the probe could not detect gamma radiation in the energy ranges associated with uranium and thorium daughter products. The 1993 gamma survey results reported a detectable quantity of U-235 in 76 of 195 measurements; the average U-235 concentration was reported to be 77.4 ± 139.2 picoCuries per gram (pCi/g) (ARCO/B&W, 1995).

However, after further review of the data by MJW Corporation of Williamsville, New York (MJW, a subcontractor to ARCO), it was determined that the background data to which the down-hole gamma results were compared were unreliable and of little value. MJW indicated that the background data was obtained from piezometers of steel construction and the TWSPs were of PVC construction. The different construction was the primary reason the background data was deemed unreliable. Furthermore, some of the data collected in 1993 were considered suspect due to improper calibration and computer programming. Therefore, the 1993 down-hole gamma results were deemed to be generally not representative of site-related contamination. Table 2-3 provides a summary of key elements of the 1993 down-hole gamma survey (ARCO/B&W, 1996).

To expand the 1993 down-hole gamma measurement database and resolve questions associated with the 1993 survey, 22 new 4 inch (10 centimeter) diameter TWSPs were installed within the trenches during a 1995 field investigation conducted by ARCO/B&W in 1995. The 1995 down-hole gamma survey program utilized a more sensitive and larger diameter NaI detector with upgraded hardware and software within the 4 inch (10 centimeter) diameter TWSPs. The locations of trench TWSPs installed in 1993 and 1995 are shown in Figure 2-4.

Down-hole gamma logging conducted on the 2 inch (5 centimeter) diameter TWSPs during the 1995 Field Investigation was completed using a Ludlum model 44-62 gamma scintillation detector (0.9 inch [2.3 centimeter] in diameter by 7.8 inches [20 centimeter] long). A Bicron model 3M3/3, 3 inch by 3 inch (7.6 centimeter by 7.6 centimeter), sodium iodide gamma scintillation detector was used for down-hole gamma logging conducted on the 4 inch (10 centimeter) diameter TWSPs. Both the 2 inch (5 centimeter) and 4 inch (10 centimeter) TWSP gamma detector systems were able to consistently identify the presence of U-235 in the soil/water near the TWSP based on the use of calibration sources constructed to match the down-hole counting geometry. The 4 inch (10 centimeter) TWSP detector system was readily able to identify picoCurie quantities of uranium and thorium series daughter products; however, results showed that the system did not detect these target nuclides above typical environmental levels in soils of a few pCi/g. Uranium-235 was the only nuclide consistently detected in TWSP measurements by both gamma logging systems, with the 4 inch (10 centimeter) TWSP system data considered to be more accurate than the 2 inch (5 centimeter) TWSP data.

The 1995 results also showed the presence of U-235 in approximately 24 percent of the measurements. Of the 76 positive measurements (out of a total of 310 measurements taken), the average U-235 concentration measured in the 4 inch (10 centimeter) diameter TWSPs was 15.9 pCi/g. The 1995 Field Investigation report indicated that the total uranium content could range from 21 to 84 times the U-235 concentration, depending on the level of enrichment. Based on the range of positive U-235 data (from 0.74 to 165.49 pCi/g), and assuming an average U-235 enrichment of 5 percent, the total uranium content could then vary from 16.4 to 3,674 pCi/g (ARCO/B&W, 1996).

Each 4 inch (10 centimeter) TWSP was also evaluated for the presence of Am-241. Neither Am-241 nor any other unexpected nuclides were detected during the down-hole gamma logging.

A brief summary of the key elements of the 1995 down-hole gamma survey program is provided in Table 2-3.

2.2.5 Surface Soil Sampling Data

In previous investigations, surface soils were defined as soils between ground surface to a depth of six inches (15 centimeters) below ground surface. The cumulative radiological and chemical surface soil sampling data generated during previous investigations are presented in tabular form in Appendices A and B. Details regarding surface soil samples collected during previous investigations are presented in the Summary of Historical Surface Soil Sampling found in Appendix S. Details of the recent RI surface soil sampling program are presented in Section 3.0 of this report and in the Field Sampling Plan (SAP) (USACE, 2003a).

In 1981, 120 surface soil samples were collected by ORAU and analyzed for U-235, U-238, Th-232, Ra-226, Cs-137 and Co-60. Several samples collected during the 1981 investigation were taken from areas that were subsequently remediated by B&W (see Section 2.2.3). As a result, data from samples identified as: S36, S59, S64, S65, S72, S76, S77, S80, S81, S82, S87, S88, S98, S99, S103 through S114, and S116 through S120 were removed from the database. The remaining 104 sample locations are shown on Figures 4-1 and 4-2. Individual analytical results for the majority of the samples collected during the 1981 investigation were not reported, only statistical summaries of groups of samples.

In 1986 and 1989, ORAU completed surface soil sampling programs within the areas remediated by B&W to evaluate the potential presence of residual uranium (ORAU, 1987, 1990). The remediated areas were gridded and four surface soil samples were collected from each grid. In addition, one surface soil sample was collected from each of three test pits (grid locations 17, 46, and 81). A total of 139 samples were collected in 1986 and 40 samples were collected in 1989. Sample grid locations are shown on Figure 4-2. All samples were analyzed for U-235 and U-238.

In 1995, a surface soil sampling program was conducted in the vicinity of Trench 10 to investigate and delineate the presence of americium and plutonium (ARCO/B&W, 1996). A total of 206 samples were collected from a sampling grid established northwest of the high wall. Four surface soil samples were collected from each sample grid and analyzed for total uranium and Am-241, with a limited number of samples being subjected to Am-241, Pu-241, Target Analyte List (TAL) metals, and Target Compound List (TCL) volatile analyses. Sample grid locations are shown on Figure 4-1.

As part of the decommissioning of the former Parks facility license, the NRC required that radiological surveys be completed in each survey unit. Survey Unit E was a large parcel located directly northeast, east and southeast of SLDA. In September 2000, ORISE completed a radiological survey of Survey Unit E in an effort to obtain license closure. However, the discussion presented below pertains only to the 12-acre (4.9 hectare) portion of Survey Unit E that was added to the SLDA license SNM-2001 (identified subsequently in this report as the "12-acre parcel").

ORISE was unable to conduct a gamma walkover survey over the entire 12-acre (4.9 hectare) parcel since the ground surface was overgrown with tall grasses and forested. Therefore, the gamma survey was completed in areas cleared by BWXT within five randomly selected grid blocks. Initially, ORISE intended to collect one or two soil samples from each of the selected grid blocks within Survey Unit E. However, surface scans in grid block 87 identified areas of suspected soil contamination. Surface soil samples were collected from four of these identified locations to quantify the activity levels; several other areas of elevated activity were not sampled. Each sample was analyzed for U-235 and U-238. Sample locations identified as 109/110, 111/112, 113, and 114/115 are shown on Figure 4-2.

In summary, the majority of the historical surface soil samples were analyzed for the following radiological constituents: U-235, U-238, total uranium, and Am-241. Most of the U-235 and U-238 data was generated from sampling associated with site remediation activities while the total uranium and Am-241 data was obtained during the 1995 Field Investigation completed by ARCO. Radiological testing results associated with previous investigations and the current sampling are combined and discussed in Section 4.0, Nature and Extent of Contamination. As illustrated in Figures 4-1 and 4-2, the spatial distribution of historical surface soil sampling points was focused near Trench 10 and the areas remediated in the 1980s. Other than the 1981 data that were presented as statistical summaries, the historical surface soil data were reviewed against project needs and were found to be usable for determining the nature and extent of contamination. Historical surface soil data was not considered for use in risk assessment (USACE, 2003a).

2.2.6 Subsurface Soil Sampling Data

In previous studies, subsurface soils were defined as soils from depths greater than six inches (15 centimeters) below ground surface. The cumulative radiological and chemical subsurface soil sampling data generated during previous investigations and this RI are presented in tabular form in Appendices A and B. Details regarding subsurface soil samples collected during previous investigations are presented in the Summary of Historical Subsurface Soil Sampling found in Appendix T. Details of the RI subsurface soil sampling program are presented in Section 3.0 of this report and in the SAP (USACE, 2003a).

In 1981, 166 subsurface soil samples were collected by ORAU and analyzed for U-235, U-238, Th-232, Ra-226, Cs-137 and Co-60. Sample locations for the Trench 10 and upper trench areas are shown in Figure 4-3 and 4-4. Individual analytical results for most of the samples collected during the 1981 investigation were not reported, only statistical summaries.

In 1986, subsequent to the remediation efforts, ORAU conducted a confirmation sampling program to evaluate the effectiveness of the remediation. Although the focus of this sampling program was collection and analysis of surface soil samples, test pits were also excavated at three locations (grid blocks 17, 46, and 81, see Figure 2-2) to facilitate subsurface soil sample collection. Five subsurface soil samples were collected from each test pit from depths ranging from six to 36 inches (15 to 91 centimeters) in six-inch (15 centimeter) increments. Each sample was analyzed for U-235 and U-238 by gamma spectroscopy. Sample locations are shown in Figure 4-4.

In 1993, ARCO/B&W advanced a total of 157 soil borings immediately adjacent to the perimeters of the trenches (determined by various geophysical studies as described in Section 2.2.4.1). The spacing between borings was 50 feet (15 meters) as shown in Figures 4-3 and 4-4. Continuous split-spoon samples were collected at two-foot (61 centimeter) intervals from the ground surface to bedrock. A total of 1,200 subsurface soil samples were collected from the perimeter of the disposal trenches. Each sample was screened in the field for total uranium using an in-process counter (a sodium iodide detector with a single channel analyzer). Samples that exhibited potential uranium concentrations at or near 30 pCi/g were submitted for laboratory analysis. NRC had developed the 30 pCi/g cleanup level for total uranium for sites being released for unrestricted use. 294 samples were analyzed for total uranium and 46 samples were analyzed for other radionuclides of concern (ROCs) including U-234, U-235, U-238, Am-241, Pu-238, Pu-239/240, and Pu-242. Although these data provided a significant database of subsurface soil radiation levels, the data collected were limited for the following reasons:

- There was no indication of how the counts per minute measured with the in-place counter correlated to total uranium.

- There was no indication of how the counts per minute measured with the in-place counter correlated to sampling procedures and quality control/quality assurance protocols.
- In most cases, only one sample collected from a given boring was analyzed at a laboratory.
- In most cases, samples were only analyzed for total uranium.

Chemical testing for TCL VOCs, TCL semi-volatile organic compounds (SVOCs), and TAL metals was also completed on 134 samples collected during the 1993 Site Characterization activities.

As part of the 1995 investigation completed by ARCO/B&W, 10 subsurface soil samples were collected while installing monitoring wells MW-37 through MW-46 (see Figure 4-5 for monitoring well locations). Each soil sample was analyzed for total uranium, TCL VOCs, TAL metals, tributyl phosphate (TBP), and 8-OH.

Three subsurface soil samples were collected by ORISE in 2000 during the Parks facility decommissioning project. These samples were collected from the southeastern end of the areas remediated in the 1980s as shown in Figure 4-4. Each sample was analyzed for U-235 and U-238.

In summary, the majority of the historical subsurface soil samples were analyzed for total uranium, U-235 and U-238. Radiological testing results associated with previous investigations and the current RI sampling were grouped together and are discussed in Section 4.0, Nature and Extent of Contamination. As illustrated in Figures 4-3 and 4-4, the spatial distribution of subsurface soil samples collected during previous investigations is focused around the perimeter of the disposal trenches. Other than the 1981 sample data that were presented as statistical summaries, the existing subsurface soil data were reviewed against project needs and found to be generally usable for determining the nature and extent of contamination. Historical subsurface soil data was not considered for use in risk assessment (USACE, 2003a).

2.2.7 Groundwater Sampling Data

The cumulative radiological and chemical groundwater data from previous and current studies are presented in tabular form in Appendices A and B. Details regarding groundwater samples collected during previous investigations are presented in the Summary of Historical Groundwater Sampling found in Appendix U. Details of the RI groundwater sampling program are described in Section 3.0 of this report and in the SAP (USACE, 2003a).

In 1981, 25 groundwater samples were collected by ORAU and analyzed for U-235, U-238, Th-232, Ra-226, Cs-137 and Co-60. A limited number of samples were also analyzed for Ra-226 using the EPA Radon Emanation technique and Am-241 and Pu-239 using alpha spectroscopy. Individual analytical results for the majority of the samples collected were not reported and only statistical summaries were presented. Groundwater samples collected in 1981 were taken from open boreholes not from groundwater monitoring wells which is considered the industry wide standard for groundwater sampling. Therefore, samples collected during the 1981 investigation may not have been representative of groundwater quality (ORAU, 1982).

The majority of radiological groundwater data consist of gross alpha and gross beta analyses completed during the B&W quarterly groundwater monitoring program initiated at the SLDA site in 1991. Additional radiological and chemical groundwater sampling data were generated during the Site Characterization (1990 and 1994) and the 1995 Field Investigation. In most cases, the groundwater sampling completed during the Site Characterization and the 1995 Field Investigation was completed during the B&W quarterly groundwater monitoring sampling events. Refer to Table 2-2 for specific analytical testing completed during the Site Characterization and 1995 Field Investigation.

Groundwater samples were collected from five water bearing zones identified by ACRO/B&W in the conceptual model: Subsoil (overburden), First Shallow Bedrock, Second Shallow Bedrock, Upper Freeport Coal, and Deep Bedrock. Figures 4-6 through 4-10 illustrate the locations of groundwater monitoring wells and piezometers where groundwater samples were collected at SLDA for each water bearing zone.

Radiological groundwater testing results associated with previous investigations and the recent RI sampling were grouped together and are discussed in Section 4.0, Nature and Extent of Contamination. Other than the 1981 groundwater sampling data, the existing groundwater data were reviewed against project needs and found to be generally usable for determining the nature and extent of contamination. Historical groundwater data was not considered for use in risk assessment (USACE, 2003a).

2.2.8 Surface Water and Seep Sampling Data

The radiological and chemical surface water and groundwater seep sampling data from previous and current studies are presented in tabular form in Appendices A and B. Details regarding surface water/groundwater seep samples collected during previous investigations are presented in the Summary of Historical Surface Water, Groundwater Seep, and Sediment Sampling found in Appendix V. The RI sampling program is described in Section 3.0 of this report and in the SAP (USACE, 2003a).

Beginning in 1972, B&W conducted monitoring for radiological contamination at the SLDA site as part of a routine health and safety program associated with the adjacent Parks Facility. Surface water samples were collected from five locations along Dry Run identified as 1 through 5 and analyzed for gross alpha and gross beta. No information was provided regarding the number of samples collected, analytical methods, results of individual samples, or analytical reports. The average gross alpha and gross beta concentrations were reported in the Site Characterization Work Plan (ARCO/B&W, 1995) as 3.4 and 4.5 pCi/L, respectively.

In 1981, six surface water samples identified as W01 through W06 were collected by ORAU and analyzed for U-235, U-238, Th-232, Ra-226, Cs-137 and Co-60. Two of the samples were also analyzed for Am-241 and Pu-239 using alpha spectroscopy. Figure 4-11 illustrates the sample locations.

Between February and March 1990, ARCO/B&W completed a Preliminary Assessment which included the collection and analysis of four surface water samples (S-01, S-02, S-04, and S-09) and five groundwater seep samples (S-03, S-05, S-06, S-07, and S-08). Figure 4-11 illustrates the sample locations. Each sample was field tested for temperature, pH, and specific conductance. Samples S-03 and S-05 through S-09 were then analyzed for total organic halogens (TOX). Based on the field monitoring and the TOX results, samples S-06 through S-09 were analyzed for gross alpha, gross beta, total and dissolved beryllium, and Priority Pollutant list VOCs.

Surface water and groundwater seep sampling was also conducted by ARCO/B&W in July 1990 during Phase I of the Site Characterization. Samples were collected from two surface water (S-01 and S-02) and five groundwater seep (SS-01 through SS-05) sampling locations situated along or near Dry Run. Figure 4-11 illustrates the sample locations. These sample locations are not identical to the Preliminary Assessment sampling locations even though some of the sample identifications were the same. Each sample was analyzed for various water quality parameters, total organic carbon (TOC), TOX, TAL dissolved metals, and TCL VOCs. Each of the surface water samples from S-01 and S-02 was also analyzed for total metals.

Additional surface water and groundwater seep sampling occurred during Phases II through IV of the Site Characterization on a bi-annual basis (January 1991, October 1991, June 1992, December 1992, and May 1993). Surface water samples S-01 and S-02 and groundwater seep samples SS-01 through SS-05 collected in January 1991 were analyzed for various water quality parameters, cyanide, total and dissolved metals, VOCs, SVOCs, and polychlorinated biphenyls (PCBs). Groundwater seep samples SS-04 and SS-05 collected in October 1991 and June 1992 were analyzed for dissolved metals, select VOCs, select SVOCs, gross alpha, and gross beta. Surface water samples S-01 and S-02 and groundwater seep samples SS-01 through SS-05 collected in December 1992 were analyzed for various water quality parameters, dissolved metals, VOCs, select SVOCs, gross alpha/beta. In May 1993 surface water sample S-02 and groundwater seep samples SS-01, SS-04 and SS-05 were analyzed for various water quality parameters, dissolved metals, VOCs, select SVOCs, gross alpha/beta.

The majority of radiological surface water and groundwater seep data consists of gross alpha and gross beta analyses completed during the B&W quarterly groundwater monitoring program initiated at the SLDA site in 1991. Quarterly samples were collected from surface water locations S-01 and S-02 and groundwater seep samples SS-01 through SS-05. A variety of chemical analyses were also completed during this program on a semi-annual basis until the May 1993 event, after which samples were only analyzed for gross alpha and gross beta.

Surface water and mine outfall samples were also collected from along Carnahan Run during the 1995 Field Investigation completed by ARCO/B&W. Carnahan Run is a stream located several thousand feet south-southeast of the site where groundwater from the deep mine beneath the SLDA site discharges. The purpose of the Carnahan Run sampling was to assess whether the mine discharge transports trench-derived constituents to the surface water and sediments of Carnahan Run. There were no figures or survey coordinates presented in the 1995 Investigation Report indicating where these samples were collected.

One sample of the Carnahan Run mine outfall discharge was filtered with three different sized filters and analyzed for gross alpha and gross beta. According to the 1995 Investigation Report, solids from the mine outfall sample were also analyzed for total uranium; however, there was no discussion regarding how the solids were generated. It is assumed that the solids portion of the sample was comprised of the solids generated during the filtration process. The solids were analyzed for total uranium using gamma spectroscopy. The mine outfall sample was also analyzed for several chemical constituents as summarized in Table 2-2.

One surface water sample was also collected from Carnahan Run for analysis. There was no description in the 1995 Investigation report text or figures indicating where the surface water sample was collected. However, the sample was identified as "Under Bridge – Water", indicating that the sample may have been collected from beneath the bridge over Carnahan Run near Lee Lake. The surface water sample was filtered with three different sized filters and analyzed for gross alpha and gross beta. According to the 1995 Investigation Report, solids from the surface water sample were also analyzed for total uranium; however, there was no discussion regarding how the solids were generated. It is assumed that the solids portion of the sample was comprised of the solids generated during the filtration process. The solids were analyzed for total uranium using gamma spectroscopy. The surface water sample was also analyzed for several chemical constituents as summarized in Table 2-2.

Radiological surface water and groundwater seep testing results associated with previous investigations and the recent RI sampling were grouped together and are discussed in Section 4.0, Nature and Extent of Contamination. In general, the existing surface water and groundwater seep data were reviewed against project needs found to be usable for determining the nature and extent of contamination. The notable exception is data associated with the B&W Monitoring Program initiated in 1972 (since actual sample results were not available) and Carnahan Run sampling (since no locational data was provided). Historical surface water and seep data was not considered for use in risk assessment (USACE, 2003a).

2.2.9 Sediment Sampling Data

The radiological and chemical sediment data from previous and current studies are presented in tabular form in Appendices A and B. Details regarding sediment samples collected during previous investigations are presented in the Summary of Historical Surface Water, Groundwater Seep, and Sediment Sampling found in Appendix V. The RI sediment sampling program is described in Section 3.0 of this report and in the SAP (USACE, 2003a).

The majority of radiological sediment data consists of total uranium analyses completed during the B&W quarterly sediment monitoring program initiated at the SLDA site in 1992. The sediment samples were collected along Dry Run at designated locations where sediment traps were installed by B&W. The sediment sample locations were identified as Trib 0 through Trib 7. However, locational data were only provided for sample locations Trib 1 through Trib 5; therefore, only these sample locations are shown in Figure 4-12. Each sample was analyzed for total uranium.

Sediment samples were collected during the May 1993 Site Characterization sampling event at the same locations as the surface water (S-1 and S-2) and groundwater seep (SS-1 through SS-5) samples. Each sediment sample was analyzed for total uranium, Th-232, Ra-226, Co-60, Cs-137, Am-241. Figure 4-12 illustrates the sediment sample locations.

Sediment samples were also collected during the ARCO/B&W 1995 Field Investigation. The purpose of the sediment sampling program was to further evaluate potential constituent migration pathways through surface water and into the mine. Sediment samples were collected from locations identified as S-1, S-2, SS-1 through SS-5, Trib 0 through Trib 6, and HA-1 through HA-4 as shown on Figure 4-12. Sediment samples HA-1 and HA-3 were collected from the ground surface to six inches below ground surface. Samples HA-2 and HA-4 were obtained using a hand auger from a depth of two feet below ground surface. Each sample was analyzed for total uranium using gamma spectroscopy, VOCs, SVOCs, metals, and surfactants.

A second component of the 1995 Investigation sampling program consisted of sediment sampling of Carnahan Run. The purpose of the Carnahan Run sampling was to assess whether the mine discharge transports trench-derived constituents to the sediments of Carnahan Run. However, there were no figures or survey coordinates presented in the 1995 Investigation report indicating where these samples were collected.

A sediment sample was collected from Carnahan Run where the mine discharge enters Carnahan Run (identified as "Outfall – Sediment") and a second sample was collected from an undisclosed location (identified as "Under Bridge – Sediment"). Each sediment sample was analyzed for total uranium, surfactant, TBP, and 8-OH.

Radiological sediment testing results associated with previous investigations and the RI sampling were grouped together and are discussed in Section 4.0, Nature and Extent of Contamination. In general, the existing sediment data were reviewed against project needs and found to be usable for determining the nature and extent of contamination. However, the absence of locational information regarding Carnahan Run samples makes direct comparison with RI data difficult. Historical sediment data was not considered for use in risk assessment (USACE, 2003a).

2.2.10 Trench Contents and Leachate Sampling Data

This report defines trench contents as any material not occurring naturally (process waste, soil, equipment, etc.) buried at the site. Leachate is the liquid obtained from the TWSPs. Samples collected during previous and current investigations and analyzed for radiological and chemical parameters are presented in tabular form in Appendices A and B. Details regarding trench and leachate samples collected during previous investigations are presented in the Summary of Historical Trench Contents Sampling found in Appendix W. Sampling of trench waste material that was collected during previous investigations is discussed in this section, while samples collected during the RI work are described in Section 3.0 of this report and in the SAP (USACE, 2003a).

In 1993 during the Site Characterization investigation, ARCO/B&W advanced over 150 soil borings around the perimeter of the geophysical anomalies interpreted as the disposal trenches (ARCO, B&W, 1995). The purpose of this work was to assist in determining the trench boundaries and to assess the potential presence and concentration of contamination that may have migrated from the trench waste. During a review of this data, it was evident that 14 borings advanced within the trench footprints encountered waste (see Appendix W for the rationale basis for this determination). Figure 4-13 illustrates the locations of waste samples collected.

Review of this data indicates that 26 samples were collected from these 14 borings and the samples were classified as either waste or trench soil samples. The samples were obtained in two-foot increments from ground surface to bedrock, composited over the two-foot interval, and field screened for total uranium. Samples that exhibited a potential total uranium concentration at or near 30 pCi/g were submitted to the laboratory for gamma spectroscopy to determine total uranium and, in some cases, isotopic distribution and chemical contaminants of concern. NRC had developed the 30 pCi/g cleanup level for total uranium for sites being released for unrestricted use. Fifteen of the 26 samples were also submitted for laboratory analysis for TCL VOCs, TCL SVOCs, and/or TAL metals analysis.

The leachate sampling program completed during the site characterization involved the installation of 36 TWSPs within the trenches at the locations shown on Figure 2-4. The TWSPs were constructed of 2 inch (5 centimeters) ID PVC screens and risers with the screens wrapped in filter fabric. For TWSP installation methods, refer to Section 2.2.4.2.

In 1993, composite samples created from samples obtained from the standpipes from each trench were analyzed for gross alpha, gross beta, total uranium, National pollutant Discharge Elimination System (NPDES) SVOCs, metals, and water quality parameters. In 1995, individual

TWSPs were sampled and analyzed for gross alpha, gross beta, VOCs, SVOCs, various metals and water quality parameters. Appendix W provides a summary of the analytical results.

In 1994, ARCO/B&W completed an investigation, entitled *Studies for Geochemical Parameters*, in an effort to characterize the potential for migration of constituents from Trenches 1 through 9. As part of this investigation, 29 TWSPs were sampled in November 1994 and the filtered portions of the samples were analyzed for total uranium using inductively coupled plasma mass spectrometry (ICP-MS) methods at Lockheed Analytical Laboratories.

As part of the 1995 field investigation, 22 new, 4 inch (10 centimeter) diameter TWSPs were installed to supplement existing TWSPs (Figure 2-4). The new 4 inch (10 centimeter) diameter TWSPs were installed in a similar fashion to the 2 inch (5 centimeter) TWSPs (i.e., screens are wrapped in filter fabric, steel casing is driven through the trench cover and waste to the bedrock, TWSPs are installed within the casing, and the casing is subsequently removed). Both sets of TWSPs were sampled during the 1995 Field Investigation. The following provides a discussion of the sampling and laboratory analysis of the leachate samples collected from the TWSPs.

Two distinct sampling events were completed during the 1995 Field Investigation and were described as Geochemical Leachate Testing and Standard Leachate Testing. The Geochemical Leachate Testing involved sampling 12 TWSPs and analyzing the samples for numerous radiological and chemical parameters to analyze the effect of site-specific geochemical conditions on uranium concentrations. The Standard Leachate Testing program consisted of sampling and analysis of 29 TWSPs installed during the Site Characterization and the 1995 Field Investigation. Radiological analyses were completed on filtered leachate and filtered leachate solids during both sampling events. Chemical analyses were completed on filtered and unfiltered leachate as well as filtered solids.

Filtered leachate samples collected during the geochemical and standard leachate sampling were analyzed for gross alpha and gross beta as well as total uranium, Am-241, Cs-137, and Co-60 by gamma spectroscopy. Filtered liquid leachate samples collected during the geochemical leachate testing were analyzed for various water quality parameters including major anions, major cations, total organic nitrogen, Kjeldahl nitrogen, silica, pH, oxidation-reduction potential, conductivity, and total dissolved solids. Filtered leachate samples collected during the standard leachate testing were analyzed for several metals including rare earth elements, U-235 and U-238. Filtered solids from the leachate samples collected during the geochemical and standard leachate testing were analyzed for surfactants, VOCs, 8-OH, TBP, ethylenediaminetetraacetic acid (EDTA), and TAL metals.

Unfiltered leachate samples collected during the standard leachate testing were analyzed for VOCs, SVOCs, total petroleum hydrocarbons (TPH), organic carbon, biological oxygen demand (BOD), chemical oxygen demand (COD), turbidity, pH, oxidation-reduction potential, surfactants, 8-OH, and EDTA.

After review of the analytical results for filtered liquids and filtered solids, select samples were sent to the B&W Nuclear Environmental Services, Inc. (NESI) Nuclear Environmental Laboratory (NEL) in Lynchburg, Virginia for additional alpha spectroscopy analyses.

The 1995 Field Investigation report stated that additional quarterly sampling of TWSPs would be completed; however, no documentation summarizing this subsequent work was identified. Various gamma spectroscopy analytical reports provided by ARCO/B&W were reviewed to determine if the reports identified quarterly TWSP sampling. Based on this review, it was determined that leachate samples were collected from certain TWSPs on a quarterly basis between June 1996 and May 1997. The quarterly leachate samples were analyzed for gross alpha and gross beta.

Radiological trench contents testing results associated with previous investigations and the recent RI sampling were grouped together and discussed in Section 4.0, Nature and Extent of Contamination. In general, the existing trench contents sampling data were reviewed against project needs and found to be usable. Historical trench contents sampling was not considered for use in risk assessment (USACE, 2003a).

2.2.11 Biota Sampling Data

Radiological biota sampling data generated during previous investigations are presented in tabular form in Appendix A. No chemical testing of biota samples was completed. Details regarding biota samples collected during previous investigations are presented in the Summary of Historical Biota Sampling found in Appendix X.

Beginning in 1972, B&W conducted monitoring for radiological contamination at the SLDA site as part of a routine health and safety program associated with the adjacent Parks nuclear fabrication facility. The monitoring program included walkovers, visual inspection, and periodic collection of soil, surface water, and vegetation samples for analysis.

Vegetation samples were collected from five sample locations identified as locations 1 through 5 and located along Dry Run. The vegetation samples described as grasses, weeds, and other plants characteristic of the site area, were analyzed for total uranium. No information was provided regarding the number of samples collected, analytical methods, or analytical results. As a result, the B&W Health and Safety Monitoring Program will not be discussed further in this assessment.

In May and June 1981, the ORAU completed a radiological survey at the SLDA site, during which a total of 13 vegetation samples identified as V01 through V13 were collected from the lower and upper trench areas at the locations shown on Figure 4-14. The samples consisted of the summer growth of grasses, weeds, and other plants characteristic of the selected location. Each vegetation sample was analyzed for U-235, U-238, Th-232 (Ra-228), Ra-226, Cs-137, and Co-60. Other radionuclides present in "significant quantities" (if any) were identified by a visual inspection of the spectra.

None of the samples analyzed contained Th-232 (Ra-228) or Co-60 above background. The U-235 concentrations ranged from <0.02 to 0.24 pCi/g. The highest U-235 concentration was detected in sample V10, which was identified as being from above Trench 6. The U-238 concentrations ranged from 1.2 to 18.2 pCi/g. The maximum concentrations of Ra-226 and Cs-137 were 0.69 pCi/g and 0.27 pCi/g, respectively.

Three composite vegetation samples were collected during the Site Characterization program completed by ARCO/B&W. Sample locations, identified as Site #13, Site #15, and Site #16, are shown on shown on Figure 4-14. Each sample was analyzed for total uranium, total thorium, Ra-226, Cs-137, Co-60, and K-40. The total uranium concentration reflected the total concentrations of U-234, U-235, and U-238.

Composite sample Site #16 contained 6.2 pCi/g total uranium. Total uranium, total thorium, Ra-226, Cs-137, and Co-60 were not detected in samples Site #13 and Site #15 above the detection limit, however, the detection limits were elevated above expected background levels.

Additional vegetation samples would allow corroboration of risk assessment model results, however this data is not essential for site characterization. Additional data would ultimately be used to supplement (confirm) RESRAD results. However, the benefit of collecting additional biological samples was considered unnecessary by the project team since the previously testing was of sufficient quality and quantity to address RI project needs.

2.2.12 Background Sampling Data

Background sampling data generated during previous investigations are reported in Appendix A. Background sampling and analysis was completed for the following media: surface soils, subsurface soils, groundwater, surface water, coal, and biota (ORAU, 1981; ARCO/B&W, 1995). However, no chemical testing of background samples was completed. Details regarding background samples collected during previous investigations are presented in the Summary of Historical Background Sampling found in Appendix Y. The existing background data were reviewed against project needs and were found to be generally not usable since the location of off-site samples could not be corroborated (USACE, 2003a).

Six off-site background surface soil samples were collected during the 1981 Investigation. Approximate sample locations, identified as S121 through S126, are illustrated on Figure 2-5. Each sample was analyzed for U-235, U-238, Th-232, Ra-226, Cs-137, and Co-60.

Twelve off-site and four on-site background surface soil samples were collected during the Site Characterization. Approximate sample locations, identified as Site # 1 through Site #16 are illustrated on Figures 2-5, 4-1 and 4-2. Each sample was analyzed for total uranium, Th-232, Ra-226, Cs-137, Co-60, K-40, and Am-241. The reported total uranium concentration is the sum of the concentrations of U-234, U-235 and U-238.

One background subsurface soil sample and one background groundwater sample were collected during the 1981 Investigation. Both samples were collected from an open borehole (B-45) located on the extreme eastern end of the B&W property. The actual sample location was not shown on the figures in the 1981 Investigation report. The sample was analyzed for U-235, U-238, Th-232, Cs-137, and Co-60.

Four background surface water samples were collected during the 1981 Investigation from locations in the vicinity of the SLDA site. Approximate sample locations, identified as W7 through W10 are shown on Figure 2-6. The samples were analyzed for U-235, U-238, Th-232, Ra-226, Cs-137, and Co-60.

Eight background coal samples were collected during the Site Characterization during the drilling of on-site monitoring wells MW-16, MW-17 and MW-18. The coal samples were collected from the Upper Freeport coal seam and higher coal seams. The sample locations are illustrated on Figure 4-5. Two samples were collected from MW-16 (at depths of 91.2 and 105.9 feet), four from MW-17 (at depths of 27.8, 30.8, 50.6, and 75.1 feet), and two from MW-18 (at depths of 45.7 and 92.7 feet). The coal samples were analyzed for total uranium and Th-232, Ra-226, Co-60, Cs-137, and Am-241.

One background vegetation sample (V14) was collected during the 1981 Investigation. The sample was collected from the extreme eastern end of the B&W property, however, the actual sample location was not shown on the figures in the report. The sample was analyzed for U-235, U-238, Th-232, Ra-226, Cs-137, and Co-60.

Seven off-site and three on-site background vegetation samples were collected during the Site Characterization. Approximate sample locations are illustrated on Figures 2-7 and 4-14.

Each sample was analyzed for total uranium, Th-232, Ra-226, Cs-137, Co-60, and K-40. The total uranium concentration consists of the sum of the concentrations of U-234, U-235 and U-238.

The existing background data were considered unusable for nature and extent of contamination and risk assessment purposes since specific locational data (coordinates) were absent (USACE, 2003a). The background coal data collected from monitoring wells MW-16, MW-17 and MW-18 is the only exception since coordinates for these wells have been established.

2.2.13 Historical Environmental TLD Data

Thermoluminescent dosimeter (TLD) measurements were collected during the B&W Health and Safety Monitoring Program between 1987 and 1993 (ARCO/B&W, 1995). The program included collection of TLD data at the 19 locations shown in Figure 2-8. TLD data are presented in Appendix Z.

2.2.14 Air Monitoring Data

Air monitoring was conducted by ARCO/B&W during site characterization field activities that had the potential for generating airborne contaminants (1990-1994). No airborne radiological contamination was created or measured during the field activities (ARCO, 1995).

In January 2002, BWXT initiated an air monitoring program at four stations located on and near the SLDA site. Air samples are taken monthly from the four air monitoring stations and analyzed for gross alpha and gross beta/gamma activity by Pace Analytical Services, Inc. (Pace) of Madison, Pennsylvania. Earth Science Consultants, Inc. (Earth Science) of Export, Pennsylvania prepares a monthly report and submits the findings to BWXT.

The monthly reports do not contain a plan illustrating the location of the air monitoring stations; however, a description of the locations is included:

- Station No. 8 Northeast of Parking Lot Area
- Station No. T-3 Southeast Fence – Unit C
- Station SLDA-1 Near Office Trailer
- Station 5 Background Station Off-Site

Based on information contained in various site investigation reports and a site walkover, it appears that the two stations located within the SLDA site limits are Stations T-3 and SLDA-1. Station No. T-3 is situated west of Trench 10 and along the southwest property line and Station SLDA-1 is approximately 240 feet (73 meters) southeast of the access gate off Kiskimere Road. Station No. 8 is likely northeast of the former Parks facility parking lot. The location of Station 5 is unknown.

Each monthly report presents tables summarizing the gross alpha and gross beta results for the four samples analyzed, cumulative field data sheets summarizing performance of the air monitoring stations, and the Pace analytical report. The testing results are compared to maximum allowable Derived Air Concentrations (DACs) for gross alpha ($2x10^{-14}$ μCi/mL) and gross beta ($2x10^{-10}$ μCi/mL) in accordance with 10 CFR Part 20, Appendix B. To date, none of the samples have exceeded the maximum allowable DACs (Earth Sciences Consultants, 2003).

2.2.15 <u>Historical Aerial Photographic Analysis</u>

The United States Army Topographic Engineering Center (TEC) completed a historical aerial photographic analysis of the SLDA site and presented the findings in the report entitled, "Shallow Land Disposal Area - Historical Photographic Analysis" issued in June 2003 (TEC, 2003). The final TEC report is presented as Appendix AA. The report summarized a review of available aerial photographs of the SLDA site taken between 1950 and present with special emphasis on potential disposal activities. Key findings included:

- Apparently disturbed ground surface at or near Trench 1 and south of the upper trenches where the waste exhumation had reportedly occurred.

- A raised area in the lower trench area where the ground surface appeared to have been "scraped".
- Time periods during the 1960s where there were soil piles apparent in the upper trench area within the area where the waste exhumation occurred.
- Apparent trenches that corresponded well with the locations of Trenches 4 and 6.
- A pit (within a barrier) in the area where Trench 9 is located.
- Stockpiled materials and two cleared areas north of Trench 10.
- A disturbed area where vehicle tracks were leading into a rectangular area oriented parallel to and just south of Trench 8.
- Vehicles and disturbed ground surfaces near the upper trench area in 1993 potentially due to environmental site investigations completed during that time period.

In general, the disturbed areas of the site correspond to the trench locations determine by the geophysical survey; however there was no one to one correlation between the disturbed areas of soil to trench outlines based upon geophysical studies. This report was used to guide the RI and was included as part of the SAP (USACE, 2003a).

2.3 Site Characteristics

This subsection describes regional and site-specific physical characteristics as well as the land use surrounding the site. This information was compiled from past investigation reports and updated with RI results.

2.3.1 Topography

The SLDA site is situated on a hillside, which slopes from the southeast to the northwest toward the Kiskiminetas River (see Figure 1-2). Trenches 1 through 9 are located in the higher elevated area of the site. Trench 10 is located in a relatively flat area in the topographically lower area of the site. Topographic relief at the site ranges from about 950 feet (290 meters) above mean sea level (MSL) in the southwest to about 830 feet (253 meters) above MSL in the northern end of the site. This is an elevation change of approximately 121 feet (37 meters) over a distance of approximately 2,500 feet (762 meters), resulting in an overall slope of over 4 percent. In addition, a significant elevation drop (over 40 feet [12 meters]) occurs at the "high wall" area (located in the northwestern end of the site), which transects the site from southwest to northeast where a bedrock outcrop is present.

2.3.2 Geology

2.3.2.1 Regional Geology

The site is located in the central part of the Pittsburgh Low Plateau Physiographic Section of the Appalachian Plateau Physiographic Province (PA DCNR, 2000). This region is located southwest of the glaciated area of the state and is characterized by rolling upland surfaces cut by numerous, narrow, relatively shallow valleys (PADEP, 1999).

Near-surface geologic units in the region are Pennsylvanian in age and belong to the Allegheny and Conemaugh groups. Lithologically, these groups consist of cyclic sequences of sandstone, siltstone, shale, claystone, and coal. The basal sandstones and shales are interpreted as river and delta deposits, whereas the coals formed in coastal swamps and the limestones formed in either shallow marine or freshwater swamps (PADEP, 1999). Due to the juxtaposition of these different depositional environments and the cyclic transgression and regression of the inland sea, facies and lithologic changes occur rapidly in both horizontal and vertical directions. Mines located in Armstrong County extract Allegheny Group coals. The upper-most coal member of this sequence is the Upper Freeport Coal. Figure 2-9 is a stratigraphic section showing the stratigraphic names and positions of the beds in the region.

The soils in the vicinity of the site belong primarily to the Allegheny and Rainsboro series. Whereas the Allegheny soils generally occur on gently or sloping terrain, the Rainsboro soils are most often terrace deposits. Both series are described as silt loam and are moderately drained (USDA, SCS, 1977). These soils are formed from material weathered from the interbedded shale, siltstone, and sandstone parent rock. Depth to bedrock for both soil series is described to be generally greater than six feet (USDA 1977).

2.3.2.2 Site Specific Geology

The RI field activities included the drilling of overburden, bedrock, and mine fill borings. In addition, numerous shallow borings to the top of bedrock were completed for soil sampling purposes at the site. At each of the borings, the overburden was sampled and characterized. With the exception of two locations, all bedrock borings were cored continuously in generally ten-foot core runs and the lithology was characterized. Nine bedrock borings were converted to groundwater monitoring wells. Five overburden borings were also converted to monitoring wells. Two borings completed within the mine fill in the vicinity of trench 10 were also completed as monitoring wells. In addition, five bedrock borings were completed with Flexible Liner Underground Technology (FLUTe) monitoring systems. Boring locations are shown on Figure 4-4, boring logs are presented in Appendix C, and monitoring well construction diagrams are provided in Appendix D.

2.3.2.2.1 Surface Soils

The nature and distribution of soils present at the SLDA site are identified based on information provided in the Armstrong County Soil survey (USDA, SCS 1977). Four types of soils are identified to exist at the site as shown on Figure 2-10 and as described below:

Allegheny silt loam (AlB; 3-8 percent slopes) - Deep, well drained, gently sloping soils on terraces. Formed in loamy alluvium derived from sandstone, siltstone, and shale. Observed generally in the central portion of the site.

Rainsboro silt loam (RaA; 0-3 percent slopes) - Deep, moderately well drained, nearly level to sloping soils on undulating to rolling stream terraces. Formed in loess and underlying loamy sediment that commonly grades to sandy or gravelly material. Observed in the eastern and southeastern portions of the site.

Rainsboro silt loam (RaB; 3-8 percent slopes) - Deep, moderately well drained, nearly level to sloping soils on undulating to rolling stream terraces. Formed in loess and underlying loamy sediment that commonly grades to sandy or gravelly material. Observed generally near Dry Run in the northern portion of the site.

Strip mines (Sm) – Overburden materials comprised of soil and rock removed from strip mining operations.

Based on observations of surface soils from borings completed at the site, the surface soils are generally comprised of a very thin layer of organic silty organic topsoil. This thin veneer of topsoil overlies a silty clay, or clayey silt, which may contain some sand at various locations at the site.

2.3.2.2.2 Site Lithology and Stratigraphy

The term lithology as used in this document refers to the lithological or regularity of subsurface deposits or the description of rock types present in a stratigraphic sequence. Stratigraphy therefore refers to a series of divisions and subdivisions that attempt to correlate the lithological deposits. Lithologic characteristics of subsoil and bedrock, are described in distinct boreholes. The stratigraphy is the correlation of these various subsurface units into distinct stratigraphic sequences. The result of this correlation is the development of a site conceptual model that attempts to identify a series of stratigraphic (and hydrostratigraphic) units based on relatively similar characteristics of the deposits in question. Discussion of the site conceptual model is provided in Section 2.3.3.4.

2.3.2.2.3 Overburden

The subsurface soils in the upper trench area include a consistent silty clay layer underlying the topsoil. This silty clay layer was found to range generally between four and 20 feet (6 meters), and was all but absent near the high wall (MW-02). Beneath the silty clay layer a coarser, two to five foot (0.6 to 1.5 meter) thick, silty to gravelly sand layer was encountered, referred to in previous reports as the "Subsoil" zone. In some places at the site, this zone was saturated. However, the water within this zone is considered perched above a discontinuous layer of weathered bedrock comprised of either weathered shale or weathered siltstone. The significance of this perched water-bearing zone is discussed in more detail in Section 2.3.3.2. The total thickness of the overburden materials ranges from zero on the western edge of the open field area at the top of the bedrock high wall (MW-2 and MW-2A) to over 20 feet (6 meters) in the eastern portion of the site (NWS-02).

To better define the physical characteristics of the subsurface soils, a series of six soil samples were submitted for geotechnical analysis. Six composited samples from six separate borings were submitted for grain size analysis, moisture content, Atterberg Limits, specific gravity, and Unified Soil Classification System (USCS) classification. The samples within each borehole were composited due to the volume of material needed to complete the analyses.

SLDA Soil Samples Submitted for Geotechnical Analysis	
Boring Location	**Depth Interval Below Ground Surface Composited (ft)**
MW-52	2 to 10
MW-54	2 to 12
MW-57	6 to 16
NWS-01	2 to 12
NWS-02	12 to 20
NWS-03	10 to 18

The geotechnical results are summarized in Table 2-4 and the laboratory results are provided in Appendix E. As indicated in Table 2-4, with the exception of the sample from NWS-01, the subsurface soils contain varying amounts of sand, silt, and clay. The sample from NWS-01 had a preponderance of gravel. As indicated in the boring logs (Appendix C), the subsurface soils tend to be generally coarser with depth.

2.3.2.2.4 <u>Bedrock Lithology</u>

The subsurface bedrock lithology includes a series of interbedded horizontal sedimentary beds of sandstone, siltstone, claystone, coal, and shale. Beneath the unconsolidated overburden at the site, weathered bedrock with a clayey matrix was encountered in most of the borings completed in the upper trench areas at the site, but is inconsistent. This weathered zone consists of unconsolidated bedrock fragments and weathering products, was capable of being augered-through, but is generally structurally intact (i.e., saprolitic). This weathered zone acts to plug the rock fractures in the upper portion of the bedrock and forms a confining unit that limits downward percolation of groundwater. Beneath the weathered zone, sequences of alternating bands of siltstone, claystone fine sandstone, and shale were encountered (referred to as the first and second shallow bedrock zones). The significance of these two zones is discussed in detail in Section 2.3.3. Significant facies changes were observed in the borings over relatively short distances. A generally continuous, black, predominantly shale unit was encountered in all borings lying beneath the upper bedrock units and directly overlying the Upper Freeport coal. This black shale appeared to be thickest (15-20 feet [4.6 to 6 meters]) in the eastern portion of the site (NWS-02) and was about 10 feet (3 meters) thick in the northeastern portion of the site (NWS-05).

Due to the strip-mining activities that took place in the western portion of the site in the vicinity of Trench 10, these alternating beds overlying the upper Freeport coal were removed and replaced with mine fill during strip mining operations. A bedrock high wall (with a relief of over 40 feet [12 meters]), trending northeast to southwest, separates the strip mined area from the deep mined area. The first bedrock unit encountered under the mine fill is a thin unit of claystone that was also encountered beneath the coal or mine voids in the upper trench area. The Upper Freeport coal layer beneath the upper trench areas was deep mined. Between 70 feet (21 meters, NWS-05) and 120 feet (37 meters, NWS-02) of overlying soil and rock exist above the coal mine in the upper trench area. Because of these vast differences, the upper and lower trench areas of the site have distinct geological and hydrogeological characteristics. Even so, there appears to be a relationship in the groundwater flow at the base of the mine fill and the flow within the residual coal and open mine areas beneath the site. This is discussed in further detail in Section 2.3.3.2.

2.3.2.2.5 Bedrock Stratigraphy

Bedrock units encountered at the site are illustrated in a stratigraphic column (Figure 2-9), and in a series of two geologic cross sections developed from previous boring data and the RI boring and coring data. The cross section locations are shown in Figure 2-11. Figures 2-12 and 2-13 present stratigraphic cross sections through the site. Cross section AA' (Figure 2-12) provides a west to east cross section beginning west of Trench 10 and ending in the southeastern portion of the site, upgradient of the upper trench area. Cross section BB' (Figure 2-13) provides a north-to-south cross section through the upper trench area of the site.

As indicated in Figure 2-9, the bedrock units lying above the Upper Freeport Coal at the site belong to the Conemaugh Group (Glenshaw Member). The Allegheny Group exists beneath the Conemaugh formation and the top of this formation includes the Freeport member which in-turn includes the shale directly above the coal, the Upper Freeport coal, and the claystone (underclay) beneath the coal. The bedrock units beneath also belong to the Allegheny Group and include the Butler and Freeport Sandstones.

Observations in core samples from the borings indicate that significant fracturing exists along horizontal bedding planes and at contact points between sandstone and shale sequences. Minor subvertical fractures (up to 2 to 3 inches [5 to 7.6 centimeters] in length) were observed generally in the upper 20 feet (6 meters) of the bedrock. Many of these subvertical fractures exhibited signs of weathering and iron staining. Observations of bedrock outcrops along the incised streambed of Dry Run (generally north-central area of the site) substantiate the horizontal bedding fractures and general site lithology. Other observations of core samples included clay-infilling between shale bedding fractures (up to 2 inches [5 centimeters] in width), sandstone which is typically fine-grained and well cemented, and very few calcareous inclusions.

The frequency of the horizontal bedding fractures typically decreased within the shale units lying above the Upper Freeport coal. This black, generally tight shale was observed to vary in thickness from 12 to 15 feet (3.7 to 4.6 meters) thick in the western portion of the site to over 30 feet (9.1 meters) thick in the eastern portion of the site. No significant vertical fracturing was observed in the cores within this shale layer directly above the coal.

The Upper Freeport coal, where encountered at the site, was on average three to four feet (0.9 to 1.2 meters) thick. Figure 2-14 illustrates the extent of the deep mining beneath the site. The coal was removed by the room and pillar method. Consequently, pillars were left to support the mine. Borings completed during the RI which extended through the elevation of the coal either encountered coal (assumed to be a pillar or residual coal) or a void (removed coal). Core samples of the coal were retained within the core boxes of the particular boring that encountered the coal.

As indicated, a claystone or underclay, typical of coal beds was encountered beneath the coal. Underlying the claystone, a sequence of interbedded layers of shale, siltstone, and sandstone were encountered. However, the thickness and coarseness of the sandstone beds generally increases with depth. The upper sandstone units are likely the Butler Sandstone. The deepest sandstone encountered (NWS-05) is likely the Freeport Sandstone.

The stratigraphic model incorporating these units has been constructed principally from the degree of transmissivness or degree of permeability and occurrence of groundwater within these units and is discussed in more detail in Section 2.3.3.2, Site Hydrogeology.

2.3.3 Hydrogeology

2.3.3.1 Regional Hydrogeology

Regionally, the drainage basins tend to be small with marked relief (PADEP, 1999). These factors, in conjunction with the humid climate, generally produce a groundwater system that is recognized to be assembled of three parts (Toth, 1963):

1. Local or shallow – This system underlies hills and discharges to streams and springs. In some cases, local systems include water that is perched above beds of lower permeability. The hills constitute "hydrologic islands" where discrete localized groundwater flow systems operate within these hydrologic islands.

2. Intermediate – This flow system is recharged by the shallow systems and recharge generally takes place at or near the drainage basin divide. Flow passes beneath the two or more hydrologic islands and discharges in valleys above the lowest level of the drainage basin.

3. Regional - The regional flow systems are deep flow systems with groundwater flow occurring beneath the level of the shallow and intermediate flow systems. These groundwater systems operate independently of the other systems but receive recharge from major drainage divides and from the upper systems.

2.3.3.2 Site Hydrogeology

As described in Section 2.3.2.2, the significant lateral heterogeneity due to the lithologic facies changes creates a rather complex hydrogeological setting. The orientation and distribution of fractures, joints, and bedding planes generally control the occurrence and flow of groundwater. In order to refine the existing hydrogeological conceptual model, a series of investigative activities and procedures were performed during the RI. These activities included bedrock coring to assess lithology and degree of fracturing, packer permeability testing to assess transmissiveness and hydraulic conductivity of the bedrock, and rising and falling head tests (slug tests) performed on shallow overburden and mine fill wells to assess average permeability of the unconsolidated materials. In addition groundwater elevation measurements were obtained. The hydraulic head and conductivity results were used to determine and substantiate groundwater occurrence as well as horizontal and vertical gradients through and between hydrostratigraphic units. Table 2-5 summarizes the packer permeability testing results and the data and calculations are provided in Appendix F. The slug test results are summarized in Table 2-6 and the slug test data and calculations are provided in Appendix G. Appendix H provides a summary of the water elevation data.

Based on the previous site investigations and the RI, five principal hydrogeologic units have been identified at the SLDA site:

- The overburden materials lying immediately over the weathered bedrock (referred to as the subsoil [SS] zone in previous reports),
- The first shallow bedrock (1SB) consisting of interbedded siltstone, sandstone, and shales,
- The second shallow bedrock (2SB) consisting of similar interbeds as in the 1SB, but with slightly lower hydraulic conductivity than the 1SB,

- The Upper Freeport (UF) coal (including the mine workings), and
- The deep bedrock (DB) beneath the mine, consisting of siltstone and shale interbeds generally beneath the mine workings and gradually transitioning into sandstones at deeper depths.

These hydrostratigraphic units are discussed below with regard to the individual unit characteristics and significance, and their interrelationships to the overall site conceptual model. As stated previously, the upper and lower trench areas have distinct hydrogeological characteristics and therefore are discussed separately.

2.3.3.2.1 Lower Trench Area

The unconsolidated materials in the lower trench area consist entirely of mine fill, derived from strip mining activities. The materials are composed of a heterogeneous mixture of soil and rock debris, ranging from clay to coarse gravel, including coal. The maximum thickness of fill encountered was approximately 28 feet (8.5 meters) in the vicinity of MW-6. The fill sits on claystone (underclay) which acts to inhibit groundwater from percolating downward. Therefore, water is perched within the base of the fill above the claystone. The mine fill was observed to extend northeast across Dry Run, as expected as the strip mining extended north and east of the SLDA property. Surface water flow within Dry Run, generated in the upper reaches (upper trench area), was observed to disappear or seep into the mine spoil material just below the weir previously installed across Dry Run. The weir was constructed directly on a bedrock outcrop within the stream bottom. Surface flow was observed within the lower reaches of Dry Run during significant storm events. The groundwater that enters the fill, in all probability, flows along the slope of the claystone or underclay and eventually enters the mine workings at or near the interface of the highwall and the mine fill. As shown on the historical mine workings map (Figure 2-14), a haulageway (or widened passage within the coal seam) appears to have been constructed through the center of the highwall. This may provide a direct point of communication between the groundwater within the mine fill and the mine workings.

The groundwater elevations within the mine fill are considered analogous to the groundwater elevations within the open mine workings and residual coal seams or pillars.

Groundwater within the fill appears to flow towards the highwall to the east. A groundwater seep (SP-05-DR) located north of Trench 10 where the mine fill is intersected by Dry Run (Figure 2-15) was observed to flow on a consistent basis into the Dry Run streambed. This indicates that at least some groundwater may flow along the highwall and then moves north to northeast.

2.3.3.2.2 Upper Trench Area

The upper trench area incorporates a majority of the site, from the top of the high wall on the western side of the site to the eastern property line of the "new" twelve-acre parcel. Certain objectives of the RI field activities were to confirm and/or refine the existing hydrogeologic conceptual model. To accomplish this, a total of 14 monitoring wells were installed within the various hydrostratigraphic zones identified at the site. In addition, five multiport FLUTe sampling systems were installed at strategic locations at the site. Hydraulic conductivity data was collected and water level elevations obtained and used to assess the conceptual model fundamentals such as groundwater occurrence and flow direction.

Groundwater contour maps showing groundwater flow direction for each of the hydrostratigraphic units were prepared for the January 2004 (Figures 2-16 to 2-19) and June 2004 (Figures 2-23 to 2-27) water-level monitoring events. While similar groundwater flow patterns were observed for both the January and June 2004 monitoring events, in general, water levels were somewhat higher during the January event. Also, the inclusion of water elevation data for MW-61 and NWS-01A-02 for the Second Shallow Water-Bearing Zone (Figure 2-25) provides a southwest flow pattern not interpreted previously in the southern portion of the site. A discussion of the hydrogeologic characteristics of each of the hydrostratigraphic zones is provided below.

2.3.3.2.3 Overburden

In the upper trench area, the overburden consists of a silty clayey surficial soil that is relatively impermeable as evidenced by considerable ponding and the need for four-wheel drive and tracked vehicles for site access. However, subsurface soils contain more sand, and generally become coarser with depth. The overburden overlies a discontinuous layer of highly weathered rock, generally composed of shale or siltstone. This weathered rock has low hydraulic conductivity and therefore prevents water from percolating through the weathered zone and creates a perched water zone within the lower portions of the overburden. This "first water bearing zone" is referred to as the subsoil zone in previous reports. This discontinuous saturated zone (typically three to five feet in thickness) consists of somewhat coarser materials and as mentioned above, in some locations the coarseness increases with depth. The discontinuous nature of the perched zone was evident in the presence of dry overburden borings and monitoring wells. Dry borings were observed generally where weathered rock was absent or extremely thin.

Groundwater movement within this overburden perched zone is characterized by horizontal flow generally to the north-northwest that follows topography. Figure 2-16 illustrates the groundwater contour map for the overburden. The average hydraulic gradient calculated for the overburden groundwater is approximately 0.07 feet per foot (Table 2-7). Figure 2-16 was generated without using the temporary waste sampling points (TWSPs). These TWSPs (PVC standpipes) were installed by ARCO/BWXT within approximately the center of the predicted waste trenches. Therefore, it is expected that the waste materials and disturbed soils within the waste trenches have slightly higher hydraulic conductivity than the surrounding natural or undisturbed soils. This creates some pooling or accumulation of water within certain waste trenches as evidenced by historic water levels (Appendix H). These areas are located generally in the northeast portion of the site where the deposits are thicker (i.e., Trenches 4, 5, 6, and 7). Downward vertical seepage to the shallow bedrock occurs where the weathered rock zone is thin to absent. It is highly likely, and especially during or immediately following storm events, that groundwater within this perched zone in the northeastern portion of the site flows into Dry Run. The overburden soil materials sampled during drilling of shallow borings in the vicinity of Dry Run (lying immediately above the weathered rock and below the elevation of Dry Run) were observed to be dry during the RI field activities.

2.3.3.2.4 <u>Shallow Bedrock</u>

The existing conceptual model identifies the shallow bedrock (overlying the mine workings) to be comprised of two hydrostratigraphic units – the first shallow (1SB) and second shallow bedrock (2SB). It was previously acknowledged by ARCO/BWXT that a distinct separation of each of these zones was not overtly recognizable. Bedrock cores were obtained and packer permeability tests were conducted during the RI to characterize the shallow bedrock in terms of hydraulic conductivity and groundwater occurrence. Based on examination of the bedrock cores from over 15 borings (over 1,500 feet [460 meters] of rock core), and evaluation of the packer testing results, the shallow bedrock stratigraphy is composed of a heterogeneous sequence of sedimentary strata, generally gray in color with rapid facies changes over short distances. The bedrock has little primary porosity (rock matrix). Groundwater flow is controlled primarily by horizontal fractures, which were observed to occur along bedding planes and lithologic facies changes. Very minor vertical fractures with relatively small apertures were observed generally to occur in the upper 20 to 30 feet (6 to 9 meters) of the bedrock. These vertical fractures exhibited signs of iron staining – indicating water storage and/or movement.

The packer permeability test results were used to determine screened intervals for the multiport FLUTe systems. Based on the results of the packer testing (Table 2-5), within the shallow bedrock, a discontinuous low hydraulic conductivity zone was evident which appears to act as a semi-confining unit between the first and second shallow bedrock hydrostratigraphic units (Figure 2-12, Stratigraphic Cross Section AA'). Subsequently, this low conductive zone acts to perch water in the upper shallow bedrock (a.k.a. first shallow bedrock).

An examination of the groundwater elevations within the first shallow bedrock zone indicates that groundwater was measured below the tops of the screens in almost half of the wells screened within this zone (Table 2-8). This supports the concept that indicates that the first and second shallow bedrock is not fully saturated and experiences unconfined conditions. At locations where the water elevation measured within a well was above the top of the screen, may be due to the presence of a higher degree of fracturing within the rock at these discrete locations. It should be noted that the majority of the wells where the groundwater level was measured above the top of the well screens, are located upgradient of the upper trenches in the apparent recharge area (Table 2-8 and Figure 2-17). The flow of groundwater under an average horizontal gradient of about 0.07 feet per foot is to the north and west as illustrated by the groundwater elevation contour map for the first shallow bedrock zone (Figure 2-17).

Groundwater within the first shallow bedrock zone appears to be perched as well, impeded from moving vertically downward by a dense black shale unit lying directly above the mine workings or coal layer. This "second shallow bedrock zone" (second shallow bedrock) has generally the same characteristics as the "first shallow bedrock zone" although the estimated hydraulic conductivity is slightly lower than the first shallow bedrock zone (Table 2-7). This portion of the shallow bedrock is also unsaturated. This is supported by the fact that out of the nine wells screened in the second shallow bedrock, only one well exhibits groundwater elevations above the top of the screen (MW-45), as shown in Table 2-8. Groundwater within this zone moves generally north under an approximate horizontal gradient of about 0.06 feet per foot (Figure 2-18). The stratigraphy of this zone also consists of alternating layers of gray siltstone, fine sandstone, and shale.

2.3.3.2.5 Mine Workings

As indicated in Section 2.3.2.2, the Upper Freeport coal has been strip mined in the western portion of the site in the vicinity of Trench 10 and deep mined beneath the upper trench area. Out of a total of 16 wells that monitor this hydrostratigraphic zone above the high wall, 10 wells are screened within coal (probable coal pillars) and six monitor the groundwater flow within a void space. Based on information provided on the boring logs, the average thickness of the coal or void space is just over 3.5 feet (1.1 meters). Further data from the borings that intersected the mine voids indicate that the mine remains open and significant roof collapse has not occurred. Monitoring wells installed to monitor the groundwater within the mine had the screens placed so as to intersect the mine floor since the groundwater levels within the mine are approximately coincident with the mine floor. The mine is considered to be freely draining and therefore groundwater flow in the mine is characterized as "open channel flow". Immediately beneath the coal a persistent (two to three foot thick) claystone or "underclay" exists (essentially the mine floor material) and functions to retard vertical percolation of groundwater flow. This unit is typical of the coal bed horizons. This unit is consistent beneath both the upper and lower trench areas.

In the vicinity of the high wall, groundwater may pool and form temporary "ponds". These "ponds" may also occur sporadically and are likely localized within the room and pillar areas due to collapse and/or spoil piles within the subsurface. Groundwater found in the mine occurs as a result of seepage of water along the highwall, as well as vertically through fractures from overlying water-bearing zones. The mine spoil in the lower Dry Run ravine, which is infiltrated by water flowing in Dry Run, also creates a pathway for surface water to enter the mine near the highwall. Further, underground mine openings can intercept and convey surface water and groundwater. When excavated below the water table, mine voids induce groundwater to move to the openings from the surrounding saturated rock (PADEP, 1999). The result is the dewatering of the contiguous rock units via drainage of fractures and water bearing strata. In general, significant dewatering can extend between 20 and 100 feet (6.1 and 30.5 meters) vertically above drained room-and-pillar mines, but is usually restricted to within about 40 feet (12.2 meters) vertically (PADEP, 1999). Very little vertical fracturing was observed within the rock cores obtained of the black shale unit lying above the coal mine and this shale unit is considered to be unsaturated.

A groundwater contour map of the Upper Freeport coal is presented in Figure 2-19. Groundwater flow is shown to flow to the south, under a horizontal gradient that varies from approximately 0.01 feet per foot to almost 0.03 feet per foot. Groundwater flow within the mine workings generally flows with the floor elevation of the coal mine and is believed to eventually discharge to Carnahan Run. At least one mine outfall location southeast of the site has been identified which drains directly into Carnahan Run (Figure 2-20). Due to the high variability of the subsurface mine workings, site specific and localized flow irregularities within the mine workings cannot be fully determined.

The mine works is the most significant hydrogeologic feature at the site. The void space and open channel flow, creates a strong downward vertical hydraulic gradient beneath the upper trench area. Although the predominant direction of groundwater flow in the upper bedrock is horizontal, the numerous and frequent facies changes (both laterally and vertically) as well as incongruous (albeit infrequent) vertical fracturing almost certainly allows vertical infiltration which eventually enters the mine. This flow regime within the upper bedrock can be interpreted as a “tortuous flow pattern”. This is evident in the frequent and numerous horizontal fracturing observed in the rock cores obtained from borings NWS-01 and NWS-01A. The rock had frequent horizontal bedding fractures between bedding planes, rock quality designations (RQDs) recorded to be below 80 percent between 45 feet (14 meters) below ground surface (bgs) and the top of the mine, and some subangular to subvertical fractures present through the same interval. The downward vertical gradient is supported by the groundwater elevations within the nested wells and within the multiport sampling FLUTe systems (Table 2-9).

2.3.3.2.6 Deep Bedrock

Directly beneath the underclay, a series of interbedded siltstone, sandstone, and shale strata were identified in site borings. This lithology is consistent with previous borings and regional descriptions. Based on the packer permeability data, the upper 20 to 30 feet (6.1 to 9.1 meters) of these strata has a generally low permeability of 10^{-6} cm/sec or less (Table 2-5). It is also recognized that the occurrence of sandstone generally increases with depth and exhibits a slightly higher hydraulic conductivity (10^{-4} to 10^{-5} cm/sec). Two of the prominent sandstone strata are correlative with the Butler and Freeport sandstones. The sandstone units grade from very fine to medium-grained sandstone. Monitoring wells were installed across the site to monitor this “deep bedrock” zone. Based on the pieziometric head measurements of these wells, it appears these sandstone beds are hydraulically connected. The pieziometric head elevations appear to exist within the overlying lower permeable interbeds indicating a confined groundwater condition (Figure 2-12). Although a downward gradient is expected from groundwater that vertically seeps through the mine floor, an upward gradient within the deep bedrock could be expected as one nears the Kiskiminetas River to the northwest of the site. Horizontal gradients calculated for this zone range from 0.02 to 0.03 feet per foot and groundwater flow is generally to the south-southwest (Figure 2-21).

2.3.3.3 Surface Water and Groundwater Relationship

The principal surface water feature at the site is Dry Run, an ephemeral stream with the headwaters located within the eastern property boundary (Figure 1-2). The upper reaches of the stream have very little relief (i.e., they are not incised within the overburden soil). Due to the relative impermeability of the subsoil horizon, most, if not all of the runoff within this portion of the stream is not lost into the subsurface but continues flowing downstream within Dry Run. Approximately 300 linear feet (91 meters) from the headwaters, the stream channel begins to cut through the overburden (approximately one to two feet [0.3 to 0.6 meters]) and exposes boulders and bedrock within the bottom and sidewalls of the channel. This upper portion of the stream receives direct overland flow as evident during storm events observed during the RI activities. As the stream flows downslope to the northwest, the stream channel cuts through the overburden into the upper portions of the bedrock. It is most likely that in this general area of the stream channel, groundwater within the overburden flowing horizontally along the surface of the weathered bedrock, enters the Dry Run stream channel via seeps along the sidewalls of the channel. One of seeps (SP-DR-01) was observed to flow a considerable distance along the ground surface prior to entering Dry Run.

The most significant channel incisement of Dry Run occurs in the portion of the stream cutting through the north-central portion of the site. Bedrock outcroppings within the sidewalls of the stream are prevalent. The stream channel relief in this area is over 40 feet (12 meters) and bedrock outcrops within the base of the stream. Within approximately 50 feet (15 meters) downstream of this outcrop, base flow and low intensity storm flow within the stream dissipates through mine fill materials, placed in the area from previous strip mining activities. The topography at the base of the ravine at this point flattens-out as the stream channel continues across the mine fill materials, which are similar to samples taken from split spoons near Trench 10.

Surface water seepage into the mine fill likely percolates downward vertically until the underclay is reached. Groundwater flow then likely travels along the dip of the underclay in the vicinity of the highwall and eventually enters the mine workings. A portion of this seepage may also continue down valley within the mine fill and resurface in the valley downstream or downslope of the high wall as seeps or wet areas (as in the case of seep SP-DR-05).

2.3.3.4 Site Conceptual Hydrogeological Model

The site conceptual hydrogeological model discussed below is a condensed summation of the hydrogeological characteristics of the site presented above. Each of these hydrogeologic aspects is integrated into the hydrogeological conceptual model of the site.

Figure 2-22 illustrates by graphical means the disposition of recharge and surface flow and the interrelationships of the various hydrostratigraphic zones discussed above. One of the goals of the RI was to validate and/or refine the initial or preliminary conceptual hydrogeological model put forth by BWXT/ARCO. Based on the data obtained during the RI, the conceptual hydrogeologic model remains generally intact. This conceptual model identifies five hydrostratigraphic units where groundwater is acknowledged to occur. Various hydrogeologic properties of these units contribute to the relative significance of these units with regard to potential contaminant occurrence and migration. The refined conceptual hydrogeologic model is discussed below.

Recharge of the hydrogeologic system at the site occurs in the form of precipitation. Infiltration is slow however due to the clayey surface soils. The recharge area of the site is thought to exist in the southeastern portion of the site in the region with the highest topographic elevations. This is supported by the groundwater contour map of the overburden (Figure 2-16). The subsurface is also recharged by seepage of surface water flow, discharging within Dry Run, into the unconsolidated materials (overburden soils and mine fill), as well directly into the upper portions of the rock (during drier times of the year) where overburden materials are absent.

Dry Run is considered an ephemeral stream. However, during most of the months the RI field activities were conducted (August 2003 through June 2004), at least a trickle of flow was observed in the streambed. During these conditions and after minor storm events, this "minor" flow disappeared into the mine fill at the site below the location of the weir. Only during extended warm and dry periods was flow completely suspended. During major storm events, with high flow rates, surface water within Dry Run migrated downstream, continued to the lower reaches of the stream, and flowed off site. Most of the flow that percolates vertically into the mine fill likely reaches the underlying claystone and then travels horizontally until the flow reaches the mine workings. Some of this seepage may also likely travel downslope within the mine fill and reappear as seeps below the high wall area, where it is available to recharge the deep bedrock water bearing zone.

The first groundwater zone in the upper trench area encountered is within the base of the overburden, where perched water is impeded from vertical percolation due to the presence of a weathered bedrock unit. This weathered unit is discontinuous across the site. The direction of groundwater flow within this perched zone is horizontal. Within close proximity to Dry Run, groundwater within the overburden discharges to Dry Run via seeps at the overburden/bedrock interface, or, in the case of one seep (SP-DR-01), directly along the ground surface – emanating from the base of a slope directly adjacent to Trench 5. Where the weathered bedrock zone is thin (generally two feet or less) or absent, the soils are dry, as seepage continues vertically into the upper bedrock.

The upper bedrock consists of interbedded zones of siltstone, shale, claystone, and sandstone. The frequent facies changes both horizontally and vertically produces high variability of the hydraulic conductivity of the rock strata. Although it has been shown that there is no sharp division or boundary between the units, there are sections or zones within the upper bedrock that maintain relatively lower hydraulic conductivities and thus, impede groundwater from moving vertically. Therefore, this groundwater becomes perched and is recognized as two zones: Identified as the first shallow bedrock and the second shallow bedrock. These groundwater-bearing zones have slightly higher hydraulic conductivities and likely contain more fractures than the impeding layers. Consequently, it is not a change in lithology (i.e., primary porosity), but the presence of horizontal bedding plain fractures that contributes to the retention of the groundwater (secondary porosity) within these units.

Groundwater within the upper bedrock generally flows horizontally northwards. The groundwater within the first shallow bedrock likely does not contribute flow to Dry Run, as the groundwater elevations are below the stream elevation. There is a downward component or downward vertical gradient from the upper bedrock to the mine workings. The voids within the mine and the horizontal flow along the mine floor create the strong vertical downward gradient. Flow within the mine generally follows the dip of the beds southward, but may also locally pond and change direction due to collapse or other materials that could cause damming. Flow within the mine will seek downgradient discharge points that have been identified to be located along the banks of Carnahan Run located generally south of the SLDA site.

Although the claystone (underclay) below the mine impedes water from moving downward into the lower or deep bedrock, some seepage does occur. In some boreholes, the claystone was observed to maintain very little structure and was broken. In some places, the claystone was observed to consist almost as rubble at the base of the coal seam. It is also feasible that the claystone could have been removed in certain places during mining activities, allowing greater chance of vertical migration into the deep bedrock. Head levels within the deep bedrock indicate the piezometric surface to be within 10 to 20 feet (3 to 6 meters) below the coal mine. Groundwater flow in the deep bedrock is generally horizontal through interbedded sandstone units that appear to be hydraulically connected. Based on limited site data, the direction of flow in the deep bedrock is likely southward, but this may be localized.

2.3.4 Surface Drainage

There are no surface water impoundments on site. During significant rain events, some ponding of rainwater occurs due to the silt and clay-rich soils at the site. The majority of the runoff enters Dry Run, which flows along the north property boundary and eventually empties into the Kiskiminetas River through a culvert beneath Route 66. The headwaters or source of Dry Run initiates from ponded water in the northeastern portion of the site. Where the stream is incised, boulders and bedrock outcrops are exposed.

The USACE defines the Kiskiminetas River as a navigable river. The Kiskiminetas River incorporates a drainage area of approximately 1,825 square miles (4,730 square kilometers), flows generally north, and empties into the Allegheny River approximately 8 miles (13 kilometers) from the site. As reported by the United States Geological Survey (USGS), Yellow Creek Lake, Conemaugh River, Loyalhanna Lake, and several other smaller reservoirs regulate the flow of the Kiskiminetas River. The mean flow of the river is 4,484 cubic feet per second (cfs) (127 cubic meters)(USGS 2004).

Observations made by the project team while at the site during performance of the RI indicate that a diminutive, but continuous flow was present within Dry Run. Immediately following precipitation events, the surface flow within Dry Run was much more appreciable. At least on one occasion, after a significant rain event, Dry Run overflowed its meager banks in the headwaters area and completely filled the incised areas within the lower reaches of the stream on site.

B&W calculated a water budget for the site as part of the site characterization study in 1993. As part of this effort, B&W installed a v-notched weir within Dry Run at approximately the center-point of the stream length. B&W reported the annual infiltration to be 9.2 inches (23 centimeters), the direct runoff to be 7.5 inches (19 centimeters), and the total calculated runoff to be 16.7 inches (42 centimeters, assuming all infiltration discharged to surface water). B&W calculated a drainage basin for Dry Run to be 92.4 acres (37 hectares)(62 acres of the drainage area located above the weir).

2.3.5 Meteorology

Armstrong County is situated along the northern border of the Southwest Plateau climatic division where the climate is humid continental (USDA, 1977). Most weather systems that affect this area develop in the Central Plains or Midwest and are driven eastward by the prevailing winds. Cold air comes down from Canada to the north and warm air and moisture comes mainly from the Gulf of Mexico to the south.

Based on Ford City, PA records (USDA, 1977), Armstrong County receives an average of 39.6 inches (101 centimeters) of precipitation (equivalent rainfall) annually, including 40.1 inches (102 centimeters) of snow. The average daily maximum temperature is 61°F and the average daily minimum is 37°F. The highest and lowest temperatures on record are 98°F and -23°F, respectively. The National Oceanographic and Atmospheric Agency (NOAA) weather station located in Pittsburgh indicates Pittsburgh receives an average of 37.85 inches (96 centimeters) of precipitation (equivalent rainfall) annually, including 43.0 inches (109 centimeters) of snow (NOAA website 2004). The annual average maximum wind speed was reported to be 58 miles per hour (mph) (93 kilometers per hour) and the average wind speed as 9.0 mph (15 kilometers per hour) at this station.

2.3.6 Surrounding Land Use and Populations

According to the U.S. Census Bureau information, Armstrong County had a population of 72,392 in 2000. Between 1990 and 2000, the population of Armstrong County decreased from

73,478 to 72,392, equating to approximately 0.15 percent per year. Assuming this rate of decline remains constant, the projected population of Armstrong County will be approximately 71,306 by the year 2010.

The boroughs (towns) within 1.5 miles (2.4 kilometers) of the SLDA site include Hyde Park and Leechburg to the northwest, and Vandergrift and North Vandergrift/Pleasant View to the southeast. The 2000 and 1990 U.S Census Bureau data are compared for these boroughs in Table 2-10. The total population for this area decreased from 10,381 to 9,709, a rate of 0.67 percent per year. The number of housing units decreased at a rate of 0.32 percent per year, from 4,955 in 1990 to 4,800 in 2000.

Land use within the vicinity of the SLDA site is mixed, consisting of small residential communities, rural residences, small farms, idle farmland, forested areas, and light industrial development. The residential community of Kiskimere is located just to the south of the site. A restaurant and car wash located along Route 66 to the northwest of the site are the closest commercial businesses near the site.

2.3.7 Ecology

2.3.7.1 Vegetation

Armstrong County originally had a dense cover of trees that were cut down for commercial purposes or cleared for houses and farms. The present commercial woodland consists of second- and third-growth stands and occupies approximately 50 percent of the land area. The principal forest types and percentage of commercial woodland are oak-hickory (30 percent), elm-ash-red maple (25 percent), aspen-birch (20 percent), maple-beech-birch (18 percent), white pine (5 percent), and other oak types (2 percent). In general, the soils of Armstrong County support good growth for yellow-poplar, ash, red oak, and sugar maple (USDA, 1977).

Vegetation in the region is representative of the eastern mixed mesophytic forest zone. Most of the SLDA site, including the trench areas, has been cleared of trees with vegetation consisting of mixed grasses and wild perennials. The remainder of the site is wooded.

2.3.7.2 Wetlands

A wetland survey at the site was completed by BWXT in 1993. According to BWXT, three wetland areas were identified at the site: two along the south side of Dry Run and one along the southeastern border of the site (as depicted on Figure 3-5 in the Site Characterization Report). In addition, a search was completed of the U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) for federally identified wetlands on or in the vicinity of the site. Environmental Data Resources (EDR) performed this search. No NWI wetlands are present at the SLDA site, based on the EDR report. However, five NWI wetlands (two riverine and three palustrine) were identified by EDR as being within a 1.0-mile (1.6 kilometer) radius of the SLDA site. The full EDR report is provided in Appendix I.

2.3.7.3 Wildlife

White-tailed deer are abundant throughout Armstrong County, especially where there is brush, young trees, and small open areas. Black bear are seen in the rugged hills adjacent to the Allegheny River and its major tributaries, mainly within the Weikert-Gilpin soil association. Wild turkey thrive in rugged woodland undisturbed by farms within the Weikert-Gilpin soil association. Ruffed grouse are prevalent in idle lands and strip mines, particularly where woodlands provide good habitat in grapevines and brushy areas. Gray and fox squirrels inhabit most of the county, especially woodlands with dominant oak and hickory stands. Part of the southern half of Armstrong County has established local populations of pheasant, although survival is low and annual restocking is necessary. Cottontail rabbits, raccoon, and woodchuck are abundant throughout the county. Bobwhite quail occupy parts of the Gilpin-Weikert-Ernest soil association. Woodcock inhabit the bottomland where alders dominate. Red fox inhabit farms and gray fox occupy woodlands in the county (USDA, 1977).

During performance of the RI, white-tailed deer, squirrels, woodchucks were observed to inhabit the site. Numerous species of birds and other fowl were also observed including wild turkey, crows, woodpeckers, and red-tailed hawks.

Due primarily to the ephemeral nature of Dry Run, no fish were observed within this tributary. However, the Allegheny River provides good habitat for a number of fish species especially below the locks where dissolved oxygen concentrations are highest. The species include muskellunge, northern pike, large and small mouth bass, walleyes, and other warm-water fish. Trout is stocked for put-and-take fishing in 13 streams and two lakes in Armstrong County (USDA, 1977).

3.0 REMEDIAL INVESTIGATION ACTIVITIES

The purpose of this section is to provide a description of the RI activities completed between August 2003 and June 2004. The gathering of data for this remedial investigation was performed in a manner consistent with procedures outlined in the final RI work plans prepared for the site entitled, *Remedial Investigation Sampling and Analysis Plan, Part I - Field Sampling Plan and Part II - Quality Assurance Project Plan, Site Safety and Health Plan, and Radiation Protection Plan* (USACE, 2003a and 2003b), hereafter referred to as the SAP. Some modifications were made to procedures outlined in these plans. These modifications are presented in Table 3-1.

URS completed a Daily Quality Control Report (DQCR) at the end of each work day or the following morning to document equipment on-site, work completed, samples collected, quality control activities, health and safety activities and any other noteworthy occurrence. DQCRs are included as Appendix Q. All workers and visitors were required to sign the Employee/Visitor Register in the office trailer upon entering and exiting the site. URS conducted a daily health and safety meeting in the office trailer prior to initiating work. During the course of the safety meeting, the scope of work for the various crews was discussed, as well as potential safety issues and suggestions or requirements to minimize risk to workers or visitors to the site. All attendees of the daily health and safety meeting were required to sign the Daily Safety Meeting Log, which was prepared by the field manager and summarized the personal protective equipment (PPE) protection levels to be worn, work activities, etc. Photographs taken throughout the field program are presented in Appendix J.

3.1 Background Sampling

On October 20 and 21, 2003, SJB Drilling, Inc. (SJB) mobilized a Simco-2400 direct-push rig and operator to advance soil borings for background soil sample collection at Gilpin/Leechburg Community Park. Analysis of background surface and subsurface soils was deemed necessary to evaluate the regional radionuclide concentrations in an effort to determine background levels of radionuclides for the SLDA site. Gilpin/Leechburg Community Park is located in Gilpin Township approximately three miles northwest of the SLDA site as shown in Figure 3-1. The park location was selected for background sample collection due to the presence of similar soil types as SLDA, the fact that the park has had no adverse environmental impacts based upon an environmental database report, and was assumed to be free of any potential impacts from SLDA.

A gamma walkover survey was performed at the park in June 2003 to generate background data for the gamma survey completed at the SLDA site. Background data collected using the NaI and Field Instrument for Detecting Low Energy Radiation (FIDLER) probes were presented as Appendix R of the SAP (USACE, 2003a). The mean concentrations for the three NaI probes were 25,399 counts per minute (cpm). The mean concentration for the four FIDLER probes was 12,151 cpm.

A URS geologist and radiation technician provided direction to the Simco operator, completed field screening of soils retrieved during drilling, and collected background soil samples. The workers completed background soil sampling in Level D personal protective equipment. A total of 18 borings were advanced at locations based on a 300 by 300-foot (91 by 91-meter) grid with 50-foot (15 meter) spacing between grid nodes, resulting in an overall area of 90,000 square feet (8,360 square meters). Background soil borings were identified as BK-001 through BK-018. The actual boring locations are presented in Figure 3-1.

Prior to drilling and sample collection activities, URS measured background concentrations of radiation using a "microR" meter (Ludlum Model 19 or Bicron microRem) and a FIDLER coupled to a Ludlum Model 2221 ratemeter. VOCs were measured with a calibrated multigas indicator manufactured by Minirae, Inc.

At each boring location, URS collected a surface soil sample from ground surface to a depth of 0.5 foot (15 centimeters) using a stainless steel trowel. In an effort to collect a sufficient volume for laboratory analysis, the diameter of the hole was approximately 6 inches (15 centimeters). The URS geologist classified the excavated soils to document conditions such as soil type, grain size, color, density, moisture and other overburden soil characteristics. In addition, the potential presence of environmental contamination was evaluated through field screening using the microR meter, FIDLER, calibrated multigas indicator and visual/olfactory observations (i.e., odors/staining). Subsequent to field screening, the surface soil sample was placed into a labeled, 16-ounce plastic sample bottle and temporarily stored in a precleaned cooler.

SJB utilized a 4-foot (1.2 meters) long, 1.5-inch (3.8 centimeters) inside diameter macrocore sampler attached to the end of the Simco rods to recover subsurface soils. Each boring was advanced to a depth of 4 feet (1.2 meters) below ground surface using the Simco hydraulic system. SJB retracted the macrocore sampler from the ground once the terminal boring depth was achieved and removed the acetate liner from within the sampler by unscrewing the shoe. The acetate liner was then cut open with a utility knife to gain access to the subsurface soils. The URS geologist evaluated the recovered subsurface soils using the same procedures as were used for the surface soils (described above). Subsequent to field screening, one subsurface soil sample was collected from a depth of 2 to 4 feet (0.6 to 1.2 meters) below ground surface. Representative soils from the 2- to 4-foot interval were placed into a labeled, 16-ounce plastic sample bottle and temporarily stored in a precleaned cooler. Table 3-2 presents a summary of samples that were collected during the background sample collection program. Information presented in Table 3-2 includes sample identification, sample depth, field screening measurements and laboratory analysis completed.

Subsurface logs were prepared for each boring which contained a description of soils encountered based on the visual classifications, field screening measurements and additional information collected during advancement of the boring. Subsurface logs are presented in Appendix C with a key sheet explaining the terms and symbols used.

Once the boring was completed, the hole was filled with the residual soils recovered during drilling, and the remainder of the hole was filled with a bentonite/cement grout slurry to grade.

The background soil samples were shipped under chain-of-custody to General Engineering Laboratories (GEL) in Charleston, South Carolina for analysis. Each of the 36 background samples was analyzed for the primary list of radionuclides consisting of: U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. In addition, four of the samples (approximately 10 percent) were analyzed for the secondary list of radionuclides consisting of: Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, and Pu-242. Quality assurance/quality control (QA/QC) samples were also collected in accordance with the objectives presented in the SAP. Details regarding the analytical testing program completed on the collected background samples are found in Section 3.3.

3.2 Summary of On-Site Investigation Activities

A field office trailer and storage drop box were mobilized to the SLDA site in late August 2003 and set up along the southwest property line approximately 250 feet southeast (76 meters) of the access gate. Water and electric utility connections were arranged by URS. A decontamination pad manufactured by Ultra Containment Berms, Inc. (Ultimate model) was also set up in late August 2003 adjacent to an existing stone road east of the office trailer. The decontamination pad was designed for subcontractor equipment and vehicle decontamination as required. A 60- by 80-foot (18 to 24 meter) drum storage pad was constructed of crushed stone and sand directly southeast of the office trailer. Two 4,000-gallon (15,100-liter), double-walled aboveground storage tanks were staged adjacent to the decontamination pad and were designed to contain all decontamination, rock coring, and well development water generated during field investigations. One 1,200-gallon (4,500-liter), polypropylene aboveground storage tank was also staged adjacent to the decontamination pad; this tank was designed to be used for steam cleaning and drilling operations. Existing on-site utilities, including three natural gas lines, were marked by contacting Pennsylvania One Call.

The URS Certified Health Physicist (CHP) conducted a daily source check to confirm that the microR, FIDLER, and pancake radiation meters were functioning prior to use in the field. In addition, a URS geologist or environmental technician calibrated field screening or groundwater sampling equipment on a daily basis prior to use in the field.

3.2.1 Project Goals

Development of project goals was initiated at the Technical Project Planning (TPP) meeting conducted by the USACE in August 2002, which was attended by the stakeholders associated with the site. The intent of the project goals was to collect sufficient data to assess the potential presence of radiological contaminants in SLDA site media in a manner compliant with applicable federal, state, and local regulations and to evaluate potential remedial alternatives. The specific goals for the SLDA site are presented below with a discussion of how these goals were or were not achieved during the RI work (USACE, 2003b):

1. Determine whether or not the trench contents pose the potential for unacceptable risk to human health and/or the environment, and characterize the trench contents for disposal purposes. This project goal was achieved through the collection and laboratory analysis of soil and waste samples from within the trench limits identified by ARCO using geophysical surveys. Leachate samples were also collected to aid in this determination. The data collected were used in a qualitative risk assessment to determine if the 25 millirem/year dose limit was exceeded (refer to Section 6.0 for the baseline human health risk assessment). In addition, the data generated from chemical laboratory analysis (toxicity characteristic leaching procedure [TCLP], Resource Conservation and Recovery Act [RCRA] parameters and PCBs) were used to aid in the characterization of the trench contents for disposal purposes and to better evaluate health and safety concerns for remediation workers.

2. Investigate for the presence of additional disposal areas and reduce the uncertainty regarding the horizontal limits of the waste trenches. Information was obtained through the collection/analysis of samples from trench borings and soil borings from the areas surrounding the trenches. Some of the soil borings were located based upon the historical aerial photographic analysis (USACE, 2003). However, upon review of the materials retrieved during drilling and sampling, it was determined that this project goal was only partially achieved since the limits of disposal Trenches 2, 4, 5, 6, 7, and 9 were refined and the limits of Trenches 1, 3, 8 and 10 were not.

3. Determine direction of horizontal and vertical groundwater flow on site, in and between the five hydrogeologic stratigraphic units. Project goal No. 3 was addressed through installation of several additional groundwater monitoring wells including five FLUTe multiport sampling systems installed at strategic locations on the site perimeter. Each FLUTe system was designed to measure water levels and collect groundwater samples from four discrete water bearing zones using a multiport

monitoring system installed in one hole. Subsequent to the monitoring well and FLUTe system installation, water levels were measured and aquifer testing was completed to refine the existing hydrogeologic site model.

4. Confirm the list of radionuclides of potential concern (ROPCs) at the site. The list of ROPCs was based on historical information, previous sampling, and professional judgment (refer to Section 2.1.1 for rationale). Primary ROPCs for the SLDA site included: U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, Am-241, and gross alpha/beta (waters and air only). Additional potential radionuclides (secondary ROPCs) that may be present based on anecdotal information and proximity to the former Parks Nuclear Fabrication facility included: Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, and Pu-242. This project goal was attained by analyzing each sample for the primary ROPC and ten percent of the samples for secondary ROPCs. Since a significant number of samples were analyzed from each media of concern, the resulting analytical results confirmed the list of ROPCs at the SLDA site (refer to Section 4.0).

5. Determine if radium-228 (Ra-228) could be used as a surrogate to determine the concentration of thorium-232 (Th-232), based upon secular equilibrium. Establishing a correlation between the Th-232 and Ra-228 would allow Ra-228, as determined from gamma spectrometry, to be used for estimating the Th-232 concentration (in place of alpha spectrometry for Th-232). This project goal was attained since the correlation between Ra-228 and Th-232 was established from the significant number of samples analyzed (refer to Section 3.3 and Appendix P).

6. Determine background concentrations of ROPCs in surface and subsurface soils from Gilpin/Leechburg Community Park. A total of 18 surface and subsurface soil samples were collected from the park. Project goal No. 6 was achieved through analyzing these samples and calculating the mean and 95 percent upper tolerance limit (UTL) of the data set (refer to Sections 4.1 and 6.0).

7. Determine upgradient concentrations of ROPCs in sediments, surface water, and groundwater. On-site upgradient concentrations of ROPCs in sediments were obtained through analysis of samples collected from locations SD-DR-05 and SD-

DR-06. On-site upgradient concentrations of ROPCs in surface water were obtained through analysis of samples collected from locations WS-DR-05 and WS-DR-06. Concentrations of ROPCs in Carnahan Run sediments upgradient of the Mine Outfall were obtained through analysis of samples collected from locations SD-CR-01 and SD-CR-02. Concentrations of ROPCs in Carnahan Run surface water upgradient of the Mine Outfall were obtained through analysis of samples collected from locations WS-CR-01 and WS-CR-02. Upgradient concentrations of ROPCs in the overburden groundwater were obtained from samples collected from monitoring wells MW-59, MW-64, and MW-69. Upgradient concentrations of ROPCs in the first shallow bedrock zone were obtained from samples collected from groundwater monitoring wells MW-08, MW-09A, MW-14, MW-15, and MW-24. Upgradient concentrations of ROPCs in the second shallow bedrock zone were obtained from samples collected from groundwater monitoring wells MW-33, MW-45, and MW-52. Upgradient concentrations of ROPCs in the Upper Freeport Coal zone were obtained from samples collected from monitoring wells MW-01, MW-05, MW-06, and MW-56. Upgradient concentrations of ROPCs in the Deep Bedrock zone were obtained from samples collected from monitoring wells MW-19, and MW-58, and FLUTe system ports NWS-03-04, NWS-04-04, and NWS-05-04.

8. Determine ambient baseline levels of ROPCs in air. Project goal No. 8 was accomplished through completion of a perimeter air sampling and analysis program. Samples were collected from five air sampling locations on a weekly basis during the RI activities between August 26 and December 9, 2003 and on a monthly basis between January 6 and August 12, 2004.

9. Determine the nature and extent of ROPCs above background in on-site media for surface soils and subsurface soils and above upgradient concentrations for groundwater, sediments, and surface waters. To achieve this goal, surface and subsurface soil samples were collected from over 100 boring locations. A total of 103 surface soil and 304 subsurface soil samples were collected and analyzed for primary ROPCs. Two separate groundwater, sediment, surface water, and groundwater seep sampling events were also completed to provide sufficient data to satisfy this project goal. Samples were collected during a dry season (winter 2003) and a wet season (spring 2004) and each sample was analyzed for primary ROPCs.

Approximately 10 percent of all samples collected were also analyzed for secondary ROPCs. Analytical results were compared to background concentrations determined while completing project goal Nos. 6 and 7.

10. Determine risk to human health and the environment from ROPCs in on-site media including surface soils, subsurface soils, groundwater, sediments, and surface waters. This project goal was accomplished by completing human health and ecological risk assessments as described in Sections 6.0 and 7.0, respectively.

11. Characterize solid and aqueous investigation-derived waste (IDW) for disposal purposes. To achieve this project goal, samples were collected of liquid and soils IDW generated during the RI work that did not exhibit any indication of radiological contamination based on field screening. Waste profiles were prepared based on the process that generated the materials, the IDW sample analytical results and the disposal facility requirements.

3.2.2 Gamma Walkover Survey

On behalf of the USACE, URS completed a gamma survey at the SLDA site between June 9 and 20 and on July 24, 2003. The gamma survey was performed in accordance with USACE-reviewed Gamma Walkover Survey Work Plans (USACE 2003a) and completed to generate coverage maps showing variations of gamma radiation levels in site surface soils. An additional purpose was to identify specific health and safety concerns for workers conducting future activities at the site. The results of the survey were used to generate site drawings depicting the variations among the measured gamma radiation levels. This information was then used to help select soil sample locations.

Radiation measurement data were collected using a Ludlum Model 44-20, 3-inch by 3-inch (7.6-centimeter by 7.6-centimeter)(3x3) NaI scintillation detector and a FIDLER, both coupled to separate Ludlum Model 2221 count-rate meters. In the open areas where a reliable global positioning system (GPS) signal could be obtained, a Trimble Pathfinder PROXR GPS unit recorded the geographic position and matched it to the count rate at that location. GPS was not used in the wooded areas, where the signal was not reliable. Instead, the locations of the gamma measurements in the wooded areas were tied to site grid nodes that were marked at 33-foot (10-meter) intervals in the field. The data from both detectors, the GPS data (from the open areas), and the grid node locations (in the wooded areas) were electronically logged and downloaded to an onsite computer for reduction, transfer, and storage.

URS obtained background radiation data at Gilpin/Leechburg Community Park located on Pennsylvania State Route 66 approximately 3 miles (4.8 kilometers) from the SLDA site. Background gamma walkover measurements were collected, in both static (stationary) and walkover modes, from a 98-foot-by-98-foot (30-meter-by-30-meter) reference area. Several measurements were made so that statistical evaluations of background levels could be determined (mean, standard deviation, upper tolerance level of the mean, etc.).

These background measurements for the particular detectors used were higher than had been assumed in estimating the Minimum Detectable Concentrations (MDCs) for suspect contaminants using the field instrumentation. This does not impact the overall results of this survey since the values for both detectors are still well below the tentative PRGs for all radionuclides except plutonium-239. The low detection efficiency for Pu-239 emissions results in MDCs much higher than the PRGs, regardless of the variation in background.

Data were collected in open areas at SLDA by slowly walking the 3x3 NaI detector and the FIDLER, mounted on a carriage (a modified baby stroller), in straight-line sections. Both detectors were held approximately 1 foot (30 centimeter) above the ground surface with a linear scan rate of approximately 1.6 foot/second (50 centimeter/second). The spacing between the straight-line sections was about three feet (0.9 meters). The count rate was automatically logged during the survey. At the completion of the survey, the count rate, matched to its physical coordinates (via GPS), was downloaded into a computer and transmitted to the URS office for input into a GIS.

In those areas where it was not possible to use the stroller-mounted unit, a grid of survey stakes was established with a spacing of 33 feet (10 meters). Gamma measurements were taken within each 33-foot-by-33-foot (10-meter-by-10-meter) grid using both detectors and recorded by the data loggers. The readings were recorded at a rate of one per second, which typically resulted in 100 to 400 readings taken per grid.

The data collected at SLDA were compared to the background data obtained at Gilpin/Leechburg Community Park. Twice the background mean is a common metric used to identify elevated readings, and is suitable for screening the large amount of data obtained during this survey to identify areas for biased sampling. Further evaluation of locations with gamma readings in excess of the background UTL will be carried out, if necessary, in the Feasibility Study based on any isotopes identified as Contaminants of Concern.

None of the data collected with the 3x3 NaI detector were greater than twice the background mean. The data collected using the FIDLER identified three different areas above twice the background mean as illustrated in Figure 3-2. Two of the areas were in the northwest portion of the site: one was directly off of the northwest corner of Trench 10, and the other was just above the highwall, southeast of Trench 10. Area 3 was located southeast of the upper trench area, near the limits of the waste exhumation completed in 1965.

Levels above background, but below twice the background mean, were also identified in the areas of the trenches as well in the northern portions of Dry Run. These elevated levels in Dry Run may have been due to the exposed shale in these areas, and higher levels of naturally occurring radiation. This may have also been the case in the areas of the trenches due to potential excavation of shale during waste disposal activities completed in the 1960s and 1970. The elevated levels in the trench areas may have also been due to the material that was placed in the trenches themselves or residual material deposited around them as a result of the disposal or waste exhumation operations.

The results of the gamma survey indicated that elevated levels of radioactivity relative to background were present in three relatively small areas. However, none of the gamma levels identified, or the areal extent of the respective areas, constituted imminent threats to health and safety. To confirm this, the RI soil sample collection program incorporated these three areas in an effort to quantify the presence of radionuclides, if any.

3.2.3 Trench Investigations

Waste material from the Apollo plant operations was deposited at SLDA in a series of pits. No historical records were found that provide the exact location of these pits. Geophysical data from previous studies reported 10 geophysical anomalies that have been interpreted as disposal Trenches 1 through 10. These geophysically-delineated areas were subsequently investigated by ARCO/B&W through the installation of borings around the perimeter of each anomaly. Trench investigations completed during the RI were deemed necessary since no direct sampling and analysis of the waste material had been performed to date.

Between November 4 and 22, 2003, SJB mobilized a Simco-2400 direct-push rig and operator to the SLDA site to advance borings within the limits of the disposal trenches and to facilitate collection of subsurface soils or waste material. A URS geologist and radiation protection technician provided direction to the Simco operator; completed field screening of soils, fill materials, and/or waste retrieved during drilling; and collected samples for laboratory analysis. Field screening of recovered soils/fill materials was completed on a soil classification table equipped with a wood and aluminum apparatus designed to support the radiation meters and allow a consistent approach to scanning each 4-foot (1.2 meter) core (i.e., the geometry remained consistent throughout the program). The workers completed the trench investigations in Level B personal protective equipment, which included supplied breathing air.

The on-site URS CHP was directly involved with health and safety issues related to the trench investigations. In this role, the CHP implemented an air monitoring program during intrusive work and procedures to minimize potential spread of contamination. The air monitoring program generally involved collection of air samples from the geologist's breathing zone and down wind of the work area. The samples were analyzed on-site for gross alpha and beta radiation using a Ludlum model 2929 alpha beta scaler equipped with a model 43-10-1 sample counter. Section 3.2.9.2 provides additional detail on the procedures and results of the air monitoring program.

A total of 44 trench borings were advanced at locations generally corresponding to the 43 locations proposed in the SAP. Additional trench boring TR-10-007R was advanced since refusal was encountered at TR-10-007. The actual trench boring locations are presented in Figures 4-3 and 4-4.

In accordance with the SAP, the following protocols were used for sample collection during the trench boring program:

1. A biased soil or waste sample was collected from the depth that exhibited the highest instrument reading above background during field screening.
2. In the event there were no elevated measurements recorded using the field screening instruments, the sample was collected at the depth where visible evidence of waste material was present.
3. If there were no elevated measurements (above background) using the field screening instruments, and there was no visible evidence of contamination, soil samples were collected from the following depths: ground surface to 0.5 feet, 4 to 6 feet, 8 to 10 feet, and 12 to 14 feet (0.15 meters, 1.2 to 1.8 meters, 2.4 to 3.1 meters, 3.7 to 4.3 meters).

SJB utilized a 4-foot (1.2-meter) long, 1.5-inch (3.8 centimeter) inside diameter macrocore sampler to recover subsurface soils. Each boring was advanced to a depth of 20 feet (6.1 meters) below ground surface or refusal using the Simco hydraulic system. SJB retracted the macrocore sampler from the ground once the sampler was advanced 4 feet (1.2 meters) or had reached the terminal boring depth and removed the acetate liner from within the sampler by unscrewing the shoe. The acetate liner was cut open with a utility knife to gain access to the subsurface soils.

The URS geologist classified the recovered material to document conditions such as the presence of fill or waste materials, soil type, grain size, color, density, moisture and other characteristics. In addition, the potential presence of environmental contamination was evaluated through field screening using the microR meter, FIDLER, calibrated multigas indicator, and visual observations (i.e., the presence of fill materials, staining). Field screening was completed at the soil classification table. Subsurface soils, fill materials, or waste materials identified for sampling using the protocols described above were placed directly into a labeled, 16-ounce plastic sample bottle and temporarily stored in a precleaned cooler.

In cases where a surface soil sample was required, URS collected a surface soil sample from ground surface to a depth of 0.5 feet (15 centimeters) using a stainless steel trowel. In an effort to collect sufficient a volume for laboratory analysis, the diameter of the hole was approximately 6 inches (15 centimeters). The URS geologist classified the surface soils to document conditions such as soil type, grain size, color, density, moisture and other overburden soil characteristics. In addition, the potential presence of environmental contamination was evaluated through field screening as described above. The surface soil sample, when required, was then placed into a labeled, 16-ounce (470 milliliter) plastic sample bottle and temporarily stored in a precleaned cooler.

Background radiation and VOC measurements were made at the soil classification equipment table prior to initiating work and were re-measured when the table was moved to a different location. The table was typically placed in one location central to several borings and only moved once or twice a day.

Subsurface logs prepared for each boring contained a description of soils or materials encountered based on the visual classifications, field screening measurements and additional information collected during advancement of the boring. Subsurface logs are presented in Appendix C with a key sheet explaining the terms and symbols used.

Eleven of the thirteen borings completed within the lower trench area were advanced to depths greater than approximately 16 feet (4.9 meters). Of the 31 trench borings completed in the upper trench area, the maximum depth achieved was 18 feet (5.5 meters), the minimum depth was 4.9 feet (1.5 meters) and the average depth was 11.1 feet (3.4 meters) below ground surface. For borings where no elevated field screening measurements or visible waste materials were apparent, the URS geologist collected samples at the depths identified in protocol No. 3 and, in some cases, modified the depth of the deepest sample to meet the intent of the program (refer to Table 3-1). Other factors, such as the presence of weathered rock and very low sample recoveries, also affected actual sample depths.

30 Borings did not exhibit elevated field screening measurements or visual evidence of waste materials, but a total of 14 borings were sampled in accordance with sampling protocol

Nos. 1 and/or 2 listed above. The borings where elevated field screening measurements or waste materials were detected were identified as: TR-002-021, TR-002-023, TR-002-024, TR-002-025, TR-004-039, TR-004-040, TR-006-037, TR-006-038, TR-007-031, TR-007-033, TR-008-030, TR-009-026, TR-009-027, and TR-009-028. Other than boring TR-008-030 (which did not exhibit elevated radiological field screening measurements), one sample was collected from each trench boring and analyzed for radionuclides. Table 3-3 presents a summary of samples that were collected during the trench boring program. Information presented in Table 3-3 includes sample identification, sample depth, field screening measurements and laboratory analysis completed.

A total of 100 soil samples were collected from the 30 trench borings that did not exhibit elevated field screening measurements or visual evidence of waste materials (protocol No. 1). Due to the number of samples collected, the absence of any contamination detected during field screening, and the project goals established for the trench boring program, the project team identified 33 samples for radiological testing. Table 3-4 presents a summary of samples collected in accordance with protocol No. 3 that were submitted for laboratory analysis including sample identification, sample depth, field screening measurements and laboratory analysis completed, if any. Table 3-5 summarizes information pertaining to samples collected in accordance with protocol No. 3 that were not submitted for laboratory analysis.

A total of 10 samples were also collected during the trench boring program for chemical analyses. The purpose of the chemical analytical testing was to obtain additional information related to potential treatment, storage and/or disposal of trench materials. Five of these samples were collected of waste material or materials that exhibited elevated radiation or chemical contamination levels based on field screening (Trenches 2, 4, 6, 7, 8, and 9). Although samples collected for chemical analysis from Trenches 1, 5, and 10 did not exhibit any evidence of contamination, samples were collected to provide data for the feasibility study. Information pertaining to samples collected for chemical testing is also presented in Tables 3-3 and 3-4 including sample identification, sample depth, field screening measurements recorded and laboratory analysis completed.

The samples collected during the trench boring program were shipped under chain-of-custody to GEL for analysis. Each of the trench samples designated for radiological testing were analyzed for the primary list of radionuclides consisting of: U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. In addition, approximately 10 percent of the samples collected were analyzed for the secondary list of radionuclides consisting of: Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, and Pu-242. Several samples were also collected from trench borings for chemical testing. One sample was collected from Trenches 1, 2, 4, 5, 6, 7, and 9 and two samples were collected from Trench 10. Each sample was analyzed for the full TCLP list of parameters, RCRA characteristics, and PCBs. In addition, two samples were collected from Trench 8 for chemical testing. The sample collected from 14-16 feet (4.3-4.9 meters) was analyzed for RCRA characteristics and PCBs and the sample collected from 16-16.7 feet (4.9-5.1 meters) was analyzed for the TCLP list of parameters. QA/QC samples were also collected in accordance with the objectives presented in the SAP. Details regarding the analytical testing program completed on samples collected during the trench boring program are found in Section 3.3.

Once the trench boring was completed, the hole was filled with the residual materials recovered during drilling, provided there were no indications the materials were contaminated based on field screening. The remainder of the hole was filled with a bentonite/cement grout slurry to grade.

During drilling at Trench 6, a small quantity of radioactively contaminated PPE, acetate liners, soil cuttings and decontamination water was generated. The liners were decontaminated and size reduced to fit into a 55-gallon (208-liter) drum, the decontamination water was put into a second drum and the soil cuttings were put in a third drum. PPE was deemed similar to the acetate liners (i.e., compactable dry active waste [DAW]) so any contaminated PPE was put into this waste stream. The three 55-gallon (208-liter) drums were removed from the trench area and staged on the drum storage pad, adjacent to the IDW drums. The drums were labeled as “Radioactive Material” and are in a posted Radioactive Materials Area (RMA) pending results of sample analysis to characterize the wastes.

3.2.4 Surface and Subsurface Soil Sampling

Between October 22 and November 24, 2003, SJB mobilized a Simco-2400 direct-push rig and operator to the SLDA site to advance soil borings for soil sample collection. Subsurface soil sampling locations around the upper and lower trenches were designed to help establish the horizontal and vertical concentrations of ROPCs at or near the disposal trenches. Another purpose of these borings was to evaluate if any radionuclides have migrated from the disposal trenches into the surrounding soils. Soil borings were also located where 29 historical soil samples contained radionuclide concentrations greater than the PRGs, shown in Table 6-1, in an effort to determine the nature and extent of the elevated concentrations.

A URS geologist and radiation technician provided direction to the Simco operator, completed field screening of soils/fill materials retrieved during drilling, and collected soil samples for laboratory analysis. Field screening of recovered soils/fill materials was completed on the soil classification table equipped with a wood and aluminum apparatus that supported the radiation meters and allowed a consistent approach to scanning each 4-foot core (1.2-meter) (i.e., the geometry remained consistent throughout the program). The workers completed these activities in Level D personal protective equipment.

In addition, the on-site project CHP was directly involved with health and safety issues related to the soil boring program. In this role, the CHP implemented an air monitoring program during intrusive work and procedures to minimize potential spread of contamination. The air monitoring program generally involved collection of air samples adjacent to soil classification table and down wind of the work area. The samples were analyzed on site for gross alpha and beta radiation using a Ludlum model 2929 alpha beta scaler equipped with a model 43-10-1 sample counter. Section 3.2.9.2 provides additional detail on the procedures and results of the air monitoring program.

A total of 103 soil borings were advanced at locations generally corresponding to the 102 locations proposed in the SAP. The borings were identified as SB-001 through SB-102 and SB-102R. Boring SB-102R was advanced near SB-102 where elevated radiation levels were measured on the ground surface during drilling activities using the microR meter. The actual boring locations are presented in Figures 4-3 and 4-4.

At each boring location, URS collected a surface soil sample from ground surface to a depth of 0.5 feet (15 centimeters) using a stainless steel trowel. In an effort to collect a sufficient volume for laboratory analysis, the diameter of the hole was approximately 6 inches (15 centimeters). The URS geologist classified the excavated soils to document conditions such as soil type, grain size, color, density, moisture and other overburden soil characteristics. In addition, the potential presence of environmental contamination was evaluated through field screening using the microR meter, FIDLER, calibrated multigas indicator, and visual/olfactory observations (i.e., odors/staining) at the soil classification table. The surface soil sample was then placed into a labeled, 16-ounce (470-milliliter) plastic sample bottle and temporarily stored in a precleaned cooler.

SJB utilized a 4-foot (1.2-meter) long, 1.5-inch (3.8-centimeter) inside diameter macrocore sampler to recover subsurface soils. Each boring was advanced to a depth of 20 feet (6.1 meters) below ground surface or refusal using the Simco hydraulic system. SJB retracted the macrocore sampler from the ground once the sampler was advanced 4 feet (1.2 meters) or had reached the terminal boring depth and removed the acetate liner from within the sampler by unscrewing the shoe. The acetate liner was cut open with a utility knife to gain access to the subsurface soils.

The URS geologist evaluated the recovered subsurface soils using the same procedures as were used for the surface soils (described above). Background radiation and VOC measurements were made at the table prior to initiating work and were re-measured when the table was moved to a different location. The table was typically placed in one location central to several borings and only moved once or twice a day.

In accordance with the SAP, if there were no elevated measurements recorded using the field screening instruments or visual evidence of waste material, soil samples were collected from the following intervals:

- From ground surface to 0.5 feet (15 centimeters, surface soils).
- From 4 to 6 feet (1.2 to 1.8 meters).
- From 8 to 10 feet (2.4 to 3.1 meters).
- From 12 to 14 feet (3.7 to 4.3 meters).

In the event that elevated field screening measurements and/or visual evidence of waste material were detected, the following protocol was used:

- One soil sample was collected from ground surface to 0.5 feet (15 centimeters, surface soils).
- One sample was collected from the depth where the highest field screening measurement was detected or where visible evidence of waste was present.
- Two additional samples were collected directly above and below the apparent impacted soils in an effort to "bound" the contamination.

The majority of the borings completed encountered refusal at depths of less than 12 feet (3.7 meters) and several could not be advanced to depths greater than 7 or 8 feet (2.1 or 2.4 meters). As a result, the URS geologist collected samples at the depths identified above where appropriate and, in some cases, modified the depth of the deepest sample to meet the intent of the program. Other factors, such as the presence of weathered rock and very low sample recoveries, also affected actual sample depths. Soils or fill materials identified as sample material were placed into a labeled, 16-ounce (470-milliliter) plastic sample bottle and temporarily stored in a precleaned cooler.

None of the eight samples collected from borings GB-67 through GB-70 were shipped to the laboratory for analysis since these samples were not collected from the intended locations. Borings GB-67 through GB-70 were to be located around monitoring well MW-39 just south of the high wall. The borings were located in the field using a Global Positioning System (GPS) based on coordinates provided by ARCO early in the investigation planning process. Subsequent to drilling and sampling activities, it was apparent that monitoring well MW-39 was actually located approximately 200 feet (61 meters) to the southwest. After discussions with the project team, it was decided that the samples collected would not be analyzed and that borings GB-67 through BG-70 would not be re-drilled.

In addition, the four samples collected from boring GB-102 were not analyzed since the samples from replacement boring GB-102R were analyzed instead. GB-102 was to be drilled where elevated radiation was detected during the gamma survey. However, after drilling and sampling at GB-102, the elevated radiation was detected on the ground approximately 10 feet (3.1 meters) away and GB-102R was drilled. Table 3-6 presents a summary of samples collected for laboratory testing including sample identification, sample depth, field screening measurements recorded and analysis completed.

The samples collected during the soil boring program were shipped under chain-of-custody to GEL for analysis. A total of 304 soil samples were analyzed for the primary list of radionuclides consisting of: U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. In addition, 32 soil samples (approximately 10 percent) were analyzed for the secondary list of radionuclides consisting of: Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, and Pu-242. QA/QC samples were also collected in accordance with the objectives presented in the SAP. Details regarding the analytical testing program completed on samples collected during the soil boring program are found in Section 3.3.

Subsurface logs prepared for each boring contained a description of soils encountered based on the visual classifications, field screening measurements and additional information collected during advancement of the boring. Subsurface boring logs are presented in Appendix C with a key sheet explaining the terms and symbols used.

Once the boring was completed, the hole was filled with the residual soils recovered during drilling, and the remainder of the hole was filled with a bentonite/cement grout slurry to grade.

3.2.5 Groundwater Monitoring Well Installation and Development

Prior to mobilization to the particular monitoring well locations, a site reconnaissance of the proposed drilling locations was conducted to stake the locations and identify areas that required clearing of trees and shrubs and utility clearances. Utility clearances for the on-site natural gas lines were facilitated through the Pennsylvania One Call System.

An equipment staging area, which included a decontamination pad, drilling equipment, and monitoring well construction materials storage area, was assembled near the office trailer. An on-site spigot connected to the municipal water supply supplied potable water. All drilling rigs were power-washed using steam prior to any drilling. All decontamination water was collected within the decontamination pad and transferred to two 4,000-gallon (15,100-liter) storage tanks on site for eventual off-site disposal.

All drilling and well installation activities were completed in general accordance with the procedures outlined in the SAP. SJB performed all drilling and monitoring well installation under the direct supervision of a URS geologist. Drilling was initiated using a truck-mounted Central Mine Equipment (CME)-85 drilling rig. The truck-mounted rig was eventually replaced with two track-mounted CME-850 drilling rigs, due to site access problems.

3.2.5.1 Subsoil (Overburden) Monitoring Wells

Boreholes intended for monitoring wells within the subsoil (SS) unit were advanced through the overburden using 4¼-inch (10.8-centimeter) inside diameter (ID) hollow stem augers (HSA). Soil samples were collected using 2-inch (5-centimeter) ID split-barrel samplers in accordance with American Society for Testing and Materials (ASTM) Standard D-1586-99. Soil samples were collected continuously in two-foot intervals until refusal on bedrock was obtained. As the split-barrel samplers were opened, the soil samples were screened using a photoionization detector (PID), a Ludlum model 19 microR meter to measure low-level gamma radiation, and FIDLER connected to a Ludlum model 2221 portable rate meter. The soil samples were examined, classified, inspected for visual signs of contamination (i.e., staining and/or presence of waste material), and placed into jars labeled with the boring/well location, sample number, depth interval, blow counts, and date. Samples were later stored in the lock-box on site. Soils were classified according to the USCS and as specified in the RI SAP. All observations were recorded in the field on a field boring log. Final boring log forms are provided in Appendix C. Notations regarding start and stop times, weather, drilling operations, and other significant observations were recorded in dedicated project field books.

Five overburden wells (MW-47, MW-59, MW-64, MW-69, and MW-74) were installed in the upper trench area (Figure 4-6). At two of the proposed locations (MW-48 and MW-49), no water was encountered in the borings and these two locations were tremie backfilled with cement-bentonite grout to the ground surface. These two boring locations are identified as Test Borings (TB) TB-03 and TB-04, respectively. Additionally, two borings were completed within the mine fill of the strip-mined area in the vicinity of Trench 10 (MW-54 and MW-56). However, these two wells were constructed to monitor the groundwater flow at the base of the Upper Freeport (UF) Coal seam, and therefore were considered UF monitoring wells and not subsoil monitoring wells (discussed in further detail in Section 3.2.5.2.2).

The subsoil monitoring wells were constructed of two-inch ID schedule 40 PVC threaded flush-jointed riser and 0.01-inch (0.025-centimeter) slot screen with threaded end caps. All well risers and screens were new and factory-sealed in plastic. Well screen lengths varied between five and 10 feet (3.1 meters) in length, dependent on field conditions (total depth and saturated thickness of the SS unit). A sand pack, consisting of clean, well-rounded, silica sand with a grain size distribution compatible with the formation materials and screen slot size, was installed within one foot below to two feet above the top of the screen. A six-inch (15 centimeter) layer of fine silica sand was placed above the sand pack. A bentonite seal consisting of either pellets or chips was placed above the fine sand. In cases where the bentonite seal was placed above the water table, the seal was hydrated with potable water and allowed to sit for approximately one hour before a cement-bentonite grout was tremied into the remainder of the hole.

The subsoil monitoring wells were finished with a 4-inch (10-centimeter) diameter, above ground, steel, lockable protective casing. A gravel pad consisting of coarse gravel was placed on the ground around each protective casing and extended approximately three feet (0.9 meter) radially from the casing. Monitoring well construction diagrams for the subsoil monitoring wells are provided in Appendix D.

3.2.5.2 Bedrock Monitoring Wells

Installation of the bedrock monitoring wells was initiated by advancing borings with 8¼-inch (21-centimeter) inside diameter HSA to the top of bedrock. Continuous soil samples were collected according to the same sampling procedures described above for the overburden monitoring wells. Once bedrock was reached, a three-foot socket was created either by augering through weathered rock or by using 7.875-inch (20-centimeter) diameter roller bit through competent rock. After the boreholes were flushed with potable water to remove any rock cuttings, a six-inch inside diameter steel casing was placed into the borehole with an approximate two-foot stick up. The steel casing was tremie grouted into the hole and allowed to seal for at least 12 hours before additional drilling was initiated.

3.2.5.2.1 First and Second Shallow Bedrock Monitoring Wells

Three first shallow bedrock (1SB) monitoring wells were installed (MW-50, MW-51, and MW-60). Three second shallow bedrock (2SB) wells were also installed (MW-52, MW-53, and MW-61). The monitoring well locations are depicted on Figures 4-7 and 4-8, respectively. Monitoring wells MW-50, MW-51, MW-52, and MW-53 were installed according to the procedures specified in the SAP and as summarized below. Following installation of the six-inch (15-centimeter) steel casing, the drill rig was re-mobilized over the casing and a nominal four-inch (10-centimeter) outside diameter (OD) or 3.5-inch (8.9-centimeter) ID HQ diamond-tipped core barrel was used to advance the borehole to approximate targeted depths. In most cases, 10-foot (3.1-meter) long core samples were retrieved. In some cases core lengths were shorter to address field conditions. Each core sample retrieved was inspected and monitored with the field instruments as described for the soil samples. Bedrock cores were evaluated for degree of weathering, fracture presence, aperture, orientation, grain size, and RQD were calculated by totaling the sections of the core runs at least four inches (10 centimeters) in length divided by the entire run length. The run intervals, RQD, bedrock descriptions, and field instrument measurements were recorded on a field boring log form or field book.

Monitoring well MW-60 was installed in the borehole originally advanced for NWS-01 and intended for a FLUTe installation. However, the drilling rods and core barrel become lodged in the borehole and a second borehole (NWS-01A) located about 55 feet (17 meters) northwest of the original borehole was advanced and utilized for the FLUTe installation. Once the drilling tools were removed from the original borehole, the borehole was converted to MW-60 – a 1SB monitoring well. The intent of monitoring well MW-60 was to assist in verifying the groundwater elevation within the first shallow bedrock in this area of the site. The well construction diagram is presented in Appendix D. Prior to constructing MW-60, the borehole was backfilled with grout from 150 feet (46 meters) to the bottom of the mine estimated to be at 101 feet (31 meters) below ground surface. A rubber plug was placed into the borehole above the mine at a depth of approximately 90 feet (27 meters). Grout was placed into the borehole from 90 feet to 50 feet (27 meters to 15 meters) below ground surface, the depth where construction of well MW-60 was initiated.

Monitoring well MW-61 was installed to monitor groundwater within the second shallow bedrock, within 20 feet (6.1 meters) of the FLUTe system installed at NWS-01A. MW-61 was installed several months after the NWS-01A FLUTe system was installed to assist in verifying the groundwater elevation within the second shallow bedrock in this area of the site. As agreed to with the USACE, and because of the existing subsurface information obtained from the surrounding boreholes, MW-61 was drilled utilizing a 4.875-inch (12.4-centimeters) roller bit only and was not cored. Final boring logs for the 1SB and 2SB bedrock monitoring wells are provided in Appendix C.

Subsequent to completion of the coring for these wells, packer permeability testing was completed on all open boreholes (with the exception of MW-61). Descriptions of the packer testing procedures are provided in Section 3.2.5.8 and the packer testing results are discussed in Section 2.3.3.2.

At the completion of the packer testing, the bedrock cores and packer testing results were compared and the screened intervals for these wells were confirmed based on degree of fracturing, stratigraphy, and hydraulic conductivity results from the packer testing. The screen interval for MW-61 was placed at the same interval as that for the FLUTe monitoring system which was designed for the second shallow bedrock-monitoring zone. The boreholes were then reamed with a 4.875-inch (12.4-centimeters) roller bit to the completion depth of the boreholes. Each borehole was washed with potable water to remove rock cuttings. Each of the first and second shallow bedrock wells was constructed utilizing a 10-foot (3.1-meter) long, 2-inch (5-centimeter) diameter PVC well screen and PVC riser. The sand pack, fine silica sand, bentonite seal and cement/bentonite grout were placed according to the procedures specified in the SAP and as described above for the subsoil wells.

The bedrock monitoring wells were finished with a 4-inch (10-centimeter) diameter, above ground, steel, lockable protective casing, which was grouted within the six-inch (15-centimeter) steel casing. A gravel pad consisting of coarse gravel was placed on the ground around each protective casing and extended approximately three feet (0.9 meters) radially from the casing. Monitoring well construction diagrams for the shallow bedrock monitoring wells are provided in Appendix D.

3.2.5.2.2 Upper Freeport Mine Monitoring Wells

The SLDA site has two different geologic regimes. In the upper trench area, between 85 and 100 feet (26 and 31 meters) of strata overly the Upper Freeport coal seam. This coal seam was deep mined using the room and pillar method. This mining method leaves pillars or blocks of coal to provide support for the overlying strata. In the area of Trench 10, the area was strip-mined and all of the overlying strata were removed in order to access the coal, which was subsequently removed. Groundwater monitoring wells were installed at the site to monitor the ground water elevation concomitant with the coal seam. Accordingly, monitoring well screens were installed across the coal seam or mine void within the upper trench area, and in the case of the Trench 10 area at the base of the mine fill and at the top of the claystone (underclay) where the coal previously existed. Specifically, monitoring wells MW-57 and MW-62 were installed to monitor the coal within the eastern portion of the site (Figure 4-9). These monitoring wells were installed as described above for the shallow bedrock wells with the following modifications. A 2-inch (5-centimeter) diameter PVC well screen was placed so that at least two feet (0.6 meters) of the well screen was below the base of the coal seam to create a “sump”. The top of the screen was placed at least five feet (1.5 meters) above the top of the coal to accommodate possible water elevation changes within the coal. Monitoring well MW-62 was installed several months after FLUTe monitoring system NWS-04, located just northwest of MW-62. MW-62 was installed in an attempt to help substantiate the groundwater elevation within the coal or underground mine in this vicinity of the site. Monitoring wells MW-57 and MW-62 were both subsequently installed through residual coal and not void spaces.

Monitoring wells MW-54 and MW-56 were installed in the Trench 10 area at the base of the mine fill and above the underclay. Monitoring wells MW-54 and MW-56 were installed by first advancing 4-¼ inch (10.8 centimeter) ID HSAs to the point of refusal. Split-barrel samples were obtained continuously ahead of the augers as specified in the SAP. Due to the variable thickness of the mine fill, five-foot (1.5-meter) long and 10-foot (3.1-meter) long well screens were installed for monitoring wells MW-54 and MW-56, respectively. These monitoring wells were installed according to procedures previously described for the overburden (subsoil) monitoring wells.

The monitoring well construction details for the Upper Freeport monitoring wells installed during the RI are provided in Appendix D.

3.2.5.2.3 Deep Bedrock Monitoring Wells

Monitoring well MW-58 was installed to monitor the groundwater within the deep bedrock (DB) aquifer, which is present within sandstone units occurring beneath the Upper Freeport coal seam. Monitoring well MW-58 was located next to Dry Run in the northwest portion of the site, within the strip-mine area where a significant amount of overlying strata is no longer present. Although bedrock cores were obtained to a depth of 81.2 feet (25 meters), the screened interval was placed between 25 and 35 feet (7.6 and 10.7 meters) bgs. The borehole was therefore reamed with a 4.875-inch (12.4 centimeters) roller bit to a depth of 35 feet (10.7 meters). The boring was backfilled with cuttings to 42-feet (12.8 meters) bgs on top of which a bentonite seal was placed to 38-feet (11.6 meters) bgs. A sand pack was installed three feet (0.9 meters) below and two feet (0.6 meters) above the top of the screen. The bentonite seal and cement/bentonite grout were installed as described previously. The boring log and monitoring well construction details for this well are provided in Appendices C and D, respectively.

3.2.5.3 Monitoring Well Development

Each of the newly installed monitoring wells was developed by either pumping or bailing to remove particulates and residual drilling water. Pumping consisted of utilizing either a peristaltic pump for shallow wells or a down-hole 4-stage Monsoon submersible pump for deeper wells. Monitoring wells that recharged slowly were generally developed with a dedicated plastic bailer. Monitoring well development was performed in accordance with the procedures detailed in the SAP. Field measurements of temperature, pH, specific conductivity, and nephlometric turbidity units (NTUs) were obtained until these parameters stabilized. If a well did not recharge appreciably, an attempt to remove at least three well volumes was made. Monitoring well development records are provided in Appendix K.

3.2.5.4 FLUTe Well System Installation and Development

Five nested well sets (NWSs) were installed at locations along the north side of Dry Run and in the eastern and southern portions of the site (NWS-01A through NWS-05 - see Figure 4-5). The bedrock wells for each nested well set were constructed utilizing the FLUTe multiport or multi-level groundwater sampling system. Conventional 2-inch (5-centimeter) diameter PVC monitoring wells were installed at four of the five (NWS-01A through NWS-04) locations to monitor the overburden groundwater (refer to Figure 4-6 for locations). Figure 3-3 presents a schematic illustration of a single port FLUTe system designed to monitor one water-bearing zone. The FLUTe systems installed at SLDA monitored the four bedrock water bearing zones discussed in Section 2.3.3 (first and second shallow bedrock, Upper Freeport coal, and deep bedrock). FLUTe well NWS-05 was equipped with two sampling ports in the deep bedrock zone.

One boring at each nested well location was advanced into the deep bedrock zone. Each borehole was initially cored in general accordance with the procedures described for the shallow bedrock wells. It should be noted that at the location for NWS-01, coring was initiated with a PQ-sized core bit (4.875 inches [12.4 centimeters] outside diameter). However, the PQ coring tools became lodged in the borehole beneath the mine and were later removed by overdrilling techniques and a first shallow bedrock well (MW-60) was installed within the upper portion of the borehole (as previously discussed in Section 3.2.5.2.1). Subsequently, a second nested well borehole (NWS-01A) was advanced approximately 55 feet (16.8 meters) northwest of the original borehole. Coring of all the remaining nested well boreholes was completed using an HQ-sized (3.75-inch [9.5 centimeter] diameter hole) diamond-studded core bit to a depth of approximately five feet (1.5 meters) below the Upper Freeport coal or mine void. This upper portion of the borehole was then packer tested beginning approximately three to five feet (0.9 to 1.5 meters) above the coal or mine void to just below the bottom of the six-inch (15-centimeter) steel casing previously installed. Following packer testing of the upper portion of the borehole, this portion of the borehole was reamed with a 4.875-inch (12.4-centimeter) roller bit to approximately five feet (1.5 meters) below the coal or mine void. Temporary four-inch (10 centimeter) ID steel casing was then installed to a depth coincident to the bottom of the reamed hole. Coring with the HQ core bit resumed to a targeted depth within the deep bedrock zone at each boring location. Once the bottom portion of the borehole was cored, this portion of the borehole was subsequently packer tested. The portion of the borehole below the temporary four-inch (10 centimeter) casing (below the coal mine) in each of the nested well boreholes was not reamed.

Preliminary results from the packer testing (procedures and results are discussed in Sections 2.3.3.2 and 3.2.5.8, respectively) were used in conjunction with inspection and annotations of the bedrock cores to determine the specific targeted monitoring intervals for the FLUTe systems. Following completion of the coring and reaming of each borehole, the recommended monitoring intervals were transmitted to the FLUTe Company so the FLUTe systems could be manufactured and shipped to the site. Details of the FLUTe installation procedures are described below.

3.2.5.5 FLUTe System Installation

Following completion of the coring and packer testing of the nested well boreholes, a "blank" FLUTe liner was installed into the boreholes to prevent down-hole, cross contamination of the hydrostratigraphic units and to maintain borehole integrity. The "blank" liner was constructed of a polyurethane coated nylon fabric "sleeve" that expanded against the borehole walls and contained no sampling or monitoring points. The blank liner was installed within each borehole while the individual FLUTe systems were constructed. To facilitate the installation of the blank liners, the four-inch (10 centimeter) ID temporary steel casing was re-installed into the boreholes and the blank liners were advanced into the borehole utilizing a shipping reel. The top of the liner was attached to the six-inch (15-centimeter) steel casing and the liner was then pushed down inside the 4-inch (10-centimeter) casing a short distance. Water was added to the interior of the liner, driving the liner deeper into the hole, pulling the inside-out liner from the reel. The interior water pressure on the liner was the driving force of the installation. The installation of the liner was affected by the depth and diameter of the boreholes, the relative transmissivity of the formation, the depth of the water table and the rate at which water was added to the interior of the liner. Rates of descent to the bottom of the boreholes for the blank liners ranged from several hours to several days. The water within the liner forced it against the borehole walls, sealing the formation and preventing cross-contamination between water-bearing zones. The blank liners remained in the boreholes until the manufactured FLUTe monitoring system liners were ready for installation.

Once the FLUTe monitoring system liners were ready for installation, the blank liners were removed from the borehole by removing the water within the blank liners and collapsing the blank liner as it was pulled from the borehole. At two of the locations (NWS-03 and NWS-05), the temporary or blank liners became wedged in the boreholes and, after numerous unsuccessful attempts to collapse and then retrieve the liners, the blank liners at these two locations were subsequently pulled out of the boreholes using the drill rig winch.

The individual monitoring ports of the FLUTe system comprised a “spacer” defining the sampling interval. The “spacer” was constructed of a permeable material that was connected to the exterior of the liner (between the liner and the borehole wall) that allowed groundwater to enter the spacer. Pore water (groundwater) entering the spacer was directed by gravity to a sampling port (located at the center of the spacer interval) that collected the formation water for future sampling. Figure 3-3 shows a typical FLUTe sampling port system (for simplicity, only one sampling port is shown). The water flowed from the formation into the spacer, through the port, into the tube that was on the inside surface of the liner. The water flowed from the port via the tube, to the bottom of the hole, and then upward through a Teflon/stainless steel check valve into the "U" shaped tube. The water rose in both legs of the U tube. In the larger (1/2-inch [1.3-centimeter] ID) tube, the water level could be measured from the ground surface. Formation water to be purged for sample collection was forced out through the smaller diameter tubing by an inert gas (nitrogen) pressure source. The spacer, port, tubing and pump system were duplicated for each port. The liner was pressed against the borehole wall by the excess head in the liner above the local water table. The design allowed obtaining groundwater samples from discrete intervals within the formation, assuming sufficient groundwater existed within the formation to flow into the spacer and monitoring port systems.

At the SLDA site, the FLUTe systems installed at nested well sites NWS-01A through NWS-04 contained four individual spacers, referred to as ports 01 through 04 – coinciding to each of the bedrock monitoring zones (i.e., 1SB, 2SB, UF, and DB, respectively). At NWS-05, a second, deep bedrock spacer/monitoring port was placed in the deep bedrock (port 05). At nested well locations NWS-01A, NWS-03, and NWS-05, port 03 was placed across the mine void encountered. The FLUTe liners placed at these locations were reinforced through the section of liner intersecting the mine void. At NWS-02 and NWS-04, port 03 spanned across coal. FLUTe system as-builts (i.e., well construction details) for the five FLUTe systems installed at the SLDA site are provided in Appendix D.

Although the final monitoring port FLUTe system liners were installed in generally the same manner as the blank liners, once the FLUTe systems were installed in the boreholes, the water collected in the tubing for each port was evacuated using nitrogen in an attempt to stabilize the system and to facilitate reaching equilibrium of the various groundwater head elevations. During the purging of the sample ports and monitoring of the water elevations within the tubing, it emerged that the FLUTe systems were not providing reliable or accurate groundwater elevation data. Based on review of the field measurements, and after consultation with the FLUTe Company and the USACE, the following was concluded regarding the FLUTe systems:

1. FLUTe systems at NWS-02 and NWS-05 were apparently leaking water from the liner and, as a result, were unable to permanently seal the zones being monitored. Similar leaks were found to exist in the blank liners suggesting difficulty in installation due to the unique geology at this site.

2. Water was not present at ports monitoring the shallow bedrock (ports 01 and 02) in FLUTe systems at NWS-01A, NWS-04, and NWS-05, suggesting these zones were

dry. This finding seemed incompatible with the presence of groundwater in shallow bedrock wells installed in close proximity to these FLUTe systems.

3. At FLUTe system locations NWS-02 and NWS-04, water levels in the deep bedrock zone were measured at levels above the Upper Freeport coal seam (port 03). This condition suggested the existence of an upward hydraulic gradient, which is not likely to exist at the site.

To address the issue of data reliability and in order to compensate and seal the liners (in order to generate accurate groundwater head elevation data), URS performed the following tasks to confirm the functionality of the FLUTe systems based on the recommendations of the FLUTe Company:

1. URS purged and monitored the recovery of the groundwater elevations within the FLUTe monitoring systems over a period of approximately three weeks. It was determined that the groundwater elevation data was inconsistent with the water level elevation data from the other monitoring wells installed at the site.

2. URS field personnel added water to the interior of the liners to bring the head levels within the liners above the shallowest water table. At NWS-01A, NWS-04, and NWS-03, bringing the head level above the shallow water table allowed the liner to seal properly. At NWS-02 and NWS-05, after adding water to the liner, the water levels declined substantially, indicating apparent leaks in these two liner systems.

3. URS measured the total depths of each of the monitoring tubes, confirming each was labeled and constructed pursuant to the as-builts provided by the FLUTe Company.

4. A vacuum test was completed on the monitoring port tubing lines for the upper two shallow bedrock ports. The results of the tests indicated the lines were indeed open and would allow groundwater to collect in the sample ports if present.

To address the leaks within the FLUTe liners at NWS-02 and NWS-05, each of these FLUTe liners were grouted in-place using a cement/bentonite grout in May 2004. Each liner was grouted starting at the bottom of the liner in stages. The portion of the borehole/liner below the mine void or coal seam was initially grouted. The following day, a second lift of approximately

20 to 40 linear feet (6.1 to 12.2 linear meters) of grout was placed into the liner each day until the grout within the liner was at approximately 10 feet (3.1 meters) below grade. Once the grouting was completed, the monitoring ports were purged with nitrogen and these two FLUTe systems were re-developed in general accordance with the procedures described below.

3.2.5.6 **FLUTe Monitoring System Development**

Development of the FLUTe system involved purging formation water through the tubing bundles for each monitoring port interval. The same process used for development was also used for collection of groundwater samples, except the pressure applied for sampling was less than what was used for purging. Nitrogen was used to pressurize the larger tubing to force water out through the smaller diameter sample tubing. Each port was purged of the water that collected in the port/tubing system (if any). Once the volume of water was purged (generally up to 2 gallons [7.6 liters] at a time), called a "stroke", the ports system was allowed to recharge before another stroke was initiated. Time intervals between strokes were influenced by permeability and transmissivity of the particular zone monitored (generally at least 10 minutes between strokes). During each stroke, a groundwater sample was obtained in order to measure temperature, pH, specific conductivity, and turbidity. Development continued until these parameters generally stabilized. Development records for the FLUTe system development are provided in Appendix K.

During re-development of the FLUTe system at NWS-02, it became evident that grout contamination had affected the formation groundwater. The pH values (>10 standard units) and specific conductance values (> 2000 μmhos) were determined to be elevated above the other values of these two parameters established at the site.

3.2.5.7 **Aquifer Testing**

To better quantify the hydraulic characteristics of the water-bearing units at the SLDA site, two types of hydraulic conductivity tests were performed during the RI. These two methods included packer tests in bedrock borings, and slug tests within newly installed subsoil monitoring wells and two of the UF monitoring wells screened within the mine fill.

3.2.5.8 Packer Testing

Packer permeability tests were conducted on all bedrock monitoring wells (including the FLUTe system locations) prior to the installation of the well/FLUTe materials. The packer testing was conducted in general accordance with ASTM Standard D 4630 and with the procedures specified in the SAP to provide estimates of the fracture permeability in the rock. Open boreholes were tested at 10-foot (3.1-meter) intervals over the entire rock-exposed borehole. The only intervals not tested included the mine void or coal seams and intervals that would have overlapped the lowest portions of the surficial six-inch (15-centimeter) steel casing previously installed in each borehole. The drilling subcontractor performed the tests under the direct supervision of a URS geologist.

The packer test apparatus consisted of two inflatable neoprene packers separated by a perforated one-inch (2.5-centimeter) diameter pipe. Prior to use at the site, the down-hole portions of the apparatus were steam-cleaned and tested for leaks. The down-hole portions of the apparatus were also steam-cleaned between borehole locations. The water level was measured within the borehole prior to insertion of the packer assembly to determine the hydrostatic pressure in the borehole. The packer assembly was then inserted into the borehole to the desired depth and the packers were pneumatically inflated utilizing nitrogen to a working pressure that ensured proper seals of the packers (generally 100 to 200 pounds per square inch [psi]). Clean water was injected into the packer assembly and through the perforated pipe within the designated, isolated interval within the bedrock borehole and the volume of water injected was determined for a measured period of time. The flow rate and corresponding pressure was recorded over a number of increasing and decreasing pressure steps. The hydraulic conductivity was calculated from the flow rate, length and radius of the test interval in the borehole, and effective hydraulic head. The analysis of the packer test data are included in Appendix F and the results are discussed in Section 2.3.3.2.

3.2.5.9 Slug Testing

In-situ hydraulic conductivity tests of newly installed monitoring wells within the subsoil and mine fill water bearing zones utilized the slug test method. In this method, rising and falling head conductivity tests were performed to provide estimates of the horizontal hydraulic conductivity of unit screened. A one-inch outside-diameter (OD) stainless steel slug was used to raise and lower the water level in the well, and an electronic pressure transducer and data logger were used to monitor the recovery of the water level back to static conditions.

The Bouwer and Rice method for unconfined aquifers was used to analyze the test data (Bouwer and Rice 1976; Bouwer 1989). Slug test analyses are provided in Appendix G and the results are discussed in Section 2.3.3.2.

3.2.5.10 Water Level Monitoring

Water levels within existing monitoring wells and piezometers and in newly installed monitoring wells were recorded with a 0.0625-inch (1.6-centimeter) diameter electronic water level indicator probe. The FLUTe monitoring port water levels were measured using a 0.375-inch (1-centimeter) diameter water level indicator probe. A complete round of the existing wells and piezometers was taken on November 25, 2003. Water levels were also collected during well development and sampling activities. Water levels within all existing wells and piezometers and newly installed wells were collected on January 11, 2004. An additional round of water levels was taken on June 7, 2004 during the second groundwater sampling event of site wells. Water level data collected at the site is provided in Appendix H. The water level data were used to develop potentiometric surface contour maps for the various stratigraphic zones at the site (see Section 2.3.3.2).

3.2.6 Groundwater Sampling

Groundwater samples were collected from site groundwater monitoring wells in December 2003 (a dry season) and in June 2004 (a wet season). Sampling was conducted after the newly installed wells were allowed to stabilize. Figure 4-5 illustrates the new and existing groundwater monitoring wells on site. Also shown in Figure 4-5 are the five FLUTe multiport sampling system locations. The SAP specified analysis of groundwater samples collected from all new and existing monitoring wells to establish and update groundwater quality data associated with each hydrostratigraphic unit. Field personnel completed groundwater sampling activities in

Level D personal protective equipment. Groundwater sampling activities were completed pursuant procedures specified in the SAP.

3.2.6.1 Groundwater Monitoring Well Sampling

URS completed groundwater sampling events in December 2003 and June 2004. During each sampling event, two URS sampling crews attempted to sample all existing and new groundwater monitoring wells on site. The work generally involved gauging the water level in the well, purging the well and sampling the well using low-flow sampling techniques presented in the SAP. Tables 3-7 and 3-8 present a summary of the well identification, sample date and analysis completed for each event.

Low-flow groundwater sampling refers to the velocity with which water enters the pump intake from the surrounding formation in the immediate vicinity of the well screen; it does not necessarily refer to the flow rate of water discharged at the surface. This procedure provided a method that minimized the amount of impact the purging process had on the groundwater chemistry during sample collection and minimized the volume of water that needed to be purged and ultimately disposed of.

Whenever possible, groundwater was pumped from the well with a Monsoon 4-stage pump with a flow controller manufactured by Proactive Industries. In a very limited number of wells, groundwater was evacuated using a bailer, low-density polyethylene (LDPE) tubing with a check valve, or a Grundfos Ready Flow II submersible pump. Water quality parameters including pH, temperature, conductivity, dissolved oxygen, and oxidation reduction potential (ORP) were monitored on a continuous basis using a YSI Groundwater Monitoring Multiprobe System model 556 MPS equipped with a flow-through cell. Turbidity was measured using a Lamotte turbidity meter model 2020. The YSI and Lamotte instruments were calibrated for pH, conductivity, dissolved oxygen, ORP and turbidity in the field trailer every morning prior to well purging or sampling. The Monsoon pump was powered with a 12-volt car battery.

Well purging was initiated at wells that were suspected to be the least contaminated (typically upgradient), and progressed systematically to those wells that were presumed to be the most contaminated. The determination of whether a well was suspected to be impacted from historical site activities was based largely on previous chemical and radiological sampling results and whether the well was upgradient or downgradient of the disposal trenches. The following tasks were completed during well purging:

(1) Placed plastic sheeting on the ground around the well head and noted the condition of the well.

(2) Recorded all data on the Low Flow Groundwater Purging/Sampling Logs. Unlocked the well cover and measured the depth to groundwater and depth to the bottom of the well using an electronic water level indicator. Measurements were referenced to the top of the well casing. Decontaminated the end of the water level meter probe between well measurements.

(3) Placed the pump and support equipment next to the well and slowly lowered the pump and LDPE tubing down into the monitoring well until the location of the pump intake was set within the screened interval.

(4) Measured the water level to the nearest 0.01-foot (0.31-centimeter) and recorded the water level during purging.

(5) Connected the discharge line from the pump to the YSI Groundwater Monitoring Multiprobe System flow-through cell. Groundwater discharged from the flow-through cell was collected in 5-gallon (19-liter) pails and transferred to a 55-gallon (208-liter) drum or was pumped directly into the drum.

(6) Groundwater was pumped from the well at a low flow rate and the rate was slowly increased while the water level was monitored. A steady flow rate was maintained through a trial and error process without creating a large drawdown, where possible.

(7) Estimated the discharge rate of the pump by timing the volume that accumulated in a 5-gallon (19-liter) bucket. Continued purging while periodically recording the flow rate and water level.

(8) Purged a minimum of one tubing volume (including pump and flow-through cell volumes) prior to taking field measurements. Monitored and recorded field parameters every 3 to 5 minutes.

(9) Continued purging the well until stabilization criteria was met or the well became dry. Stabilization criteria consisted of three consecutive stable measurements of the water quality field parameters (less than 10 percent deviation). The well was considered purged once stable water quality measurements were obtained.

(10) In the event stabilization criteria were not achieved, the well was purged of at least three well volumes prior to obtaining the groundwater sample. If three well volumes were not evacuated from a very low-producing well, the volume evacuated was documented and a groundwater sample was obtained if the water was deemed representative.

(11) Transferred all purged water into the on-site bulk storage tanks for storage until final disposal.

Subsequent to well purging, a groundwater sample was collected if sufficient volume was present in the well. If the well recharged slowly, the sample was collected over a period of time, but within 24 hours of purging. Specific groundwater sampling procedures are listed below:

(1) If possible, collected the groundwater sample immediately after the well was purged. In the event the sample crew had to allow the well to recharge, the pump that was used during purging was left in the well and used on subsequent intervals to obtain the required sample volume from the well.

(2) Collected groundwater samples directly from the discharge port of the pump tubing prior to its passing through the flow-through cell. The samples were

collected into two 1-gallon (3.8 liter) plastic bottles and pre-preserved with nitric acid.

(3) Placed the caps on the sample containers, recorded the time of sample collection, and placed the samples in a pre-cleaned cooler.

(4) Removed the pump and tubing from the well, placed the pump into a plastic bag and transported it to the decontamination pad where it was decontaminated by an environmental technician using an Alconox and water solution.

(5) Replaced the well cap, locked the outer casing, and cleaned up the area.

(6) Completed chain-of-custody information and shipped the samples to the laboratory for analytical testing.

Low Flow Groundwater Purging/Sampling Logs are presented as Appendix L. Groundwater samples were shipped under chain-of-custody to GEL in Charleston, South Carolina for analysis. Each groundwater sample was analyzed for the primary list of radionuclides consisting of: U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. In addition, approximately 10 percent of the samples were analyzed for the secondary list of radionuclides consisting of: Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, Pu-242 and gross alpha/gross beta. QA/QC samples were also collected in accordance with the objectives presented in the SAP. Details regarding the analytical testing program completed on samples collected during the groundwater sampling program are found in Section 3.3.

3.2.6.2 FLUTe System Groundwater Sampling

Due to the complications related to the FLUTe systems described in Section 3.2.5.5, most of the FLUTe systems were not sampled during the first sampling event completed in December 2003. Three samples were collected from FLUTe sampling ports NWS-01A-02, NWS-01A-03, and NWS-01A-04 during the December 2003 sampling event, but the data were subsequently rejected due to the inability to confirm the samples were collected from isolated water bearing zones. Groundwater samples were obtained from the FLUTe systems in June 2004 according to the procedures specified in the SAP and as summarized below.

Prior to actual sample collection, the water level within each port system was measured with a micro-tip electronic water level indicator. The water that collected within the sample ports was then pumped from the U-shaped tube by the downward displacement of the water surface in the large tube (see Figure 3-3). Applying a nitrogen gas pressure to the top end of the large tube (utilizing an air-tight compression valve assembly) effected the water displacement. The water in the large tube was displaced downward through the bottom of the U and upward through the second check valve (steel ball with spring). The water in the slender tube was then forced to the surface. During the purge cycle, the water was completely displaced from the tubing and then allowed to refill. At least 10 minutes were required between purge cycles and, in some cases, up to one half hour was required for recharge.

During the initial purge events, field parameters of pH, temperature, specific conductance, turbidity, dissolved oxygen, and ORP were obtained to monitor the inflow of fresh formation water into the tubing systems. Field sampling forms are provided in Appendix L. At each FLUTe system installation, it became evident that many of the monitoring port intervals did not provide sufficient recharge and were therefore not sampled. In most cases, several hours were required to obtain sufficient sample volume for the required analyses. The FLUTe monitoring port intervals sampled in June 2004 included:

- NWS-01A -ports 02, 03, and 04,
- NWS-02 - none (due to grout contamination),
- NWS-03 - port 03,
- NWS-04 - none, and
- NWS-05 - port 04.

3.2.7 Temporary Waste Sampling Point Sampling

Leachate samples were collected from site TWSPs in December 2003. ARCO/BWXT installed the 58 TWSPs along the assumed centerline of the ten disposal trenches to allow collection of "leachate" samples (Figure 2-4 illustrates the location of the TWSPs). Sampling of TWSPs during the RI was considered important to:

- Determine whether or not the trench contents pose the potential for unacceptable risk to human health and/or the environment (Project Goal No. 1),
- Characterize the trench contents for disposal purposes (Project Goal No. 1), and
- Confirm the list of ROPCs at the site (Project Goal No. 4).

The workers completed TWSP sampling activities in Level D personal protective equipment.

During the sampling event, a URS sampling crew attempted to collect a leachate sample from each TWSP. The work generally involved purging the TWSP of one standing well volume and sampling the TWSP once sufficient recharge was apparent. A total of 58 TWSPs were included in the sampling event; however, 14 TWSPs were considered dry or had insufficient recharge to collect a sample. Table 3-9 presents a summary of the TWSP identification, sample date and analysis completed.

Information gathered during TWSP purging and sampling was recorded on the Well Purge Logs presented in Appendix M. Prior to purging, the URS sampling crew placed plastic sheeting on the ground around the TWSP in an effort to minimize any impact to the surface soils. The TWSP well cover was unlocked and the depth to groundwater and depth to the bottom of the well was measured to the nearest 0.01 foot (0.31-centimeter) using an electronic water level indicator manufactured by Testwell, Inc. Measurements were referenced to the top of the well casing. The water level indicator tape was decontaminated by rinsing the tape and probe with an alconox/water solution and a deionized water rinse (the decontamination water was collected and drummed for disposal). The wellhead was scanned for the presence of VOCs, hydrogen sulfide, oxygen and carbon monoxide, as well as the percent lower explosive limit, using a multigas indicator manufactured by Minirae, Inc. TWSP water level measurements are presented in Appendix H.

The number of gallons in the well was calculated based on the height of the water column and the TWSP diameter. A new 1.5-inch-diameter plastic disposable bailer and polypropylene rope was used to evacuate water from the TWSP. The water was transferred from the bailer into a 5-gallon bucket to estimate the volume removed during purging. As indicated in the SAP, the TWSP was considered purged after removing one well volume. All purge water was transferred into the on-site bulk storage tanks for storage until final disposal.

Water quality parameters including pH, temperature, conductivity, dissolved oxygen, and ORP were measured on samples of leachate using a YSI Groundwater Monitoring Multiprobe System model 556 MPS. Turbidity was measured using a Lamotte turbidity meter model 2020. In general, field measurements were taken at the beginning of purging and during sample collection. The YSI, Lamotte and Minirae instruments were calibrated for pH, conductivity, dissolved oxygen, ORP, turbidity and VOCs in the field trailer every morning prior to TWSP purging or sampling.

Subsequent to TWSP purging, a leachate sample was collected if sufficient volume was present. If the TWSP recharged slowly, the sample was collected within 24 hours of purging. In some cases, the sample collection process continued over several days to collect a total of two gallons, as required by the laboratory.

Leachate samples were collected by lowering the dedicated disposable bailer into the water column, allowing the bailer to fill and pouring the water directly into two labeled, 1-gallon sample bottles and preserved with nitric acid. The sample time was recorded on the label and purge log and the sample was temporarily stored in a precleaned cooler prior to shipment to the laboratory.

The samples collected during the TWSP sampling program were shipped under chain-of-custody to GEL for analysis. Each of the 44 leachate samples was analyzed for the primary list of radionuclides consisting of: U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241.

In addition, five samples (approximately 10 percent) were analyzed for the secondary list of radionuclides consisting of: Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, Pu-242 and gross alpha/gross beta. QA/QC samples were also collected in accordance with the objectives presented in the SAP. Details regarding the analytical testing program completed on samples collected during the TWSP sampling program are found in Section 3.3.

3.2.8 Surface Water, Sediment and Groundwater Seep Sampling

Surface water and sediment sampling was performed in two areas: on-site in Dry Run and off-site in Carnahan Run.

3.2.8.1 On-site Surface Water, Sediment and Groundwater Seep Sampling

Surface water, sediment, and groundwater seep samples were collected from the SLDA site in December 2003 (a wet season) and June 2004 (a dry season). Surface water and sediment sample collection from along Dry Run was completed to assess any impact that the disposal trenches may have had on Dry Run surface water/sediments and to evaluate the potential for radiologically contaminated surface water or sediment to be transported off site. The workers completed these sampling activities in Level D personal protective equipment.

Each surface water and sediment sample was co-located. Two sample locations along Dry Run were upgradient of the trenches, two locations were adjacent to the trenches, and two locations were downgradient of the trenches as shown on Figure 4-11. Six sample locations along Dry Run were selected based upon assumed hydrologic and depositional conditions. The SAP called for the collection of two samples from a drainage swale adjacent to the site road near Trench 10; however, during the course of the RI field work it was apparent that this was not a drainage feature. As a result, there were no sediment or surface water samples collected from this location.

Surface water and sediment sampling in Dry Run proceeded from downstream locations to upstream locations so that disturbances related to sampling would not affect the samples collected on the upstream side. In addition, the surface water sample was collected before the sediment sample to reduce any impact from sediment sample collection. Surface water samples were collected from locations where a smaller plastic sampling cup could be filled directly by submerging it in the surface water and allowing it to fill. The water was then poured directly into two labeled, 1-gallon plastic bottles and preserved with nitric acid.

Sediment samples were collected using a stainless steel trowel and placed directly into a labeled, 16-ounce plastic bottle. A Field Sampling Report form was filled out at the time of sample collection to document field screening measurements, visual observations, sample collection details, sample identification, time and analysis to be completed, etc. The Field Sampling Report forms are presented in Appendix N.

A total of five groundwater seep sample locations were identified from seeps identified during previous investigations. Figure 4-11 illustrates the location of the groundwater seeps sampled. Although the SAP called for installation of horizontal PVC well points, these were not feasible at most locations since the water was flowing at the base of the ground surface. As a result, URS installed new 5-gallon buckets with several holes drilled in them at each seep location several days prior to sampling. Using this approach, the necessary sample volume could be obtained in a short period of time. The groundwater seep samples were obtained by submerging a small plastic sampling cup in the 5-gallon bucket and allowing it to fill. The water was then poured directly into two labeled, 1-gallon plastic bottles and preserved with nitric acid. The buckets were removed two days prior to the June sampling event, decontaminated with alconox and water and reinstalled to facilitate collection of a representative sample.

Field measurements of specific conductance, pH, and temperature were taken while collecting all groundwater seep and surface water samples using a calibrated YSI Groundwater Monitoring Multiprobe System model 556 MPS and turbidity was measured using a Lamotte turbidity meter model 2020. Field measurements were completed on water in the plastic sample collection cup prior to pouring it into the sample bottles. Field measurements were recorded on the Field Sampling Report form.

Surface water, sediment and groundwater seep samples were shipped under chain-of-custody to GEL for analysis. Each of the samples was analyzed for the primary list of radionuclides consisting of: U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. In addition, one surface water and one sediment sample were analyzed for the secondary list of radionuclides consisting of: Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, and Pu-242. QA/QC samples were also collected in accordance with the objectives presented in the SAP. Details regarding the analytical testing program completed on surface water, sediment and groundwater seeps samples are found in Section 3.3. Tables 3-10 through 3-13 present a summary of the surface water, sediment, and groundwater seep sample identification, sample date and analysis completed.

3.2.8.2 <u>Surface Water, Mine Outfall, and Sediment Samples Collected from Carnahan Run</u>

On December 7, 2003 and June 13, 2004 URS collected surface water and sediment samples from Carnahan Run, a stream located approximately 2,000 feet south of the site. Carnahan Run surface water and sediment sampling was completed to evaluate background radiological concentrations in surface waters/sediments and to assess effects that any mine outfalls or seeps may have had on radiological concentrations in sediments. The workers completed the sampling activities in Level D personal protective equipment. Figure 4-15 illustrates the locations of surface water, sediment and mine outfall samples collected from Carnahan Run.

On January 10, 2004, representatives of USACE and URS conducted a reconnaissance of Carnahan Run to identify additional mine seeps along the northern creek banks. A total of three seeps or "outfalls" were identified. The mine outfall that was sampled on both December 7, 2003 and June 13, 2004 consisted of orange colored water flowing from the ground adjacent to an apparent abandoned mine opening (railroad tracks were observed nearby). This outfall is identified on Figure 4-15 as SP-CR-01. The most up-stream seep was located approximately 2,000-feet up-stream of outfall SP-CR-01 and can be described as a 12-inch diameter steel, corrugated pipe. This outfall was not sampled and is not shown on Figure 4-15. The most down stream mine seep was located adjacent to a bridge at Lee Lake. On December 7, 2003, water was flowing from a bedrock face approximately 60-feet above the lake surface at a relatively high flow of approximately 500 to 1,000 gallons per minute. This outfall identified as SP-CR-02 was sampled on June 13, 2004.

Similar to the on-site sampling, each Carnahan Run surface water and sediment sample was co-located. Two sample locations were upgradient of the mine outfall identified by ARCO/BWXT, two locations were adjacent to the outfall, and two locations were downgradient of the outfall. Sample locations are shown on Figure 4-15.

Each surface water sample was collected before the sediment sample to reduce any impact from sediment sample collection. Surface water samples were collected from locations where a smaller plastic sampling cup could be filled directly by submerging it in the surface water and allowing it to fill. The water was then poured directly into two labeled, 1-gallon plastic bottles and preserved with nitric acid.

Field measurements of specific conductance, pH, and temperature were measured using a calibrated YSI Groundwater Monitoring Multiprobe System model 556 MPS and turbidity was measured using a Lamotte turbidity meter model 2020. A Field Sampling Report form was filled out at the time of sample collection to document field screening measurements, visual observations, sample collection details, sample identification, time and analysis to be completed, etc. The Field Sampling Report forms are presented in Appendix N.

Sediment samples were collected using a stainless steel trowel and placing the sediments directly into a labeled, 16 ounce plastic bottle. A Field Sampling Report form was filled out at the time of sample collection to document field screening measurements, visual observations, sample collection details, sample identification, time and analysis to be completed, etc. The Field Sampling Report forms are presented in Appendix N.

Surface water and sediment samples were shipped under chain-of-custody to GEL for analysis. Each of the samples was analyzed for the primary list of radionuclides consisting of: U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. In addition, one sediment sample and the sample collected from the mine outfall were analyzed for the secondary list of radionuclides consisting of: Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, and Pu-242. QA/QC samples were also collected in accordance with the objectives presented in the SAP. Details regarding the analytical testing program completed on samples collected from Carnahan Run are found in Section 3.3. Tables 3-10 through 3-13 present a summary of the surface water, sediment, and mine outfall sample identification, sample date and analysis completed.

3.2.9 Air Monitoring

Air monitoring completed at the SLDA site during the RI work consisted of perimeter air monitoring, work place air monitoring, and breathing zone air monitoring. The perimeter air-monitoring program was completed in accordance with the Ambient Air Sampling Plan found in Appendix D of the Site Safety and Health Plan presented in the SAP. Work place and breathing zone air monitoring was completed during intrusive work (while drilling soil borings) as warranted by site conditions such as weather.

3.2.9.1 Perimeter Air Monitoring Program

The perimeter air monitoring program at the SLDA site consisted of collection and analysis of air samples from five air sampling stations located around the perimeter of the site. In addition, a weather station manufactured by Global Water Instruments, Inc. (model WE800) was installed on site to acquire weather data to aid in the interpretation of the analytical data and significance of the air sampling results. Figure 3-4 illustrates the location of the air sampling stations and weather station. Photograph Nos. 1 and 2 presented in Appendix J illustrate one of the air sampling stations.

Air samples were collected from the five air sampling stations on a weekly basis between August 26, 2003 and December 16, 2003. Samples were then collected on a monthly basis thereafter (January to August 2004). The purpose of the perimeter air-monitoring program was to:

1. Establish the ambient baseline or background levels of the radionuclides of concern.

2. Compare data collected during site work to baseline levels to ensure that there have not been any airborne releases from the site that would result in an exceedance of acceptable levels.

The air sampling locations were based on the prevailing wind direction as indicated from wind speed and wind direction data generated for Parks Township and the proximity of the site to the local community.

On August 18 and 19, 2003, URS installed two high-volume air sampling pumps (model VS23-0523CV) manufactured by HI-Q Environmental Products Company (HI-Q) at each air sampling location. The pumps were equipped with a sample filter holder, 5-foot sample tube, electronic hour meter and venturi flow meter. Two pumps were required at each air sampling station since two filters were needed by the laboratory to complete the specified analyses.

On August 19, 2003, URS inserted filters (47 millimeter, HI-Q part number FP5211-47) into the filter holders and turned the pumps on, initiating the first weekly sampling event. URS recorded the time the pump was turned on, hour meter reading, and flow reading corresponding to each pump. On August 28, 2003, the flow rate of each pump was adjusted to approximately 2.25 standard cubic feet per minute (SCFM), which allowed sufficient volume through the filter for the detection limits required. The pumps were operated continuously and were adjusted periodically to maintain a flow rate of between 2 and 2.25 SCFM.

At the end of each sampling period, the filter was carefully removed from the filter holder, placed into a ziplock sample bag and shipped to GEL under proper chain-of-custody for analysis. The date and time, hour meter reading, and flow rate reading were recorded at the time of sample collection to allow calculation of the volume of air that passed through the filter. GEL analyzed the two filters collected from each air monitoring station for the list of parameters summarized in Table 3-14. Four unused ("blank") sampling cartridges were also submitted to GEL for analysis to satisfy QA/QC objectives. Details regarding analytical testing results of air samples collected during the perimeter air monitoring program are found in Section 3.3.

3.2.9.2 <u>Work Place and Breathing Zone Air Monitoring</u>

The on-site radiation safety officer (RSO) was responsible for implementation of work place and breathing zone air monitoring during RI activities. Work place air monitoring was completed during drilling activities when the potential existed for airborne particulates to be present and no other information was available to indicate there was minimal risk. Work place air monitoring was completed during overburden drilling for well installations, Simco drilling for soil borings and Simco drilling for trench borings. Breathing zone air monitoring was only completed during the trench boring program. Sampling was not typically conducted in heavy rain since the potential for airborne contaminants was greatly reduced at those times.

Work place air samples were collected using high volume air sampling pumps (model VS23-0523CV manufactured by HI-Q) mounted on a steel dolly. The pumps were equipped with a sample filter holder, 5-foot sample tube, and venturi flow meter. Work place air monitoring completed during overburden drilling for well installation involved locating one sampling apparatus approximately 20 to 40 feet downwind of the back of the drill rig. Work place air monitoring completed during the soil boring program consisted of locating two air sampling pumps adjacent to the soil classification table and approximately 50 to 100 feet downwind of the drilling operation. Sample pumps used for work place air monitoring during the trench boring program were located near the Simco rig and approximately 50 to 100 feet downwind of the Simco rig.

Once the air sampling pumps were in position, URS installed filters (47-millimeter HI-Q filters, part number FP5211-47) into the filter holders. The pumps were turned on during intrusive activities as directed by the radiation safety officer. At the end of each sampling period, the filter was carefully removed from the filter holder and placed into a paper envelope. The date and time, drilling location, and flow meter reading were recorded on the envelope.

Breathing zone air monitoring was completed during the trench boring program and involved the use of a breathing zone apparatus (BZA). The URS geologist was equipped with a BZA consisting of a Cassella Apex low-flow sampling pump, tubing and a filter holder mounted on the shoulder. Air was pulled through the filter (47-millimeter HI-Q filter, part number FP5211-47) during the course of the workday at a flow rate of approximately 4 liters per minute (lpm). Flow rate was checked daily using a Gilian Gilbrator.

The radiation safety officer analyzed each sample collected during the work place and breathing zone air monitoring programs on site using a Ludlum Model 2929 Alpha Beta Scaler with Model 43-10-1 Sample Counter. Samples were analyzed for gross alpha and beta radiation as discussed in the Site Safety and Health Plan.

In addition, passive radon monitoring was initiated using a track-etch dosimeter. These were co-located with the five perimeter air sample stations, and in a background area of the Gilpin/Leechburg Community Park. The track-etch dosimeters were deployed on September 17, 2003 and removed for analysis on June 15, 2004.

3.3 Analytical Program

3.3.1 Data Quality Objectives

Data Quality Objectives (DQOs) are qualitative and quantitative statements that specify the quality of data required to support the Remedial Investigation/Feasibility Study (RI/FS) at the SLDA site, while considering the intended use of the data. The DQOs for field and laboratory activities were established based upon available site investigation information and potential Applicable, or Relevant and Appropriate Requirements (ARARs) pertaining to the SLDA site. The intent of the DQOs is to ensure compliance with applicable federal, state, and local regulations related to the handling and assessment of radiological contaminants present at the site and evaluate potential remedial alternatives to address the radiological waste and/or impacted site media. The specific Project Goals (PGs) designed to meet the DQOs for the SLDA site are as follows:

- Determine whether or not the trench contents pose the potential for unacceptable risk to human health and/or the environment, and characterize the trench contents for disposal purposes.
- Investigate for the presence of additional disposal areas and reduce the uncertainty of any undocumented disposal areas and regarding the horizontal limits of the waste trenches.
- Determine direction of horizontal and vertical groundwater flow on site, in and between the five hydrogeologic stratigraphic units.

- Confirm the list of radionuclides of potential concern (ROPC) at the site. The list of ROPC is based on historical information, previous limited sampling, professional judgment, and public law, and consists of the following primary radionuclides: uranium (U)-234, U-235, U-238, plutonium (Pu)-239, Pu-241, radium (Ra)-228, thorium (Th)-232, americium (Am)-241, and gross alpha/beta (waters and air only). All samples will be analyzed for the primary ROPC. Additional potential radionuclides (secondary ROPC) that may be present based on anecdotal information and proximity to the former Parks Nuclear Fabrication facility include: cesium (Cs)-137, cobalt (Co)-60, Th-230, Ra-226, Pu-238, Pu-240, and Pu-242. Only 10 percent for the samples collected were analyzed for secondary ROPC.

- Determine if Ra-228 could be used as a surrogate to determine the concentration of Th-232, based upon secular equilibrium. Establishing a correlation between the Th-232 and Radium-228 would allow for the use of Radium-228, as determined from gamma spectrometry, to be used for estimating the Th-232 concentration (in place of alpha spectrometry for Th-232). This would be useful in reducing the number of samples and respective costs for future site work.

- Determine background concentrations of ROPC in surface and subsurface soils from Gilpin/Leechburg Community Park.

- Determine upgradient concentrations of ROPC in sediments, surface water, and groundwater.

- Determine ambient baseline levels of ROPC in air.

- Determine nature and extent of ROPC above background in on-site media for surface soils and subsurface soils and above upgradient concentrations for groundwater, sediments, and surface waters.

- Determine risk to human health and the environment from ROPC in on-site media including surface soils, subsurface soils, groundwater, sediments, and surface waters.

- Characterize solid and aqueous IDW for disposal purposes.

- Verify the data quality indicators (DQIs) (i.e., precision, accuracy, representativeness, comparability, completeness, and sensitivity [PARCCS]), support data usability, and contract compliance.

3.3.2 Field Screening Methods

Field measurements for aqueous samples included specific conductance (EPA 120.1), pH (EPA 150.1), temperature (EPA 170.1), turbidity (EPA 180.1), dissolved oxygen (DO) content (EPA 360.1), and oxidation-reduction (redox) potential (ASTM D1498-00), which were recorded initially (in that order) during groundwater monitoring well purging, and prior to groundwater sampling.

Each soil sample and rock core retrieved was surveyed for the presence of gross radioactivity in the field. The survey was performed using a Ludlum model 44-9 NaI pancake scintillation detector and a FIDLER, both coupled to a Ludlum Model 2221 count-rate meter (or equivalent). A multi-Rae plus (or equivalent) direct reading instrument was also used at each soil boring and monitoring well drilling location to monitor for VOCs, combustible gas, lower explosive limit (LEL), and hydrogen sulfide.

At each trench boring location, each soil/waste sample was surveyed for the presence of gross radioactivity in the field. The survey was performed using a Ludlum model 44-9 NaI pancake scintillation detector and a FIDLER, both coupled to a Ludlum Model 2221 count-rate meter (or equivalent). An HNu Model PI-101 PID was used to scan for VOCs. The detector readings and the geological description of the material was documented in the field logbook and on a boring log. A Bacharach Model Senteniel 44 combustible gas indicator (CGI), or equivalent, was used to measure oxygen content, lower explosive limit/combustible gases, and hydrogen sulfide for health and safety purposes during intrusive activities.

3.3.3 Overview of Laboratory Analytical Parameters and Methods

The laboratory procedures that were performed include methodologies from the USDOE Environmental Measurements Laboratory (EML) Health and Safety Laboratory (HASL), USEPA 600/4-80-032 and SW-846, as presented in Table 3-15. All samples were analyzed following the guidance presented in EM 200-1-3, Appendix I (USACE 2001).

3.3.4 Analytical Data Quality Assessment

Analytical data quality assessment (or validation) is a systematic procedure for reviewing a body of data against a set of established criteria to provide a specified level of assurance of validity prior to its intended use. The laboratory analytical reports were evaluated by URS against the Comprehensive Data Package requirements, as defined in EM 200-1-3, Appendix I (USACE 2001), for all matrices, except air, which were evaluated against the Screening Data Package requirements. Also, electronic data deliverables (EDD) were verified for accuracy against the laboratory data packages.

The validation of the 2003 radiochemistry data was performed by URS using general guidelines contained in the following documents:

- Science Applications International Corporation (SAIC) document, *Laboratory Data Validation Guidelines for Evaluating Radionuclide Analyses*, Document No. 143.20020404.001, Revision 07, 04 April 2002;
- USACE reporting requirements as referenced in EM 200-1-3, Appendix I (USACE 2001);
- USEPA *Risk Assessment Guidance for Superfund*, Volume 1, Human Health Evaluation Manual (Part A), EPA 540/1-89/002, December 1989;
- USEPA/DOD/DOE, *Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual, Draft*, NUREG-1576, EPA 402-B-01-003, August 2001.

The radiochemistry data collected during the June 2004 sampling of groundwater, surface water, and sediment was validated by the USACE. Validation of the TCLP/RCRA/PCB data was performed by URS following the general guidelines in USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Organic Data Review, EPA540/R-99/008, October 1999 and USEPA CLP National Functional Guidelines for Inorganic Data Review, EPA 540-R-01-008, July 2002. All samples were reviewed independently (i.e., separately from the laboratory) for evaluation of the following:

1. QC data provided in the laboratory deliverables were scientifically sound, appropriate to the method, and completely documented,
2. QC samples were within established guidelines,
3. Data were appropriately flagged by the laboratory,
4. Documentation of all anomalies in sample preparation and analysis was complete and correct,
5. Corrective action forms, if required, were complete,
6. Holding times and preservation were documented,
7. Data were ready/acceptable for risk assessment process and incorporation into the final report, and
8. Data package was complete and ready for data archive.

Additionally, a higher level of review was performed on 10 percent of the environmental and QC samples collected during this investigation. This higher level of review included verification of instrument calibration, assessment of laboratory precision and accuracy based upon duplicates and spike results, verification of adherence to method specifications, and assessment of matrix interference. The independent review of data was performed by environmental chemists, under the supervision of the Chemical QA/QC Task Leader, to verify compliance with specified analytical methods and project-specific PARCCS parameters.

In general, all sample analyses were found to be compliant with the method criteria, except where noted in the data validation reports (see Appendix BB). Results qualified as estimated (J) were considered conditionally usable, while results qualified rejected (R) were unusable.

During the data validation of the June 2004 groundwater and sediment data, it was noted that plutonium-239 and/or plutonium-241 were detected at four groundwater sample locations (i.e., WG-MW-09A, WG-MW-16BC, WG-MW-34 and WG-NWS-01A-04) and at two sediment sample locations [i.e., SE-CR-03 and SE-FD-01 (field duplicate of SE-DR-03)]. The laboratory was asked to re-evaluate the plutonium data to verify the detections, because neither radionuclide was detected at the affected sampling locations during in the December 2003 groundwater and sediment sampling event. Upon re-evaluation of the data, GEL noted that the plutonium-239 detections were actually false-positive, due to peak-tailing of the tracer radionuclide into the region of interest for plutonium-239. In order to compensate for this situation, GEL reintegrated the sample spectrum, which yielded non-detect plutonium-239 results.

In regards to the plutonium-241 data, GEL re-prepared/reanalyzed samples WG-MW-09A and SE-FD-01, whereupon the resulting data yielded non-detect plutonium-241 results. Gel noted that the discrepancies in the plutonium-241 results may be due to, but not limited to, one or more of the following reasons: (1) Intermittent instrument electronic noise, (2) Non-homogeneous nature of the sample matrix, (3) Low-level cross-contamination from another sample, and (4) Laboratory contamination. Since the original plutonium-241 results are only slightly above the minimum detected activity (MDA), and the results minus their uncertainties are < MDA, the initial plutonium-241 results are likely false-positives.

As part of the assessment of the analytical program and evaluation of project goals, a comparison of the number of samples collected was compared to the number of samples planned for the RI program. Table 3-16 presents the results of this comparison. Percent completeness was calculated to range from 90 to 100 percent.

3.3.5 Correlation Between Ra-228 and Th-232 Data

One of the project goals identified at the Technical Project Planning (TPP) meeting in August 2002 was to determine if Ra-228 could be used as a surrogate for Th-232 at the SLDA site based upon secular equilibrium. Although uranium is the predominant radioactive contaminant in the waste trenches in the upper trench area, historical records indicate that a small amount of thorium (Th-232) oxide was also disposed of at the site, most likely in Trench 6. Establishing a correlation between Th-232 and Ra-228 would permit the use of Ra-228 (which can be detected using gamma spectrometry) to estimate the concentration of Th-232 (which can only be detected using the more time-consuming and expensive alpha-spectrometry process).

This would allow for a more expeditious determination of the effectiveness of remedial actions at the site (especially in the vicinity of Trench 6), should active remediation of the trenches, i.e., waste excavation, be a component of the selected remedy.

Ra-228 has a half-life of 5.8 years, and this radionuclide generally exists in secular equilibrium with Th-232 (half-life of 14 billion years) in natural solid environmental media such as soil and rock. This is not necessarily the case for liquid media (surface water and groundwater), due to the different solubilities of these two radionuclides. Since the wastes were disposed of at the site more than 30 years ago, sufficient time has elapsed for significant Ra-228 ingrowth to occur. Equilibrium (or near-equilibrium) conditions would be expected to exist in the previously disposed of wastes, which records indicate were containerized. Such conditions would also likely exist for nearby contaminated soil. However, this conclusion cannot be extended to leachate in the trenches, or to surface water and groundwater at the site, due to the differing solubilities as described above. This was noted by PADEP at the TPP meeting conducted in March 2004.

The data collected in the recent characterization program to support development of the RI report were reviewed to determine if a definitive conclusion could be made regarding the presence of secular equilibrium between Ra-228 and Th-232 in solid environmental media at the site. The measured concentrations of these two radionuclides were all in the general level of background, with no samples measured above twice background for either radionuclide; samples were not obtained from the buried solid thorium oxide at the site. Since the samples were associated with soil, the inherent variability in background and near-background sample results would significantly affect the calculated ratio between Ra-228 and Th-232. It should be noted that the reported background values for these two radionuclides (while treated as a single value in the RI report) also have variability. Scatter plots of Ra-228 and Th-232 data associated with the various media generated for this analysis are presented in Appendix P.

The data given in the RI report for these two radionuclides indicate that a sizable portion of the samples contained background concentrations of Ra-228 and Th-232. In the 102 surface soil samples, only 35 contained either Ra-228 or Th-232 in a concentration above the defined background levels for the site. Ten samples had Ra-228 above its measured background concentration of 1.42 pCi/g, and 30 samples had Th-232 above its background of 1.31 pCi/g. Five samples had both radionuclides characterized as being above background.

If the concentrations of these two radionulclides in these soil samples are averaged, the ratio of Ra-228 to Th-232 is 1.00. If this calculation is limited to those samples that have above-background concentrations, the ratio is 1.06. A plot of the Ra-228 and Th-232 soil concentrations indicate a correlation, although there is quite a bit of scatter in the data (see Figure P-1 in Appendix P). While these calculations support the conclusion of secular equilibrium between these two radionuclides at the site, this may be more a reflection of this condition in natural soils than indicative of site-related contamination.

The significance of this calculation includes the following considerations:

- 50 percent of the measurements that had Ra-228 above background also had Th-232 above background (5 out of 10 samples).
- 50 percent of the measurements that had Ra-228 above background had Th-232 below background (5 out of 10 samples).
- Th-232 was above background in 25 samples that showed Ra-228 below background. This represents 27 percent of the samples (25 out of 92 samples).
- Ra-228 correctly correlated with an elevated Th-232 result 17 percent of the time (5 out of 30 samples).

Looking only at the samples with elevated concentrations (the five samples that showed both radionuclides above background), the correlation is quite weak. As shown in Figure P-2 in Appendix P, there is significant variability in the data above the background threshold. A significant component of this generally weak correlation is the variability in background concentrations at these low concentrations.

While the current data do not allow for a definitive conclusion to be reached as to the presence of secular equilibrium between these two radionuclides at the site, the data do support the contention that such a condition may exist. Should the selected remedy include excavation of the wastes from the trenches, additional data should be collected from the excavated wastes (in particular from Trench 6) to provide a more definitive conclusion as to the existence of secular equilibrium between Ra-228 and Th-232. Assuming a positive correlation, the concentration of Ra-228 would be used as a surrogate for Th-232 in determining the effectiveness of site remediation and compliance with cleanup criteria. This is consistent with the approach identified in Section 4.3.2 of MARSSIM on the use of surrogate measurements.

4.0 NATURE AND EXTENT OF CONTAMINATION

This section discusses the nature and extent of radioactive contamination at the SLDA. As described in Section 2.2, a significant amount of analytical data has been generated corresponding to environmental samples collected at the SLDA site over the past three decades.

The analytical database used to generate figures and tables for this section consisted of data collected from previous investigations that met project quality criteria (USACE 2003a and b) and validated data from RI field work completed in 2003 and 2004 by the USACE. The human health and ecological risk assessments discussed in Sections 6.0 and 7.0 only utilized data collected during the RI program since these data were collected using QA/QC protocols presented in the RI SAP and were validated using current industry-wide accepted standards (USACE, 2003b). Radiological and chemical data generated during the historical investigations and during the RI are presented in Appendices A and B, respectively. The focus of the discussion herein, will be the nature and extent of radiological parameters although a limited discussion of chemical results of waste samples will also be presented for use in the FS.

Section 4.1 discusses the results of the background soil sampling at Gilpin/Leechburg Park and development of background concentrations to be used in this report. Sections 4.2 and 4.3 summarize the nature and extent of radionuclides in the surface soils, subsurface soils, and the disposal trenches as compared to the background levels developed. Sections 4.4 and 4.5 discuss the nature and extent of radionuclides in surface water and sediments in Dry Run (on site) and Carnahan Run (off site). Section 4.6 presents nature and extent of radionuclides in groundwater samples collected from the five hydrostratigraphic zones identified at the SLDA as compared to upgradient concentrations. Fate and transport of radionuclides in on-site media are discussed in Section 5.0. Constituents considered as potentially significant with regards to risk were further evaluated in the human health and ecological risk assessments discussed in Sections 6.0 and 7.0 of this report.

Although background concentrations were the primary criteria used in this section to compare with solid media data results (soil, trench, and sediment samples), PRGs are also presented in the data summary tables as alternative screening criteria. Background concentrations were added to the PRGs to develop these screening criteria. The use of PRGs is discussed in more detail in Section 6.0, Baseline Human Health Risk Assessment.

Information gathered from previous site investigations, historical records, and citizen interviews indicate that the radiological contamination at the SLDA was largely limited to the wastes in the ten trenches. Therefore, the RI site characterization program focused on nearby environmental media to determine the extent to which these media had been impacted from migration of trench wastes. Samples were also collected directly from the trenches to further evaluate the radioactive characteristics of the wastes to determine if these materials pose a potential risk to human health and the environment, and to support analyses to be conducted in the FS. The data obtained by this limited intrusive sampling of the ten trenches were consistent with historical information.

Sampling results of the RI program confirmed that there is very little soil contamination outside of the disposal trenches. Localized areas of contaminated soil are present (generally in the vicinity of Trench 10), and there are localized areas of contaminated sediment in Dry Run. The concentrations of radioactive contaminants in most soil samples were generally comparable to background. The maximum surface soil concentrations measured at the SLDA were for Am-241 (320 pCi/g), Pu-239 (325 pCi/g), and Pu-241 (628 pCi/g) by Trench 10; the maximum subsurface soil concentration was for U-234 (508 pCi/g) in the upper trench area. The maximum sediment concentration in Dry Run was 29 pCi/g for U-234. The average concentrations of these radionuclides were much lower. Other than elevated concentrations of Am-241 and plutonium in isolated areas of surface soil by Trench 10, U-234 was generally the radionuclide that had the highest concentrations in soil, which is indicative of enriched uranium.

The surface water and sediment in Carnahan Run were determined to not have been impacted, while low levels of radionuclides were identified in surface water and sediment in Dry Run and in groundwater seeps in the upper trench area. Groundwater at SLDA, outside of perched areas within the trenches, does not appear to be contaminated other than some localized areas in the First Shallow Bedrock zone downgradient of Trenches 1 and 2. The primary contaminated environmental medium at the site (other than for the materials in the trenches) is soil, including sediment in Dry Run.

Several isotopes can be detected by more than one analytical method. Radiochemical approaches are used to isolate specific isotopes of interest, such as uranium, radium, thorium, plutonium, and americium, which may not be detectable by general gamma spectroscopy. Even isotopes that do have detectable gamma emissions will have lower detection limits using radiochemical methods and will therefore be more reliable. Gamma spectroscopy does not isolate these nuclides from the sample matrix, and is subject to interference from photons of similar energies. Therefore, the radiochemical method results are used in this report for evaluating background and contamination levels, and for comparison with other isotopic concentrations. More specifically, for both solid and liquid media, U-235 results are reported for both alpha and gamma spectroscopy. For liquid media only, Am-241 and Ra-226 were reported for both alpha and gamma spectroscopy, and Ra-228 was reported for both (beta) gas flow proportional counting and gamma spectroscopy. Therefore, the Am-241, U-235, Ra-226, and Ra-228 data presented in tables and figures in this section are reported according to the analytical method used. Activity based on alpha, beta, and gamma spectroscopy analysis is indicated by (alpha), (beta), and (gamma), respectively. The gamma spectroscopy results are presented for informational purposes only.

Comparison of upgradient and downgradient ROPC activities in sediment, surface water, and groundwater are Project Goal Nos. 7 and 9 (USACE, 2003b). Calculation of average upgradient radionuclide activities to be used for comparison with downgradient activities was accomplished using the following approach:

- If the parameter was detected in all upgradient samples, the results were averaged.
- If the parameter was detected in one or more but not all of the upgradient samples, the detected values were averaged with one-half of the detection limits for the non-detections.
- If the parameter was not detected in any of the upgradient samples, the upgradient activity was taken to be less than the detection limit.

Using one-half the detection limit for non-detected data was recommended in the USEPA document entitled, *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part A), Section 5.3.3* (USEPA, 1989). Sections 4.4 through 4.6 provide the results of laboratory testing performed on surface water, sediment, and groundwater samples collected during the RI field activities.

4.1 Background Soils

4.1.1 Evaluation of Background Soil Sampling Results

Many of the primary and secondary ROPCs and other nuclides detected at SLDA are present as a result of the natural composition of the soil. To identify contributions to activity caused by naturally occurring isotopes, background soil samples were collected from Gilpin/Leechburg Park and analyzed for nuclear isotopes. The park location was selected for background sampling because it has similar soil types as those at SLDA (USDA, 1977), the same general regional demographics, and no adverse environmental impacts (based upon the EDR report presented as Appendix I).

The comparison of background values to site-specific data allowed for an evaluation of impacts from previous site operations. Background nuclide levels need to be representative of local settings and indicative of land use in the area of the site (e.g., industrial, urban, rural). As such, the media sampled from background locations in the vicinity of the site displayed a range of constituents and contaminants as a result of anthropogenic pollution (i.e., the general impact of people on the environment). An example of anthropogenic pollution of particular interest for the SLDA site is the presence of Cs-137 (a fission product) and Co-60 (an activation product) in surface soil due to fallout from weapons testing.

The background sampling and analysis conducted at the SLDA followed the procedures presented in the SAP (USACE 2003a) and are described in detail in Section 3.1 of this report. A total of 18 borings were advanced at locations based on a 300 by 300-foot grid with 50-foot spacing between grid nodes, resulting in an overall sampling grid measuring 90,000 square feet (Figure 3-1).

One surface soil and one subsurface soil sample were collected at each boring location. The surface soil sample was collected from ground surface to a depth of 6 inches below ground surface. The subsurface soil sample was collected from 2 to 4 feet below ground surface using a Simco direct push rig. Background soil borings were identified as BK-001 through BK-018.

Each background sample was analyzed for the primary ROPCs. In addition, two background surface soil and two background subsurface soil samples were analyzed for secondary ROPCs (approximately 10 percent). Background soil analytical data are presented in Appendix A.

Table 4-1 presents a statistical summary of the background surface soil analytical data. A total of 13 of 20 radionuclides were detected in background surface soils. Of the 13 detected nuclides, five were primary ROPCs and three were secondary ROPCs. Four of the remaining isotopes (Bi-212, Pb-212, Pb-214, and Th-234) are decay products of ROPCs, and are related to the presence of the ROPCs. The last isotope detected is Potassium-40 (K-40), which is a naturally occurring radioactive isotope and not a concern at the SLDA site. Such photon-emitting isotopes may be detected by gamma spectroscopy, which is a non-isotope specific analysis.

Primary ROPCs detected in background surface soil samples included U-234, U-235 (alpha), U-238, Th-232, and Ra-228. U-234 was detected in all 18 background surface soil samples ranging from a minimum activity of 0.72 pCi/g to a maximum of 1.3 pCi/g. U-235 (alpha) was detected in only three background surface soil samples with activities of 0.19, 0.18, and 0.17 pCi/g. U-238 was detected in all 18 background surface soil samples ranging from a minimum activity of 0.74 pCi/g to a maximum of 1.3 pCi/g. As shown in Table 4-1, statistical parameters such as the minimum, maximum, and average activities for U-234 and U-238 were very similar.

Th-232 was detected in all 18 background surface soil samples ranging from a minimum activity of 0.74 pCi/g to a maximum of 1.3 pCi/g. Ra-228 was also detected in all 18 background surface soil samples ranging from a minimum activity of 0.92 pCi/g to a maximum of 1.4 pCi/g.

Secondary ROPCs detected in background surface soil samples included Cs-137, Ra-226, and Th-230. Cs-137 was detected in each of the 18 background soil samples analyzed at activities ranging from 0.18 to 0.79 pCi/g. Ra-226 was also detected in each of the 18 samples analyzed at activities between 0.72 and 1.3 pCi/g. Th-230 was detected in both samples analyzed at activities of 1.18 and 1.24 pCi/g.

Other radionuclides detected in background surface soil samples included Bi-212, Pb-212, Pb-214, K-40, and Th-234. Bi-212 was detected in 16 of 18 samples at activities ranging from 0.55 and 0.87 pCi/g, respectively. Pb-212 was detected in each of the 18 background surface soil samples analyzed at activities between 0.99 and 1.5 pCi/g. Pb-214 was also detected in each background surface soil sample at activities ranging from 0.84 to 1.5 pCi/g. K-40 was present in each of the background surface soil samples at activities between 8.8 and 13 pCi/g. Th-234 was present in seven of 18 samples analyzed at activities between 0.95 and 2.2 pCi/g.

Table 4-2 presents a statistical summary of the background subsurface soil analytical data. A total of 12 of 20 radionuclides were detected in background subsurface soils. Of the 12 detected nuclides, five were primary ROPCs and two were secondary ROPCs. Four of the remaining isotopes (Bi-212, Pb-212, Pb-214, and Th-234) are decay products of ROPCs, and are related to the presence of the ROPCs. The last isotope detected is K-40, which is naturally occurring.

The same primary ROPCs detected in background surface soil samples were also found in the background subsurface soil samples: U-234, U-235 (alpha), U-238, Th-232, and Ra-228. U-234 was detected in all 18 background surface soil samples ranging from a minimum activity of 0.72 pCi/g to a maximum of 1.3 pCi/g. U-235 (alpha) was detected in only four background subsurface soil samples with activities between 0.17 and 0.27 pCi/g. U-238 was detected in all 18 background subsurface soil samples ranging from a minimum activity of 0.71 pCi/g to a maximum of 1.4 pCi/g. As shown in Table 4-2, statistical parameters such as the minimum, maximum, and average activities for U-234 and U-238 were very similar.

In natural uranium, the isotope U-238 comprises 99.2745 percent of the mass, U-235 is about 0.72 percent of the mass, with the remainder (approximately 0.0055 percent) being U-234.

Because of differences in the half-lives of these isotopes, U-238 and U-234 are expected to have the same activity in a sample of natural uranium, and U-235 is expected to be 4.6 percent of the U-238 activity. The three surface soil samples with detected U-235 had average activities of about 17 percent that of U-238. However, the uncertainty (one sigma) reported for the U-235 was greater than 50 percent for each of these samples, and the corresponding U-238 analyses each had uncertainty greater than 25 percent. The concentration ratios for the samples with non-detect ("U" qualified data) are much lower than for the samples with detections. Consideration of historical data from earlier site investigations and the analytical uncertainty in the current results indicate that the background samples are consistent with uranium with natural isotopic abundances.

Th-232 was detected in 17 of 18 background subsurface soil samples ranging from a minimum activity of 1.1 pCi/g to a maximum of 1.8 pCi/g. Ra-228 was detected in all 18 background subsurface soil samples ranging from a minimum activity of 1.2 pCi/g to a maximum of 1.7 pCi/g.

Secondary ROPCs detected in background subsurface soil samples included Ra-226 and Th-230. Ra-226 was detected in each of the 18 samples analyzed at activities between 0.82 and 1.3 pCi/g. Th-230 was detected in both samples analyzed at activities of 1.1 and 1.2 pCi/g. The absence of Cs-137 in the subsurface soils is not unexpected since it is often attributed to fallout and would be largely isolated to the surface soils.

Other radionuclides detected in background subsurface soil samples included Bi-212, Pb-212, Pb-214, K-40, and Th-234. Four of these isotopes (Bi-212, Pb-212, Pb-214, and Th-234) are decay products of ROPCs, and are related to the presence of the ROPCs. K-40 is a naturally occurring radioactive isotope and is not a concern at the SLDA site. Such photon-emitting isotopes may be detected during gamma spectroscopy, which is a non-isotope specific analysis.

Bi-212 was detected in 17 of 18 samples at activities ranging from 0.75 and 1.2 pCi/g, respectively. Pb-212 was detected in each of the 18 background subsurface soil samples at activities between 1.4 and 2.0 pCi/g. Pb-214 was also detected in each background subsurface soil sample at activities ranging from 0.99 to 1.5 pCi/g. K-40 was present in each of the background surface soil samples at activities between 11 and 21 pCi/g. Th-234 was present in seven of 18 samples analyzed at activities between 1.4 and 2.8 pCi/g.

There was no discernable pattern associated with the spatial distribution of radionuclides in either surface or subsurface soils. In general, the number and activity of radionuclides detected in surface soils and subsurface soils were similar. One notable exception was that Cs-137 was detected in each surface soil sample but was absent in the subsurface soil samples. This could be attributed to the fact that Cs-137 is a fission product and typically present in surface soils from fallout. Other than Cs-137 and Th-230, average nuclide activities were 5 to 52 percent higher in the subsurface soils.

4.1.2 Calculation of Background Values

To evaluate the contribution of naturally occurring isotopes not associated with site activities, background values for radionuclides were calculated from the background soil sampling data. Tables 4-3 and 4-4 report the calculated background values for nuclides in surface and subsurface soils. The background values listed in Tables 4-3 and 4-4 are the lower of either the calculated upper tolerance limit (UTL) or the maximum activity detected for each radionuclide. The first step in calculating the UTL was to evaluate whether the background analytical results for a particular radionuclide were normally distributed (refer to Table 6-4). This was accomplished by applying the Shapiro-Wilk test to the data set. Most of the surface and subsurface background soils data were found to be normally distributed. The one-sided, 95 percent UTL was calculated for those normally distributed data sets in accordance with the following formula (USEPA 1989d and USEPA 1992d):

$$UTL = M + t_{n-1,1-\beta} * \sigma_M * \sqrt{(1 + 1/n)}$$

Where: M – Mean
t_n – Test statistic based on degrees of freedom (n-1) and probability
ß – Probability
σ_M – Standard Deviation
n – Number of Observations

The statistical distribution for the following background data sets was found to be other than normal and was assumed to be lognormally distributed:

- Surface soils – Ra-228
- Surface soils – U-235 (alpha)
- Subsurface soils – Th-232
- Subsurface soils – U-234
- Subsurface soils – U-235 (alpha)

The UTL for non-normal data sets were determined by:

1. Taking the log of each radionuclide activity.
2. Calculate the UTL using the aforementioned formula.
3. Then taking the antilog to arrive at the final UTL.

The background values given in Tables 4-3 and 4-4 are used as points of reference for comparison in the following discussion. These are convenient points of reference, but are not to be taken as definitive in terms of identifying contaminated areas at the site. For example, elevated levels of naturally occurring radionuclides reported as being above background may simply represent the very high end of the natural fluctuation in background concentrations. Also, some radionuclides such as Cs-137 and Co-60 could be present at the site in subsurface soil samples due to fallout from aboveground nuclear weapons tests, with subsequent redistribution to the subsurface by regrading activities at the site (such as occurred during previous site remediations). Such considerations may not be represented in the background soil location at Gilpin/Leechburg Community Park. No conclusions as to the likely sources of these "elevated" values are presented in this report. The comparisons to the calculated background concentrations are included simply to provide additional perspective on the nature and extent of contamination at the site.

4.2 Soil Sampling Results

This section discusses the nature and extent of radiological parameters in SLDA surface and subsurface soils. Chemical data collected during previous investigations will not be discussed since Public Law 107-117, Section 8143 directs the USACE to clean up radioactive wastes or mixed wastes.

The data used in this evaluation consisted of hundreds of samples collected during previous environmental investigations and during the RI sampling effort completed between August 2003 and June 2004. The cumulative radiological and chemical soil sampling data generated during previous investigations and the RI are presented in tabular form in Appendices A and B. Details regarding surface and subsurface soil samples collected during previous investigations are presented in Appendices S and T. Field procedures implemented and samples collected during the RI soil sampling program are presented in Section 3.2.4 of this report and in the SAP (USACE 2003a).

Soil samples collected from within the limits of the disposal trenches (trench limits as shown on Figure 1-2) are included in this section unless the samples were considered "trench waste". The categorization of samples as "trench waste" or "soil" is discussed in detail in Section 4.3, Trench Sampling Results.

4.2.1 Surface Soils

The locations of surface soil samples collected from near Trench 10 and from the upper trench area are illustrated in Figures 4-1 and 4-2, respectively. Each sample location was coded to indicate the investigation when the sample was collected and the sample identification. Surface soils are defined as soils from ground surface to a depth of six inches below ground surface. Table 4-5 presents a statistical summary of the surface soil radiological analytical data.

Calculated background values presented in Section 4.1 were used to evaluate on-site surface soil sampling data to identify areas at the SLDA where nuclides were present above background. In cases where background was greater than zero, a second criterion of twice background was also used to screen the data. A third criteria, consisting of the PRG plus background, was also evaluated for isotopes in which PRGs were established (see Table 6-1). Fate and transport of radionuclides in surface soils will be discussed in Section 5.0. Nuclides considered potentially significant with respect to risk are further evaluated in the baseline human health risk assessment discussed in Section 6.0 of this report.

Surface soil samples were analyzed for one or more of the 20 nuclides listed in Table 4-5. In addition, some samples were analyzed for total thorium and/or total uranium (for a total of 22 parameters). A total of 19 of the 22 radiological parameters were detected in at least one surface soil sample. The nature and extent of the nuclides detected in surface soils are discussed in the following sections and are grouped according to Primary ROPCs, Secondary ROPCs, and Other Nuclides.

4.2.1.1 Primary ROPCs

All eight primary ROPCs were detected in the surface soil samples analyzed. Figures 4-16 through 4-20 illustrate the distribution and activities of U-234, U-235 (alpha), U-238, total uranium and total isotopic uranium relative to background. Although not specifically identified as a Primary ROPC during the development of the SAP, total uranium and total isotopic uranium data are presented in this section since the significant uranium nuclides are U-234, U-235, and U-238. A total uranium or total isotopic uranium background activity of 2.76 pCi/g was calculated by adding up the background values for U-234, U-235, and U-238.

U-234 was detected in each of the 102 samples analyzed with activities ranging from 0.57 to 71 pCi/g. U-235 (alpha) was detected in 57 of the 102 samples analyzed at activities ranging from 0.15 to 4.0 pCi/g. U-238 activity was reported in 194 of 296 samples ranging from 0.44 to 280 pCi/g. Total uranium was detected in each of the 207 samples analyzed with activities ranging from 0.74 to 22 pCi/g. Total isotopic uranium was detected in each of the 102 samples analyzed ranging in activity from 1.0 to 92 pCi/g. The average activity of U-234, U-235 (alpha), U-238, total uranium, and total isotopic uranium was 5.0, 0.36, 3.0, 4.0, and 6.9 pCi/g, respectively.

A total of 71 of 102 samples analyzed for U-234 exceeded the background value of 1.32 pCi/g. In addition, 46 of 102 samples analyzed for U-234 exceeded twice background (2.64 pCi/g). As shown in Figure 4-16, 42 of the 46 samples exceeding twice background for U-234 were collected from the upper trench area. The maximum U-234 activity was detected in sample GB-084 located approximately 250 feet south of Trenches 2 and 9 (71 pCi/g). None of the 102 samples analyzed contained U-234 above the PRG screening criterion of 97.72 pCi/g.

A total of 51 of 102 samples analyzed for U-235 by alpha spectroscopy exceeded the background value of 0.19 pCi/g. In addition, 28 of 102 samples analyzed for U-235 by alpha spectroscopy exceeded twice background (0.38 pCi/g). As shown in Figure 4-17, 27 of the 28 samples exceeding twice background for U-235 (alpha) were collected from the upper trench area. The maximum U-235 (alpha) activity was detected in sample GB-084 located approximately 250 feet south of Trenches 2 and 9 (4.0 pCi/g). None of the 102 samples analyzed contained U-235 (alpha) above the PRG screening criterion of 34.79 pCi/g.

A total of 134 of 296 samples analyzed for U-238 exceeded the background value of 1.25 pCi/g. In addition, 52 of the 296 samples collected exceeded twice background (2.50 pCi/g). As illustrated in Figure 4-18, 48 of the 52 samples exceeding twice background for U-238 were collected from the upper trench area. The maximum U-238 activity (280 pCi/g) was detected in sample 113 located approximately 190 feet south of Trench 7. This sample was collected during the Parks facility decommissioning work completed by the Oak Ridge Institute for Science and Education in early 2000. Sample 113 also was the only sample that exceeded the PRG screening criterion of 124.25 pCi/g.

Figure 4-19 illustrates the distribution of surface soil samples analyzed for total uranium and total isotopic uranium. Most of the surface soil samples analyzed for total uranium were collected from the area north and west of Trench 10. This data was generated during the 1995 Field Investigation completed by ARCO/B&W in an effort to delineate Am-241 detected in surface soils; samples were analyzed for both Am-241 and total uranium. A total of 153 of the 207 samples analyzed for total uranium exceeded the background value of 2.76 pCi/g (Figure 4-19). In addition, 23 of the 207 samples collected exceeded twice background (5.52 pCi/g). The maximum total uranium activity (22 pCi/g) detected was in sample BC-14 located approximately 15 feet north of Trench 10.

Total isotopic uranium was calculated for each of the 102 samples collected during the RI by adding the activities of U-234, U-235 (alpha), and U-238 (Figure 4-20). A total of 64 of 102 samples exceeded the background value for total isotopic uranium of 2.76 pCi/g. In addition, 37 of 102 samples exceeded twice background (5.52 pCi/g). The maximum total isotopic uranium value was from sample GB-084 located approximately 250 feet south of Trenches 2 and 9 (92 pCi/g).

Many of the samples that reported one uranium isotope above background also contained other uranium isotopes above background. The percentage of samples exceeding twice background for uranium isotopes were higher in the following areas:

- The vicinity of the upper trenches,
- The area where surface soils were remediated by B&W in 1986 and 1989,
- The area where trench materials were exhumed from Trenches 2, 4, and 5 in 1965.

A total of 33 of 110 samples analyzed for Th-232 exceeded the background value of 1.31 pCi/g. None of the samples exceeded twice background. As shown in Figure 4-21, 23 of the 34 samples exceeding background for Th-232 were collected from the upper trench area. The maximum Th-232 activity was detected in sample GB-012 located approximately 115 feet west of Trench 10 (1.8 pCi/g). None of the 110 samples analyzed contained Th-232 above the PRG screening criterion of 2.66 pCi/g.

Ra-228 was detected above the background activity of 1.415 pCi/g in 14 of 102 surface soil samples analyzed. None of the samples exceeded twice background. As shown in Figure 4-22, all of the samples exceeding background for Ra-228 were collected from the upper trench area. The maximum Ra-228 activity was detected in sample GB-051 located approximately 15 feet southeast of Trench 8 (2.2 pCi/g). None of the 102 samples analyzed contained Ra-228 above the PRG screening criterion of 3.11 pCi/g.

The background value for Am-241 is zero; therefore, any Am-241 detection exceeds background. Am-241 was detected in 130 of 247 samples analyzed. As shown in Figure 4-23, all of the Am-241 detections were collected from the Trench 10 area. The maximum Am-241 activity was detected in the sample collected from GB-101 located approximately 75 feet southwest of Trench 10 (320 pCi/g). Four of the 247 samples analyzed contained Am-241 above the PRG screening criterion of 27.7 pCi/g.

The background values for Pu-239 and Pu-241 are zero. Therefore, any Pu-239 or Pu-241 detection exceeds background. Pu-239 was detected in 19 of 96 samples analyzed, while Pu-241 was detected in 8 of 93 samples. As shown in Figure 4-24 and 4-25, almost all of the Pu-239 and Pu-241 detections were collected from the Trench 10 area (one detection was reported in a sample collected from near Trench 7). The maximum Pu-239 activity was detected in the sample collected from GB-102R located approximately 30 feet west of Trench 10 (325 pCi/g). The maximum Pu-241 detection was also from the sample collected at GB-102R (628 pCi/g). Two of the 96 samples analyzed for Pu-239 exceeded the PRG screening criterion of 32.6 pCi/g. None of the 93 samples analyzed contained Pu-241 above the PRG screening criterion of 892 pCi/g.

4.2.1.2 <u>Secondary ROPCs</u>

Secondary ROPCs detected in surface soil samples included Cs-137, Co-60, Th-230, and Ra-226. Only two of 113 samples analyzed for Cs-137 exceeded the background value of 0.791 pCi/g. As shown in Figure 4-26, these two samples were located approximately 50- and 25-feet from Trenches 1 and 2, respectively. None of the samples analyzed for Cs-137 exceeded twice background.

The background value for Co-60 is zero. Therefore, any Co-60 detections exceeded background, and Co-60 was detected in seven of 111 samples analyzed. As shown in Figure 4-27, the spatial distribution of Co-60 in surface soils was random. The maximum Co-60 activity was detected in sample S-095 located approximately 50 feet northwest of Trench 10 (0.47 pCi/g).

Th-230 was only analyzed in 10 surface soil samples as shown in Figure 4-28. Seven of the 10 samples contained Th-230 activity levels above the background value of 1.24 pCi/g. None of the samples collected exceeded twice background (2.48 pCi/g). The maximum Th-230 activity was detected in sample GB-084 located approximately 250 feet south of Trenches 2 and 9 (1.5 pCi/g).

As shown in Figure 4-29, only two of the 114 samples analyzed for Ra-226 exceeded the background value of 1.32 pCi/g. None of the samples exceeded twice background. The maximum Ra-226 activity was detected in sample GB-051 located approximately 15 feet southeast of Trench 8 (1.6 pCi/g).

4.2.1.3 Other Nuclides

Six other radiological parameters were detected by gamma spectroscopy analysis while analyzing samples for Primary and Secondary ROPCs. These other radiological constituents detected in surface soil samples included Bi-212 (Figure 4-30), Pb-212 (Figure 4-31), Pb-214 (Figure 4-32), K-40 (Figure 4-33), Th-234 (Figure 4-34), and total thorium. Bi-212 was detected in 97 of 102 samples at activities ranging from 0.52 and 2.1 pCi/g, respectively. Pb-212 was detected in each of 102 surface soil samples analyzed at activities between 0.89 and 2.6 pCi/g. Pb-214 was also detected in each of 102 surface soil samples at activities ranging from 0.82 to 1.8 pCi/g. K-40 was present in each of 106 surface soil samples analyzed at activities between 5.7 and 26 pCi/g. Th-234 was present in 34 of 102 samples analyzed at activities between 0.92 and 21 pCi/g. Total thorium was detected in each of the four samples analyzed at activities between 1.9 and 2.4 pCi/g.

4.2.1.4 Summary of Surface Soil Sampling Results

As discussed in Section 2.0, uranium and to a lesser extent thorium-contaminated materials generated at the Apollo facility were placed into the SLDA disposal trenches. Americium and plutonium isotopes were not associated with processes at Apollo but were detected in soil samples collected by ARCO/B&W in the 1990s near Trench 10. The source of the americium and plutonium is unknown; however, ARCO/B&W speculated that the presence of these isotopes could have come from storage of equipment used at the Parks facility. Nuclides associated with historical site operations detected in surface soil samples at levels notably above background include:

- U-234, U-235, and U-238 near both the upper trenches and Trench 10.
- Am-241, Pu-239, and Pu-241 near Trench 10.

Th-232 was reportedly a small component of the Apollo facility process wastes placed into the trenches at SLDA. Although Th-232 was detected above background in approximately one-third of the samples analyzed, it was not detected above twice background. The spatial distribution, activities, and types of nuclides detected in surface soil samples collected during the RI were consistent with findings of previous investigations.

Findings of the RI gamma survey identified five small areas in three different locations with FIDLER measurements greater than twice the background mean (Figure 3-2). Surface soil samples collected from boring locations GB-097, GB-101, and GB-102R contained uranium and/or plutonium isotopes greater than twice background. These locations corresponded to three of the five small areas with FIDLER measurements greater than twice the background mean. Samples collected from the other two areas (GB-096 and GB-099) also had activities above background (GB-099 was above twice background). It should be noted that samples collected from GB-101 and GB-102R had the highest activities reported for Am-241 (320 pCi/g), Pu-239 (325 pCi/g), and Pu-241 (628 pCi/g).

The percentage of samples with uranium isotopes exceeding twice background was higher in the area of the upper trenches than near Trench 10. The extent of total uranium contamination in the Trench 10 area has been delineated reasonably well. The spatial distribution of Am-241, Pu-239, and Pu-241 activities above background was limited to the vicinity of Trench 10, except for one sample collected from near Trench 7 where Pu-241 was detected. The PRG screening criteria were exceeded for Am-241, Pu-239, and U-238 in only a very small percentage of samples.

In natural uranium, the isotope U-238 comprises 99.2745 percent of the mass, U-235 is about 0.72 percent of the mass, with the remainder (approximately 0.0055 percent) being U-234.

Because of differences in the half-lives of the isotopes, U-235 is expected to be 4.6 percent of the U-238 activity. Since U-234 is a member of the U-238 decay chain, U-238 and U-234 are expected to have the same activity in a sample of natural uranium (secular equilibrium). As discussed above, the uranium isotopes were all detected at concentrations above their respective backgrounds. It appears that the contamination represented by these sampling results is derived from enriched uranium.

Table 4-5 presents statistical summaries of the ratios of U-234 to U-238 and U-235 to U-238 for individual surface soil samples analyzed during this RI data. There was no historical surface soil sampling completed for these isotopes. The ratios were prepared to better understand the presence or absence of enriched uranium in surface soils.

Figure 4-35 shows the ratio of the U-235 concentration to the expected concentration if it was in equilibrium with U-238 (4.6 percent of the U-238 activity). That is, if the U-235 activity was 4.6 percent of the U-238 activity, corresponding to natural abundance, the ratio would be unity. For the surface soil samples depicted in the chart, the lowest result has the U-235 concentration as twice the value for a natural mix of nuclides. The high-normalized ratios for the samples with higher U-235 activities indicate that where contamination has been detected, the U-235 concentration is significantly higher than natural abundance. This is consistent with knowledge that enriched uranium was used in site-related operations.

4.2.2 Subsurface Soils

The locations of subsurface soil samples collected from the SLDA site are illustrated in Figures 4-3 and 4-4. Each sample location was coded to indicate the investigation program and the sample identification. Approximately 1,000 subsurface soil samples were collected at the SLDA site at depths ranging from 0.5 to 24 feet below ground surface. Table 2-2 summarizes analytical testing completed on subsurface soil samples collected during previous investigations. Tables 3-4 and 3-6 indicate the analytical testing completed on subsurface soil samples collected during the RI.

Sample depth was plotted against activity for each nuclide to develop depth intervals for the subsurface soils data. Three depth intervals were used for each nuclide and figures were prepared to illustrate the spatial distribution of the analytical results. The depth intervals used to present the data consisted of: greater than 0.5 to 4 feet, greater than 4 to 10 feet, and greater than 10 feet below ground surface. The depth interval of 4 to 10 feet below ground surface also generally corresponded to the depth of waste disposal, as refusal due to bedrock often occurred in the upper trench area at approximately 10 feet. Tables 4-6, 4-7, and 4-8 report statistical summaries of the subsurface soil radiological analytical data for depth intervals of greater than 0.5 to 4 feet, greater than 4 to 10 feet, and greater than 10 feet below ground surface, respectively.

Calculated background values presented in Section 4.1 were used to screen and evaluate on-site subsurface soil sampling data by identifying areas at the SLDA where nuclides were present above background. In cases where background was greater than zero, a second criterion of twice background was also used to screen the data. A third criteria, consisting of the PRG plus background, was also evaluated for isotopes in which PRGs were established (see Table 6-1). Fate and transport of radionuclides in subsurface soils will be discussed in Section 5.0. Nuclides considered potentially significant with respect to risk are further evaluated in the Baseline Human Health Risk Assessment discussed in Section 6.0 of this report.

The nature and extent of the nuclides detected in subsurface soils are discussed in the following paragraphs and are grouped according to Primary ROPCs, Secondary ROPCs, and Other Nuclides.

4.2.2.1 **Primary ROPCs**

All eight primary ROPCs were detected in the subsurface soil samples analyzed. Figures 4-36 through 4-50 illustrate the spatial distribution and activities of U-234, U-235 (alpha), U-238, total uranium, and total isotopic uranium relative to background. Although not specifically identified as a Primary ROPC during the development of the SAP, total uranium and total isotopic uranium data are presented in this section since the significant nuclides are U-234, U-235, and U-238. A total uranium background activity of 2.96 pCi/g was calculated by adding the background values for U-234, U-235, and U-238.

The PRG screening criteria was exceeded in a very low percentage of samples analyzed. For the 0.5 to 4 foot depth interval the PRG criteria was exceeded for Am-241, Pu-239, and U-234 (1 sample for each isotope). In the 4 to 10 foot interval, the PRG screening criteria was exceeded for Am-241 (one sample), Pu-239 (two samples), U-234 (six samples), and U-235 (one sample). None of the samples collected from the greater than 10 foot interval exceeded the PRG screening criteria.

U-234 was detected in each of the 239 subsurface soil samples analyzed from all depths with activities ranging from 0.37 to 508 pCi/g. The greatest percentage of detections above background (80 percent) occurred in the >4-to-10-feet interval; 18 percent were at the >10-feet interval and 2 percent were at the >0.5-to-4-feet interval.

U-234 was detected each of the 11 samples analyzed from 0.5 to 4 feet; however, nine samples reported activities that were below background (see Figure 4-36). Only sample 07U05 (2-4 feet) had a U-234 activity exceeding twice background. It should be noted that this boring was advanced very close to Trench 6 and 7 and based on the U-234 activity, it may have been located within a disposal trench.

A total of 180 samples collected from 4 to 10 feet below ground surface were analyzed for U-234. Of the 180 samples analyzed, 66 exceeded the background value of 1.28 pCi/g and 31 samples exceeded twice background. As shown in Figure 4-37, all but two of the locations exceeding twice background for U-234 were collected from the upper trench area. The maximum U-234 activity (508 pCi/g) detected between 4 and 10 feet below ground surface was in sample GB-043 (4-6 feet) located approximately 30 feet northwest of Trench 4. Many of the samples exceeding twice background were collected from borings advanced within the trench areas identified by geophysical methods, but no obvious waste materials or elevated field screening measurements were recorded for these samples.

A total of 48 samples collected from greater than 10 feet below ground surface were analyzed for U-234. Of the 48 samples analyzed, 15 exceeded background and six samples exceeded twice background. As shown in Figure 4-38, all of the locations exceeding twice background for U-234 were collected from the upper trench area. The maximum U-234 activity

(90 pCi/g) detected at depths greater than 10 feet below ground surface was in sample 01U23 (10-12 feet) located approximately 25 feet northeast of Trench 1.

U-235 (alpha) was detected in 68 of the 239 subsurface soil samples analyzed from all depth intervals with activities ranging from 0.058 to 47 pCi/g. At the >0.5-to-4-feet interval, only one detection of U-235 (alpha) was reported from 11 samples (see Figure 4-39); sample 07U05 (2-4 feet) had a U-235 (alpha) activity that exceeded twice background (5.0 pCi/g). It should be noted that this boring was advanced very close to Trenches 6 and 7 and based on the U-235 (alpha) activity, it may have been located within a disposal trench.

A total of 180 samples collected from 4 to 10 feet below ground surface were analyzed for U-235 (alpha). Of the 180 samples analyzed, 28 exceeded the background value of 0.269 pCi/g and 18 samples exceeded twice background. As shown in Figure 4-40, all of the samples exceeding twice background for U-235 (alpha) were collected from the upper trench area. The maximum U-235 (alpha) activity (47 pCi/g) detected between 4 and 10 feet below ground surface was in sample GB-043 (4-6 feet) located approximately 30 feet northwest of Trench 4. Many of the samples exceeding twice background were collected from borings advanced within the trench areas identified by geophysical methods, but no obvious waste materials or elevated field screening measurements were recorded.

A total of 48 samples collected from depths greater than 10 feet below ground surface were analyzed for U-235 (alpha). Of the 48 samples analyzed, eight exceeded background (0.269 pCi/g) and four samples exceeded twice background. As shown in Figure 4-41, the four samples that exceeded twice background were in very close proximity to Trenches 2 and 8 (upper trenches only). The maximum U-235 (alpha) activity (3.5 pCi/g) detected at depths greater than 10 feet was in sample 01U23 (10-12 feet) located approximately 25 feet northeast of Trench 1.

U-238 was detected in 246 of the 257 subsurface soil samples analyzed from all depth intervals with activities ranging from 0.23 to 37 pCi/g. No samples collected in the lower Trench 10 area reported detections above twice background.

Of the 29 samples collected from 0.5 to 4 feet, eight exceeded background (1.41 pCi/g) and six exceeded twice background. As illustrated in Figure 4-42, five of the sample locations exceeding twice background were located approximately 250 to 350 feet south of the upper trenches. Sample 07U05 (2-4 feet) also exceeded twice background and was located very close to Trenches 6 and 7. The maximum U-238 activity (15 pCi/g) detected between 0.5 and 4 feet below ground surface was in sample 046 (1-1.5 feet) located approximately 250 feet south of Trench 9.

A total of 180 samples collected from 4 to 10 feet below ground surface were analyzed for U-238. Of the 180 samples analyzed, 46 exceeded the background value of 1.41 pCi/g and 12 samples exceeded twice background. As shown in Figure 4-43, all of the samples exceeding twice background for U-238 were collected from the upper trench area. The maximum U-238 activity (37 pCi/g) detected between 4 and 10 feet below ground surface was in sample GB-043 (4-6 feet) located approximately 30 feet northwest of Trench 4.

A total of 48 samples collected from depths greater than 10 feet below ground surface were analyzed for U-238. Of the 48 samples analyzed, 13 exceeded background (1.41 pCi/g) and four samples exceeded twice background. As shown in Figure 4-44, the three samples that exceeded twice background were in very close proximity to Trenches 1, 3, and 8 (upper trenches only). The maximum U-238 activity (11 pCi/g) detected at depths greater than 10 feet was in sample 03U06 (10-12 feet) located in Trench 3.

Figure 4-45 illustrates the distribution of total uranium and total isotopic uranium in subsurface soil samples collected from >0.5 to 4 feet bgs. Total uranium was detected in each of the 328 subsurface soil samples analyzed from all depths with activities ranging from 1.8 to 630 pCi/g. Of the 67 samples collected from >0.5 to 4 feet, 62 exceeded background (2.96 pCi/g) and 46 exceeded twice background, as illustrated in Figure 4-45. The maximum total uranium activity (130 pCi/g) detected at the >0.5 to 4 foot depth interval was in sample 01U20 (2-4 feet) located at the southeastern corner of Trench 1.

Total isotopic uranium was detected in 239 of the 239 subsurface soil samples analyzed for all depths with activities ranging from 0.71 to 590 pCi/g. Of the 11 samples collected from the >0.5 to 4 feet (bgs) depth interval, two exceeded background (2.96 pCi/g) and one exceeded twice background. As illustrated in Figure 4-46, the sample exceeding twice background for total isotopic uranium (07U05) was located adjacent to Trench 7 at an activity of 160 pCi/g.

Figure 4-47 illustrates the distribution of total uranium and total isotopic uranium in subsurface soil samples collected from 4 to 10 feet bgs. A total of 131 samples collected from the 4 to 10 foot depth interval were analyzed for total uranium. Of the 131 samples analyzed, 116 exceeded the background value of 2.96 pCi/g and 80 samples exceeded twice background. As shown in Figure 4-47, the vast majority of the samples analyzed for total uranium were collected from adjacent to the trenches (typically within ten feet). The maximum total uranium activity (630 pCi/g) detected between 4 and 10 feet below ground surface was in sample 02U08 (6-8 feet) located adjacent to the northern edge of Trench 2.

A total of 180 samples collected from the 4 to 10 foot depth interval were analyzed for total isotopic uranium. Of the 180 samples analyzed, 52 exceeded the background value of 2.96 pCi/g and 24 samples exceeded twice background (Figure 4-48). The maximum total isotopic uranium activity (590 pCi/g) detected for this depth interval was in sample GB-043.

Figure 4-49 illustrates the distribution of total uranium and total isotopic uranium in subsurface soil samples collected from >10 feet bgs. A total of 130 samples collected from the greater than 10 foot depth interval were analyzed for total uranium. Of the 130 samples analyzed, 124 exceeded background (2.96 pCi/g) and 73 samples exceeded twice background. The maximum total uranium activity (120 pCi/g) detected at depths greater than 10 feet bgs was in sample 04U03 (10-12 feet) located adjacent to Trench 4.

A total of 48 samples collected from the >10 foot depth interval were analyzed for total isotopic uranium. Of the 48 samples analyzed, 15 exceeded background (2.96 pCi/g) and five samples exceeded twice background (Figure 4-50). The maximum total isotopic uranium activity (100 pCi/g) detected at depths greater than 10 feet was in sample 03U06 located at Trench 3.

Statistical summaries of the U-234/U-238 and U-235/U-238 ratios are presented in Tables 4-6, 4-7, and 4-8 for subsurface soil samples analyzed. The ratios were developed for both the RI and historical data collected to better understand the presence or absence of enriched uranium in subsurface soils.

Figure 4-51 illustrates the ratio of the U-235 concentration in subsurface soils to the expected concentration if it was in equilibrium with U-238 (4.6 percent of the U-238 activity). Similar to the uranium activities reported in the surface soil, subsurface soil data indicates that some of the contamination is due to enriched uranium. While the uranium contamination seems to be less extensive than for surface soils, Figure 4-51 shows that when contamination is identified, the U-235 activity is significantly above that expected for natural uranium.

Th-232 was detected in 290 of the 292 subsurface samples analyzed from all depths with activities ranging from 0.28 to 2.8 pCi/g. Th-232 was not reported to be present above twice background in any sample at any depth. Of the 30 samples collected from the >0.5 to 4 foot depth interval, four exceeded background (1.77 pCi/g) and none exceeded twice background (Figure 4-52).

A total of 202 samples collected from the 4 to 10 foot depth interval were analyzed for Th-232. Of the 202 samples analyzed, 34 exceeded the background value of 1.77 pCi/g; however, none of the samples exceeded twice background (Figure 4-53).

A total of 60 samples collected from the greater than 10 foot depth interval were analyzed for Th-232. Of the 60 samples analyzed, 16 exceeded background (1.77 pCi/g) and none of the samples exceeded twice background (Figure 4-54). Based on the significant number of subsurface soil samples collected and analyzed, Th-232 contamination above twice background does not appear to be significantly present.

The background value for Am-241 in subsurface soils was zero. Therefore, any Am-241 detection exceeds background. Am-241 was detected in 29 of 311 subsurface samples analyzed from all depths with activities ranging from 0.019 to 38 pCi/g. Am-241 was detected in 10 of the 40 samples collected from the >0.5 to 4 feet depth interval. As illustrated in Figure 4-55, all but one of the Am-241 detections were located in the southwestern end of Trench 10 within an area measuring approximately 40 feet across. The maximum Am-241 activity (34 pCi/g) detected between >0.5 and 4 feet below ground surface was in sample 10L24 (0-2 feet) located at the southwestern end of Trench 10.

A total of 210 samples collected from the 4 to 10 foot depth interval were analyzed for Am-241. Of the 210 samples analyzed, Am-241 was detected in 16 samples with activities ranging from 0.12 to 38 pCi/g. As shown in Figure 4-56, all of the Am-241 detections were in samples collected from the southwestern end of Trench 10. The maximum Am-241 activity (38 pCi/g) detected between 4 and 10 feet below ground surface was in sample 10L07 (4-6 feet) located at the southwestern end of Trench 10.

A total of 61 samples collected from the depth interval greater than 10 feet were analyzed for Am-241. Of the 61 samples analyzed, Am-241 was detected in three samples with activities ranging from 0.24 to 13 pCi/g. As shown in Figure 4-57, the three Am-241 detections were in samples collected from the southwestern end of Trench 10. The maximum Am-241 activity (13 pCi/g) detected for this depth interval was in sample GB-101 (12-14 feet) located approximately 75 feet southwest of Trench 10.

The background value for Pu-239 in subsurface soils was zero. Therefore, any Pu-239 detection exceeds background. Pu-239 was detected in 17 of 217 subsurface soil samples analyzed from all depth intervals with activities ranging from 0.0003 to 88 pCi/g. Pu-239 was detected in two of the 11 samples collected from the >0.5 to 4 feet depth interval (Figure 4-58). The maximum Pu-239 activity (69 pCi/g) detected for this depth interval was in sample 10L24 (0 – 2 feet) located in the southwestern end of Trench 10.

Pu-239 was detected in 13 of 166 samples collected from the >4 to 10 foot depth interval. Detected Pu-239 activities ranged from 0.12 to 88 pCi/g. As shown in Figure 4-59, all but one of the Pu-239 detections were in samples collected from the southwestern end of Trench 10. Pu-239 activity greater than twice background was also detected in one sample collected from approximately 30 feet north of Trench 4. The maximum Pu-239 activity (88 pCi/g) detected between 4 and 10 feet below ground surface was in sample 10L07 (4-6 feet) located at the southwestern end of Trench 10.

A total of 40 samples collected from the >10 foot depth interval were analyzed for Pu-239. Of the 40 samples analyzed, Pu-239 was detected in two samples with activities of 0.80 and 3.0 pCi/g. As shown in Figure 4-60, the two Pu-239 detections were in samples collected from the southwestern end of Trench 10 and southwest of Trench 10. The maximum Pu-239 activity detected at depths greater than 10 feet below ground surface was in sample GB-101 (12-14 feet) located approximately 75 feet southwest of Trench 10.

The background value for Pu-241 in subsurface soils was zero. Therefore, any Pu-241 detection exceeds background. Pu-241 was detected in four of 209 subsurface soil samples analyzed from all depth intervals with activities ranging from 14 to 27 pCi/g. Pu-241 was not detected in any of the nine samples collected from the >0.5 to 4 foot depth interval (see Figure 4-61).

Pu-241 was detected in three of the 162 samples collected from the 4 to 10 foot depth interval. Detected Pu-241 activities ranged from 14 to 24 pCi/g. As shown in Figure 4-62, the three Pu-241 detections were located southwest of Trench 1, southeast of Trench 7, and southwest of Trench 10. The maximum Pu-241 activity detected between 4 and 10 feet below ground surface was in sample GB-008 (4-6 feet) located approximately 70 southwest of Trench 10.

Pu-241 was detected in only one of 38 samples collected from the >10 foot depth interval. Analysis of sample GB-052 (10-12 feet) indicated a Pu-241 activity of 27 pCi/g. As shown in Figure 4-63, sample location GB-052 was located approximately 60 feet southeast of Trench 7.

Ra-228 was detected in each of the 229 subsurface soil samples analyzed from all depth intervals with activities ranging from 0.37 to 2.2 pCi/g. None of the 10 samples collected from the 0.5 to 4 feet (bgs) depth interval exceeded the background activity of 1.66 pCi/g (see Figure 4-64).

A total of 174 subsurface soil samples collected from the 4 to 10 foot depth interval were analyzed for Ra-228. Of the 174 samples analyzed, 30 exceeded the background value of 1.66 pCi/g and no samples exceeded twice background (see Figure 4-65). The maximum Ra-228 activity (2.2 pCi/g) detected at this depth interval was in sample GB-019 (4-6 feet) located approximately 20 feet southwest of Trench 1.

A total of 45 samples collected from the >10 foot depth interval were analyzed for Ra-228. Of the 45 samples analyzed, nine exceeded background (1.66 pCi/g) and no samples exceeded twice background (Figure 4-66). The maximum Ra-228 activity (2.1 pCi/g) detected at this depth interval was in sample GB-093 (12-14 feet) located approximately 120 west of Trench 8.

4.2.2.2 Secondary ROPCs

Statistical summaries of secondary ROPC data reported by depth interval are presented on Tables 4-6 through 4-8. The horizontal distribution is illustrated on Figures 4-67 through 4-72. Secondary ROPCs detected in subsurface soil samples include Cs-137, Co-60, Pu-238, Pu-242, Ra-226, and Th-230.

The background value for Cs-137 in subsurface soils was zero. Therefore, any Cs-137 detection exceeds background. Cs-137 was detected in only 19 of 277 subsurface samples analyzed (less than 10 percent). As shown in Tables 4-6 through 4-8, the maximum activity detected and frequency of Cs-137 detection both decreased with increasing depth. The maximum Cs-137 activity (0.30 pCi/g) was detected in sample MW-41 (0-2').

The background for Co-60 in subsurface soils was zero. Therefore, any Co-60 detection exceeds background. Co-60 was detected in only 1 of 290 subsurface samples analyzed; sample MW-40 (2-4') contained Co-60 at an activity level of 0.03 pCi/g.

The background value for Pu-238 in subsurface soils was zero. Therefore, any Pu-238 detection exceeds background. Pu-238 was detected in only 5 of 27 subsurface samples analyzed (less than 20 percent). As shown in Figure 4-69, the Pu-238 detections were all from a very localized area on the southwestern end of Trench 10. The maximum Pu-238 activity (3.2 pCi/g) was detected in sample 10L07 (4-6').

The background value for Pu-242 in subsurface soils was zero. Therefore, any Pu-242 detection exceeds background. Pu-242 was detected in only 1 of 23 subsurface samples analyzed; sample GB-050 (12-14') contained Pu-242 at an activity level of 0.15 pCi/g.

A total of 30 samples collected from between 0.5 and 4 feet below ground surface were analyzed for Ra-226. Of the 30 samples analyzed, only one exceeded background (1.5 pCi/g) and none exceeded twice background. A total of 202 samples collected from between 4 and 10 feet below ground surface were analyzed for Ra-226. Of the 202 samples analyzed, 14 exceeded background (1.32 pCi/g) and none exceeded twice background. A total of 60 samples collected from greater than 10 feet below ground surface were analyzed for Ra-226. Of the 60 samples analyzed, seven exceeded background (1.32 pCi/g) and none exceeded twice background. As shown in Figure 4-71, all of the samples exceeding background were collected from the upper trench area. The maximum Ra-226 activity (2.3 pCi/g) detected was in sample GB-092 (12-14 feet) located approximately 100 feet west of Trench 8.

A total of 23 subsurface soil samples were analyzed for Th-230. Of the 23 samples analyzed, 12 exceeded background (1.155 pCi/g) and one exceeded twice background (2.31 pCi/g). As shown in Figure 4-72, sample GB-081 (8-10') which contained the highest activity (2.4 pCi/g) was located approximately 100 feet south of Trench 9.

4.2.2.3 <u>Other Nuclides</u>

Five other radiological parameters were detected by gamma spectroscopy analysis while analyzing samples for Primary and Secondary ROPCs. These other radiological constituents detected in subsurface soil samples included Bi-212, Pb-212, Pb-214, K-40, and Th-234.

Bi-212 was detected in 223 of 229 subsurface soil samples at activities ranging from 0.27 to 1.7 pCi/g. Pb-212 was detected in all 229 subsurface soil samples analyzed at activities between 0.40 and 2.6 pCi/g. Pb-214 was also detected in all 229 subsurface soil samples at activities ranging from 0.35 to 2.7 pCi/g. K-40 was present in all 229 subsurface soil samples at activities between 3.6 and 30 pCi/g. Th-234 was present in 74 of 229 subsurface samples analyzed at activities between 0.66 and 19 pCi/g. A statistical summary of the subsurface soil sample results are found on Tables 4-6 through 4-8.

4.3 Trench Sampling Results

This section discusses the nature and extent of radiological contamination encountered in the trench areas identified by geophysical methods. Samples of trench material were defined as solid samples that exhibited elevated field screening levels using the FIDLER or microR meters or had (visual) evidence of waste materials present. The data used in this evaluation consist of samples of radiologically contaminated soil or waste material and leachate collected during the site characterization work completed by ARCO/B&W and the RI sampling effort completed by the USACE (August 2003 through June 2004). The cumulative radiological and chemical sampling data generated during the site characterization and the RI are presented in tabular form in Appendices A and B. Details regarding samples of soil/waste and leachate collected during previous investigations are presented in Appendix W. Field procedures implemented and samples collected during the RI program are presented in Section 3.2.3 of this report and in the SAP (USACE, 2003a).

4.3.1 Historical Background

As stated in Section 2.1, detailed records documenting disposal activities at SLDA do not exist. In addition, there were no investigations completed prior to the RI designed to determine the physical and chemical composition of the waste other than sampling of the perched groundwater within the trenches (leachate sampling – see Section 4.3.4). As a result, information regarding the vertical and horizontal distribution of trench contents is limited. However, the information that does exist indicates the materials placed in the geophysical areas designated as trenches were highly heterogeneous with respect to distribution, physical nature, and chemical composition.

The ten disposal trenches were initially delineated in 1981 by Oak Ridge Associated Universities based on a geophysical survey completed by Geo-Centers, Inc. of Newton Upper Falls, Massachusetts. As described in Appendix W, ARCO/B&W further refined the limits of the trenches during the site characterization work completed in the 1990s using information gathered from the following work:

- A perimeter boring program consisting of 157 soil borings advanced around the trenches; trench limits and volumes were subsequently adjusted based on information gathered from soil samples collected.
- A terrain conductivity survey.
- A magnetometer study.

The location and limits of the ten disposal trenches as delineated by ARCO/B&W are illustrated on the Site Plan presented as Figure 1-2 (ARCO/B&W, 1995).

Citizen interviews conducted during the RI provided additional information pertaining to the disposal methodology employed during the 1960s and early 1970s. Reportedly, process wastes from the Apollo facility were packaged in wooden crates, bags, fiber drums, or other containers, or not packaged at all, and were periodically transported to the SLDA site for disposal.

Disposal activities in the upper trench area involved placement of waste materials into an excavated pit and then backfilling the hole with the excavated soils. Hence, the wastes were placed into a series of pits rather than an engineered, rectangular-shaped trench as depicted on Figure 1-2.

Trench 10 was essentially an open pit located along the high wall, which was either a low area that resulted from previous strip mining activities, an excavated pit, or a combination of the two. This trench received some process waste; however, a significant quantity of the materials reportedly placed in Trench 10 was uncontaminated construction and demolition debris including excavated soil, foundations, etc. Trench 10 was described as an open trench between 1960 and 1971 (ARCO/B&W, 1995).

Information related to the trench contents was obtained from citizen interviews, former NUMEC employee interviews, and gleaned from various site investigation reports, NUMEC files and records, including letters to and from Atomic Energy Commission (AEC) and state officials, Nuclear Material Discard Reports (NMDRs), work orders, invoices, and internal memos. Information on when the various trenches were opened is based on notes and an accompanying map dated 1971 prepared by NUMEC as well as information provided by ARCO/B&W.

The disposal activities were reportedly completed in accordance with the regulations previously found in 10 CFR 20.304 (rescinded in 1981). Under these regulations, disposals were controlled by location, activity (in curies), and frequency. The minimum disposal burial depth was four feet below ground surface. Successive burials were to be separated by a minimum of six feet and no more than 12 disposals could be completed in a given year. The maximum radiological activity of the disposed waste was not to exceed 50 millicuries (mCi) uranium or thorium per disposal event, with a maximum activity of 600 mCi per year.

Historical records report that NUMEC employed an administrative limit for uranium of ten percent of the activity limits specified in 10 CFR 20.304. The Site Characterization report stated that NUMEC employees responsible for waste disposal were aware of these limits and that disposals complied with requirements of 10 CFR 20.304.

In addition to the process wastes, the SLDA disposal trenches received contaminated and potentially contaminated equipment, scrap, and other materials (work clothes, wipes, etc.) from the Apollo facility, and process wastes from other nuclear facilities that were sent to Apollo for recovery but determined not to be recoverable, and related scrap (shipping containers, etc.). The bulk of the material disposed of at the SLDA (in terms of volume, not in terms of radioactivity) appears to be the equipment, scrap, and other materials from the Apollo facility.

The Apollo facility utilized uranium in all enrichments and thorium. Thus, the primary radioactive contaminants of interest from the Apollo operations are U-238, U-235, U-234, and Th-232. The primary non-radiological waste constituents potentially disposed of at the SLDA include: fluorides; process chemicals such as ammonia, kerosene, TBP, hydrogen peroxide, and 8-OH; cleaning solvents such as TCE, TCA, and methylene chloride; lubricants such as oil, grease, and hydraulic fluids; and other wastes including beryllium-bearing material and laboratory chemicals.

Table 2-1 presents a summary of materials placed in the disposal trenches based on available documentation, not formal disposal records with disposal manifests. Although the actual trench depths were not recorded, the depths were estimated assuming the trenches were excavated to the top of weathered bedrock, as reported in Site Characterization report (ARCO/B&W, May 1995). Table 4-9 presents the estimated depth of each trench based on the depth to bedrock recorded on boring logs generated during the Site Characterization perimeter boring program.

An estimate of the trench contents based on the approximate depth and lateral extent was provided in the Site Characterization report (Table 5-10, ARCO/B&W, 1995). The estimated total trench volume was approximately 23,500 cubic yards.

In 2000, ARCO submitted a summary of the trench contents to the United States Department of Justice, which listed the various types of materials placed in the trenches. This submittal estimated the trench contents to be approximately 36,700 cubic yards.

The range of trench volume estimates is, therefore, between 23,500 and 36,700 cubic yards. It should be noted, however, that these volume estimates also include backfill material that may not be impacted by radiological material.

4.3.2 Definition of Trench Samples

This section discusses the methodology used to identify samples collected that were representative of the trench contents.

ARCO/B&W advanced a total of 157 soil borings in 1993 around the perimeter of the disposal trenches to determine the extent of contamination and assist in determining the trench boundaries. During a review of this data, it was evident that a number of the borings had been advanced within the trench footprints and encountered waste. Subsurface soil samples collected during the Site Characterization investigation were evaluated to determine if the samples were representative of the subsurface soils surrounding the trenches or representative of the waste within the trenches. This evaluation consisted of the following steps:

1. Reviewed the Site Characterization report summarizing the perimeter boring program to determine if any samples were reportedly collected from within the trenches. If it was stated either on the boring log or in the report text that a sample was collected from within the trenches, then the sample was considered to be representative of the trench contents.

2. The remaining sample locations were reviewed to determine if the location falls within the limits of the trenches. If the boring location indicated it was advanced within the limits of the trenches, the boring log was reviewed to further evaluate whether the material encountered is consistent with the description of the materials placed in the trenches. If materials recovered were consistent with Table 2-1, the sample was considered representative of the trench contents.

Tables 4-10 and 4-11 present the findings of this evaluation and list the samples collected during the perimeter soil boring program that are considered representative of the waste placed in the trenches or associated contaminated soil. Table 4-11 also indicates whether the sampled material was waste or contaminated soil based on the information in the boring log. A total of 13 borings were apparently drilled during the site characterization into the disposal trenches and encountered waste or contaminated soils (borings were 01U06, 01U09, 01U13, 01U15, 02U02, 02U04, 02U12, 02U13, 03U04, 05U05, 06U01, 07U05, and 10L13). Figure 4-73 illustrates the locations of both the historical and current RI borings advanced where waste or contaminated soils were encountered (total of 27 borings).

A total of 27 samples collected from 13 borings completed during the site characterization completed by ARCO/B&W are considered representative of trench waste or associated contaminated soil. The only boring where waste was encountered during the Site Characterization investigation and a representative sample of trench contents was not collected was 05U04; the samples were collected from a depth above the waste. Figure 4-73 illustrates the boring locations where waste or associated radiologically contaminated soils were encountered.

A total of 44 trench borings were advanced down the centerline of the ten disposal trenches as part of the RI work (Figures 4-3 and 4-4). The intent of this sampling effort was to collect samples of the trench waste materials to determine the radiological nature and extent of the waste material. A secondary objective was to better understand the physical and chemical composition of the trench contents and refine the limits of the trenches.

Evaluation of subsurface soils and other materials recovered during drilling revealed that 30 of the 44 borings did not encounter any evidence of waste (Figure 4-73). This determination was based on the following criteria:

- If the materials recovered during drilling contained waste based on visual examination (i.e., man-made materials) it was considered waste material collected from within the disposal trenches, and/or
- If soils recovered during drilling exhibited elevated (above background) field screening levels as measured with the FIDLER or microR meters it was considered contaminated soils collected from within the disposal trenches.

Fourteen of the 44 RI trench borings encountered waste material or impacted soils as shown in Figure 4-73. A total of 13 samples of waste or contaminated soil were collected and analyzed for primary and secondary ROPCs (see Table 3-3). In addition, seven samples were collected from these 14 borings for chemical testing (full TCLP list, PCBs, and RCRA characteristics).

Table 4-12 lists the sample ID and depth of waste or contaminated soil samples collected from within the disposal trenches for both the site characterization work completed by ARCO/B&W and the RI.

Waste materials encountered in the trench samples collected during the RI included wood, fibrous material, plastic sheeting, filter paper, glass, nails, cinders, rubber, etc. In general, the volume of these waste materials was very low compared to the surrounding soils in the trenches. Table 4-13 presents the sample identification, depth of sample collection, FIDLER measurement, background FIDLER measurement, and a description of the waste encountered for borings advanced into the disposal trenches during the RI.

A total of 100 soil samples were collected from the 30 borings that did not encounter waste. Thirty-three samples of the 100 collected were analyzed for primary and/or secondary ROPCs (see Section 3.2.3 of this report for rationale). In addition, four samples were collected from these 30 borings for chemical testing (full TCLP list, PCBs, and RCRA characteristics). Since samples collected from the 30 borings that did not encounter waste were more representative of soil, these samples are discussed in Section 4.2.2, Subsurface Soils.

4.3.3 Discussion of Trench Sampling Results

This section discusses the analytical results associated with samples collected from within the disposal trenches (samples listed in Table 4-12). Table 4-14 presents a statistical summary of the trench sample radiological analytical data. Calculated background values for subsurface soils presented in Section 4.1 were used to evaluate the trench sampling data to identify those trenches where nuclides were present above background and twice background, when background was greater than zero. A third criteria, consisting of the PRG plus background, was also evaluated for isotopes in which PRGs were established (see Table 6-1). Nuclides considered potentially significant with respect to risk are further evaluated in the Baseline Human Health Risk Assessment discussed in Section 6.0 of this report.

Figure 4-74 presents nuclides and associated activities detected in the trench samples analyzed. Trench samples were analyzed for one or more of the 20 nuclides listed in Table 4-14. In addition, some samples were analyzed for total uranium. Total isotopic uranium results were calculated by adding the activities for U-234, U-235 (alpha), and U-238. A total of 15 of the 22 radiological parameters were detected in at least one trench sample. The nature and extent of the nuclides detected on site in trench samples are discussed in the following sections and are grouped according to Primary ROPCs, Secondary ROPCs, and Other Nuclides. Total uranium and total isotopic uranium results are presented with Primary ROPC results. A brief discussion of chemical testing completed on trench samples is presented after the radiological testing results.

4.3.3.1 Primary ROPCs

Am-241, Pu-239, and Pu-241 were not detected in any of the trench samples analyzed. This is significant since these nuclides were not associated with routine processes completed at the Apollo facility but were detected in surface soils near Trench 10 (see Section 4.2). The presence of americium or plutonium in trench samples would have provided an indication that wastes from the Parks facility or other sites may have been disposed of at SLDA (the Parks facility manufactured products containing plutonium).

Ra-228, Th-232, U-234, U-235 (alpha), and U-238 were detected in nearly every trench sample analyzed. A total uranium or total isotopic uranium background activity of 2.96 pCi/g was calculated by adding the background values for U-234, U-235, and U-238 for subsurface soils presented in Section 4.1.

As indicated in Table 4-14, all of the samples analyzed for U-234 and U-235 exceeded twice background. Figures 4-75 and 4-76 illustrate the spatial distribution of U-234 and U-235 (alpha) in the trench material compared to 10, 100, and 500 times background. U-234 was detected in each of the 23 samples analyzed with activities ranging from 12 to 2,200 pCi/g. U-235 (alpha) was detected in each of the 22 samples analyzed at concentrations ranging from 1.2 to 220 pCi/g. The maximum U-234 and U-235 (alpha) activities, 2,200 and 220 pCi/g, respectively, were detected in sample TR-04-040 (11 to 13 feet) located in the southeastern end of Trench 4. The PRG screening criterion for U-234 (97.68 pCi/g) was exceeded in 16 samples, while the PRG screening criterion for U-235 (alpha) (34.87 pCi/g) was exceeded in five samples.

All of the 23 samples analyzed for U-238 exceeded the background value of 1.41 pCi/g. In addition, 19 of the 23 samples collected exceeded twice background (2.82 pCi/g). The PRG screening criterion for U-238 (124.41 pCi/g) was exceeded in two samples. The U-238 activities ranged from 1.5 to 580 pCi/g. Figure 4-77 illustrates the spatial distribution of U-238 in the trench material compared to 10, 100, and 500 times background. The maximum U-238 activity was detected in sample TR-07-033 (8-15.8 feet) located on the northwestern end of Trench 7.

Figure 4-78 illustrates the spatial distribution of total uranium and total isotopic uranium in the trench material. As indicated in Table 4-14, all of the 26 samples analyzed for total uranium exceeded twice background. The total uranium activities ranged from 9.8 to 1,100 pCi/g. As shown in Figure 4-78, total uranium in the trench material was compared to 10, 100, and 500 times background. The maximum total uranium activity detected was in sample 01U06 (8-10 feet) located on the southeastern edge of Trench 1.

Total isotopic uranium was calculated for trench samples collected during the RI by adding the activities for U-234, U-235 (alpha), and U-238. All of the 23 samples analyzed for total isotopic uranium exceeded the twice background. The total isotopic uranium activities ranged from 15 to 2,500 pCi/g. Figure 4-79 illustrates the spatial distribution of total isotopic uranium in the trench material compared to 10, 100, and 500 times background. The maximum total isotopic uranium activity detected was in sample TR-04-040 (11-13 feet) located on the southeastern edge of Trench 4. This range of total isotopic uranium correlates well with the total uranium data gathered during the down-hole gamma logging work completed by ARCO/B&W (16 to 3,700 pCi/g, see Section 2.2.4.2).

A total of three of the 13 samples analyzed for Th-232 exceeded the background value of 1.77 pCi/g. None of the samples exceeded twice background. None of the 13 samples exceeded the PRG screening criterion of 3.12 pCi/g. The maximum Th-232 activity was detected in sample TR-02-023 (8-12 feet) located in the center of Trench 2 (2.60 pCi/g).

Ra-228 was detected above the background activity of 1.66 pCi/g in 4 of the 13 trench samples analyzed. One of the samples exceeded twice background and the PRG screening criterion of 3.35 pCi/g. The maximum Ra-228 activity was detected in sample TR-02-023 (8-12 feet) located in the center of Trench 2 (4.3 pCi/g).

4.3.3.2 Secondary ROPCs

Secondary ROPCs detected in trench samples included Cs-137, Ra-226, and Th-230. The background value in subsurface soils for Cs-137 is zero; therefore, any Cs-137 detections exceeded background. Cs-137 was detected in eight of the 12 samples analyzed with activities ranging from 0.14 to 0.66 pCi/g. Ra-226 was detected in all 13 trench samples analyzed with three samples above the background level of 1.32 pCi/g. None of the samples exceeded twice background. Ra-226 activities ranged from 0.84 to 1.6 pCi/g. Th-230 was detected in each of the three trench samples analyzed with activity levels ranging from 1.3 to 2.2 pCi/g. Each of the samples exceeded the background activity of 1.155 pCi/g; however, none of the activities were greater than twice background.

4.3.3.3 <u>Other Nuclides</u>

Five other radiological parameters were reported by the laboratory since they were detected during the gamma spectroscopy analysis. These other radiological constituents detected in trench samples included Bi-212, Pb-212, Pb-214, K-40, and Th-234.

Bi-212 was detected in 12 of the 13 samples analyzed with activities ranging from 0.60 to 2.9 pCi/g. Three samples contained Bi-212 activity above the background level of 1.24 and one sample was above twice background.

Pb-212 was detected in each of the 13 samples analyzed at concentrations between 1.1 and 5.1 pCi/g. Only one sample analyzed for Pb-212 exceeded the background level of 2.0 pCi/g and the same sample also exceeded twice background.

Pb-214 was also detected in each of the 13 samples analyzed with activities ranging from 1.0 to 1.7 pCi/g. Four samples analyzed for Pb-214 exceeded the background activity of 1.46 pCi/g and no samples were above twice background.

K-40, a naturally occurring nuclide, was present in each of the 13 trench samples analyzed at activities ranging between 8.8 and 25 pCi/g. Only one sample analyzed for K-40 exceeded the background level of 20.8 pCi/g and no sample exceeded twice background.

Th-234 was present in 11 of the 13 samples analyzed at activities ranging between 2.9 and 460 pCi/g. All 11 of the detections had activities greater than the background activity of 2.77

and 10 were greater than twice background. The average Th-234 activity detected in the 11 samples was 50 pCi/g, well above background. The maximum Th-234 activity detected was in sample TR-07-033 (8-15.8 feet) located in the northwestern end of Trench 7.

The maximum Bi-212, Pb-212, and K-40 activities were detected in sample TR-02-023 (8-12 feet) located in the center of Trench 2. The maximum Pb-214 activity was detected in sample TR-06-037 (15-16 feet) located in the center of Trench 6 (1.7 pCi/g).

4.3.3.4 Chemical Testing

A total of 10 trench samples, plus one duplicate sample, were also collected from trench borings for chemical testing to evaluate their waste characteristics. One sample was collected from Trenches 1, 2, 4, 5, 6, 7, and 9 and two samples were collected from Trench 10. Each sample was analyzed for the full toxicity characteristic leaching procedure (TCLP) list of parameters (i.e., volatiles, semivolatiles, pesticides, herbicides, and metals), Resource Conservation and Recovery Act (RCRA) characteristics (i.e., corrosivity [as pH], reactivity [cyanide and sulfide], ignitability, and pH), and polychlorinated biphenyls (PCBs). In addition, two samples were collected from Trench 8; the sample collected from 14-16 feet was analyzed for RCRA characteristics and PCBs and the sample collected from 16 – 16.7 feet was analyzed for the TCLP list of parameters. Table 4-15 presents a statistical summary of the trench sample chemical analytical data.

Trichloroethene (TCE) was detected in 1 of the 10 samples (i.e., TR-08-030 [16-16.7 feet]) at a concentration of 0.0098 mg/L. Pentachlorophenol was detected in 1 of the 10 samples at a concentration of 0.048 mg/L for TR-06-037 (11.8-16 feet). No TCLP pesticides or herbicides were detected in the trench samples.

Barium was detected in each of the 10 trench samples analyzed at concentrations ranging from 0.24 mg/L to 2.8 mg/L. The maximum barium concentration was detected in sample TR-10-002 (4-6 feet). Cadmium was detected in 2 of the 10 samples at a maximum concentration of 0.006 mg/L for TR-10-002 (4-6 feet). Chromium was detected in 4 of the 10 samples at concentrations ranging from 0.004 mg/L to 0.0098 mg/L. The maximum chromium concentration was detected in sample TR-10-002 (4-6 feet). Lead was detected in 5 of the 10 samples at concentrations ranging from 0.03 mg/L to 0.05 mg/L. The maximum lead concentration was detected in sample TR-09-027 (8-9.5 feet). Mercury was detected in 1 of the 10 samples at a maximum concentration of 0.001 mg/L at location TR-07-033 (8–12 feet). Silver was detected in 2 of the 10 samples at concentrations of 0.006 mg/L for TR-09-027 (8-9.5 feet) and 0.008 mg/L for TR-10-002 (4-6 feet).

The corrosivity of the trench samples ranged from 6.1 to 7.6 pH units. Reactive cyanide was detected in 1 of the 10 samples (i.e., TR-09-027 [8-9.5 feet]) at a concentration of 9.0 µg/kg. Reactive sulfide was detected in 8 of the 10 samples at concentrations ranging from 27 mg/kg to 160 mg/kg. The maximum reactive sulfide concentration was detected in sample TR-05-041 (6-8 feet). The trench samples did not exhibit an ignitability characteristic below 140^{o}F.

None of the TCLP, RCRA, and PCB results exceeded 40 CFR Part 261 (TCLP/RCRA) and 40 CFR Part 761 (PCB) hazardous waste criteria.

4.3.3.5 Summary of Nature and Extent of Radionuclides in Trench Samples

Sampling and analysis of trench contents provided important information regarding the configuration, location, and contents of the disposal trenches. An important observation, common to borings advanced into the disposal trenches during previous studies and the RI work, was the fact the waste was present in very isolated pockets surrounded with significant quantities of soil. This finding was consistent with the disposal requirements in 10 CFR 20.304 and accounts provided by previous employees regarding the procedures used for disposal (into a series of pits). As a result, delineation of "disposal trenches" may not be feasible. A more plausible approach may be identification of general areas where waste was encountered and surrounded by groupings of borings where uncontaminated conditions were apparent.

Waste materials and/or contaminated soils were detected more frequently in samples recovered from borings advanced in Trenches 2, 4, 6, 7, and 9. Close examination of Figure 4-73 in the area of those trenches reveals that a significant number of borings were completed (on the order of 100) where no waste or impacted soils were encountered. Some of these borings were located within the trench areas, including 30 borings advanced along the centerline of each trench during the current RI. These borings provided information that reduced the uncertainty regarding the horizontal limits of the waste trenches (Project Goal No. 2). As a result, additional refinement of the limits of Trenches 2, 4, 6, 7, and 9 may not be necessary for the feasibility study, but would be necessary for engineering design.

Trench waste was not encountered at Trenches 1 and 10 during the RI work, although a limited number of waste samples were collected during previous work. As illustrated in Figure 4-73, a significant number of borings were advanced near Trench 1 and only four intercepted waste and/or impacted soils. Since a large percentage of materials placed into Trench 10 was reportedly uncontaminated construction and demolition (C&D) debris, the likelihood of sampling radiologically impacted materials in this trench was significantly lower than in the other disposal trenches on-site. Therefore, additional soil borings advanced for the purpose of further delineation of Trenches 1 and 10 may not yield different results.

As indicated in the above paragraphs, there is uncertainty regarding the specific distribution of waste. However, Figure 4-80 illustrates the areal distribution of waste materials encountered at the site based on current information.

A total of 40 trench samples were collected and analyzed for radiological parameters during previous investigations and the RI work. The objective (Project Goal No. 1), which was to collect a sufficient number of samples of trench materials to complete a qualitative human health risk assessment, was achieved (USACE, 2003a and b).

The objective of Project Goal No. 4, to confirm the list of radionuclides of potential concern in the trench material, was achieved through isotopic analysis of trench samples. Analysis of trench samples indicated that uranium isotopes U-234, U-235, and U-238 were detected at levels well over 100 times background. In addition, americium and plutonium isotopes that were detected in surface soils near Trench 10 were not detected in any trench samples. The nuclides detected in trench samples were consistent with the process waste generated at the Apollo facility and allowable under 10 CFR 20.304. Th-232, also reportedly present in a small fraction of Apollo facility process wastes, was not detected in trench samples at levels significantly above background. Th-234 was consistently detected in trench samples at levels above background. The presence of Th-234 was expected since it is a short-lived decay product of U-238. Based on the limited trench sampling and analysis completed for secondary ROPCs, it does not appear that wastes containing significant levels of secondary ROPCs were placed in the disposal trenches. Therefore, secondary ROPCs will not be evaluated in the baseline human health risk assessment presented in Section 6.0.

A limited characterization of the trench materials was completed through analysis of 10 trench samples for chemical parameters typically required for disposal purposes including a full TCLP analysis, PCBs, and RCRA parameters (see Table 4-15). Results of this sampling indicated the trench contents are not considered a hazardous waste.

4.3.4 Leachate Sampling Results

TWSPs were installed by ARCO/B&W between 1993 and 1995 to facilitate trench leachate sample collection (refer to Section 2.2.10 for details). Leachate samples were collected during various sampling events by ARCO/B&W through the mid- to late-1990s and samples were analyzed for several radiological and chemical parameters (see Appendix W). As discussed in Section 3.2.7, leachate samples were collected during the RI (see Figure 4-81) to better evaluate the trench contents for risk assessment purposes and to further assess potential disposal option for the trench waste material. TWSP locations are found on Figure 2-4.

Table 4-16 presents a statistical summary of the leachate sampling radiological data from the RI sampling event completed in December 2003. U-234 and total uranium were the most frequently detected Primary ROPCs in the 44 samples collected. U-234 was detected at activities ranging from 1.2 to 24,000 pCi/L. U-238 was detected in 38 of 44 samples with activities ranging ranging from 1.2 pCi/L to 2,300 pCi/L. U-235 (alpha) was detected in 35 of 44 samples with detected results from 0.29 to 2,500 pCi/L. Ra-228 reported activities ranged from 1.2 to 16 pCi/L in 23 of 44 samples. Th-232 was detected in 12 of 44 samples with activities ranging from 0.59 to 9.8 pCi/L. Pu-239 was detected only once in 44 samples at an activity of 1.2 pCi/L in TWSP 05-03 located at Trench 5. Am-241 was not detected in any of the 44 samples analyzed.

The number of nuclides detected in the TWSPs appear to be generally consistent between the trenches, with the greatest number of reported activities occurring in Trenches 1, 2, 3, and 5. Figures 4-82 through 4-84 illustrate the spatial distribution of U-234, U-235 and U-238 for the December 2003 samples. These three nuclides were selected based on the greatest number of detections. Table 4-17 provides a summary of the historical data collected from the TWSP. In general, the nuclides detected and the activities from the historical data were similar to those reported for the December 2003 sampling event.

4.4 Surface Water

Surface water sampling, both on site and off site, was performed during the RI and in previous studies completed at the SLDA site. RI surface water samples were collected in December 2003 and June 2004 from Dry Run and five groundwater water seeps located on site. In addition, surface water samples were collected off site during the RI from Carnahan Run and from two groundwater seeps (apparent mine outfalls) located adjacent to Carnahan Run. These surface water locations have also been sampled previously by others as reported in Appendix V and Section 2.2.8. The RI surface water and seep sampling program is described in Section 3.0 of this report and the laboratory data are found in Appendix A.

The following subsections provide the results of the laboratory testing performed on surface water samples collected during the RI. The first subsection discusses the on-site surface water sampling results and the second discusses the off-site sampling results. As discussed in Section 4.0, average upgradient ROPC activities were compared to average downgradient activities to satisfy Project Goal Nos. 7 and 9. Isotopic specific data for Am-241, U-235, Ra-228, and Ra-226 were used to generate figures. As discussed in Section 4.0, isotopic-specific analyses are considered more representative than the gamma spectroscopy data.

4.4.1 On-Site Surface Water

The 11 surface water sampling locations established on site during the RI are shown on Figure 4-85. Table 4-18 presents a statistical summary of the analytical data generated from the December 2003 and June 2004 surface water sampling completed on site during the RI.

Sample locations WS/SE-DR-05 and WS/SE-DR-06 were designated as surface water sampling locations upgradient of the disposal trenches. There were no Primary ROPCs detected in the samples collected from these upgradient locations during either RI sampling event. Project Goal No. 7 was to determine upgradient concentrations of ROPCs in surface water. With the data collected from these two locations, this project goal has been achieved. Since no Primary ROPCs were detected in any of the four upgradient surface water samples, any detections of Primary ROPCs in downgradient surface water/seep samples would have exceeded upgradient levels.

In December 2003, the surface water sample collected from location WS/SE-DR-05 was also analyzed for Secondary ROPCs. Th-230 was the only Secondary ROPC detected at an activity of 0.99 pCi/L.

RI Project Goal No. 9 was to determine the nature and extent of ROPCs in surface water above upgradient activities. To achieve this goal, four surface water sampling locations were established downgradient of the upper disposal trench area (Trenches 1-9). Ra-228 (beta) and U-234 were the only Primary ROPCs detected in the downgradient surface water samples collected from Dry Run in either December 2003 or June 2004. Ra-228 (beta) was detected in three of the eight samples analyzed during both sampling events with activity levels ranging between 1.1 and 1.7 pCi/L. U-234 was present in seven of eight samples at activities between 0.53 and 6.6 pCi/L. The average downgradient activities for Ra-228 (beta) and U-234 were calculated to be 1.1 and 2.0 pCi/L, respectively (one-half the detection limit was used for non-detections).

Seep samples were collected from each of the five groundwater seep locations in December 2003 and from four seep locations in June 2004 (see Figure 4-85). Four Primary ROPCs and four Secondary ROPCs were detected in seep samples. Ra-228 (beta) was detected in five of nine samples analyzed during both sampling events with activities ranging from 1.2 to 1.9 pCi/L. U-234 was detected in five of nine samples at activity levels between 0.43 and 21 pCi/L. U-235 (alpha) ranged between 0.38 and 1.6 pCi/L in three of the nine samples analyzed. U-238 was present in four of nine samples at activities ranging between 0.57 and 0.86 pCi/L. The average downgradient activities for these radionuclides were calculated to be: 1.3 pCi/L for Ra-228 (beta), 5.3 pCi/L for U-234, 0.37 pCi/L for U-235 (alpha), and 0.40 pCi/L for U-238 (one-half the detection limit was used for non-detections).

Secondary ROPCs detected in the two downgradient samples analyzed included gross alpha (2.9 and 13 pCi/L), gross beta (9.8 pCi/L), Ra-226 (gamma) (1.5 pCi/L), and Th-230 (0.95 and 0.97 pCi/L). However, Ra-226 was not detected by the alpha spectroscopy analysis, the isotopic specific method widely considered more accurate. As a result, the Ra-226 activity for seep sample SP-DR-01 collected in June 2004 is taken to be below detection. The average activities for these radionuclides were calculated to be: 8.0 pCi/L for gross alpha, 5.9 pCi/L for gross beta, and 0.96 pCi/L for Th-230 (one-half the detection limit was used for non-detections).

In summary, based on the Dry Run RI surface water and seep sampling data, the following observations were made:

- U-234 was detected at low activity levels in surface water samples collected from locations downgradient of the upper trenches (WS-DR-01 through WS-DR-04). The calculated average U-234 activity in downgradient samples (2.0 pCi/L) was slightly elevated compared to the average upgradient activity (below detection).
- The calculated average Ra-228 (beta), U-234, U-235 (alpha), and U-238 activities in downgradient seep samples were higher than the corresponding average upgradient activities (all below detection). Seep samples SP-DR-01 and SP-DR-02, located downgradient of Trenches 4/5 and Trench 2, respectively, contained U-234 and U-235 (alpha) at levels indicating potential impacts from the disposal trenches. Seep sample SP-DR-03 contained U-234 indicating a potential impact from upgradient Trench 1.

Fate and transport of radionuclides in surface water are discussed in Section 5.0.

Table 4-19 summarizes the on-site historical surface water data. A comparison with the RI data (Table 4-18) indicates general correlation with respect to the radionuclides detected, the frequency of detection, and the range of activity. However, there are a few significant differences including the following:

- The majority of the historical surface water samples were only analyzed for gross alpha and gross beta.

- During the RI sampling, isotopic analysis was conducted with only ten percent of the samples analyzed for gross alpha and gross beta.
- Pu-239 was reported in one historical sample (0.01 pCi/L), Cs-137 was reported in one historical sample (50 pCi/L), and U-236 was reported in three historical samples.
- There was a higher frequency of detections in historic samples (e.g., U-238, U-235).
- There were much higher activities detected in the samples collected during historical investigations (e.g., U-238 maximum-2,500 pCi/L vs. 0.99 pCi/L during the RI; U-235 maximum-42 pCi/L vs. 1.6 pCi/L during the RI; U-234 maximum-1,500 pCi/L vs. 21 pCi/L during the RI). There may be several reasons for these discrepancies including the presence of high turbidity in the samples collected during historical investigations, which would indicate high concentrations of entrained particulates.

4.4.2 Off-Site Surface Water

The eight off-site surface water sampling locations established along Carnahan Run during the RI are shown on Figure 4-86. Table 4-20 presents a statistical summary of the analytical data generated from the December 2003 and June 2004 surface water sampling events completed off site during the RI.

Project Goal No. 7 was to determine upgradient concentrations of ROPCs in surface water. Off-site sample locations WS/SE-CR-01 and WS/SE-CR-02 were designated as surface water sampling locations upgradient of any potential influence from the SLDA site. Ra-228 (beta) was the only radionuclide detected in the upgradient samples during the RI (2.1 pCi/L). The method detection limits for the three other upgradient samples were 1.5, 1.5, and 1.8 pCi/L. The upgradient Ra-228 activity was calculated to be 1.1 pCi/L (the average of the one detection and one half of the three for non-detections).

Project Goal No. 9 was to determine the nature and extent of ROPCs in surface water above upgradient concentrations. To meet this goal, four crossgradient or downgradient sample locations were established and sampled.

The sampling results indicated that Ra-228 (beta) was the only Primary ROPC detected at three of four cross/downgradient surface water sample locations in Carnahan Run. Ra-228 (beta) was detected in three of the eight samples analyzed during both sampling events with activity levels between 1.5 and 2.6 pCi/L. The average Ra-228 (beta) activity was calculated to be 1.2 pCi/L.

Samples were also collected from two groundwater seeps (apparent mine outfalls). Seep location SP-CR-01 was sampled during both the December 2003 and June 2004 sampling events, while location SP-CR-02 was only sampled during the June 2004 event. There were no radionuclides detected in the sample collected from SP-CR-02. Ra-228 (beta) was the only Primary ROPC in seep sample SP-CR-01 (2.6 pCi/L). The average Ra-228 (beta) activity was calculated to be 1.4 pCi/L (one-half the detection limit was used for non-detections). In addition, Secondary ROPCs gross beta and Ra-226 (alpha) were detected in SP-CR-01 at activities of 7.3 and 0.81 pCi/L, respectively.

In summary, based on the Carnahan Run surface water and groundwater seep sampling data, the following observations were made:

- Ra-228 (beta) was the only Primary ROPC detected in crossgradient or downgradient surface water samples. The average Ra-228 (beta) activity calculated for the downgradient surface water samples (1.2 pCi/L) was comparable to the average upgradient activity (1.1 pCi/L).
- Ra-228 (beta) was the only Primary ROPC detected in the three seep samples collected. The average Ra-228 (beta) activity calculated for the seep samples (1.4 pCi/L) was comparable to the average upgradient activity (1.1 pCi/L).
- Results of off-site surface water sampling indicate no apparent impact from the SLDA site.

Table 4-21 summarizes the off-site historical surface water data. Fewer locations were sampled historically than in the RI, with a greater number of detections, particularly U-238 in three of four samples. Also, fewer Primary and Secondary ROPCs were analyzed in the previous studies.

4.5 Sediments

Sediment sampling was performed both on site and off site during the RI and during previous studies conducted at the SLDA site. As part of the RI field work, sediment samples were collected in December 2003 and June 2004 from six locations along Dry Run. In addition, the RI characterization activities included the collection and analysis of sediment samples from six locations along Carnahan Run. The sediment samples collected from Dry Run and Carnahan Run were co-located with the surface water samples discussed in Section 4.4. Historical sediment sampling in Dry Run and Carnahan Run is reported in Appendix V and Section 2.2.9. The RI sediment sampling program is described in Section 3.0 of this report and the laboratory data are found in Appendix A.

The following subsections report the results of the laboratory testing performed on sediments collected during this study. The first subsection discusses the on-site sediment sampling and the second discusses the off-site sampling. As discussed in Section 4.0, average upgradient ROPC activities were compared to average downgradient activities to satisfy Project Goal Nos. 7 and 9. The U-235 activity was based on alpha spectroscopy, an isotope-specific analysis. During the course of sample analysis, U-235 was also detected by gamma spectroscopy analysis. For this reason, the figures in this section were based only on the U-235 (alpha) data, as discussed previously in Section 4.0.

4.5.1 On-Site Sediments

The six sediment sampling locations established on site during the RI, as well as sampling results, are shown on Figure 4-87. Table 4-22 presents a statistical summary of the analytical data generated from the December 2003 and June 2004 sediment sampling events completed on site during the RI.

Project Goal No. 7 was to determine upgradient concentrations of ROPCs in sediments. Sample locations WS/SE-DR-05 and WS/SE-DR-06 were designated as sediment sampling locations upgradient of the disposal trenches. Primary ROPCs detected in the upgradient sediment samples included Ra-228, Th-232, U-234, U-235 (alpha) and U-238.

Ra-228 was detected in each of the four samples analyzed at activities ranging between 0.86 and 0.95 pCi/g. Th-232 was also detected in each of the four upgradient samples with activities ranging between 0.94 and 1.1 pCi/g. U-234 ranged between 0.76 and 1.2 pCi/g in all four upgradient samples. U-235 (alpha) was not detected in either upgradient sample collected during the December 2003 sampling event; however, it was detected in both samples collected in June 2004 (at 0.09 and 0.15 pCi/g). U-238 was detected in each of the four samples analyzed at activities ranging between 0.73 and 1.1 pCi/g. The average upgradient activities for these radionuclides were calculated to be: 0.91 pCi/g for Ra-228, 1.0 pCi/g for Th-232, 0.99 pCi/g for U-234, 0.12 pCi/g for U-235 (alpha), and 0.86 pCi/g for U-238 (one-half the detection limit was used for non-detections).

Only one upgradient sediment sample was specifically analyzed for Secondary ROPCs; however, several of these radionuclides were reported as a result of the gamma spectroscopy analysis completed on all samples. Secondary ROPCs detected in the four upgradient sediment samples included Cs-137, Ra-226, and Th-230. Cs-137 was detected in each of the four samples at activities ranging between 0.09 and 0.24 pCi/g. Ra-226 was detected in each of the four upgradient samples with activities ranging from 0.53 to 0.94 pCi/g. Th-230 was only detected in upgradient sample SE-DR-05 collected during the December 2003 sampling event (1.1 pCi/g). The average upgradient activities for these Secondary ROPCs were calculated to be: 0.16 pCi/g for Cs-137, 0.76 pCi/g for Ra-226, and 1.1 pCi/g for Th-230.

Other radionuclides detected in the upgradient samples included Bi-212 (0.56 – 0.74 pCi/g), Pb-212 (0.91 – 1.1 pCi/g), Pb-214 (0.60 – 1.0 pCi/g), K-40 (6.9 – 10 pCi/g), and Th-234 (1.4 – 1.8 pCi/g). All of these are naturally occurring radionuclides.

Project Goal No. 9 was to determine the nature and extent of ROPCs in sediments above upgradient concentrations. To meet this goal, four downgradient sediment sample locations were established and sampled in December 2003 and June 2004.

Primary ROPCs detected in the downgradient sediment samples included Ra-228, Th-232, U-234, U-235 (alpha) and U-238. Ra-228 was detected in each of the eight samples analyzed at activities ranging between 0.84 and 1.5 pCi/g. Th-232 was also detected in each of the eight downgradient samples with activities ranging between 0.67 and 1.5 pCi/g. U-234 ranged between 2.1 and 29 pCi/g in all four downgradient samples. U-235 (alpha) was detected in seven of eight downgradient samples with activities ranging between 0.35 and 3.2 pCi/g. U-238 was detected in each of the eight samples analyzed at activities ranging between 1.0 and 2.1 pCi/g. The average downgradient activities for these radionuclides were calculated to be: 1.2 pCi/g for Ra-228, 1.1 pCi/g for Th-232, 16 pCi/g for U-234, 1.3 pCi/g for U-235 (alpha), and 1.6 pCi/g for U-238 (one-half the detection limit was used for non-detections).

Only one downgradient sediment sample was analyzed for Secondary ROPCs; however, several of these radionuclides were reported as a result of the gamma spectroscopy analysis completed on all samples. Secondary ROPCs detected in the eight downgradient sediment samples included Cs-137, Ra-226, and Th-230. Cs-137 was detected in seven of the eight samples at activities ranging between 0.07 and 0.16 pCi/g. Ra-226 was detected in each of the eight downgradient samples with activities ranging from 0.68 to 1.0 pCi/g. Th-230 was only detected in downgradient sample SE-DR-03 collected during the June 2004 sampling event (1.0 pCi/g). The average downgradient activities for these Secondary ROPCs were calculated to be: 0.12 pCi/g for Cs-137, 0.84 pCi/g for Ra-226, and 1.0 pCi/g for Th-230.

Bi-212, Pb-212, Pb-214, K-40 and Th-234 were also detected in most of the downgradient samples at activity levels similar to those in the upgradient samples.

In summary, based on the Dry Run sediment sampling data, the following observations were made:

- Primary ROPCs Ra-228, Th-232, U-238 and Secondary ROPC Ra-226 were detected in downgradient samples at average activity levels slightly above the corresponding average upgradient activities.
- U-234 and U-235 were detected in samples SE-DR-02, SE-DR-03, and SE-DR-04 at activity levels greater than the average upgradient activities. These samples were located crossgradient and downgradient of the upper trenches. The presence and activities of these isotopes may indicate potential impacts from historical site operations. U-234 and U-235 (alpha) activities in sample SE-DR-01, located where

Dry Run flows off site, were only slightly above average upgradient levels. A possible explanation for this pattern is the fact that, during non-peak flow periods, surface water in Dry Run infiltrates into the mine spoils, thereby preventing transport of sediments off site and at sample location SE-DR-01. Any sediment carried by the surface water would be deposited onto the streambed prior to infiltration into the mine itself.

Table 4-23 summarizes the on-site historical sediment data. The RI isotopic uranium results generated from Dry Run sampling are very consistent with the results of total uranium sediment sampling completed by ARCO in the 1990s (refer to Appendix V). Fate and transport of radionuclides in surface water is discussed in Section 5.0.

4.5.2 Off-Site Sediments

The six off-site sediment sampling locations established along Carnahan Run during the RI are shown on Figure 4-88. Table 4-24 presents a statistical summary of the RI analytical data generated from the December 2003 and June 2004 off-site sediment sampling events.

Project Goal No. 7 was to determine upgradient concentrations of ROPCs in sediment. Off-site sample locations WS/SE-CR-01 and WS/SE-CR-02 were designated as sediment sampling locations upgradient of any potential influence from the SLDA site. Primary ROPCs detected in the four upgradient sediment samples included Ra-228, Th-232, U-234, U-235 (alpha), and U-238.

Ra-228 was detected in each of the four samples analyzed at activities ranging between 1.1 and 1.3 pCi/g. Th-232 was also detected in each of the four upgradient samples with activities ranging between 0.97 and 1.1 pCi/g. U-234 ranged between 0.62 and 1.5 pCi/g in all four upgradient samples. U-235 (alpha) was not detected in either upgradient sample collected during the December 2003 sampling event; however, it was detected in both samples collected during the June 2004 sampling event (at 0.14 and 0.15 pCi/g). U-238 was detected in each of the four samples analyzed at activities ranging between 0.53 and 1.2 pCi/g. The average upgradient activities for these radionuclides were calculated to be: 1.2 pCi/g for Ra-228, 1.1 pCi/g for Th-

232, 1.0 pCi/g for U-234, 0.09 pCi/g for U-235 (alpha), and 0.88 pCi/g for U-238 (one-half the detection limit was used for non-detections).

None of the upgradient sediment samples were specifically analyzed for Secondary ROPCs; however, several of these radionuclides were reported as a result of the gamma spectroscopy analysis completed on all samples. Secondary ROPCs detected in the four upgradient sediment samples include Cs-137 and Ra-226. Cs-137 was detected in three of the four samples at activities ranging between 0.025 and 0.063 pCi/g. Ra-226 was detected in each of the four upgradient samples with activities ranging from 0.87 to 1.35 pCi/g. The average upgradient activities for Cs-137 and Ra-226 were calculated to be 0.04 and 1.1 pCi/g, respectively (one-half the detection limit was used for non-detections).

Other radionuclides detected in the upgradient samples included Bi-212 (0.60 – 1.1 pCi/g), Pb-212 (1.1 – 1.6 pCi/g), Pb-214 (1.0 – 1.5 pCi/g), K-40 (11 – 16 pCi/g), and Th-234 (0.81 pCi/g). The detected radionuclides and average concentrations in upgradient sediment samples in Carnahan Run were consistent with those reported for upgradient samples for Dry Run.

Project Goal No. 9 was to determine the nature and extent of ROPCs in sediments above upgradient concentrations. Primary ROPCs detected in the downgradient samples included Ra-228, Th-232, U-234, U-235 (alpha), and U-238. Ra-228 was detected in each of the eight samples analyzed during both sampling events with activity levels between 0.98 and 1.2 pCi/g. Th-232 was also present in each of eight samples at activities between 0.80 and 1.30 pCi/g. U-234 ranged between 0.710 and 1.3 pCi/g. U-235 (alpha) was detected in samples SE-CR-04 and SE-CR-05 during the June sampling event at activities of 0.16 and 0.065 pCi/g. U-238 was detected in each of the eight samples analyzed with activity levels between 0.57 and 1.1 pCi/g. The average downgradient activities for these radionuclides were calculated to be: 1.1 pCi/g for Ra-228, 1.0 pCi/g for Th-232, 0.94 pCi/g for U-234, 0.082 pCi/g for U-235 (alpha), and 0.78 pCi/g for U-238 (one-half the detection limit was used for non-detections).

Only one of the downgradient sediment samples were analyzed for Secondary ROPCs; however, several of these radionuclides were reported as a result of the gamma spectroscopy analysis completed on all samples. Secondary ROPCs detected in the eight downgradient sediment samples include Cs-137, Ra-226, and Th-230. Cs-137 was detected in one of the eight downgradient samples at an activity of 0.024 pCi/g. Ra-226 was detected in each of the eight downgradient samples with activities ranging from 0.66 to 1.0 pCi/g. Th-230 was detected in sample SE-CR-03 at an activity of 1.1 pCi/g. The average upgradient activities for these radionuclides were calculated to be: 0.024 pCi/g for Cs-137, 0.81 pCi/g for Ra-226, and 1.1 pCi/g for Th-230 (one-half the detection limit was used for non-detections).

Other radionuclides reported to be present in most downgradient samples included Bi-212, Pb-212, Pb-214, and K-40. The reported activity levels were similar to those in the upgradient samples.

In summary, based on the Carnahan Run sediment sampling data, the activities of ROPCs detected in downgradient sediment samples were not elevated compared to the upgradient activities. Table 4-25 summarizes the off-site historical sediment data.

4.6 Groundwater

The overall extent of radionuclide concentrations within site groundwater was evaluated by compiling and analyzing a database of existing groundwater analytical data both from previous investigations at the SLDA and from the RI sampling program. Groundwater samples were collected as part of the RI during December 2003 and June 2004; variances to the RI groundwater sampling program presented in the SAP are provided in Table 3-1.

As discussed in Section 2.3.2 of this report, the Overburden, First Shallow and Second Shallow hydrostratigraphic zones contain perched water and are effectively separated by unsaturated zones. The Upper Freeport coal and mine workings exhibit open-channel flow within the mine voids and essentially unsaturated conditions in the residual coal pillars. Most of the monitoring wells screened within the coal did not generate sufficient groundwater to obtain representative samples. The Deep Bedrock is the only fully saturated zone beneath the site.

All groundwater samples collected during the RI were analyzed for the primary ROPCs as defined in Section 3.3 of this report. Ten percent of the groundwater samples were also analyzed for secondary ROPCs. Isotopic radionuclide testing completed during the RI was not performed during previous studies (historical groundwater sampling and analysis was restricted primarily to gross alpha and gross beta analyses). The resulting database contained analytical data from 75 wells and piezometers (see Appendix A).

Pursuant to Public Law 107-117, Section 8143, which directs the USACE to address radioactive wastes at the SLDA site, this discussion focuses on the extent of radionuclide contamination in SLDA groundwater. However, site-specific chemical data obtained during previous investigations performed by ARCO/BWXT are presented at the end of this section for completeness and to provide information to be used in the FS.

Project Goal No. 7 (as listed in Section 3.2.1 of this report) was to determine upgradient concentrations of ROPCs in groundwater. Consequently, groundwater analytical results were evaluated for each of the five hydrostratigraphic zones (Overburden, First Shallow Bedrock, Second Shallow Bedrock, Upper Freeport Coal, and Deep Bedrock) identified at the site. The results were also compared to data from on-site upgradient monitoring wells within each hydrostratigraphic zone. Table 4-26 provides a list of the upgradient and downgradient monitoring wells and piezometers (relative to the waste disposal areas) sorted by hydrostratigraphic zone. Whether these monitoring points were considered upgradient or downgradient relative to the trenches was determined by evaluation of the groundwater elevation contour maps (Figures 2-16 through 2-19, 2-21, and 2-23 through 2-27).

The distribution of radionuclides detected in the groundwater during the current RI is shown in Figures 4-89 through 4-93 for both primary and secondary ROPCs for each of the five hydrostratigraphic zones. As discussed in Section 4.0, average upgradient ROPC activities were compared to average downgradient activities to satisfy Project Goal Nos. 7 and 9. Isotopic specific data for Am-241, U-235, Ra-228, and Ra-226 are used for generation of figures and for evaluation. Gamma spectroscopy data are presented but are deemed less representative than the isotopic specific analyses (as discussed previously in Section 4.0).

4.6.1 Remedial Investigation Groundwater Results

4.6.1.1 Overburden Radionuclide Analytical Results

Tables 4-27 and 4-28 provide statistical summaries of groundwater analytical results for samples collected from the Overburden zone in December 2003 and June 2004. Table 4-27 summarizes upgradient results and Table 4-28 summarizes downgradient results. Figure 4-89 illustrates radionuclides detected in Overburden wells during the RI characterization activities.

Monitoring wells MW-47, MW-59, MW-64, MW-69 and MW-74 were designated as upgradient wells for the Overburden zone. However, samples were not collected from wells MW-47 or MW-74 during either sampling event as they were dry.

Evaluation of the low-flow sampling log for the sample collected from MW-59 in December 2003 revealed that the turbidity of the groundwater at the time of sample collection was above 1,100 NTUs. Therefore, the laboratory data were considered to be biased high, were rejected, and were not used in determination of upgradient radionuclide levels.

Ra-228 (beta) was the only Primary ROPC detected in the five upgradient samples collected during the December 2003 and June 2004 sampling events. Ra-228 (beta) was present in three of the five samples collected from wells MW-59, MW-64, and MW-69 at activities ranging between 0.85 and 1.6 pCi/L. The average upgradient Ra-228 (beta) activity was calculated to be 1.1 pCi/L (one-half the detection limit was used for non-detections).

Monitoring well MW-11S was the only Overburden well identified as downgradient of the disposal trenches. There were no primary ROPCs detected in the sample collected from MW-11S.

The sample collected from MW-11S was also analyzed for Secondary ROPCs. Gross alpha (2.7 pCi/L) and Ra-226 (1.3 pCi/L) were detected in the sample collected from MW-11S. In addition, K-40 (a naturally occurring radionuclide) was detected at a level of 48 pCi/L.

Comparison of gross alpha, Ra-226 and K-40 results to upgradient groundwater quality data was not possible since upgradient samples were not analyzed for these parameters.

Based on the groundwater analytical data collected during the RI, it does not appear that the Overburden groundwater in the vicinity of well MW-11S has been adversely impacted from the disposal trenches. This observation is due to the absence of primary ROPCs in the sample collected from MW-11S and the reported gross alpha, Ra-226 and K-40 activities.

4.6.1.2 First Shallow Bedrock Radionuclide Analytical Results

Tables 4-29 and 4-30 provide statistical summaries of groundwater analytical results for samples collected from the First Shallow Bedrock zone in December 2003 and June 2004. Table 4-29 summarizes upgradient results and Table 4-30 summarizes downgradient results. Figure 4-90 illustrates radionuclides detected in First Shallow Bedrock wells during the RI characterization activities.

Monitoring wells MW-08, MW-09A, MW-13, MW-14, MW-15, MW-24, MW-32, MW-38, NWS-02-01, NWS-03-01 were designated as upgradient wells for the First Shallow Bedrock zone. However, samples were not collected from wells NWS-02-01 or NWS-03-01 during either sampling event since they were either not sampled (see Section 3.2.6) or were dry.

As noted in the December 2003 low-flow sampling log for MW-32, there was an obstruction in the well and the sample was collected using high-density polyethylene tubing equipped with a check valve. The collected sample contained a turbidity level above 1,100 NTUs. Therefore, the data associated with the December 2003 sample collected from well MW-32 were considered biased high, were rejected, and were not used in the evaluation of upgradient radionuclide activities. The sampling approach was modified for this well in the June 2004 sampling event, which successfully reduced the turbidity level to 20 NTUs. As a result, the data associated with the June 2004 sampling event was considered usable.

Primary ROPCs detected in the upgradient groundwater samples included Ra-228 (beta) and U-238. Ra-228 (beta) was present in samples collected from wells MW-08, MW-14, MW-24, MW-32, and MW-38 at activities ranging between 1.4 and 2.6 pCi/L. U-238 was detected in the sample collected from well MW-38 at an activity of 0.17 pCi/L. The average upgradient activities for Ra-228 (beta) and U-238 were calculated to be 1.1 and 0.23 pCi/g, respectively (one-half the detection limit was used for non-detections). Since the other six primary ROPCs were not detected in any upgradient samples, the average upgradient level for these radionuclides was taken to be less than detection.

The only upgradient sample analyzed for secondary ROPCs was collected from MW-15 during the December 2003 sampling event and gross alpha (130 pCi/L), gross beta (170 (pCi/L), Ra-226 (3.5 pCi/L), and Th-230 (0.87 pCi/L) were detected. In addition, K-40 was detected in sample MW-15 at a level of 87 pCi/L. Evaluation of the quarterly gross alpha and gross beta data collected by ARCO/BWXT (see Table 4-37) found that the mean gross alpha and gross beta levels over 32 sampling events for MW-15 were 1.5 and 4.0 pCi/L, respectively, with maximum values of slightly greater the 10 pCi/L. Therefore, the gross alpha and gross beta results for the sample collected from well MW-15 during the December 2003 sampling event are considered an anomaly and the historical data were used as the upgradient gross alpha and gross beta levels for the First Shallow Bedrock zone.

Monitoring wells MW-12D, MW-25, MW-26, MW-27, MW-29, MW-41, MW-42, MW-44, MW-50, MW-51, MW-60, NWS-01A-01, NWS-04-01 and NWS-05-01 were designated as First Shallow Bedrock wells downgradient of the disposal trenches. However, samples were not collected from monitoring wells MW-27, MW-44, MW-50, MW-60, NWS-01A-01, NWS-04-01, and NWS-05-01 during either sampling event since they were either not sampled (see Section 3.2.6), were not installed yet, or were dry.

Five of the eight primary ROPCs were detected in the downgradient samples analyzed. Ra-228 (beta) was detected in nine of the 13 downgradient samples analyzed with activity levels ranging from 1.3 to 2.5 pCi/L. Th-232 and U-235 (alpha) were only detected in the December 2003 sample collected from well MW-29 at activities of 1.6 and 0.95 pCi/L, respectively. U-234 was detected in three samples collected from wells MW-29 and MW-41 at activities ranging from

0.50 to 2.7 pCi/L. U-238 was detected in two samples collected from MW-12D and MW-41 at activities of 0.52 and 0.37 pCi/L, respectively. The average downgradient activities for these radionuclides were calculated to be: 1.4 pCi/L for Ra-228 (beta), 0.39 pCi/L for Th-232, 0.23 pCi/L for U-235 (alpha), 0.47 pCi/L for U-234, and 0.21 pCi/L for U-238 (one-half the detection limit was used for non-detections).

In addition, four downgradient samples were analyzed for Secondary ROPCs. Gross beta was detected in the sample collected from MW-26 during the December 2003 sampling event at an activity of 3.1 pCi/L. Ra-226 (alpha) was also detected in samples collected from MW-12D and MW-26 during the December 2003 sampling event at concentrations of 4.4 and 0.8 pCi/L. The average downgradient activities for gross beta and Ra-226 (alpha) were calculated to be 2.2 and 2.8 pCi/g, respectively (one-half the detection limit was used for non-detections).

The calculated average downgradient activities for Primary ROPCs are comparable to the calculated average upgradient levels. Based on the groundwater analytical data collected during the RI, it appears that groundwater downgradient of Trenches 1 and 2 may have been impacted by migration of radionuclides. This interpretation is supported by the presence of low activities of U-234, U-235 (alpha), U-238, and Th-232 in samples collected from downgradient wells MW-12D, MW-25, MW-29, and MW-41.

4.6.1.3 Second Shallow Bedrock Radionuclide Analytical Results

Tables 4-31 and 4-32 provide statistical summaries of groundwater analytical results for samples collected from the Second Shallow Bedrock zone in December 2003 and June 2004. Table 4-31 summarizes upgradient results and Table 4-32 summarizes downgradient results. Figure 4-91 illustrates radionuclides detected in Second Shallow Bedrock wells during the RI.

Monitoring wells MW-33, MW-45, MW-52, MW-61, NWS-02-02, and NWS-03-02 were designated as upgradient wells for the Second Shallow Bedrock zone. However, samples were not collected from MW-61, NWS-02-02 or NWS-03-02 during either sampling event since they were either intentionally not sampled or were dry.

Primary ROPCs detected in the upgradient samples included Ra-228 (beta), U-234, and U-238. Ra-228 (beta) was present in samples collected from wells MW-33 and MW-45 at an activity of 1.4 pCi/L. U-234 was detected in samples collected from MW-33 and MW-45 during the December 2003 sampling event at activities of 0.49 and 4.9 pCi/L, respectively. Similarly, U-238 was detected in samples collected from MW-33 and MW-45 during the December 2003 sampling event at activities of 0.36 and 2.1 pCi/L, respectively. The average upgradient activities for these radionuclides was calculated to be: 1.1 pCi/L for Ra-228 (beta), 1.2 pCi/L for U-234, and 0.61 pCi/L for U-238 (one-half the detection limit was used for non-detections).

The only upgradient sample analyzed for secondary ROPCs was collected from MW-33 during the June 2004 sampling event. The only Secondary ROPC detected was gross beta, which was detected at an activity of 4.5 pCi/L.

Monitoring wells MW-11D, MW-17, MW-37, MW-43, MW-53, NWS-04-02, and NWS-05-02 were designated as Second Shallow Bedrock wells downgradient of the disposal trenches. However, samples were not collected from monitoring wells MW-11D, MW-17, MW-37, MW-53, NWS-04-02, and NWS-05-02 during either sampling event since they were either not sampled (see Section 3.2.6), were not installed yet, or were dry. As a result, the only downgradient Second Shallow Bedrock well that was sampled was MW-43.

U-234 was detected in the samples collected from well MW-43 during the December 2003 and June 2004 sampling events with activities of 0.70 and 1.5 pCi/L, respectively. U-238 was detected in the December 2003 sampling event at an activity of 0.33 pCi/L, but was not detected in the June 2004 sampling event. The average downgradient activities for U-234 and U-238 were calculated to be 1.1 and 0.21 pCi/L, respectively (one-half the detection limit was used for non-detections).

The calculated average downgradient activities for Primary ROPCs were lower than the calculated average upgradient levels. Based on the analytical data collected during the RI, it does not appear that the Second Shallow Bedrock groundwater in the vicinity of well MW-43 has been impacted by the disposal trenches.

4.6.1.4 Upper Freeport Coal Radionuclide Analytical Results

A total of 17 conventional monitoring wells and five FLUTe multiport sampling systems were installed in the Upper Freeport Coal hydrostratigraphic unit. Four of these wells (MW-01, MW-06, MW-54, and MW-56) have monitored the base of the mine fill near Trench 10. Monitoring well MW-05 was screened partially within residual coal near Trench 10. Eight wells were screened through coal pillars, and the remaining four wells were screened through mine voids. Five wells were not sampled in either December 2003 or June 2004 as they did not generate enough water for representative samples (see Figure 4-92). Table 2-5 summarizes which wells were screened through voids and which wells were screened through coal. Monitoring well MW-62 was not installed until after the December 2003 sampling event took place.

Tables 4-33 and 4-34 provide statistical summaries of groundwater analytical results for samples collected from the Upper Freeport Coal zone in December 2003 and June 2004. Table 4-33 summarizes upgradient results and Table 4-34 summarizes downgradient results. Figure 4-92 illustrates radionuclides detected in Upper Freeport Coal wells during the RI.

Monitoring wells MW-01, MW-05, MW-06, MW-54, and MW-56 were designated as upgradient wells for the Upper Freeport Coal zone. Primary ROPCs detected in the upgradient samples included Ra-228 (beta), Th-232 and U-234. Ra-228 (beta) was present in samples collected from wells MW-06, MW-54, and MW-56 at activities ranging from 1.9 to 2.0 pCi/L. Th-232 and U-234 were also detected in only one upgradient well (MW-54) at activities of 1.8 and 0.62 pCi/L, respectively. The average upgradient activities for these radionuclides was calculated to be: 1.2 pCi/L for Ra-228 (beta), 0.40 pCi/L for Th-232, and 0.20 pCi/L for U-234 (one-half the detection limit was used for non-detections).

The upgradient sample analyzed for secondary ROPCs was collected from MW-05 during the December 2003 sampling event; gross beta and Ra-226 were detected at activities of 3.3 and 0.69 pCi/L, respectively.

Monitoring wells MW-02A, MW-03, MW-16, MW-20, MW-21, MW-30A, MW-31, MW-39, MW-46, MW-57, MW-62, NWS-01A-03, NWS-02-03, NWS-03-03, and NWS-04-03 were designated as Upper Freeport Coal wells downgradient of the disposal trenches. However, samples were not collected from monitoring wells MW-16, MW-20, MW-21, MW-46, MW-62, NWS-02-03, and NWS-04-03 during either sampling event since they were either not sampled (see Section 3.2.6), were not installed yet, or were dry. The data associated with samples collected from MW-03 and MW-31 during the December 2003 sampling event were rejected based on low sample volume and high turbidities (not representative of the groundwater).

Primary ROPCs detected in the downgradient samples included Ra-228, Th-232, U-234, and U-238. Ra-228 was only detected in the sample collected from MW-31 at an activity of 1.4 pCi/L. Th-232 was detected in the samples collected from wells MW-30A and MW-57 during the December 2003 sampling event at activity levels of 6.0 and 5.3 pCi/L, respectively. U-234 was detected in the samples collected from wells MW-31 and MW-57 at activity levels of 0.39 and 7.8 pCi/L, respectively. U-238 was present in the sample collected from MW-57 at 4.9 pCi/L. The average downgradient activities for these radionuclides was calculated to be: 0.79 pCi/L for Ra-228 (beta), 1.4 pCi/L for Th-232, 0.93 pCi/L for U-234, and 0.63 pCi/L for U-238 (one-half the detection limit was used for non-detections).

The downgradient sample analyzed for secondary ROPCs was collected from MW-39 during the June 2004 sampling event; gross beta and Th-230 were detected at activities of 3.8 and 0.53 pCi/L, respectively.

The calculated average downgradient activities for Primary ROPCs and gross beta are comparable to the calculated average upgradient levels. Based on the analytical data collected during the RI, it does not appear that the Upper Freeport Coal zone has been impacted from the disposal trenches.

4.6.1.5 Deep Bedrock Radionuclide Analytical Results

Tables 4-35 and 4-36 provide statistical summaries of groundwater analytical results for samples collected from the Deep Bedrock zone in December 2003 and June 2004. Table 4-35 summarizes upgradient results and Table 4-36 summarizes downgradient results. Figure 4-93 illustrates radionuclides detected in Deep Bedrock wells during the RI.

Monitoring wells MW-02, MW-16BC, MW-19, MW-23, MW-35, MW-36, MW-58, NWS-02-04, NWS-03-04, NWS-04-04, NWS-05-04, and NWS-05-05 were designated as upgradient wells for the Deep Bedrock zone. However, samples were not collected from wells MW-34A, NWS-02-04, NWS-03-04, NWS-04-04, and NWS-05-05 during either sampling event since they were either not sampled (see Section 3.2.6) or were dry.

Primary ROPCs detected in the upgradient samples included Ra-228 (beta), U-234, and U-238. Ra-228 (beta) was present in samples collected from monitoring wells MW-16BC, MW-23, MW-36, MW-58, and NWS-05-04 at activities ranging from 1.1 to 5.1 pCi/L. U-234 was present in samples collected from wells MW-19, MW-23, MW-35, MW-36, and MW-58 at activities ranging from 0.28 to 1.2 pCi/L. U-238 was only detected in the sample collected from well MW-23 at 0.52 pCi/L. The average upgradient activities for these radionuclides was calculated to be: 1.6 pCi/L for Ra-228 (beta), 0.40 pCi/L for U-234, and 0.18 pCi/L for U-238 (one-half the detection limit was used for non-detections).

The only upgradient samples analyzed for Secondary ROPCs were collected from wells MW-36 during the December 2003 sampling event and MW-58 during the June 2004 sampling event. There were no Secondary ROPCs detected in the sample collected from MW-58. Ra-226 (alpha) (1.1 pCi/L) and Th-230 (1.1 pCi/L) were the only Secondary ROPCs detected in the sample collected from MW-36. The average upgradient activities for Ra-226 (alpha) and Th-230 were calculated to be 0.67 and 0.64 pCi/L, respectively (one-half the detection limit was used for non-detections).

Monitoring wells MW-22, MW-34A, MW-40, and NWS-01A-04 were designated as Deep Bedrock wells downgradient of the disposal trenches. However, monitoring well MW-34A was not sampled during either sampling event since it was dry.

Ra-228 (beta) was the only radionuclide detected in downgradient wells. The Ra-228 (beta) activities detected in samples from wells MW-22 and MW-40 were 3.1 and 1.2 pCi/L, respectively. The average downgradient activity for Ra-228 (beta) was calculated to be 1.2 pCi/L (one-half the detection limit was used for non-detections).

There were no downgradient samples analyzed for Secondary ROPCs.

The calculated average downgradient activities for Primary ROPCs are comparable to, or less than, the calculated average upgradient levels. Based on the analytical data collected during the RI, it does not appear that the Deep Bedrock zone has been impacted by the disposal trenches.

4.6.2 Pre-Remedial Investigation Gross Alpha and Gross Beta Groundwater Monitoring

Historical radionuclide data of on-site groundwater consists of gross alpha and gross beta monitoring completed by ARCO/BWXT. Table 4-37 provides a statistical analysis of the gross alpha and gross beta groundwater monitoring results (by well) from the quarterly groundwater sampling conducted at the site by ARCO/BWXT between April 1991 and June 2002. Table 4-38 indicates by well how often the maximum values detected exceeded the gross alpha and gross beta MCLs for drinking water. As indicated in Table 4-38, most of the exceedances occurred only once or twice, and observed exceedances occurred in both up- and downgradient wells. The maximum gross alpha concentrations exceeded the drinking water MCLs on three occasions in only two locations (PZ-01 and MW-20).

4.6.3 Pre-Remedial Investigation Groundwater Chemical Analytical Results

Statistical summaries of the chemical data (VOCs, SVOCs, inorganics, and miscellaneous parameters) associated with the groundwater samples collected by ARCO/BWXT at the SLDA site prior to the RI are presented in Table 4-39. Table 4-40 also shows which of the values exceeded the Pennsylvania Act II medium-specific concentrations (MSCs), for organic regulated substances in groundwater as well as in which monitoring wells the maximum values were detected.

4.7 Perimeter Air Monitoring Analytical Results

This section summarizes the analytical results of the perimeter air monitoring program completed during the RI. The purpose of the perimeter air monitoring program was to collect and analyze perimeter air samples in order to establish baseline radiological concentration in air. Project Goal No. 8 was to determine ambient baseline levels of ROPCs in air. The baseline air data are necessary to evaluate potential health and safety exposures due to site contamination to both on- and off-site receptors.

The perimeter air-monitoring program was completed in accordance with the Ambient Air Sampling Plan found in Appendix D of the Site Safety and Health Plan presented in the SAP (USACE, 2003b). The equipment used and sample collection procedures are summarized in Section 3.2.9. The five air monitoring station locations are illustrated on Figure 3-4. Table 3-14 reports each sample identification, date collected, and analysis completed.

Statistical summaries of the perimeter air sampling analytical results for air sampling stations ASL-1 through ASL-5 are found in Tables 4-41 through 4-45, respectively. Table 4-46 is a statistical summary of all analytical data for the perimeter air monitoring program. The statistical tables present the number of results, number of detections by parameter, maximum, minimum, average and standard deviation activity by parameter, and number of samples exceeding NRC criteria contained in Table 2 of 10 CFR 20, Appendix B.

It should be noted that some of the radionuclides presented in Tables 4-41 through 4-46 were not specifically requested for analysis; however, were reported by the laboratory if detected during the gamma spectroscopy analysis. None of the samples analyzed during the perimeter air monitoring program contained Am-241, Th-232, Cs-137, and Co-60 above the method detection limit. As shown in Figure 4-41, the maximum concentrations of Ra-228, U-234, U-235 (alpha), U-238, and gross alpha measured at all of the sampling locations were at least two orders of magnitude below NRC criteria. Maximum concentrations of gross beta and Th-230 were at least one order of magnitude below NRC criteria. There were no project-specific comparison criteria for radionuclides not listed in Table 2 of 10 CFR 20, Appendix B.

Evaluation of data from individual air sampling locations indicate that there were no significant trends of increasing or decreasing radionuclide activity detected over time. Similarly, there were no large variances in radionuclide activities between sampling locations. It should be noted however, the maximum U-234, U-235 (alpha), and U-238 activities were all from ASL-04. Based on the data presented in Table 4-46, Project Goal No. 8 has been achieved.

5.0 CONTAMINANT FATE AND TRANSPORT

An evaluation of the fate and transport of contaminants at the SLDA was performed to identify the mechanisms and pathways by which radionuclides present at the site could be released from their current locations, move through environmental media, and potentially impact human and ecological receptors. This evaluation is based on the current site configuration, ongoing maintenance activities, and land-use controls utilizing information given in the first four chapters of this RI report, the SAP (USACE 2003), the site characterization report prepared by the site owners (ARCO/B&W 1995), and the draft environmental impact statement (DEIS) prepared by the NRC on decommissioning the site (NRC 1997). A Conceptual Site Model (CSM) has been developed for the SLDA (Figure 2-22), and current information does not indicate that site-related constituents are migrating off-site, but are contained on-site generally in or near the ten trenches. The CSM was developed based on historic information, as supplemented by the results of recent site characterization activities.

This section describes the physical and chemical process that affect the migration of ROPCs at the SLDA site. The two primary factors that influence contaminant release and migration from the SLDA are:

- Physical and chemical properties of the source media, and
- Physical characteristics of the site including its topography, vegetative cover, geology, hydrology, and meteorology.

These two factors are addressed in the following narrative, and they represent important input parameters in the identification of exposure pathways for potential human and ecological receptors in the baseline risk assessment (BRA). The human health BRA is presented in Chapter 6, and a screening-level ecological risk assessment (SLERA) is given in Chapter 7.

5.1 Source Media

The primary source of contaminants at the SLDA is the radioactive wastes previously disposed of in the ten trenches at the site. Nine of the trenches (Trenches 1 through 9) are located in the southeastern portion in a topographically elevated area of the site and were reportedly excavated to the weathered shale bedrock. These nine trenches are reportedly a series of pits that were constructed adjacent to one another, giving the appearance of linear trenches. Trench 10 is located 300 m (1,000 ft) northwest of the upper trench area, and was excavated in coal strip mine spoils on the northwest side of a high wall of bedrock in a generally flat area of the site (see Figure 1-2). In actuality, there are only nine trenches at the site, as Trench 3 in the upper trench area appears to have been a settling basin, and not a disposal trench (USACE 2003).

Radioactive wastes from the Apollo nuclear fuel fabrication facility located about 4 km (2.5 mi) south of the SLDA were disposed of at the site from 1961 through 1970 in accordance with AEC regulations in effect at that time given in 10 CFR 20.304; this regulation was rescinded in 1981. The Apollo facility processed uranium of all enrichments at a capacity of about 350 to 400 metric tons (390 to 440 tons) per year and a limited amount of thorium, generally for special applications. Most of the material processed at the plant was low-enriched uranium (defined to contain less that 20 percent by weight U-235). A maximum of 600 mCi of uranium and thorium could be disposed of at the SLDA site in any year as specified in 10 CFR 20.304, although historical records indicate that an administrative limit of 10 percent of this amount was used (at least for enriched uranium). The main radioactive contaminants in the wastes are thus uranium and thorium (ARCO/B&W 1995).

The uranium-contaminated materials placed in the trenches had various levels of enrichment, ranging from less than 0.2 percent U-235, i.e., depleted uranium, to greater than 45 percent U-235. The uranium isotopes of concern in these previously disposed of wastes are those associated with natural uranium, i.e., U-234, U-235, and U-238. The main thorium isotope of concern is thorium-232; the radioactive decay product Ra-228 is also present due to radionuclide ingrowth which has occurred since the thorium-232 contaminated wastes were disposed of at the site. A wide variety of materials were placed in these trenches in a highly heterogeneous manner and include the following types of wastes, as identified in USACE (2003):

- Process wastes (slag, crucibles, spent solvent, sludges, organic liquids, debris);
- Laboratory wastes (sample and reagent vials);
- Outdated or broken equipment and construction debris;
- General maintenance items (paint, oil, lubricants) and solvents; and
- Protective clothing and trash (shipping containers, paper, wipes).

Some of these wastes were placed in cardboard boxes and metal drums, some were bagged, and some were placed in the trenches with no special packaging or containers (USACE 2002). Most of the wastes containing radioactive contaminants were solid, although some liquid wastes were placed in the trenches.

The trenches at the SLDA site were excavated and used for disposal of radioactive waste between 1961 and 1970. Following placement in the trenches, the waste materials were covered with about 1.2 m (4 ft) of clean soil, as specified in the requirements given in 10 CFR 20.304. The average waste thickness in Trenches 1 through 9 is estimated to range from 2.6 to 4.8 m (8.5 to 15.8 ft), and the average waste thickness in Trench 10 is estimated to be 5.5 m (18.1 ft) (USACE 2002). The volume of potentially contaminated waste and soil in the ten trenches has been estimated to be between 18,000 and 27,500 m^3 (23,500 and 36,700 yd^3) (USACE 2003). Much of this material is likely uncontaminated soil.

Trenches 1 through 9 were generally developed and used sequentially (with Trench 1 first and Trench 9 last), and these nine trenches contain most of the radioactive contaminants at the site. The bottoms of these trenches reportedly sit on the weathered shale bedrock. The predominant radioactive contaminant in these trenches is uranium associated with wastes resulting from the material processing and scrap recovery activities conducted at the Apollo facility. A small amount of thorium oxide was also disposed of in these trenches (most likely in Trench 6), although thorium contaminated soil was reported in the vicinity of Trenches 4 and 5. Wastes from other facilities were also periodically approved for burial, and records indicate that solutions containing beryllium oxide-uranium oxide were disposed of at the site. The use of Trench 10 was markedly different from the other nine trenches. Most of the waste disposed of in

Trench 10 is uncontaminated or only mildly contaminated equipment and construction debris, which would not have required immediate cover for contamination control (ARCO/B&W 1995).

The former Parks nuclear fuel fabrication facility was located adjacent to and northwest of the SLDA site, in the vicinity of Trench 10. The three buildings that comprised the Parks facility were decommissioned in 2000 and the site is currently vacant land owned by BWXT. In addition to nuclear fuel fabrication, the Parks facility was used for the production of plutonium-beryllium neutron sources and devices containing Am-241. Parks facility equipment was reportedly stored in the area of Trench 10, where both surface and subsurface soil in this area contains elevated levels of plutonium (Pu-239 and Pu-241) and Am-241. The distribution of these nuclides is limited to the southwest end of the trench (at an apparent access drive into the trench), adjacent areas near the bedrock highwall, and the gated site entrance near Trench 10. This distribution indicates that the Parks facility staged contaminated equipment in the Trench 10 area, which leached removable contamination to the surface soil and later subsurface. Although no plutonium or americium contamination has been found in Trench 10 samples, their disposal in Trench 10 is suspect. The SLDA site was not authorized to dispose of materials from the Parks facility (USACE 2003).

While waste disposal records are available, there is little information in these records on the specific radionuclides present in the wastes and even less documentation on potential chemical constituents. The disposal records generally only identified the specific radionuclides of interest in a given disposal campaign, i.e., U-235, total uranium, and thorium, consistent with the requirements of 10 CFR 20.304. The site owners concluded that to adequately characterize the waste contents by direct sampling would require an inordinate number of samples of a large number of different materials including soil, water, sludges, metal, plastic, and miscellaneous debris. In addition, due to the extreme heterogeneity of the disposed materials, the representativeness of the samples would still be questionable (ARCO/B&W 1995). Additional sampling was performed in the waste trenches as part of the recent site characterization program, and the results of this activity confirmed the highly heterogeneous nature of the materials in the trenches. Only 14 of the 46 borings in the estimated footprints of the trenches had field-screening evidence of waste materials (visual or elevated gamma radiation readings).

The site owners have performed several remediation projects at the SLDA in the past as described in Section 2.1. The contents of Trenches 2, 4, and 5 were exhumed in 1965 to investigate discrepancies in the amount of uranium disposed of at the site. The exhumed materials were placed on the ground south of the upper trenches and sorted, with some of the exhumed materials placed back in the trenches in 1966 and the remainder shipped off-site for disposal. In addition, surface soil containing uranium at concentrations above NRC guidelines was removed in 1986 and 1989. These projects removed most of the contaminated surface soil at the site, and radiological surveys were conducted following the remedial actions to confirm the effectiveness of these actions (USACE 2003). The recently completed gamma walkover survey and site characterization program have confirmed that contaminated surface soil is present in a few isolated areas, and the concentrations of radionuclides at these locations are not high.

Preliminary ROPCs were developed for the SLDA based on historical uses (specifically the radiological characteristics of the wastes buried in the trenches) and previous characterization activities. These preliminary ROPCs are presented in Section 1.1.3 of the SAP, and are divided into "primary" ROPCs and "secondary" ROPCs. The primary ROPCs are those radionuclides expected to be present at the site at levels potentially posing a risk concern based on current information. The primary ROPCs for the SLDA are: U-234, U-235, U-238, Th-232, Ra-228, Am-241, Pu-239, and Pu-241. Additional radionuclides may also be present based on anecdotal information and activities conducted at the adjacent Parks facility. These secondary ROPCs were determined to be: Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, and Pu-242.

The primary and secondary ROPCs were identified to help focus site characterization activities by making use of existing information, consistent with EPA CERCLA guidance. All of the soil and trench samples were analyzed for the primary ROPCs, and ten percent of these samples were analyzed for the secondary ROPCs as specified in the SAP. The SAP was discussed with stakeholders (including representatives from the NRC and PADEP) prior to implementation. Based on the results of this remedial investigation, the ROPCs can be limited to the primary ROPCs identified above.

Based on these considerations, the source media is identified to be the previously disposed of wastes, unknown volumes of intra-trench soil contaminated by leachate, and a few small isolated areas of contaminated soil. Characterization information suggests that the radioactive contaminants are still largely contained within the trenches and have not migrated from the vicinity of the ten trenches. Contaminant information for these wastes is limited, so there is a high degree of uncertainty associated with the source media at the site. However, the ROPCs have been determined to be U-234, U-235, U-238, Th-232, Ra-228, Am-241, Pu-239, and Pu-241, with uranium isotopes being most prevalent.

5.2 Constituent Release and Transport Mechanisms

Constituent release and transport mechanisms are those environmental processes that facilitate movement of the ROPCs from their current locations (generally within the ten trenches) to locations where they can potentially impact human and ecological receptors. The primary release mechanisms for the ROPCs at the SLDA site are wind erosion; surface water runoff, erosion, and deposition; and infiltration of water into the trenches with leaching of contaminants from the waste materials to groundwater. These release mechanisms can act on the source media increasing contaminant mobility and enabling the ROPCs to migrate from their current locations to adjacent media, e.g., from the buried waste materials to subsurface soil. The primary transport mechanisms affecting the migration of ROPCs within and away from the SLDA site include wind transport, surface water runoff, water infiltration, and groundwater flow.

The following discussion provides a general description of the release and transport mechanisms associated with the SLDA site. The primary source media at the site are the wastes buried in the ten trenches, although localized areas of contaminated soil are also present.

5.2.1 Wind Erosion

Prevailing winds in the area are from the west-southwest and average from about 3 m/s (7 mph) in August to 5 m/s (11 mph) in March. These wind speeds are about average for the continental United States (NRC 1997). The highest recorded wind gust at the site is 22 m/s (50 mph) (ARCO/B&W 1995). A weather station was recently installed at the site to gather wind speed, wind direction, and temperature data. The data from this station are consistent with the findings of previous investigations, although the prevailing wind direction was determined to be from the west-northwest (as opposed to west-southwest) for the time that the station has been in operation. On average, about two tornadoes occur each year in western Pennsylvania, or about one tornado every 10 to 15 years in a typical county (NRC 1997). The probability of a severe, damaging tornado at the site in the next several years is considered to be very low, given the small size of the site and the relatively low incidence of tornadoes in western Pennsylvania.

Armstrong County has a humid, continental-type climate, with monthly average temperatures ranging from about -4°C (25°F) in January to 21°C (70°F) in July. Daily low temperatures fall to the freezing point or lower on most nights from November through March. The average annual precipitation is 91 cm (36 in.) and is distributed relatively even throughout the year (ARCO/B&W 1995). Thunderstorms occur on about one day in five during the summer months, with hail occurring about twice a year (NRC 1997). In winter, about one-fourth of the precipitation occurs as snow and measurable snow covers the ground an average of 33 days per year. Information compiled by site owners indicate that about 70 percent of the annual precipitation is returned to the atmosphere by evapotranspiration (combined evaporation and transpiration by plants), with the remainder lost by surface runoff and infiltration into soil (ARCO/B&W 1995). However, on-line data from the USGS and PADEP indicate that evapotranspiration in this area of Pennsylvania is 47 percent and 52 percent, respectively; the RESRAD modeling used to develop PRGs employed a value of 53 percent, so a best (averaged) estimate for evapotranspiration is 51 percent.

Wind erosion is not considered to be a significant mechanism for contaminant releases from the site. The wastes are located about 1.2 m (4 ft) below the ground surface (in the ten trenches) and are covered with uncontaminated soil. Most areas of the site having surface soil contamination were previously remediated by the site owners as described in Section 2.1, and surface vegetation limits the likelihood for airborne emissions of any remaining contaminated surface soil. The results of the recent site investigations indicate that contaminated surface soil is present in only a few isolated areas, and these areas are covered by vegetation (grasses) that is actively maintained (mowed). The concentrations of radioactive contaminants in these isolated areas are generally low. The relatively low wind speeds and high moisture content of the soil in this area limit the amount of fugitive dust generation.

One of the decay products in both the uranium and thorium decay chains is radon, which is a gas. Rn-222 (half-life of 3.8 days) is a decay product of Ra-226, and Rn-220 (half-life of 56 seconds) is a decay product of Ra-228. Radon gas is released from soil (and waste) particles at the site from the radioactive decay of radium. A relatively small percentage of this gas (typically no more than 10 to 20 percent) is released from the contaminated materials into the spaces between the grains of soil and waste material, and can diffuse towards the surface. Soil moisture greatly retards radon diffusion, and essentially all of the radon gas produced in the waste materials and contaminated soil will undergo radioactive decay prior to reaching the surface. The relatively low concentrations of radium in soil and waste materials, presence of 1.2 m (4 ft) of uncontaminated soil cover over the waste trenches, relatively high moisture content in the soil, and short half-lives of radon isotopes (in particular for Rn-220) result in very low releases of radon gas from the site.

Radionuclide concentrations have been measured at the site perimeter since last fall and these results have all been very low. The concentrations have been a very small fraction of the NRC reference values given in 10 CFR 20.1302, confirming that wind erosion (including radon releases) is not a significant release and transport mechanism for radionuclides at the site.

5.2.2 Soil Erosion and Surface Water Runoff

The site is situated on a hillside that slopes from southeast to northwest toward the Kiskiminetas River, with a relatively flat bench area in the northwest portion. The Kiskiminetas River is located about 270 m (900 ft) west of the site (Figure 1-1). The north end of the site is about 250 m (830 ft) above MSL and rises toward the southeast to about 290 m (945 ft) above MSL. Trench 10 is located in the flat bench area in the northwest portion of the site, and immediately southeast of this trench is a high wall of bedrock which is covered by a thin soil layer and scrub vegetation. Above the outcrop, the ground rises to the southeast at an average slope of about 20 percent, and then at a gentler slope of about 5 to 8 percent. Trenches 1 through 9 are located in the 5 to 8 percent slope area, approximately 300 m (1,000 ft) southeast of Trench 10 (ARCO/B&W 1995). Figure 1-2 is a contour map of the site exemplifying the different site slopes and waste burial areas.

There are no surface water impoundments at the SLDA site, although in the wooded upland areas in the southern portion of the site, precipitation creates saturated soil to standing water conditions that do not readily drain. Rainwater runoff generally flows to Dry Run along the north side of the site, and surface water in Dry Run flows in a northwesterly direction towards the Kiskiminetas River, which is the dominant surface water feature in this area (Figure 1-1). Dry Run is an intermittent stream, although flow in this feature is fairly consistent during the winter and spring seasons and occurs following rainfall events during other times of the year. Several groundwater seeps are located on-site north of Trenches 1 through 9 along the steep sections of the Dry Run creek banks, where seepage flows into Dry Run. The seeps are not constant and are dry for extended periods (ARCO/B&W 1995).

Surface water runoff and associated suspended sediment following a rain or snowmelt event is not considered to be a significant pathway for contaminant transport from the site. Most of the contamination is below ground (in the ten waste trenches) and the site is covered with vegetation that limits the amount of soil erosion from surface water runoff. The site owners calculated the rate of soil loss to be about 0.021 cm (0.0084 in.) per year, using the Universal Soil Loss Equation and a vegetative cover of good condition meadow (ARCO/B&W 1995). Small areas of contaminated surface soil are present, but these are generally in areas where the terrain is relatively flat (such as near Trench 10). Surface water and sediment in Dry Run were sampled in the recent site characterization program and determined to have detectable levels of site contaminants relative to upgradient samples; however, these levels in surface water are below promulgated standards for drinking water and the levels in sediment are generally quite low. These data indicate that surface water runoff is not an active transport mechanism of trench related contaminants at the SLDA site.

5.2.3 Infiltration and Groundwater Flow

Precipitation at the SLDA site may runoff the site (as discussed above), return to the atmosphere through evaporation or through plant uptake and transpiration, or infiltrate into soil. Water that infiltrates into soil can remain fixed in the unsaturated vadose zone soils or percolate to groundwater (Figure 2-22). Water percolating through contaminated soil or the waste trenches can result in the dissolution of water-soluble compounds that can be transported by groundwater.

Although the main radioactive contaminants at the SLDA site (uranium and thorium) are generally not very soluble or readily mobile, it is possible for transport of ROPCs to groundwater to occur. A discussion of the groundwater characteristics at the SLDA as a potential transport mechanism is given in Section 5.3.2.

As noted previously in Section 2.3.4, the average annual precipitation at the site is about 91 cm (36 in.) with 51 percent of this amount returned to the atmosphere by evapotranspiration. The topography of the site in the vicinity of the upper trench area supports surface water runoff (about 17 percent of precipitation is lost to stormflow generally to Dry Run), so only about 32 percent of the precipitation in this portion of the site infiltrates the surface soil and is available for groundwater recharge (and baseflow). The area by Trench 10 is generally flat and allows precipitation to collect on the surface, where significant infiltration through this trench occurs into the permeable mine spoils. However, this trench contains only a small amount of the radioactive contamination at the site.

The migration of ROPCs in the unsaturated zone is dependent on the recharge to groundwater, and the properties of the contaminants and soil. As noted previously, the bottoms of Trenches 1 through 9 reportedly sit on the weathered shale bedrock, and any radionuclides in trench water (leachate) could contaminate the upper and lower shallow bedrock water-bearing zones. To evaluate this possibility, the site owners instituted a sampling program to collect leachate from each trench for radiological and chemical characterization, as well as to provide water-level data from within the trenches for information on the hydraulic characteristics of the trenches. Sample locations were positioned along the centerline of each trench at intervals of about 15 m (50 ft), with a minimum of two locations per trench (ARCO/B&W 1995). The leachate sampling data indicated that the waste composition was highly variable both between trenches and within individual trenches. Previous leachate samples were analyzed for gross alpha, gross beta, and total uranium activity; the data had a wide range of values, with maximum concentrations being about 7,900, 960, and 29,500 pCi/L, respectively (ARCO/B&W 1995).

Leachate samples were collected from 44 of 58 TWSPs in the recent site characterization program (several TWSPs were dry), with similar results. The samples were not filtered (in accordance with the SAP) and isotopic analyses were performed for the ROPCs. The highest concentration reported was 28,200 pCi/L for U-234 for a sample collected from Trench 1. Most leachate samples had isotopic uranium concentrations in excess of 100 pCi/L, while the concentrations of all other radionuclides were less than 20 pCi/L. The uranium concentrations in leachate collected from Trench 10 were much lower (by close to a factor of 100) than samples collected in the upper trench area. This information confirms that uranium in the upper trench area is the radionuclide of most concern in terms of potential groundwater contamination at the SLDA.

The investigations conducted by the site owners have indicated that although contaminated leachate is present in the waste trenches, there has been limited movement of these radionuclides away from the trenches (ARCO/B&W 1995). The site characterization studies completed to date support this conclusion, as contaminated groundwater has not been identified at the site.

5.3 Characteristics of Environmental Media and Constituents

The physical and chemical characteristics affecting the fate and transport of ROPCs through and among environmental media are discussed in this section. Emphasis is placed on those characteristics and processes most likely to influence the movement of radionuclides at the SLDA, in particular to locations where they can impact potential human and ecological receptors.

5.3.1 Soil Characteristics

Soils in Armstrong County are mainly derived from water-transported and -deposited parent materials (alluvium) found on broad terraces, and residual soils formed in-place by weathering of the underlying bedrock. The soils present on or adjacent to the SLDA belong to the Rainsboro (RaA and RaB) and Allegheny (AlB) series, as shown in Figure 2-10. The soils in the southeast half of the SLDA (including the upper trench area) are generally Rainsboro silt loams, which typically consist of deep, moderately well drained soils formed in loess and underlying loamy sediments. Surface horizons consist of a dark grayish-brown silt loam underlain by several argillaceous horizons, a fragipan, and reddish-brown to yellowish-red parent material. The depth to fragipan usually ranges from 56 to 86 cm (22 to 34 in.), but some areas have a seasonal water table that rises to within 25 to 46 cm (10 to 18 in.) of the surface (ARCO/B&W 1997).

Generally, RaB soils are deep and moderately well drained silt loams with moderately low permeability. Slopes range from 3 to 8 percent on undulating to rolling stream terraces, and the runoff rate is moderate. The upper trenches are located in RaB soils (Figure 2-10), and the thickness of soil in this area ranges from about 3 to 6 m (10 to 20 ft). After they have been disturbed, RaB soils have moderate erosion potential, although the vegetative cover at the SLDA serves to minimize the likelihood soil erosion. The RaA soils are found in the headwaters of Dry Run and in the southeast portion of the SLDA, including the newly add 4.8-ha (12-acre) area. They are similar to RaB soils except that they lie on flatter slopes (0 to 3 percent) and are more erosion resistant. The RaA and RaB soils have been designated as prime farmland and farmland of statewide importance, respectively (NRC 1997).

Soils in the middle section of the SLDA are moderately permeable Allegheny silt loams on 3 to 8 percent slopes (AIB in Figure 2-10). Allegheny soils typically consist of deep, well-drained soils formed in loamy alluvium derived from sandstone, siltstone, and shale. Surface horizons are dark grayish-brown and are underlain by gravelly loams (ARCO/B&W 1995). Exposures of AIB soils are interrupted where they have been disturbed by strip-mining. After these soils have been disturbed, they present a moderate erosion hazard. The AIB soils have been designated as prime farmland (NRC 1997). No disposal activities occurred in this portion of the site, and site characterization activities have not identified any soil contamination in this area.

The northwest end of the SLDA is a strip-mined area that was backfilled with mine spoils (designated Sm in Figure 2-10). Trench 10 was excavated in the coal mine spoils immediately northwest of a high wall of bedrock in a relatively flat area. Vegetation (grass and small shrubs) is currently growing on these mine spoils. While these mine spoils present a high erosion hazard, the gentle topography in this area and vegetative cover limit the erosion potential (NRC 1977).

From a geotechnical perspective, the soils in most areas of the site (all except the coal mine spoils) can be considered cohesive materials of apparently low hydraulic conductivity. The soil can generally be classified as inorganic clayey silt of low to medium plasticity. Clayey sand is also present, but to a lesser degree. These soils are characterized by the test data found on Table 2-4, which are typical engineering properties for deposits in this region (ARCO/B&W 1995).

The upper trenches are intermittently saturated, especially during periods of heavy precipitation such as in winter and early spring when groundwater levels are elevated. Groundwater flow in the subsoil is primarily horizontal towards Dry Run, but some groundwater passes downward into the upper shallow bedrock water-bearing zone. Groundwater flow in this upper shallow bedrock zone is also predominantly horizontal towards Dry Run. Since groundwater elevations in the soil are higher than the elevation of Dry Run, a part of the groundwater in the soil discharges into Dry Run, especially during the wet period of the year.

Even though the waste materials in the trenches may be saturated, the soil properties in the upper trench area are such that there has been very little contaminant migration from trenches. The soil contains a significant amount of clay particles, which produces a high cation exchange capacity. The cation exchange capacity of a soil is positively correlated to its capacity to adsorb positively charged ions (such as the radionuclides in the waste materials) onto the surface of soil particles. Since the capacity of a soil to adsorb ions is greatly influenced by the surface area of the soil particles, ions are attracted more to the exposed mineral surfaces of clay particles, which have a large surface area. Cations are adsorbed onto clay surfaces and/or into their layered structure. Consequently, soils with high clay contents (and a correspondingly high cation exchange capacity) can be expected to slow the movement of dissolved ions much more readily than clayfree soils

In addition, the presence of natural organic carbon in soil also positively affects the adsorption of radionuclides. The organic content of clay soils is commonly higher than that of coarse-grained soils, and thus organic material tends to increase the retardation of radionuclides.

The NRC evaluated the movement of uranium from the wastes in the upper trench area to wells potentially completed in the upper shallow bedrock aquifer as part of the DEIS for decommissioning the site (NRC 1997). These wells were located near but outside the footprints of the trenches. The NRC concluded that the strongest influence on the uranium concentrations in these hypothetical drinking water wells was the ability of the soil and weathered rock beneath the trenches to retard uranium. The dense monitoring well network in the first and second shallow water bearing zone (see Figures 2-17, 2-18, 4-90, and 4-91) indicates that very low to undetected amounts of site-related contaminants are present in these two water bearing zones. Consequently, leachate migration from the trenches or adjacent subsoil zones into the bedrock zones is retarded highly by the weathered bedrock. This retardation is exemplified by the fact that over 30 years have lapsed since disposal operations ceased and leachate has been evident in the waste burials since 1993 with its earlier existence highly likely.

5.3.2 Groundwater Characteristics

The site geology is complex and consists of a series of heterogeneous units including unconsolidated overburden, several zones of shallow (interbedded) bedrock, a coal horizon, and a deep bedrock zone beneath the coal. The most significant geological feature at the site is the underlying room-and-pillar mine used to extract coal from the Upper Freeport coal seam. Prior to the time of waste disposal, coal from this seam was strip-mined where it outcropped in the northwestern part of the site, and deep-mined beneath the higher ground in the eastern part of the site. Trench 10 was developed in the fill material left from the strip mining operations, and the other nine trenches are located on the higher ground above the deep mine (USACE 2003). As much as 30 m (100 ft) of soil and rock strata overly the mine workings in the upper trench area. Below the Upper Freeport Coal seam is a layer of shale and claystone that is 9 to 12 m (30 to 40 ft) thick, followed by Butler Sandstone (ARCO/B&W 1995).

The site hydrogeology is also complex, and there are five distinct hydrostatic units at the site (see Figures 2-22 and 5-2). The uppermost unit is a subsoil water-bearing zone that can be described as clayey silt soils ranging in thickness from 1.5 to 3 m (5 to 10 ft) sandwiched between less permeable clayey surficial soils and weathered bedrock. This subsoil zone has been noted to coarsen with depth. Beneath this subsoil unit is the upper shallow bedrock water-bearing zone which consists primarily of shale, but contains interbedded siltstone and sandstone layers. The underlying lower shallow bedrock water-bearing zone is similar to the upper except that the sandstone units are less definitive. A fairly massive shale layer separates the upper and lower water-bearing zones, and a similar shale layer underlies the lower shallow water-bearing zone.

Below these zones lies the Upper Freeport coal water-bearing zone, which is approximately 1 m (3 ft) thick and is about 60 percent removed beneath the upper trench area and nonexistent where it was strip mined on the northwestern part of the site. The coal seam is underlain by relatively impermeable underclay. The deep bedrock water-bearing zone is located beneath the underclay and consists of sandy shale units with significant sandstone and limestone interbeds (USACE 2003).

The weathered bedrock, two dense shale layers, and underclay are hydraulic confining units. Since the vertical hydraulic conductivities of the confining units, which range from 1.2×10^{-7} to 3.2×10^{-7} cm/s, are less than the infiltration rate to groundwater of 3.8×10^{-7} cm/s, groundwater is perched in the soil, upper shallow bedrock zone, and lower shallow bedrock zone. The relatively high horizontal hydraulic conductivities in the upper and lower shallow bedrock zones (as shown in Table 2-5) result in groundwater flow that is primarily horizontal and is much faster than the predominantly vertical flow through the confining units (NRC 1997).

In the area of Trenches 1 through 9, groundwater in the subsoil unit flows toward Dry Run but does not enter Dry Run as surface flow except under seasonal high water-table events (usually late January through April). During such events, groundwater in the subsoil zone also flows from several groundwater seeps located along the steep sections of the Dry Run creek banks. A portion of the groundwater in the subsoil moves vertically into the upper shallow bedrock zone, where it flows primarily horizontally toward Dry Run, but does not show surface expression in the Dry Run channel. A portion of the groundwater in the upper bedrock zone also moves vertically to the lower shallow bedrock zone. Flow within the lower bedrock zone is similar to that in the upper bedrock zone. Some groundwater eventually reaches the open mine workings. Flow within the mine is characterized as open-channel flow along the floor of the mine, where it eventually discharges to Carnahan Run about 610 m (2,000 ft) southeast of the site (USACE 2003).

In the area of Trench 10, groundwater within the mine fill flows to the southeast and then into the underground mine workings where the strip mine ends and the deep mine area begins. Open mine adits have been reported in the highwall, which would hydraulically connect the spoils to the mine; this condition is likely as groundwater does not show mounding by the highwall. Groundwater also flows horizontally through the base of Trench 10 to the mine workings, and a very small portion seeps vertically into the deep bedrock. The groundwater in the underground mine workings eventually discharges to Carnahan Run southeast of the site (USACE 2003). Any contaminants entering groundwater from Trench 10 would be expected to discharge as surface water in Carnahan Run in a relatively short period of time.

Contaminant transport through groundwater is the most likely mechanism for radionuclides to move from the site and impact potential human and ecological receptors in the long term. The upper shallow bedrock water-bearing zone in the upper trench area is the groundwater system of most concern at the site, and potential contamination of this zone was considered in the development of PRGs. Given the complex hydrogeology of the SLDA site, monitoring of the various groundwater systems was determined to be the most appropriate means to evaluate the potential movement of contaminants by this pathway. The dense monitoring well network in the two shallow water bearing zones do not indicate significant contaminant movement is occurring from the trenches.

Modeling groundwater transport has been performed by the site owners (ARCO/B&W 1995), but this requires the use of a number of simplifying assumptions. The sampling results obtained to date indicate that the groundwater does not appear to be contaminated, other than some localized areas in the upper water-bearing zone downgradient of Trenches 1 and 2. Some low levels of contamination were identified at this location , which may be associated with the radioactive wastes in those two trenches.

5.3.3 Physical Characteristics of Radiological Constituents

The ROPCs at the SLDA consist of isotopes of uranium, thorium, radium, americium, and plutonium. Most of these radionuclides have very long half-lives (especially the uranium isotopes and Th-232), so very little reduction in the concentration of these ROPCs is expected over any reasonable period of time. In fact, radionuclide ingrowth (specifically Ra-228 from Th-230) is more of an issue for fate and transport considerations than decay. The transport pathway of most concern for the SLDA in the long term is through groundwater. Of the radionuclides present at the SLDA, uranium is generally the most soluble, so the following discussion focuses on this radionuclide. Thorium is typically very insoluble, with the solubilities of radium, americium and plutonium being intermediate between uranium and thorium. In addition, uranium is the most prevalent radionuclide present at the site.

Partition coefficients have been used to indicate potential concentrations of various contaminants in water based on levels in soil. The distribution coefficient (K_d) relates the concentration in the soil (solid phase) to that in the soil solution (water in the pore spaces between soil particles). This parameter can indicate the relative mobility of a contaminant and the amount that could eventually be found in groundwater at a given site. The K_d is contaminant- and setting-specific and can vary widely among sites. A high K_d value indicates that the contaminant is strongly associated with the soil/geologic material and little would be available in solution. For these cases, the concentrations in groundwater would be expected to be very low. The K_ds for thorium, radium, americium, and plutonium are typically much higher than for uranium.

Uranium is a relatively mobile radionuclide that can move through soil with percolating water to underlying groundwater. It preferentially adheres to soil particles with a soil concentration commonly about 15 to 50 times higher than that in the interstitial water in common soil types; concentration ratios are usually much higher for soils with a high clay content (the ratio can be 1,000 or possibly more). From a recent interagency effort to evaluate partition coefficients for several radionuclides, the general median log K_d for uranium was identified as 2.5, which corresponds to a K_d of about 320 cm^3/g (EPA 1999a). The site RESRAD model employed a probabilistic analysis for uranium partitioning that also cited a deterministic value of 425 cm^3/g.

Uranium occurs in a variety of compounds including oxides, fluorides, carbides or carbonates, silicates, vanadates, and phosphates, and its chemical form strongly influences its abundance in groundwater. The most common forms expected at the SLDA site based on the disposal records are oxides and fluorides. The solubility/mobility of uranium and potential for migration to groundwater is affected by a number of processes, as summarized below.

- *Presence of clays and oxy-hydroxyl coatings, cation exchange capacity, and total organic carbon (TOC).* Uranium migration decreases in the presence of clays and surface coatings of iron (Fe) and manganese (Mn) oxides and hydroxides; it is preferentially associated with the clay fraction rather than sands (and can thus be less available in soil solutions where clays are present, e.g., by a factor of 10 to 80). Uranium also is less mobile in soils and rock having high TOC. Uranium can be both physically sorbed and chemisorbed onto the clay particles and Fe/Mn coatings, and altered in high TOC environments. In contrast, uranium is more mobile in sands, light shales, and sandstones.

- *Solubility*. Solubility is determined by physicochemical constants for water in equilibrium with its surroundings; site-specific water and soil chemistry will govern those basic conditions.
- *Acidity/alkalinity.* The acidity/alkalinity of a system and buffering potential (which is higher in carbonate systems) affect uranium solubility and mobility. When the soil is acidic or basic (pH of 4 or less, or 8 or higher), uranium has a higher solubility compared to soils with a pH of 6. Uranium tends to form more soluble complexes in carbonate systems. When carbonates or hydroxides are high and the pH increases above 6, uranium can form soluble anionic complexes that migrate readily in groundwater.
- *Oxidation-reduction (redox) potential.* Oxidized forms of uranium (hexavalent) are usually relatively soluble compared with reduced (tetravalent) forms. Thus, in settings with a lot of organic material (and microbial activity under anaerobic soil conditions), oxidized forms can be reduced and precipitate out of soil solution, which limits migration to groundwater.
- *Formation of soluble complexes*. Uranium mobility is increased when it dissolves or forms soluble complexes, e.g., with acidic humic material in surface soil. The fraction of organic carbon present can positively affect local near-surface solubility and retard migration.

As noted previously, the soil contains a significant clay fraction (Table 2-4), which greatly minimizes its potential to migrate with groundwater. In addition, the pH of soil is generally neutral and contains a significant amount of organic material, which also serves to reduce the likelihood for groundwater transport. This is exemplified by the fluctuation of leachate heads in the waste burials, which has not transformed into a plume migration from the trenches. The leachate liquid may flow from the trenches but the adsorptive capacity of the surrounding soil limits coincident radionuclide transport, basically filtering the radionuclide cations from the leachate and keeping them in the immediate soil around the trench.

5.4 Conclusions

The information developed by the site owners (ARCO/B&W 1995), the NRC (NRC 1997), and USACE (2003) indicate that the radioactive contaminants at the previously disposed of wastes are generally confined to the immediate vicinity of these trenches. Sampling of air, surface water, sediment, and groundwater show no elevated levels of radionuclides migrating from the site. However, these conditions are not expected to remain indefinitely, and over time the radionuclides in the trenches would be expected to gradually migrate with the seasonal groundwater condition in the subsurface soil and possibly bedrock. The very complex hydrogeology of the site makes accurate prediction of such transport very difficult to perform.

6.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

A BRA was performed to evaluate risks to human health and the environment from potential exposures to the radioactive contaminants at the SLDA in the absence of remedial actions. An assessment of risks to human health is included in this chapter, and a screening-level ecological risk assessment (SLERA) is given in Chapter 7. These assessments are limited to the radioactive contaminants at the site, since Section 8143 of P.L. 107-117 directed the Secretary of the Army to clean up *radioactive waste* at the SLDA site. The public law clearly identified the requirement to address radioactive waste and does not discuss chemical waste. A determination has been made that the Army's authority at this site is limited to radioactive contaminants, and chemical contaminants will be addressed only if they are commingled with and cannot be separated from the radioactive contaminants. However, the chemical toxic effects of these radioactive contaminants are considered in the human health and ecological risk assessments, specifically the chemical toxicity of uranium.

This BRA was performed consistent with EPA guidance for risk assessments conducted under CERCLA, and is based on the characterization information summarized in the first five chapters of this RI report. This characterization information included historical data, which formed the basis of the SAP (USACE 2003a) and subsequent on-site investigations, and the data collected from these recent investigations. The newly collected data were obtained in accordance with approved quality assurance procedures as documented in the Quality Assurance Project Plan (QAPP) (USACE 2003b), and have been entered into a relational database. Since the historical data have a number of gaps and are of unknown quality, the assessment of risks in this BRA is largely based on the newly collected data and does not make extensive use of historical information other than to confirm the reasonableness of these data.

The BRA represents the link between the characterization information summarized in the first five chapters of this RI report and the evaluation of remedial action alternatives in the FS. This assessment considers the risks to human health and the environment associated with the radioactive contaminants at the site in the absence of any additional remedial actions, which will help focus and guide the assessment of alternatives in the FS. The risks to human health and the environment for the various remedial action alternatives will be addressed in the FS as specified in the NCP (EPA 1990).

6.1 Radiological Risk Assessment Approach

6.1.1 Overview

Remedial actions at the SLDA are being conducted under FUSRAP in accordance with CERCLA and the NCP. The EPA has developed guidance for conducting CERCLA risks assessments, and this guidance was followed in this BRA. The basic approach for this risk assessment is described in the *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part A),* commonly referred to as RAGS (EPA 1989). The first nine chapters of RAGS provide general guidance on the procedures for performing risk assessments. While the focus of this guidance is generally with sites containing chemical contaminants, much of the information is applicable to radioactively contaminated sites. Chapter 10 of RAGS (*Radiation Risk Assessment Guidance*) contains additional guidance specifically applicable for risk assessments at sites containing radioactive contaminants.

As described in RAGS, a BRA typically consists of four basic steps that can be applied to assess risks for both human and ecological receptors. This assessment for the SLDA has been developed in accordance with those steps. The first step – data compilation and analysis – consists of organizing and evaluating data that defines the nature and extent of contamination. Historical information is considered as part of this step, as is information on the concentration, mobility, persistence, and general toxicity of the contaminants present. The objective is to identify those contaminants that will be assessed in detail in the BRA due to potential risk implications for human or ecological receptors. This information is provided in Section 6.2. The major result of this step is the identification of the ROPCs that are used in this BRA.

The second step – exposure assessment – involves considering the sources of key contaminants, how they can be released from their existing locations (the ten trenches and contaminated soil areas at the site) to other media or locations, and their environmental fate over time. Hypothetical receptors who might be exposed to these contaminants in the future (such as maintenance or construction workers, or a trespasser) are then defined, and pathway-specific intakes are calculated for each receptor using exposure point concentrations (representative levels in soil, air, and water) that have been determined from measured or modeled values. The exposure assessment is given in Section 6.3 and presents the estimated intakes of the ROPCs by the hypothetical receptors.

The third step – toxicity assessment – involves identifying the types of adverse effects associated with the contaminants of potential concern for the exposures evaluated, by assessing available toxicological data. Standard toxicity values that have been developed by EPA and other scientific organizations (including cancer risk coefficients and dose conversion factors for radionuclides, and slope factors and reference doses for chemicals) are compiled, and their underlying basis is described to provide context for the subsequent risk calculations. The toxicity assessment is given in Section 6.4 and focuses on the health effects associated with radiation exposure. The chemical toxicity of the ROPCs at the SLDA is also addressed, specifically for uranium which is chemically toxic to the kidney.

The fourth step – risk characterization – combines the results of the exposure and toxicity assessments to estimate potential human health risks associated with baseline conditions. The cancer risks from radiological exposures are characterized in terms of the increased likelihood of getting cancer if those exposures occurred. The potential for noncancer health effects from exposure to uranium is assessed by comparing the estimated average daily exposure (intake) with a reference level established by EPA (which represents the amount an individual can take in every day without likely adverse health effects). The BRA also includes estimates of the radiation doses associated with these exposures. The risk characterization is given in Section 6.5, and provides estimates of the carcinogenic risks and radiation doses from exposures to radionuclides at the SLDA and the noncarcinogenic hazard index for uranium.

There are a number of uncertainties associated with the risk assessment process, and an assessment of these uncertainties is important for a proper interpretation of the results. This is specifically noted in EPA guidance documents including RAGS. An uncertainty evaluation for the risk assessment is given in Section 6.6 and addresses the uncertainties associated with characterization data, exposure assessment, and toxicity information. Based on the results given in Sections 6.5 and 6.6, the ROPCs can be refined, and an identification made of the radionuclides of concern to be carried forward into the FS evaluations. This refinement of the ROPCs and identification of the ROCs is presented in Section 6.7. Finally, the remedial action objectives (RAOs) are presented in Section 6.8, and the results of the human health risk assessment are summarized in Section 6.9. The ROCs and RAOs will be used in the FS to identify and evaluate remedial action alternatives.

6.1.2 Initial Evaluations

The SLDA site has been divided into three exposure units (EUs) to support the risk assessment process. These EUs are discussed in more detail in Section 6.3.4 and were developed based on environmental conditions, historical uses of specific areas, reasonableness of size in terms of representing receptor behavior, geographical similarity, and contamination potential. These three EUs are shown in Figure 6-1 and address the upper trench area (EU 1), the lower trench area (EU 2), and an area near the fence southeast of the upper trench area (EU 3). The EUs include both contaminated surface and subsurface media and represent areas over which receptors are assumed to spend their time while at the site, i.e., the exposures are averaged over these areas. Note that assessments of the three EUs and site-wide exposure do not include evaluation of the trenches themselves; those areas are addressed separately (see end of this section). In addition, a site-wide assessment is performed in which the receptors are assumed to access all areas of the site.

In addition to the factors noted above, the EUs were developed considering the need to identify final status survey (FSS) units for future site closeout activities as identified in the *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (DOD et al. 2000). The goal in considering FSS units while developing the EUs for this BRA is to develop consistency between the RI/FS evaluations and future site closeout activities to the extent possible. Figure 6-1 illustrates the relationship between the EUs and preliminary MARSSIM FSS units. The boundaries of these FSS units will likely change as remedial action activities are performed at the site. However, identifying these units now should help expedite closeout activities in the future.

There are three types of FSS units identified in MARSSIM. Class 1 units are areas that have a potential for radioactive contamination (based on historical uses) or known contamination (based on characterization activities) requiring remediation. On the basis of this definition, the ten disposal trenches and the areas immediately surrounding them are considered to be Class 1 units. An additional Class 1 unit is identified south of the upper trench area based on the recent characterization information. Class 1 units can cover areas up to 2,000 m^2 (0.5 acres), and four Class 1 units were identified for the site as shown in Figure 6-1.

Class 2 units are areas that have a potential for radioactive contamination, but below levels expected to require remediation. Class 2 units at the SLDA generally consist of those areas close to the ten trenches, but outside the immediate vicinity of the trenches. Class 2 units can range from 2,000 to 10,000 m^2 (0.5 to 2.5 acres), and two such units are identified for the site, i.e., one for the upper trench area (including the area near the fence and Dry Run) and one by Trench 10. The Class 2 units consist of the remaining colored areas in Figure 6-1 outside the Class 1 units (which are explicitly identified on the figure). Note that the three EUs encompass the areas covered by the Class 1 and Class 2 FSS units. Although Dry Run is not included in any of these EUs, it is included in the site-wide assessment.

Class 3 units are areas that are not expected to contain any (or very minimal) residual radioactive contamination, and there is no size limit for Class 3 areas. One class 3 unit is identified, which consists of the remaining areas at the site. A fourth type of area (non-impacted area) is identified in MARSSIM to specify those areas of a site that have no reasonable potential for residual contamination. The SLDA site is not expected to contain any non-impacted areas as defined in MARSSIM.

Preliminary ROPCs were developed for the SLDA based on historical uses (specifically the radiological characteristics of the wastes buried in the trenches) and previous characterization activities. These preliminary ROPCs are discussed in Sections 3.3.1 and 5.1, and are divided into primary and secondary ROPCs. The primary ROPCs are those radionuclides expected to be present at the site at concentrations posing a potential risk concern. The primary ROPCs for the SLDA are: Am-241, Pu-239, Pu-241, Ra-228, Th-232, U-234, U-235, and U-238. Additional radionuclides may also be present, and these secondary ROPCs for the SLDA are: Cs-137, Co-60, Pu-238, Pu-240, Pu-242, Ra-226, and Th-230.

All potentially impacted environmental media at the site were sampled in the recent site characterization program, which is described in Chapters 3 and 4. All of the collected samples were analyzed for the eight primary ROPCs and 10 percent of the samples were analyzed for the secondary ROPCs consistent with the approach described in the approved SAP (USACE 2003a). The reported results were consistent with historic information for the site. Six of the primary ROPCs were present at elevated concentrations with the upper trench area containing most of the uranium contamination, and most of the americium and plutonium contamination was in the area by Trench 10. No elevated concentrations were detected for two of the ROPCs (Ra-228 and Th-232), although these radionuclides are present in the buried wastes. There were only a few samples that illustrated elevated levels of secondary ROPCs, and most of these elevated levels were only slightly higher than the reported concentrations for background. (See Section 6.3.4 for a more complete description of the results.) Based on these results, essentially all of the risk at the SLDA site is associated with the primary ROPCs, and these can be used to estimate baseline risks to human health and the environment. That is, it is not necessary to consider the impact of the secondary ROPCs in this BRA.

PRGs were previously developed for the primary ROPCs based on an annual dose of 25 mrem/yr above background to a Subsistence Farmer residing at the site using the RESRAD computer code (ANL 2001). The annual radiation dose of 25 mrem/yr for future unrestricted uses of the site was specified as the standard that must be met in the authorizing legislation for the SLDA site, i.e., this is the standard given in 10CFR 20.1402. A Subsistence Farmer scenario was used for developing these PRGs as this scenario involves very intensive uses of the site, and the PRGs developed for this scenario will be conservative. That is, other less intensive future uses would result in lower doses than for the Subsistence Farmer. This land use is consistent with current and likely future land uses in this area (see additional discussion in Section 6.3.1.6).

The PRGs were calculated from the mean dose-to-source ratios of the peak doses over a 1,000-year time period from the individual ROPCs at the site using the probabilistic version of RESRAD, consistent with NRC decommissioning guidance (NRC 1999, 2000a, 2002). The approach used to calculate these PRGs and the input parameters for the RESRAD computer code are described in Appendix A of the SAP (USACE 2003a) and were developed with the input and concurrence of PADEP. These PRGs are presented in Table 6-1.

A screening-level evaluation was performed for the trench contents by comparing the concentrations of the primary ROPCs from samples collected within the ten trenches to these PRGs. Since there are multiple ROPCs, this is done as a sum of ratios (SORs). That is, the concentration of each radionuclide is divided by its corresponding PRG, and the individual ratios summed. A value in excess of unity (1) indicates that the dose standard of 25 mrem/yr for future unrestricted use of the site is exceeded. Since this dose standard reflects the dose attributable to radioactive contaminants at the site in excess of background concentrations, the background concentrations of the primary ROPCs (provided in Table 6-2) were subtracted from the sample results prior to performing this screening-level calculation. This evaluation is performed solely to give an indication of the risks associated with the materials in the ten trenches.

The wastes were placed in the ten trenches in a highly heterogeneous manner and much of the material in the trenches is soil. Only 14 out of a total of 44 trench borings had field-screening evidence of waste (visual or elevated gamma radiation readings). The other 30 borings appeared to be largely uncontaminated soil. One hundred samples were collected from these 30 borings; 33 of these samples were analyzed for radiological constituents and four were analyzed for chemical parameters. Forty-six samples were collected from the 14 borings that had field-screening evidence of waste; 13 of these samples were analyzed for radiological constituents and seven were analyzed for chemical parameters. Of the 13 samples that were analyzed for radiological constituents, 10 had SORs greater than 1. Three of these 10 samples had an SOR exceeding 10, with the highest SOR just over 30. These results indicate that, when wastes are encountered, the concentrations of ROPCs in these materials are high enough to present a potential future risk to human health.

As noted previously, the quantitative evaluations in this BRA are based on the newly collected data since the historical data have a number of gaps and are of unknown quality. In addition, the historical data do not include all of the primary ROPCs, so that it is not possible to calculate a meaningful SOR value for the various sampling locations. However, the previous data do confirm that the waste materials in the trench contents have relatively high concentrations of radionuclides.

For example, previous characterization activities included 14 borings into the trench contents, and from these borings a total of 26 samples were obtained for analysis (see Appendix W). Seventeen of these 26 samples were identified as being waste, with the remaining nine considered to be trench soil. Total uranium concentrations within the samples from the borings advanced through waste materials ranged from 5.82 to 1,446 pCi/g. Eight of these samples were analyzed for isotopic uranium, and the U-238 concentration ranged from 1.54 to 29.60 pCi/g, the U-235 concentration ranged from 1.59 to 47.53 pCi/g, and the U-234 concentration ranged from 56.10 to 1,368.34 pCi/g. (The number of significant figures given here should not be used to infer the accuracy of these results. These data simply reflect the values reported by the site owners.) The highest uranium concentrations were detected in samples collected from Trenches 1 and 2. In addition to these solid materials, samples of leachate were collected from the trenches for analysis. The concentration of uranium in these leachate samples ranged from the lower limit of detection up to 29,500 pCi/L (in Trench 3). As a point of reference, an individual consuming 200 mL (about 1 cup) of water having this concentration of uranium would incur a dose of about 2 mrem (corresponding to a cancer risk of about 7×10^{-7}).

Based on this simple screening-level assessment and consideration of historical information on the trench contents, it is concluded that the materials within the ten trenches present a potential radiological risk to human health and should be addressed further in the FS. No further effort need be expended on evaluating the risks associated with these materials under baseline (current) conditions in this BRA. Rather the focus of this risk assessment is on the remaining areas of the site, specifically those areas that are outside the footprints of the ten trenches but within the impacted area of the site. These areas are generally those that would be considered Class 2 FSS units as shown in Figure 6-1, although they do include some areas within the Class 1 units, i.e., those areas near to but outside the footprints of the trenches. Surficial soil above the ten trenches is considered in evaluating exposure point concentrations (see Section 6.3.4), but subsurface soil within the ten trenches as well as the previously disposed of radioactive wastes are not addressed further in this BRA. Alternatives for managing these materials will be identified and evaluated in the FS.

6.2 Identification Of Radionuclides Of Potential Concern (ROPCs)

Field characterization activities were conducted in 2003 and 2004 in accordance with the approved SAP (USACE 2003a) and QAPP (USACE 2003b). These activities were discussed with regulatory and oversight agencies including NRC and PADEP as well as interested members of the general public prior to implementation. Specific DQOs were developed for these investigations as provided in Section 3.0 of the QAPP, and the QAPP identified the data to be collected and the intended uses of these data. One of the major objectives of this fieldwork was to confirm the radionuclides present at the site, i.e., the ROPCs, and the nature and extent of contamination to allow for an assessment of risks to human health and the environment. Although a substantial amount of historical information was available to identify preliminary ROPCs (addressed as primary and secondary values as noted above), it was necessary to perform additional field investigations in accordance with approved quality assurance protocols to meet the requirements specified in CERCLA guidance and the NCP. The results of these investigations are summarized here and include an identification of the ROPCs for use in this BRA.

6.2.1 Data Collection and Evaluation

Data collection and evaluation involves the development and analysis of site data relevant to the assessment of risks to human health and the environment from the radionuclides present at the SLDA. A field-sampling program was conducted in 2003 and 2004 to collect the data necessary for this RI/FS, and these activities are summarized in Chapter 3 of this RI report. Potentially impacted media at the site were sampled and analyzed in accordance with approved procedures.

The first activity conducted at the site was a gamma walkover survey in which the gamma radiation levels at the SLDA were measured using two radiation detection instruments. The entire site was surveyed, and the results of this gamma walkover were used to identify specific areas requiring further investigation and to support the development of health and safety plans for the site. The results of this gamma walkover survey indicated that elevated levels of radioactivity were present in three relatively small areas at the site. However, it was determined that none of the gamma levels identified, or the areal extent of the respective areas, constituted immediate threats to human health and safety. To confirm this conclusion, the RI soil-sampling program incorporated these three areas to quantify the presence of radionuclides. The gamma walkover survey is described in more detail in Section 3.2.2.

Site characterization activities were conducted from late August 2003 through January 2004 and included sampling of all environmental media at the site, including soil, sediment, surface water, and groundwater. A second round of sediment, surface water, and groundwater sampling was performed in June 2004. A field office trailer, decontamination pad, and requisite support facilities were established at the site to support this characterization effort. In addition to sampling environmental media, 44 borings were advanced into the trenches to obtain waste samples for analysis (as discussed previously). These onsite sampling activities are described in Sections 3.2.3 through 3.2.8, and provided the data for use in this BRA. Air monitoring was conducted at the site perimeter, in the work place, and in the breathing zone of on-site workers to ensure that these activities were conducted safely and in accordance with the Site Safety and Health Plan (USACE 2003). The air-monitoring program is described in Section 3.2.9.

The data were reviewed as they were being collected to ensure that sufficient information would be available to conduct this BRA. Minor modifications were made to the site characterization program as it proceeded, as described in Section 3.0. Following collection, the data were evaluated for consistency and completeness, and entered into a relational database. This database serves as the primary source of information for this BRA.

6.2.2 <u>Initial Data Reduction</u>

The initial data reduction includes those activities performed to screen the information collected during site characterization activities to determine if certain data should eliminated from further use in this BRA. For example, soil and trench waste samples were analyzed using alpha and gamma spectrometry. It is possible that a mistake could be made in which a detected alpha particle or gamma ray is attributed to a radionuclide not present at the site, based on the reference information used by the analytical laboratory. This information would not be used in the BRA, provided a plausible explanation can be provided to confirm that these data are indeed erroneous.

This was not an issue for these data, as the analytical laboratory only reported information for the primary and secondary ROPCs. Also, two concentrations were reported for a few radionuclides (U-235 in soil and solid waste, and Am-241, Ra-226, and Ra-228 in surface water), reflecting values obtained using both alpha and gamma spectrometry. When this was done, the concentration reported for alpha spectrometry was used in this BRA, as this is the more sensitive technique, i.e., it has a lower detection level.

The data used in this BRA consist of sample results verified and validated using the procedures identified in the QAPP. These data have been entered into a relational database. The database includes historical information on the concentrations of radionuclides present in environmental media (including the trench contents), as well as information on gross alpha and beta activities. The measured alpha and beta activities were not used directly in this risk assessment, but were used to confirm the appropriateness of the reported radionuclide-specific values. The reported radionuclide concentrations are consistent with the measured alpha and beta activities where such comparisons could be made.

Many of the preliminary ROPCs are members of relatively long decay series, including the three naturally occurring decay series headed by U-238, U-235, and Th-232. These decay series are not presented here, but are given in a number of references including Figures N.1 through N.3 in DOE 2002. The ROPCs at the SLDA are limited to radionuclides with half-lives greater than five years, given that disposal activities occurred more than 30 years ago and any short-lived radionuclides (other than those associated with the longer-lived ROPCs) will have since decayed to insignificant levels. The short-lived decay products associated with the longer-lived ROPCs are included in the cancer risk coefficients and dose conversion factors (DCFs) used in this assessment (see Section 6.4). It is assumed that these short-lived decay products are present in equilibrium with the ROPCs, consistent with EPA guidance and the manner in which the risk coefficients are reported by EPA in HEAST (an acronym for Heath Effects Assessment Summary Tables), and the DCFs are reported in the RESRAD computer code (ANL 2001), i.e., by the notation "+D" (for plus daughter).

The data were reviewed to confirm that the reported values were consistent with historical information and that there were no obvious errors, e.g., radionuclides not consistent with previous waste disposal activities, multiple reporting of individual sample results, and double counting of parent and daughter concentrations. The data appeared to be fine from this initial screening with one exception, which is discussed as follows.

Preliminary results for groundwater samples collected at the site indicated the possible presence of Pu-241. This is the only radionuclide reported as being elevated in groundwater at the site in these preliminary results. This information was highly suspect (given that previous results did not indicate such contamination) and there does not appear to be a likely source of Pu-241 for this groundwater contamination. In addition, there were no other alpha-emitting plutonium isotopes present in these samples (Pu-241 decays by emitting a beta particle). This preliminary information was shared with PADEP. A decision was made to review these groundwater analyses and the resulting review concluded that the initial results were likely in error and that Pu-241 is not currently present in site groundwater.

The groundwater at the SLDA site does not appear to be contaminated, other than some localized areas in the upper shallow bedrock water-bearing zone downgradient of Trenches 1 and 2. Some low levels of radionuclides were identified at this location, which may be associated with the radioactive wastes in these two trenches. The groundwater will continue to be monitored and if future samples indicate the continued presence of these localized, low-level, radionuclides, or the spread of radionuclides to other areas of the site, this will be addressed in future assessments.

6.2.3 Background Screening

Most of the radionuclides present at the SLDA are naturally occurring. While isotopes of plutonium and americium are not naturally occurring, they are present in surface soils at low concentrations due to past atmospheric tests of nuclear weapons. It is necessary to distinguish the contribution associated with previous activities at the SLDA from that attributable to natural radioactivity and previous nuclear weapons tests. This is done by screening the data collected at the SLDA with background concentrations of these same radionuclides. Background soil samples were collected at 18 locations in the nearby Galpin/Leechburg Community Park as described in Section 3.1.

The radionuclide-specific 95 percent UTL with 95 percent coverage was calculated and used to identify the concentration attributable to background sources, consistent with EPA guidance (EPA 1989, 1992). The UTL is the value that the specified portion, i.e., 95 percent, of the data population will fall below with a specified level of confidence. This value is determined separately for each radionuclide addressed in the background samples. While more recent EPA guidance recommends statistical comparisons of entire data distributions rather than comparisons to UTLs (EPA 2002), this approach was not used since:

- Biased sampling was used at the site, whereas random sampling is recommended when comparing data distributions, and
- Different numbers of samples were collected in the three EUs, whereas equal numbers of site and background samples are preferred when comparing data distributions.

The background data were first reviewed to determine if the reported concentrations most closely followed a normal or lognormal distribution. Most of the background concentrations for the primary and secondary ROPCs in surface and subsurface soil were determined to be normally distributed; lognormal distributions were assumed for those data sets that were determined to not follow a normal distribution. The following equation was used to calculate the 95 percent UTL concentration for the radionuclides having normal distributions.

$$UTL = x + ks \quad (6.1a)$$

Where:

x = arithmetic mean of background measurements for the radionuclide $[1/n)\sum x_i$, with x_i representing the sample analytical results for radionuclide i];

n = number of soil samples analyzed for contaminant i;

k = 2.819 for 18 samples and a one-tailed interval (obtained from a statistics table); and

s = sample standard deviation.

The following equation was used to calculate the 95 percent UTL for the logarithmic transformed data.

$$UTL = e^{x + ks} \qquad (6.1b)$$

Where:

e = exponential conversion for lognormal data; and

the other parameters are as described above.

In calculating the UTL, results that are less than the detection limit were set to one-half the quantitation limit. In some situations (such as when the sample size is small), the UTL may exceed the maximum measured value. In these situations, the maximum value is typically used for screening instead of the UTL. For this background data set, the UTL exceeded the maximum value for all radionuclides; hence, the maximum values were used as the background concentrations for all ROPCs in surface and subsurface soil in this screen.

The site data were compared with the maximum values in the background data set on an EU-specific basis (i.e., data from each EU were compared separately from one another) and on a site-wide basis. The exposure point concentrations (EPCs) were calculated for each of the primary ROPCs in each EU and on a site-wide bases as described in Section 6.3.4, and these values were compared with the maximum measured background values for each primary ROPC. If the calculated EPC was below the maximum background value, that particular radionuclide was considered to be indistinguishable from background in that EU. In other words, radionuclides that are not detected at concentrations greater than the maximum background values are considered to be at background levels and not related to previous activities conducted at the SLDA. Conversely, if the EPC is greater than the maximum background value, that radionuclide is considered to be present above background in that EU, and is considered in the risk calculations.

The values for the radionuclides in the background screening calculation are given in Table 6-2. The secondary ROPCs are not carried forward in this BRA based on the weight-of-evidence screening, as discussed in the following section.

6.2.4 Weight-Of-Evidence Screening

The weight-of-evidence screen considers additional evidence to determine if a specific contaminant is a site-related constituent, is naturally occurring or present as a result of previous nuclear weapons tests, or was reported in error. The weight-of-evidence screen consists of evaluating the frequency of detection and further reviewing the measured radionuclide concentrations against the background data. Radionuclides detected at low concentrations in less than 5 percent of the samples from a given EU are typically dropped from further consideration. Contaminants that are detected infrequently, i.e., less than 5 percent of the time, may be artifacts in the data due to sampling, analytical, or other problems and may not be related to previous activities at the site. These radionuclides would not be included in the risk assessment. However, they would be retained if there is evidence to suggest that the data may represent a hot spot.

Because the background concentration represents the maximum detected value in a limited number of samples, it is possible to observe occasional hits above the screening criterion that are actually within the true range of background. To conduct this screen, contaminants with a low frequency of detection above the background criteria are reviewed to determine if the detects are within the complete background data range or only slightly above the UTL. If a few detections are greater that the screening value or the radionuclide was detected at levels only slightly above the background value, the radionuclide may not be a site-related constituent. In addition, if all detections fall within the background range, the radionuclide is not considered to be a site-related constituent.

All of the secondary ROPCs were deleted from further consideration in this BRA based on this screen. These radionuclides were detected very infrequently above the screening criteria other than for naturally occurring Ra-226 and Th-230 (generally in subsurface soil). As indicated in the site-wide surface soil results, there were two detections of Cs-137 above the screening value (out of 107 observations), one detection of Co-60 (out of 106 observations), and no detections for Pu-238 and Pu-242. In site-wide subsurface soil, there were five detections of Cs-137 (out of 105 observations), one detection of Pu-242 (out of 17 observations), and no detections of Co-60 and Pu-238. In addition, the five subsurface Cs-137 detections were all less than the surface soil screening value. All of the values that exceeded the screening criteria for these four radionuclides did so by less than 0.4 pCi/g.

While there were a number of detections above the screening criteria for Ra-226 and Th-230, only one value exceeded the background screening value by more than 0.7 pCi/g. This value was for Th-230 in subsurface soil, and it exceeded the background criterion by 1.24 pCi/g, or about a factor of two. The background concentrations of Ra-226 and Th-230 can vary by more than a factor of two for soil collected from the same general area. The background concentrations for these radionuclides were based on a relatively small number of samples (18), so it is not surprising that there were a number of exceedances of the background criterion. Since the amount of the exceedance was small, these samples likely represent the high-end of natural variation in the background concentrations of these two radionuclides.

6.3 Exposure Assessment

An exposure assessment was performed to estimate how hypothetical individuals could be exposed to the ROPCs at the SLDA and at what levels, if no further actions are taken at the site. The components of this exposure assessment include the ROPCs, the environmental setting, potential human exposure pathways, estimated EPCs, and estimated contaminant intakes. The exposure assessment also considers the mobility and bioavailability of the ROPCs specific to environmental conditions at the site, as well as projected land uses in order to assess exposures to hypothetical representative receptors under current (baseline) conditions.

6.3.1 Characterization of Exposure Setting

The SLDA site is located about 37 km (23 mi) east-northeast of Pittsburgh in Armstrong County, Pennsylvania. The site covers an area of about 18 ha (44 acres) and includes ten waste disposal trenches. The site was originally 13 ha (32 acres) and was surrounded by a chain link fence. An additional 5 ha (12 acres) were added to the site in 2002, and a chain link fence was recently constructed around this new area. The ten trenches cover an area of about 0.49 ha (1.2 acres), or less than 3 percent of the site. The Kiskiminetas River and Pennsylvania State Route

66 are located about 270 m (900 ft) west of the site. The north end of the site is about 250 m (830 ft) above MSL and rises toward the southeast to about 290 m (945 ft) above MSL.

6.3.1.1 Climate and Meteorology

Armstrong County has a humid, continental-type climate, with monthly average temperatures ranging from about -4°C (25°F) in January to 21°C (70°F) in July. Daily low temperatures fall to the freezing point or lower on most nights from November through March. The average annual precipitation is 91 cm (36 in.) and is distributed relatively even throughout the year. Thunderstorms occur on about one day in five during the summer months. In winter, about one-fourth of the precipitation occurs as snow and measurable snow covers the ground an average of 33 days per year. About 50 percent of the annual precipitation is returned to the atmosphere by evapotranspiration (combined evaporation and transpiration by plants), with the remainder lost by surface runoff and infiltration into soil. Prevailing winds in the area are from the west-southwest and average from about 3 m/s (7 mph) in August to 5 m/s (11 mph) in March. The highest recorded wind gust at the site is 22 m/s (50 mph) (ARCO/B&W 1995).

6.3.1.2 Topography and Surface Hydrology

The site is situated on a hillside that slopes from southeast to northwest toward the Kiskiminetas River, with a relatively flat bench area in the northwest portion. Trench 10 is located in this flat bench area, and immediately southeast of this trench is a high wall of bedrock which is currently covered by a thin soil layer and scrub vegetation. Above the outcrop, the ground rises to the southeast at an average slope of about 20 percent, and then at a gentler slope of about 5 to 8 percent. Trenches 1 to 9 are located in the 5 to 8 percent slope area, approximately 300 m (1,000 ft) southeast of Trench 10 (ARCO/B&W 1995). Most of the site is an open field that is mowed several times a year, with woody vegetation along the northeastern boundary and in the southern and southeastern corners.

There are no surface water impoundments at the SLDA site. Rainwater runoff flows to Dry Run along the north side of the site, and surface water in Dry Run flows in a northwesterly direction towards the Kiskiminetas River. Flow in Dry Run is fairly consistent during the winter and spring seasons and occurs following rainfall events during other times of the year. Several groundwater seeps are located onsite north of Trenches 1 to 9 along the steep sections of the Dry Run creek banks, and water from these seeps flows into Dry Run. A portion of Dry Run flow infiltrates through coal mine spoils at the lower elevations and into the underlying coal mine, while the balance of the flow continues off-site to the Kiskiminetas River. The Kiskiminetas River is the dominant surface water feature in this area, and it flows in a northeasterly direction into the Allegheny River about 13 km (8 mi) from the site (ARCO/B&W 1995).

6.3.1.3 Soil and Geology

The northwest end of the SLDA is a strip-mined area that was backfilled with mine spoils (Trench 10 was excavated in the mine spoils). Vegetation (grass and small shrubs) is currently growing on these mine spoils. Soils in the middle section of the SLDA are moderately permeable Allegheny silt loam, which typically consist of deep, well-drained soils formed in loamy alluvium derived from sandstone, siltstone, and shale. Surface horizons are dark grayish-brown and are underlain by gravelly loams. Soils in the southeast half of the SLDA are Rainsboro silt loams, which typically consist of deep, moderately well-drained soils formed in loess and underlying loamy sediments. Surface horizons consist of a dark grayish-brown silt loam underlain by several argillaceous horizons, a fragipan, and reddish-brown to yellowish-red parent material. The total thickness of soil in the upper trench area of the site ranges from about 3 to 6 m (10 to 20 ft). From a geotechnical perspective, the soils in most areas of the site can be considered to be cohesive materials of apparent low hydraulic conductivity (ARCO/B&W 1995).

The site geology is complex and consists of a series of heterogeneous units including unconsolidated overburden, several zones of shallow (interbedded) bedrock, a coal horizon, and a deep bedrock zone beneath the coal. The most significant geological feature at the site is the underlying room-and-pillar mine used to extract coal from the Upper Freeport coal seam. Prior to the time of waste disposal, coal from this seam was strip-mined where it outcropped in the northwestern part of the site, and deep-mined beneath the higher ground in the eastern part of the site. Trench 10 was developed in the fill material left from the strip mining operations, and the other nine trenches are located on the higher ground above the deep mine. As much as 30 m (100 ft) of soil and rock strata overly the mine workings in the upper trench area. The bottoms of

Trenches 1 to 9 reportedly sit on the weathered shale bedrock. Below the Upper Freeport Coal seam is a layer of shale and claystone that is 9 to 12 m (30 to 40 ft) thick, followed by Butler Sandstone (ARCO/B&W 1995).

6.3.1.4 Groundwater

The site hydrogeology is also complex, and there are five distinct hydrostatic units at the site. The uppermost unit is a subsoil water-bearing zone that can be described as clayey silt soils ranging in thickness from 1.5 to 3 m (5 to 10 ft) sandwiched between less permeable clayey surficial soils and weathered bedrock. Beneath this subsoil unit is the upper shallow bedrock water-bearing zone which consists primarily of shale, but contains interbedded siltstone and sandstone layers. The lower shallow bedrock water-bearing zone is next, and it is similar to the upper one except that the sandstone units are less definitive. A fairly massive shale layer separates the upper and lower water-bearing zones, and a similar shale layer underlies the lower shallow water-bearing zone. The Upper Freeport coal water-bearing zone is next, and this zone is approximately 1 m (3 ft) thick and is about 60 percent removed beneath the upper trench area and nonexistent where it was strip mined on the northwestern part of the site. The coal seam is underlain by a relatively impermeable underclay. The deep bedrock water-bearing zone is located beneath the underclay and consists of sandy shale units with significant sandstone and limestone interbeds (ARCO/B&W 1995).

In the area of Trenches 1 to 9, groundwater in the subsoil unit flows toward Dry Run but does not enter Dry Run as surface flow except under extreme high water table events. During such events, groundwater in the subsoil zone also flows from several groundwater seeps located along the steep sections of the Dry Run creek banks. A portion of the groundwater in the subsoil moves vertically into the upper shallow bedrock zone; water in this bedrock zone flows primarily horizontally toward and beneath Dry Run, but does not enter Dry Run as surface flow. A portion of the groundwater in the upper bedrock zone also moves vertically to the lower shallow bedrock zone. Flow within the lower bedrock zone is similar to that in the upper bedrock zone. Some groundwater eventually reaches the open mine workings. Flow within the mine is characterized as open-channel flow along the floor of the mine, and this groundwater eventually discharges to Carnahan Run about 610 m (2,000 ft) southeast of the site (USACE 2003a).

In the area of Trench 10, groundwater within the mine fill flows to the southeast and then into the underground mine workings where the strip mine ends and the deep mine area begins. Groundwater also flows horizontally through the base of Trench 10 to the mine workings and a very small portion seeps vertically into the deep bedrock. The groundwater in the underground mine workings eventually discharges to Carnahan Run southeast of the site (USACE 2003a).

6.3.1.5 Vegetation and Wildlife

Most of the SLDA site is an open field that is regularly mowed, and vegetation in these areas is largely various species of grasses and annuals. About 4 ha (10 acres) are woodland, mainly in the vicinity of Dry Run near the northeast boundary and also in the southern and southeastern corners of the site, and there are three small wetlands. Wildlife at the site and nearby vicinity include a number of small mammals such as mice, voles, shrews, rabbits, squirrels, chipmunks, raccoons, skunks, and woodchucks. Whitetail deer are also common in this area. There are no permanent surface water bodies, and the intermittent flows in Dry Run do not support stable or well-developed aquatic communities. Typical reptiles in this area include box turtles and garter snakes, and various species of birds would be expected to be present in the wooded areas. There are no known threatened or endangered species at the site, other than for occasional transient species such as the southern bald eagle and American peregrine falcon (NRC 1997). These potential ecological receptors are addressed in Section 7.0.

6.3.1.6 Land Use and Demography

The SLDA site is undeveloped and is bounded by Kiskimere Road to the southwest and vacant undeveloped land to the southeast and northeast. The former Parks Nuclear Fabrication Facility was located adjacent to and northwest of the SLDA site. The three buildings that comprised the Parks Facility were decommissioned in 2000 and the site is currently vacant land owned by BWXT. Land use in the vicinity of the SLDA site is mixed, consisting of small residential communities and individual rural residences, small farms with croplands and pastures, idle farmland, forested areas, and light industrial facilities including a restaurant and car wash. The small community of Kiskimere is adjacent to and southwest of the SLDA site. Drinking water for Kiskimere is obtained from Beaver Run Reservoir and is supplied by the Parks

Township Municipal Authority. The limited site improvements consist of two trailers, access roads, electric service, three underground natural gas pipelines, and a chain link fence surrounding the site (USACE 2003a).

The SLDA site and much of the area immediately surrounding it is vacant land that would be amenable to development for a number of purposes in the future, including for residential uses. Development of this area for heavy industrial purposes such as manufacturing is highly unlikely in the near term, as more appropriate areas (with much better access to utilities) are located nearby, including in Leechburg and Vandergrift. The community of Kiskimere is located adjacent to the site and there is farmland and vacant forestlands bordering two sides of the site, with some small commercial activities nearby. Since the site consists of vacant land that is clearly tillable, use of this area as a small farm in the future was considered in the development of the PRGs. This land use is conservative (but clearly reasonable) as it is consistent with current land uses in this area (there are a number of small farms located nearby), and its size and current status. The PRGs developed for this land use are preliminary values that are being used for screening purposes only.

6.3.2 Characterization of Potentially Exposed Populations

The SLDA site is located in a generally rural setting in Armstrong County, Pennsylvania, and is currently vacant. A security fence surrounds the site, and *No Trespassing* signs are in place to warn individuals that this is private land and that unauthorized access is not permitted. The site and security fence are routinely maintained (the open field area is mowed several times a year), air at the site perimeter is being monitored, and there are a number of monitoring wells to determine if groundwater is becoming contaminated, and if so to what extent. Under these conditions the site presents very little risk to human health and the environment.

The current status of the site (including BWXT ownership and administrative controls, maintenance, and environmental monitoring) cannot be guaranteed in perpetuity, and over time the radionuclides in the trenches would be expected to gradually leach to groundwater. The SLDA is also susceptible to subsidence from collapse of the abandoned mine workings beneath the site. To address the risks at the SLDA, various scenarios are postulated by which individuals could be exposed to the contaminants at the site. Likely human activities under current and future conditions were considered in identifying potential receptors at the various exposure points in this human health risk assessment. These receptors and exposures were developed in the context of the environmental setting as described in Section 6.3.1, consistent with EPA guidance that emphasizes the use of site-specific factors in risk assessments.

A range of hypothetical human receptors were identified that could reasonably be expected to be exposed to the radionuclides at the site. The SLDA site does not currently represent a risk to off-site individuals as the wastes are located about 1.2 m (4 ft) below ground (in the trenches) and are covered with uncontaminated soil, groundwater contamination is limited to on-site areas (generally within the trenches), and surface vegetation limits the likelihood for airborne emissions of potentially contaminated surface soil. To evaluate human health risks for the SLDA site, it is necessary to postulate mechanisms by which individuals could gain access to the site and be exposed to site-related contaminants.

Under current conditions, on-site receptors could include maintenance workers, visitors, and adult and adolescent trespassers. Site maintenance activities are currently taking place (including mowing the open field and repairing the security fence as needed), and these will continue for the next several years. Consideration of a maintenance worker scenario will help identify any risks that should be considered as part of the current maintenance program, e.g., are there certain locations at the site that should be avoided by such workers due to elevated risks.

Unauthorized entry (trespassing) onto the site is known to have occurred in the recent past despite the security fence and warning signs. Evaluation of the trespasser scenario will provide information on the potential risks associated with repeated unauthorized access to the site, which will assist in determining the need to continue or upgrade the existing security measures. While both an adult and adolescent trespasser could be considered, an adolescent trespasser is more likely and would probably entail greater exposures than an adult trespasser, e.g., by riding motorized vehicles such as three-wheelers at the site. Consideration of an adolescent trespasser scenario should bound the risks for this type of exposures.

The SLDA has infrequent visitors who are required to be escorted by site personnel to ensure that they do not visit areas of the site that may be contaminated, including near the ten trenches. It is possible for these visitors to wander into potentially contaminated areas and be exposed to site contaminants. The risks to such visitors will be significantly lower than those to an adolescent trespasser, so the visitor scenario need not be addressed separately. Thus, the human health BRA considers two receptors for current conditions at the site, i.e., a maintenance worker and adolescent trespasser. These two receptors are considered reasonable and should provide useful information to support the decision-making process.

It is conceivable that future land use at the site could change to include industrial or, as an extreme case, use for subsistence farming. There are a number of light industrial facilities nearby and the site is very close to a major highway and river, so it is reasonable to consider future industrial uses of the site. In addition, the community of Kiskimere is adjacent to the site, so future use of the SLDA for residential purposes is also reasonable. Dairy farming has traditionally been the chief agricultural activity in Armstrong County, although no dairy farms are currently located within 1.6 km (1 mi) of the site. Farmland in the site vicinity is largely used for cultivation of corn, wheat, and hay. Also, many residents in the area have small gardens (ARCO/B&W 1995). It is therefore reasonable to project future uses of the site to include industrial, residential, and agricultural uses.

Future on-site receptors considered in this BRA could include maintenance workers, trespassers, construction workers, industrial workers, visitors, residents, and farmers. Maintenance workers and trespassers are considered for current conditions as noted above, and a significant amount of additional information would not likely be developed by also considering these same two receptors for future conditions. Hence these two receptors are not addressed for future conditions.

Construction workers would be expected to incur greater exposures than industrial workers, as construction workers could be expected to actively disturb soil (such as with large equipment including backhoes). Hence construction workers are addressed to represent future workers at the site, and the industrial worker scenario is not addressed further. As noted above, the visitor scenario is similar to the trespasser scenario but with lower levels of exposures. This individual is considered appropriately addressed by the trespasser scenario. Finally, the resident and subsistence farmer scenarios consider the most extensive uses of the site, and of these two scenarios, the subsistence farmer would entail the greater exposures. Hence, this scenario provides a bounding estimate to future residential use of the site, and it is not necessary to evaluate a resident scenario separate from the subsistence farmer scenario.

Based on these considerations, four potential receptors are considered in this human health risk assessment. The two receptors addressed for current conditions are a Maintenance Worker and Adolescent Trespasser, and the two receptors addressed for future conditions are a Construction Worker and Subsistence Farmer. The applicable exposure pathways for these four hypothetical receptors are discussed in the following section.

6.3.3 Identification of Exposure Pathways

A description of the four hypothetical receptors is given as follows, including an identification of likely exposure pathways. These exposure pathways are illustrated in the CSM, which is shown in Figure 6-2. The CSM identifies the exposure pathways that are considered complete and those considered to be incomplete for these scenarios as applied to conditions at the SLDA.

6.3.3.1 Maintenance Worker

The SLDA site is owned by BWXT and licensed by the NRC (license number SNM-2001). As part of this license, BWXT is required to properly maintain the site in order to ensure protection of workers and the general public. To meet this requirement, the site is routinely maintained and typical activities include mowing the open areas, inspecting and repairing the security fence, and performing general maintenance activities as needed. These and similar activities are expected to continue for the next several years. For this BRA, it is assumed that these workers could be could be exposed to contaminated surface soil in the course of their maintenance activities. The exposure pathways considered for the Maintenance Worker are:

- inhalation of fugitive dust from surface soil;

- external gamma exposure from radionuclides in soil; and
- incidental ingestion of surface soil.

Inhalation of airborne gases including radon (Rn-222) is not a concern for this worker as Ra-226 is not a primary ROPC at the site, and any radon gas that would be generated would quickly dissipate to very low levels indistinguishable from background concentrations. Radon is generally a concern only for indoor exposures (usually in a house having a basement), and is considered for the Subsistence Farmer scenario. Although thoron (Rn-220) would be expected to be present with its parent radionuclide (Ra-228), thoron has a very short half-life (56 seconds). Very little (if any) thoron can escape from the wastes and soil particles to the nearby interstitial air and then migrate to the atmosphere under baseline conditions. Most importantly, Ra-228 is not elevated in the soil and sediment considered in this BRA (see Section 6.3.4).

Dermal contact with surface soil is not addressed for the primary ROPCs, as this exposure route is a very minor pathway for the radionuclides present at the SLDA. Dermal absorption is a concern only for a few specific radionuclides such as tritium (H-3), and none of these are present at the SLDA. The Maintenance Worker's water supply is assumed to be from an off-site source (consistent with current conditions) and this individual is assumed to be an adult.

6.3.3.2 Adolescent Trespasser

Although the SLDA site is fenced, it is possible for individuals to intentionally trespass onto the site. This would most likely be an adolescent (teenager), and such events have occurred in the past. It is assumed that these receptors could be exposed to contaminated surface soil and surface water/sediment in Dry Run while on the site. Small animals including rabbits, chipmunks, and squirrels are present at the site, and the trespasser could bring a gun and shoot them. However, it is not considered likely that such animals would be consumed so the game ingestion pathway is not evaluated in this human health risk assessment. (Ingestion of food grown at the site is considered for the Subsistence Farmer scenario under future-use conditions.) The potential impacts of the radioactive contamination at the site on animals are separately addressed in the ecological risk assessment given in Section 7.0. Fish consumption is not considered a complete exposure pathway for this scenario since the SLDA does not contain any bodies of water capable of supporting game fish populations. The exposure pathways considered for the Adolescent Trespasser are:

- Inhalation of fugitive dust from surface soil and dry sediment;
- External gamma exposure from radionuclides in soil and sediment; and
- Incidental ingestion of surface soil, surface water, and sediment.

As for the Maintenance Worker, exposures to radioactive gases (radon and thoron) and dermal absorption of radionuclides are not addressed for the Adolescent Trespasser.

The results of the recent site characterization program indicated that surface water in Carnahan Run is not contaminated, while low levels of radioactive contamination were identified at on-site locations in Dry Run and groundwater seeps in the upper trench area. This medium was not included in the quantitative risk calculations since the levels of radioactive contamination in this water are low, and surface water is generally present only during certain times of the year, and during and after precipitation events. Ingestion of surface water will be addressed in future assessments should sampling indicate more widespread contamination in nearby surface waters, specifically in Dry Run and Carnahan Run.

The site characterization program identified localized areas of contaminated sediment in Dry Run. Dry Run is not explicitly included in the three EUs identified for this BRA, which were largely developed based on of historical information. Hence, this contaminated sediment is not included in the risks and radiation doses identified for these three EUs. This contaminated sediment is, however, included in the assessment of risks for site-wide exposures.

6.3.3.3 <u>Construction Worker</u>

The future-use scenarios identified above include development of the site for industrial or residential uses. There are currently no habitable structures at the SLDA site, although two office trailers are present to support ongoing activities. In addition, the SLDA site has access roads, electric service, and three underground natural gas pipelines that could support future development. Construction workers would represent a likely group of receptors that could be exposed to contaminants at the site should it be developed in the future. It is assumed that these workers would be exposed to contaminated surface soil, subsurface soil (to a depth of 3 m [10 ft]), surface water/sediment in Dry Run, and groundwater from the upper shallow bedrock aquifer while working on the site. The exposure pathways considered for the Construction Worker are:

- Inhalation of fugitive dust from surface soil, subsurface soil, and dry sediment;
- External gamma exposure from radionuclides in soil and sediment; and
- Incidental ingestion of surface soil, subsurface soil, surface water, groundwater, and sediment.

As for the Maintenance Worker, exposures to radioactive gases (radon and thoron) and dermal absorption of radionuclides are not addressed for the Construction Worker. Also, since surface water in Dry Run contains only low levels of radioactive contamination, this environmental medium is not addressed for this scenario as noted above for the Adolescent Trespasser.

6.3.3.4 Subsistence Farmer

The Subsistence Farmer is considered as a conceivable, and worst-case (bounding) scenario for the SLDA site. This scenario is considered conceivable given the presence of open (undeveloped) land on the site, and nearby presence of residences and small farms. However, no subsistence farms are currently known to be in operation in this portion of Armstrong County. The subsistence-farming scenario includes the development of a working farm with livestock for meat and dairy products plus cultivated land for grains, fruits, and vegetables. It is further assumed that a small pond is developed at the site and fish are raised for consumption; this exposure pathway is highly unlikely given the nearby presence of the Kiskiminetas River which could be used as a source of fish. It is assumed that the Subsistence Farmer would be exposed to contaminated surface soil, subsurface soil, surface water/sediment in Dry Run, impacted homegrown produce, impacted meat and dairy products, and groundwater from the upper shallow bedrock aquifer. The exposure pathways considered for a subsistence farmer are:

- Inhalation of fugitive dust from surface soil, subsurface soil, and dry sediment;
- Inhalation of radon gases (Rn-222 and Rn-220) from surface and subsurface soil for indoor exposures;
- External gamma exposure from radionuclides in soil and sediment;
- Incidental ingestion of surface soil, subsurface soil, and sediment;
- Ingestion of water from the upper shallow bedrock aquifer; and
- Ingestion of homegrown produce, beef, poultry, dairy products, and fish.

Incidental ingestion of surface water and groundwater is not assessed for this individual, who is assumed to have a well at the site and use water from the upper shallow bedrock aquifer as the source of drinking water. As for the Maintenance Worker, dermal absorption of radionuclides is not addressed for the Subsistence Farmer.

The Subsistence Farmer is assumed to be an adult, to maximize exposures and intakes. This scenario is the same as that used to develop the PRGs for the primary ROPCs, as described in Appendix A of the SAP (USACE 2003a).

A summary of the environmental media and primary exposure pathways for the four hypothetical receptors considered in this BRA are shown in Table 6-3.

6.3.4 Estimation Of Exposure Point Concentrations And Intakes

Exposure points are defined as points of potential contact of a receptor with a contaminated medium. As noted in Section 6.1.2, the site was divided into three EUs to support the assessment of human health risks in this BRA as well as one site-wide exposure unit, which includes Dry Run. The EUs were developed based on environmental conditions, historical uses of specific areas, reasonableness of size in terms of representing receptor behavior, geographical similarity, and contamination potential. The EU represents the area over which each receptor is assumed to average their exposures while on the site. In addition to averaging exposures within each EU, a site-wide average value was considered to address the risk to an individual who is exposed to all contaminated areas at the site.

6.3.4.1 Exposure Units

The three EUs at the SLDA site are shown in Figure 6-1, and these are consistent with the investigation areas defined in Section 3.0 of the SAP. EU 1 consists of the area in the vicinity of Trenches 1 to 9 and is currently an open field. This EU contains contaminated surface and subsurface soil, surface water (from runoff and seeps), and groundwater (in the shallow bedrock aquifer). EU 2 consists of the area in the vicinity of Trench 10 below the high wall, and contains the same environmental media as EU 1. EU 3 consists of the area in the vicinity of the fence in the southeastern part of the site and includes portions of the area added in 2002. This EU also contains contaminated surface and subsurface soil, surface water, and groundwater. As noted in Section 6.1, EUs 1 and 2 do not include the trench contents for purposes of this BRA. However, the surface soil above the ten trenches is included in these two EUs. The site-wide exposure unit contains all of EU 1, EU 2, EU 3, as well as sediment sampling results from Dry Run.

Figure 6-1 also illustrates the relationship between these EUs and preliminary MARSSIM FSS units. An identification of these preliminary survey units was done to obtain more consistency between the RI/FS evaluations and the site closeout process that will be conducted in the future in accordance with MARSSIM. The boundaries of these survey units will likely change as the remedial action process for the site progresses. However, identifying these units now should help expedite site closeout activities in the future.

6.3.4.2 Exposure Point Concentrations

The EPC is an estimate of the concentration of each ROPC that a receptor is assumed to come in contact with during the course of an exposure event. Separate EPCs are calculated for each EU to address exposures within that EU. In addition, a site-wide EPC was calculated to address the risks to an individual who is exposed to all contaminated areas of the site. Soil (including sediment in Dry Run) is the main contaminated environmental medium at the site. Additional media could become further contaminated in the future including surface water in Dry

Run, as well as groundwater in the upper shallow bedrock aquifer. Someone accessing the contaminated areas at the site could disturb surface soil and resuspend particulates, so localized air could become a contaminated medium during periods of mechanical disturbance. The media addressed for the four receptors are identified in Section 6.3.3.

Two time periods are considered in this BRA to support the decision-making process. Current risks are assessed to determine if specific measures should be taken in the near term to reduce risks at the site. These measures could include further limiting access to certain contaminated areas by the use of barriers, fences, or more restrictive administrative controls. Future risks (out to 1,000 years) are evaluated to determine the need for more permanent remedial actions. In both cases, risks are estimated for hypothetical receptors that are assumed to be exposed to SLDA contaminants within their individual lifetimes.

The 95 percent upper confidence limit of the arithmetic average (UCL) was calculated in accordance with EPA guidance and used as the EPC for current exposures to surface and subsurface soil (EPA 1992). However, if the EPC was greater than the maximum detected value for a specific ROPC, the maximum value is used as the EPC. This was the case for a few of the primary ROPCs in EU 3, as shown in Table 6-4.

Prior to calculating the EPC, the data set was first evaluated to determine if the data could reasonably be represented by a normal distribution. Each data set was evaluated separately for each of the three EUs, and also on a site-wide basis. If the data set was not normally distributed, a lognormal distribution was used. The EPCs for soil (surface and subsurface) for those data sets that were determined to be normally distributed were calculated using the following equation:

$$\text{UCL} = x + t\,(s/n^{1/2}) \qquad (6.2a)$$

Where:

x = arithmetic mean of background measurements for the radionuclide $[1/n]\sum x_i$, with x_i representing the sample analytical results for radionuclide i];

n = number of soil samples analyzed for contaminant i;

t= Student t statistic (obtained from a statistics table) for the 95th percentile confidence interval and the appropriate degrees of freedom (n-1) determined by the sample number; and

s = sample standard deviation.

The following equation was used to calculate the 95 percent UCL for logarithmic transformed data.

$$UCL = e^{x + 0.5s^2 + sH/((n-1)^{0..5})} \qquad (6.2b)$$

Where:

e = exponential conversion for lognormal data;

H = H statistic (obtained from a statistics table) for the 95th percentile confidence interval and the appropriate degrees of freedom (n-1) determined by the sample number; and

the other parameters are as described above.

In calculating the UCL, results that are less than the detection limit are set to one-half the quantitation limit. The EPCs for airborne particulates were estimated by multiplying the soil EPCs by a mass loading factor of 2.35×10^{-5} g/m^3, obtained from the information given in NRC (2000b).

Modeling needs to be performed to estimate the EPCs for future-use conditions. This can be done using a number of standard computer codes to address the risks for the two future hypothetical receptors over the next 1,000 years. For consistency with previous calculations, use was made of the RESRAD results for determining the PRGs, as summarized in Appendix A of the SAP. The RESRAD computer code has been used for many FUSRAP sites to address the migration of radioactive contaminants in environmental media. This code accounts for radionuclide decay and ingrowth over time, and the calculation of PRGs was performed using input parameters developed in consultation with PADEP. The PRGs were calculated using the probabilistic version of RESRAD (ANL 2001).

With this approach, it is not necessary to calculate (by additional modeling) the media-specific EPCs for the two future use scenarios. Rather the RESRAD results can be used to calculate the appropriate intakes for these two scenarios for each medium of concern using the current EPCs for soil to provide an estimate of the radiation doses and cancer risks. This is the approach used in this BRA for the two future-use scenarios (see Appendix R). The EPCs for surface and subsurface soil in the three EUs and on a site-wide basis for the ROPCs at the SLDA site are summarized in Table 6-4.

To calculate the risks and radiation doses associated with site-related contaminants, it is necessary to eliminate the contribution associated with the background concentrations of the ROPCs. This was done by subtracting the background UTL concentration for each ROPC from the corresponding EPC, producing a "net EPC" as shown in Table 6-4. The "net EPC" is the value used as the exposure point concentration in the risk and dose calculations in this BRA. (This value is simply referred to as the EPC in subsequent sections of this BRA.) In many instances the background UTL value exceeded the calculated EPC; in these cases, the "net EPC" was set to zero. That is, that radionuclide was determined to not be elevated above background concentrations in that EU.

As indicated in Table 6-4, most of the EPC values are very low (less than 10 pCi/g) except for plutonium and americium in surface soil in the vicinity of Trench 10 (EU 2). This is consistent with historical information for the site, which indicates that there is minimal contamination of the site outside of the trenches. The high concentrations of plutonium and americium in surface soil in EU 2 is also consistent with documented use of this portion of the site to store contaminated equipment and possibly other materials. The "net EPC" for Pu-239 in EU 2 is indicated in Table 6-4 to be about 252 pCi/g; the "net EPC" for Am-241 is 117 pCi/g; and the value for Pu-241 is 34 pCi/g. These high concentrations appear to be based on a few isolated spots of surficial soil contamination in the vicinity of Trench 10.

The "net EPCs" for the secondary ROPCs are generally zero, and the non-zero values are very low (less than 0.4 pCi/g). This was the basis for excluding the secondary ROPCs from further evaluation in this BRA as indicated in Section 6.2.4.

6.3.4.3 Estimation of Contaminant Intakes

Contaminant intakes are identified from the EPCs combined with scenario-specific intake assumptions. The scenario-specific assumptions include factors such as the age of a potential receptor, and the frequency and duration of exposure to contaminated media; intake parameters are specific to the route of exposure, e.g., inhalation or ingestion rates. Scenario assumptions and intake parameters used to estimate exposures were based EPA guidance (EPA 1989) and in recent updates to this manual (EPA 1997a, 1997b, 2001). In general, the value used for each parameter is the 90th or 95th percentile value, although for some parameters, the 50th percentile value is recommended. The parameters used for the Subsistence Farmer scenario were based on NRC guidance documents (NRC 1999, 2000b, 2003), and included distributions for a number of parameters for the probabilistic analysis.

The intake for internal exposures represents the amount of activity (pCi) taken into the body by inhalation or ingestion. For external gamma irradiation (whereby the body is exposed to radiation external to it), intake refers to the length of time that an individual is exposed to a specific concentration of a radionuclide, generally assumed to be at a distance of about 1 m. The units for intake in this case are the product of concentration (pCi/g) and time. For consistency with published information on the toxicity of external gamma radiation, this intake is represented in units of pCi-yr/g in this report.

The assumptions and intake parameters used to estimate the radiological exposures at the site for the four hypothetical receptors are summarized in Table 6-5 and discussed as follows.

6.3.4.4 Exposure Time, Exposure Frequency, and Exposure Duration

These three parameters – exposure time, exposure frequency, and exposure duration – together define the total extent of exposure in the EU. The exposure time is the number of hours per day (or hours per exposure event) that a hypothetical receptor is assumed to be present in the EU; the exposure frequency is the number of days per year (or events per year) that exposure occurs; and the exposure duration is the total number of years over which the exposure occurs.

The hypothetical Maintenance Worker is assumed to be exposed 8 hours per day for 20 days per year over 10 years. The exposure time and frequency reflect the small size of the SLDA such that only a few days a month are expected to be spent mowing grass, repairing the security fence, and conducting other routine maintenance activities at the site. The number of working days per year for the hypothetical Maintenance Worker also considers the estimated number of days of rain or snow that would prevent outdoor activities, and the frequency with which mowing would be needed at this area. The exposure duration assumed for this receptor is conservative, because the median occupational duration for maintenance workers is less than 6 years (EPA 1997b).

The hypothetical Adolescent Trespasser is assumed to enter the SLDA site 10 times a year for 4 hours per visit over a period of 5 years. This trespasser is assumed to be a teenager, and the exposure duration is limited to 5 years as this individual is assumed to outgrow this behavior after this length of time. This individual is assumed to use a motorized vehicle (such as a three-wheeler), which could generate a significant amount of fugitive dust. Access controls including the presence of a security fence and warning signs reduce the likelihood of entry and limit the length of time a trespasser would be expected to remain in this area. Also, open lands nearby would be an attractive alternative. Nevertheless, these values have been used to represent conservative estimates of the amount of exposure a trespasser might incur over time.

The hypothetical Construction Worker scenario assumes that one or more residential or commercial buildings are constructed at the site in the future, and that construction occurs within portions of the site having residual soil contamination. A Construction Worker is assumed to work at the SLDA site 8 hours a day, 250 days per year, for one year. These values are those recommended in EPA guidance for addressing this type of scenario (EPA 2001), and are conservative as the construction season in Armstrong County is typically about eight months. Also, the relatively small sizes of the contaminated areas at the site would limit the amount of time a Construction Worker would actually spend at such areas.

This hypothetical Construction Worker would be exposed to soil contaminants during an 8-hour workday for the duration of a single construction project, expected to be no more than one year in duration. If multiple construction projects are undertaken, it is assumed that different workers would be employed for each project. This construction project is assumed to consist of earthmoving (excavation) activities as well as other construction activities such as associated with developing housing units or small industrial facilities typical of those located in this area.

The Subsistence Farmer is assumed to be an individual who develops the site into a small farm in the future. This individual is assumed to spend most of each day at the farm, with exposures divided between time spent indoors and outdoors. The subsistence farmer is assumed to raise all of his food on the farm, including fruits and vegetables, beef and poultry, dairy products, and fish from an on-site pond. The farmer is assumed to spend 18.6 hours per day at the farm for the entire year (365 days), with 15 percent of the time spent outdoors and 85 percent indoors. The remaining 5.4 hours are spent away from the farm. These values are consistent with NRC guidance documents for evaluating this type of scenario (NRC 1999). The subsistence farmer is considered as the conceivable, but unlikely and worst-case (bounding) scenario for the SLDA site.

6.3.4.5 Inhalation Rates

A scenario-specific inhalation rate of 2.0 m^3/h was derived for the hypothetical Adolescent Trespasser from average inhalation rates for adults at various activity levels and information on outdoor activity patterns given by EPA (1997a, 1997b). A higher proportion of time was assumed to be spent at moderate and heavy activity levels relative to average levels, consistent with guidance for deriving inhalation rates (EPA 1997a). In fact, this inhalation rate is the same as would be assumed for an outdoor worker equally engaged in moderate and heavy activities for short-term exposures. Because data provided by the EPA (1997a) suggest that inhalation rates for an adolescent tend to be similar to those of an adult at the same activity level, adult values were used for this trespasser.

An inhalation rate of 2.5 m^3/h was used for the hypothetical Construction Worker, consistent with EPA recommendations for this type of receptor (EPA 2001). The concentration of airborne particulates that this worker would be exposed to is assumed to be 10 times higher than for the Subsistence Farmer, due to the extensive earth-moving activities assumed to be conducted by this worker. This inhalation rate of 2.5 m^3/h was also used for the Maintenance Worker, which is conservative since this represents the inhalation rate for an outdoor worker engaged in heavy activities. The Maintenance Worker would be expected to conduct many less strenuous activities averaged over the year associated with routine maintenance activities.

An average inhalation rate of 0.98 m^3/h was used for the future Subsistence Farmer, consistent with NRC recommendations (NRC 1999). This average rate is lower than for the other three hypothetical receptors, as it includes time spent indoors resting and sleeping as well as that spent outdoors working on the farm.

6.3.4.6 <u>Incidental Ingestion Rates for Soil</u>

Individuals can inadvertently ingest soil by transferring it from hands and fingers to food or cigarettes, or simply by wiping the mouth. The values recommended by EPA as reasonable estimates for soil ingestion are 50 mg/d for adults and 100 mg/d for children 1 to 6 years of age (EPA 1997a). These rates are recommended for a resident assuming ingestion of outdoor soil and indoor dust throughout a day, as well as incidental soil on foodstuffs, so they are appropriate for the hypothetical Subsistence Farmer. The adult value of 50 mg/d is used for this individual, who is assumed to be an adult. This value is also used for the Adolescent Trespasser during each exposure event, which is assumed to be 4 hours.

The incidental soil ingestion rates for the Maintenance Worker and Construction Worker are assumed to be 100 mg/d and 330 mg/d, respectively, as provided in EPA guidance (EPA 2001). The value for the Maintenance Worker is that recommended by EPA for an outdoor worker, which is appropriate for this site. These values represent the incidental ingestion rates over an 8-hour workday.

6.3.4.7 Ingestion Rates for Water

The incidental water ingestion rate is taken to be 200 mL/d or mL/event for all scenarios except the Subsistence Farmer, who intentionally ingests water from the upper shallow bedrock aquifer. (This pathway is not relevant for the Maintenance Worker scenario.) This value is about 1 cup and is considered to be a conservative value. In situations where exposure could be to both surface water and groundwater sources, this ingestion is assumed to be split equally between these two sources. The Subsistence Farmer is assumed to ingest about 1,300 mL/d of water from the shallow bedrock aquifer at the site, consistent with NRC guidance (NRC 1999). This corresponds to drinking about one-third of a gallon of water per day from this groundwater aquifer.

6.3.4.8 Ingestion Rates for Foodstuffs

The ingestion rates for foodstuffs (produce, beef and poultry, dairy products, and fish) for the Subsistence Farmer were developed consistent with NRC guidance (NRC 1999) and are provided in Table 6-5. These values are relevant only for the hypothetical Subsistence Farmer, as the other three receptors are not assumed to consume foodstuffs produced at the site.

6.3.4.9 Equations for Estimating Intakes and Doses

The equations used to calculate the intakes of the ROPCs for the two current-use scenarios are given as follows. The intakes for the two future-use scenarios were obtained using the results of the RESRAD calculations for the Subsistence Farmer scenario, as described in Appendix R. The exposure routes considered in this BRA were external gamma irradiation, ingestion, and inhalation.

6.3.4.10 External Gamma Irradiation

External gamma irradiation from exposures to soil (surface and subsurface) at the SLDA was calculated by multiplying the length of time an individual is exposed to a given radionuclide using the following equation.

$$I_{ei} = R_{si} \times ET \times EF \times ED \times AF \times DF \times CF_1 \qquad (6.3)$$

Where:

I_{ei} = external gamma irradiation from radionuclide i (pCi-yr/g),

R_{si} = concentration of radionuclide i in soil or sediment (pCi/g),

ET = exposure time (h/d or h/event),

EF = exposure frequency (d/yr or events/yr),

ED = exposure duration (yr),

AF = area factor (dimensionless),

DF = depth factor (dimensionless), and

CF_1 = conversion factor (1.14×10^{-4} yr/h).

The area and depth factors are fractional values used to estimate the external gamma irradiation rate for a specific source area of finite size from that for a source of infinite extent. These values can be obtained using the RESRAD computer code. Both values were taken to be unity, which correspond to an areal extent of contamination greater than about 1,000 m^2 (0.3 acres) and a depth of contamination more than about 0.6 m (2 ft). This approach is conservative but reasonable, given the sizes of the three EUs and the soil contamination pattern at the SLDA.

For cases where a measured gamma exposure rate is available, the dose can be calculated as follows:

$$I_g = E \times ET \times EF \times ED \times CF_2 \qquad (6.4)$$

Where:

I_g = dose from external gamma irradiation (mrem),

E = measured exposure rate (μR/hr) and,

CF_2 = conversion factor (0.001 mrem/μR).

ET, EF, and ED are as defined in Equation 6.3.

The conversion factor reflects a commonly used value to convert exposure (in mR) to dose (in mrem), i.e., unity, multiplied by 0.001 to convert μR to mR. This approach was not used in this BRA, as measured gamma exposure rates are not available for the site. However, this could be used in future risk assessments, depending on the availability of information.

6.3.4.11 Ingestion

The intakes from ingestion of contaminated soil, water or foodstuffs were calculated using the following equation.

$$I_{ii} = R_{si} \times IR \times EF \times ED \times CF_3 \qquad (6.5)$$

Where:

I_{ii} = ingestion intake of radionuclide i (pCi),

R_{si} = concentration of radionuclide i in soil, water, or foodstuff (pCi/g or pCi/L),

IR = ingestion rate (mg or mL per d or event), and

CF_3 = conversion factor (10^{-3} g/mg or L/mL).

ET, EF, and ED are as defined in Equation 6.3.

Separate values were used to calculate the intakes associated with the incidental ingestion of soil and water, and the intentional ingestion of groundwater and foodstuffs for the Subsistence Farmer. These are indicated by the different values of IR in Table 6-5.

6.3.4.12 Inhalation

The intakes from inhalation of radionuclide particulates in air resuspended from soil and sediment were calculated using the following equation:

$$I_{ari} = R_{ai} \times IR_a \times ET \times EF \times ED \qquad (6.6)$$

Where:

I_{ari} = inhalation intake of airborne radionuclide i (pCi),

R_{ai} = air concentration of radionuclide i as respirable particulates (pCi/m^3), and

IR_a = air inhalation rate (m^3/h).

ET, EF, and ED are as defined in Equation 6.3.

The individual dose and intake estimates developed using the equations given above can be combined to assess the total exposures for the hypothetical receptors by multiple routes. These results are presented in Section 6.5.

6.4 Toxicity Assessment

Cancer is generally the only toxic effect that needs to be evaluated for radionuclides according to EPA guidance (1989), and standard risk coefficients have been developed by EPA to represent this toxicity. These risk coefficients can be used to assess the increased probability (above a background rate) that an individual will develop cancer over a lifetime as a result of chronic exposures. This is also referred to as excess lifetime risk and is based on population statistics. It is usually not necessary to evaluate the noncarcinogenic effects for radionuclides, as the cancer risk is generally the dominant concern. However this is not the case for uranium, which can also have significant noncarcinogenic effects. Hence, the noncarcinogenic chemical toxicity of uranium was also evaluated in this assessment to address the impairment of kidney function that could result from internal exposure to uranium.

In addition to cancer risks, the BRA also includes an estimate of the radiation doses associated with potential exposures to the ROPCs at the SLDA. Radiation protection criteria are generally identified in terms of dose and dose rate (mrem or mrem/yr) rather than cancer risk, and the PRGs for the SLDA were developed on this basis, i.e., by limiting the dose to a future Subsistence Farmer to 25 mrem/yr. Also, most radiation toxicity studies describe effects in terms of the doses or dose rates delivered, and dose estimates are generally used to develop and evaluate radiation protection programs. Radiation doses are estimated in this BRA using standard DCFs. Both cancer risk and radiation doses estimates are developed in this BRA to support the decision-making process.

The radiation doses and cancer risks were calculated using standard EPA methodology, and these estimates depend on the type of radiation (alpha, beta, or gamma), exposure route (external gamma irradiation, ingestion, inhalation, or dermal), and organs being irradiated. These two endpoints (radiation dose and cancer risk) were calculated separately in this BRA. A linear relationship generally exists between radiation dose and cancer risk for external exposures to low linear-energy-transfer (LET) radiation such as gamma rays. The radiation dose from external gamma radiation can be converted to cancer risk by multiplying the dose by a risk factor of 6×10^{-7} cancers per mrem. This risk factor was developed by the International Commission on Radiological Protection (ICRP) and includes the risk for all cancers (fatal and nonfatal) (ICRP 1991). The Interstate Technology and Regulatory Council (ITRC) has noted that this approach is an acceptable method for assessing the risks for external exposure to LET radiation including gamma rays (ITRC 2002). This risk factor was not used in this BRA, but can be used to estimate the cancer risk associated with measured gamma exposure rates. The cancer risk coefficients and DCFs for the primary and secondary ROPCs at the SLDA used in this BRA are presented in Table 6-6 and discussed in Section 6.4.1.

6.4.1 Toxicity Values for Carcinogenetic Effects of Radionuclides

The radioactive contamination at the SLDA can generally be characterized as low-level ionizing radiation. The potential health effects associated with exposure to this type of radiation include an increase in the probability of cancer induction (which depends on the type of radiation, means of exposure, and organ irradiated), serious genetic effects, and other detrimental health effects such as teratogenesis (fetal abnormalities). Of these, the two major concerns are cancer induction and hereditary effects. Both are stochastic and are considered to have no threshold dose, i.e., the probability of occurrence, not the severity of effect, increases with the absorbed dose, and there is assumed to be no dose level below which the risk is zero.

The main health effect associated with the radionuclides at the SLDA is cancer induction because the risk of serious hereditary effects from these exposures is much lower. Hence, the evaluation of radiological health risks is limited to this concern. This approach is consistent with EPA guidance, which notes that cancer risk is generally the limiting effect for radionuclides and that radiation carcinogenesis be used as the sole basis for assessing the human health risks at radioactively contaminated sites (EPA 1989).

Ionizing radiation is a known human carcinogen, and the relationship between radiation dose and health effects is relatively well characterized for high doses of most types of radiation. Lower levels of exposure might constitute a health risk, but it is difficult to establish a direct cause-and-effect relationship because a particular effect in a specific individual can be produced by many different processes. For example, the features of cancers resulting from radiation are not distinct from those of cancers produced by other causes. Therefore, the risk of cancer from exposure to low levels of ionizing radiation must be extrapolated from data for increased rates of cancers observed at much higher doses.

Chronic doses of low-level radiation have not directly been shown to cause cancer, although this has been assumed in order to be protective. Evidence linking radiation exposure to observable biological effects has only been found at doses above 25 rads incurred over a short time, so in translating to chronic doses far below this level it is difficult to establish a dose-response relationship. Even though information indicates that a threshold exists below which adverse effects are not distinguishable, to be conservative it is commonly assumed that the dose-response relationship is linear. This means it is assumed that any dose, no matter how small, increases the chance of getting cancer; this approach is commonly referred to as the linear no-threshold hypothesis.

Ionizing radiation causes injury by breaking molecules into electrically charged fragments (ion pairs), thereby producing chemical rearrangements that may lead to permanent cellular damage. The degree of biological damage caused by different types of radiation varies according to how spatially close together the ionizations occur. Some ionizing radiations, e.g., alpha particles, produce high-density regions of ionization. Other types of radiation, e.g., gamma rays and beta particles, produce a lower density pattern of ionizations. Equal doses (in terms of energy deposited per unit mass) of radiation from alpha particles result in much greater harm than that from gamma rays and beta particles due to the higher density of ionizations. The biological damage caused by these ionizations can result in cancer induction. On average, about half of all cancers that can be induced by radiation are fatal. The fraction of cancers that are fatal ranges from about 10 percent for thyroid cancer up to essentially 100 percent for liver cancer (EPA 1989).

Radiation exposures associated with the SLDA are limited to chronic effects (low doses over relatively long time periods) and need not consider acute effects (high doses over short time periods). Large exposures to radionuclides are required to cause acute effects, and no such exposures are associated with the SLDA under baseline conditions. Toxic effects from acute radiation exposure is only possible when humans are exposed to very large amounts of radiation, e.g., at Chernobyl from the 1986 nuclear power plant accident or in Japan from nuclear weapons detonations more than 50 years ago. Acute doses above 25 rads can induce a number of deleterious effects including nausea and vomiting, malaise and fatigue, increased body temperature, blood changes, epilation (loss of hair), temporary sterility, and others; bone marrow changes have not been identified until the acute doses reach 200 rads (Cember 1983). The residual contaminant levels at the SLDA correspond to doses that are very much lower, e.g., less than 0.01 percent of those at which adverse effects are observed, and approaching background in most areas of the site. Thus, acute toxicity is not an issue for the SLDA.

6.4.1.1 Cancer Risk Coefficients

The EPA guidance for conducting risk assessments at contaminated sites (EPA 1989) has been followed in this BRA, including the use of standard cancer risk coefficients. These coefficients represent the estimated lifetime cancer risk per unit intake averaged over all ages and both genders, for a given radionuclide and exposure. An extensive set of these coefficients for estimating cancer risk from various internal and external exposures to more than 800 radionuclides is given in Federal Guidance Report (FGR) 13 (EPA 1999b). Only a very small subset has been used for this assessment, because only a limited number of radionuclides are present at the SLDA as provided in site characterization information. Coefficients are available for both mortality and morbidity (the latter is for illness, not fatality). Although mortality values can be much smaller, morbidity may approach mortality for certain types of cancer (e.g., lung cancer). Morbidity risk coefficients have been used to estimate the likelihood of cancer incidence from radiological exposures in this assessment consistent with EPA guidance.

In developing the risk coefficients for radionuclides, EPA used contemporary dosimetric methods and models to estimate the absorbed dose as a function of time from a chronic intake (ingestion or inhalation) or exposure (external gamma irradiation) over a lifetime. Human data were considered in developing these models, albeit from much higher doses. The estimates of absorbed dose were combined with cancer risk factors through a life-table analysis, which accounts for competing risks (caused by something other than radiation exposure, such as a car accident). Competing risks are usually much larger than radiological risks and vary significantly with age, and they are accounted for using mortality statistics for the U.S. population. The basis is that people dying from other causes are not susceptible to radiation-induced cancer, even if they had been exposed to radiation from the contaminated site. Thus, these coefficients provide a conservative but realistic estimate of radiation risk from those exposures.

The radiological risk coefficients used in this assessment are given in Table 6-6. These risk coefficients are incorporated into the RESRAD (for *Res*idual *Rad*ioactivity) computer code that has been used to support the evaluation of radiological effects associated with exposures at the SLDA, including the development of PRGs for the primary ROPCs. This computer code has been used in radiological risk assessments for many projects, including for other FUSRAP sites. The contributions of short-lived decay products, which are included in the risk coefficients provided in Table 6-6, are also incorporated into the RESRAD code (ANL 2001).

6.4.1.2 <u>Dose Conversion Factors</u>

Radiation doses (in mrem) are also estimated in this BRA for the SLDA, as this allows for a direct comparison with the specified criterion of 25 mrem/yr for future unrestricted use of the site. This is also consistent with EPA guidance, which indicates it is appropriate to estimate both the risk (for the CERCLA target risk range of 1×10^{-4} to 1×10^{-6}) and dose (for compliance with relevant radiation protection standards) (EPA 1999c). Ionizing radiation causes biological damage only when the energy released during radioactive decay is absorbed in tissue. The absorbed dose gives the mean energy imparted by ionizing radiation per unit mass of tissue. This dose is typically expressed in gray (Gy) or rad (an acronym for *radiation absorbed dose*). One gray is one joule per kg and equals 100 rads.

Certain types of radiation are more effective at producing ionizations than others. For the same amount of absorbed dose, alpha particles will produce significantly more biological harm than beta particles or gamma rays. The dose equivalent approach was developed to normalize the unequal biological effects produced by different types of radiation. The dose equivalent is the product of the absorbed dose and a quality factor which accounts for the relative biological effectiveness of the radiation. The quality factors currently assigned by the ICRP are: 20 for alpha particles; 10 for neutrons and protons; and 1 for beta particles, positrons, X-rays, and gamma rays. This means that on average, for the same amount of energy absorbed, an alpha particle will inflict about 20 times more biological damage to the tissue than a beta particle or gamma ray.

The dose delivered to internal organs due to radionuclides systemically incorporated into the body may continue long after intake of the radionuclide has ceased. After being taken in, some radionuclides are eliminated fairly quickly, while others are incoporated into tissues or ultimately deposited in bones and can be retained for many years. This is in contrast to external doses, which occur only when a radiation field is present (e.g., only when an individual is close enough to be reached by the gamma rays being emitted by a radionuclide that stays outside the body). The committed dose equivalent was developed to account for the doses to internal organs from radionuclides taken into the body. The committed dose equivalent is the integrated dose equivalent to specific organs for 50 years following intake.

When subjected to equal doses of radiation, organs and tissues in the human body will exhibit different cancer induction rates. To account for these differences and to normalize radiation doses and effects on a whole-body basis, the ICRP developed the concepts of effective dose equivalent (EDE) and committed effective dose equivalent (CEDE), which are weighted sums of the organ-specific dose equivalents and committed dose equivalents (ICRP 1977). The weighting factors used in these calculations are based on selected stochastic risk factors and are used to average organ-specific dose equivalents. The total effective dose equivalent (TEDE) is the sum of the EDE for external radiation and the 50-year CEDE for internal radiation.

Using this information, the EPA has developed DCFs for internal and external exposures, and these factors are given in FGRs 11 (EPA 1988) and 12 (EPA 1993). For internal exposures, the DCF represents the 50-year CEDE per unit intake of radionuculide (mrem/pCi) and for external exposures, the DCF represents the EDE per unit of time (mrem/hr or mrem/yr) at one meter above the ground surface per pCi/g of the specified radionuclide in soil, for a number of different depths of contamination. The DCFs for infinite depth were used for external exposures in this assessment; an infinite depth corresponds to depths greater than about 0.6 m (2 ft). These DCFs are also shown in Table 6-6 and were used to calculate the radiation doses (TEDEs) for the various exposure scenarios evaluated for the SLDA. As for the cancer risk coefficients, these DCFs include the contribution of short-lived decay products and have also been incorporated into the RESRAD computer code.

6.4.2 Toxicity Value For Noncarcinogenetic Effects Of Uranium

The potential for a noncarcinogenic health effect to result from exposure to a chemical (in this case uranium) is assessed by comparing the estimated exposure (intake) to a standard toxicity value. This value is the termed the reference dose (RfD). Toxicity values are specific to the chemical, route of exposure, and duration over which the exposure occurs. An RfD is defined as an estimate of the amount humans (including sensitive subpopulations) can take in every day that is likely to be without an appreciable risk of deleterious effects during a lifetime (EPA 1989). Reference doses derived to assess oral exposures are given in units of milligrams per kilogram body weight per day (mg/kg-d).

The EPA has also developed a reference concentration (RfC) for a number of chemicals, which is expressed in milligrams per cubic meter (mg/m^3) of air inhaled. An RfC can be converted to the corresponding inhalation RfD (in mg/kg-d) by dividing by 70 kg (an assumed body weight) and multiplying by 20 m^3/d (an assumed inhalation rate). Because uranium represents a noncarcinogenic hazard only by the oral route, the EPA has not developed an RfC for uranium. In addition, dermal absorption of uranium is negligible. Hence the assessment of noncancer hazards for uranium is limited to the oral route in this BRA.

Scientific evidence indicates that a threshold exists for a number of noncancer health effects, with adverse effects being observed only after exposures exceed a certain level. For some chemicals, notably essential human nutrients such as copper, manganese, molybdenum, nickel, selenium, and zinc, low doses can be necessary for health or can otherwise be beneficial for overall health protection. To illustrate the threshold concept, a small dose of one aspirin taken every day for many years protects against heart disease, whereas a much larger daily dose would irritate the stomach lining. Thus, identifying what levels are "safe" and then comparing the intake estimated for a noncarcinogen to that exposure level can indicate whether an adverse effect might be associated with that exposure level.

In deriving chemical toxicity values, EPA work groups review all relevant human and animal studies for each compound and select the studies pertinent to deriving the specific RfD. Each study is then evaluated to determine the no-observed-adverse-effect level (NOAEL) or, if data are inadequate for such a determination, the lowest-observed-adverse-effect level (LOAEL). The NOAEL corresponds to the dose, in mg/kg-d, that can be administered over a lifetime without inducing observable adverse effects. The LOAEL corresponds to the lowest daily dose administered over a lifetime that induces an observable adverse effect. The toxic effect characterized by the LOAEL is referred to as the "critical effect" and represents the lowest dose at which any adverse effect is observed (regardless of how benign it may be).

The NOAELs are most often based on data from experimental studies in animals. Both the experimental parameters and the extrapolation of animal data to humans are potential sources of uncertainty. Hence, in deriving an RfD, the NOAEL (or the LOAEL) is divided by uncertainty factors to ensure that the RfD will be protective of human health. Depending on the available data, uncertainty factors are applied to account for (1) extrapolation of data from experimental animals to humans (interspecies extrapolation), (2) variation in human sensitivity to the toxic effects of a compound (intraspecies differences), (3) derivation of a chronic RfD based on a subchronic rather than a chronic study, and/or (4) derivation of an RfD from the LOAEL rather than the NOAEL. In addition to these uncertainty factors, modifying factors between 0 and 10 may be applied to reflect additional qualitative considerations in evaluating the data. For many compounds, the modifying factor is 1.

The EPA-verified RfD for uranium was used in this BRA and it was obtained from the Integrated Risk Information System (IRIS), an online database that contains current health risk information for many chemicals (EPA 2003). The oral RfD is 0.003 mg/kg-d and corresponding critical effect is identified as weight loss and moderate kidney toxicity. The confidence level is identified as "medium' (the options being high, medium and low), and the uncertainty factor is given as 1,000.

6.5 <u>Risk Characterization</u>

The radiological carcinogenic risks for potential exposures at the SLDA are expressed in terms of the increased probability that an individual would develop cancer over a lifetime. The EPA has defined an incremental target for carcinogenic risks associated with contaminants at Superfund sites (that is, sites which are listed on the National Priorities List), which is an excess upper bound lifetime cancer risk to an individual of between one in ten thousand (1×10^{-4}) and one in a million (1×10^{-6}) (EPA 1990). For comparison, the American Cancer Society (ACS) estimates that in the United States, men have a little less than a 1 in 2 lifetime risk of developing cancer and for women, the risk is a little more than 1 in 3 (ACS 2003). These correspond to approximate risks of 5×10^{-1} and 3×10^{-1} (0.5 and 0.3), respectively.

The EPA risk range is referred to as the target range in this discussion, and it is used as a point of reference for the risks estimated from the hypothetical exposures evaluated for the SLDA. The risk estimates presented in this BRA will be used to support upcoming evaluations to be performed in the FS. In addition to carcinogenic risks, the radiation dose (in mrem) is also calculated for exposures to the radioactive contaminants, as the cleanup objectives for this site are based on limiting the radiation dose for future unrestricted use of the site to 25 mrem/yr. This dose limit is in excess of the dose associated with naturally occurring background radiation, which the National Council on Radiation Protection and Measurements (NCRP) estimates to be 300 mrem/yr to an average individual in the United States (NCRP 1987).

The radiation doses (TEDE) to the hypothetical receptors were estimated using standard DCFs given in FGRs 11 (EPA 1988) and 12 (EPA 1993). These DCFs are based on the metabolic and anatomical model of an adult male, the ICRP reference man weighing 70 kg (150 pounds). The ICRP selected such a standardized individual for its dosimetry models because the main concern was worker protection and the majority of radiation workers are adult males. Although children are more susceptible to radiation exposure, i.e., the radiation doses are larger for children than adults for the same intake of radioactivity, such effects are significant only for very young children. The uncertainty associated with using DCFs developed for adults for an adolescent (teenager) weighing about 50 kg (110 pounds) is relatively low, and does not significantly impact the radiation doses presented in this document.

The potential for chemical, noncarcinogenic health effects from exposure to uranium was also assessed in this assessment. The quantitative measure of noncarcinogenic health effects is the hazard index (HI). The EPA has identified an endpoint-specific (segregated) HI of greater than 1 as a level of potential concern for noncarcinogenic health effects (EPA 1989).

6.5.1 Radiological Risks

Exposures to ionizing radiation can result in cancer induction, genetic defects, and other detrimental health effects. However, low levels of exposure (such as from environmental contamination) have not been directly linked to adverse health effects. Nevertheless, to be protective, conservatism is built into the risk characterization process. The predominant health concern associated with the radioactive contaminants at the SLDA (which include radionuclides that decay by emitting alpha and beta particles, with attendant gamma radiation) is cancer induction.

The radiological health risks presented in this risk assessment are limited to this concern in accordance with EPA guidance, which indicates that the risk of cancer is generally the limiting concern and is suggested as the sole basis for assessing radiation-related health effects for sites or facilities contaminated with radionuclides (EPA 1989). Radiation doses have also been calculated to provide additional information to support the decision-making process and to evaluate compliance with radiation protection standards (EPA 1999c). The primary radioactive contaminants at the SLDA are identified in Section 6.2; alpha, beta, and gamma radiation are released during the radioactive decay of these radionuclides. Each type of radiation differs in its physical properties and ability to induce damage to biological tissue, as discussed in Section 6.4. The relative hazards associated with these types of radiation depend on the manner in which exposures occur.

Alpha particles are primarily a hazard when taken into the body by inhalation or ingestion, because for external exposure, they lose their energy in the outer layer of dead skin cells of the body before reaching living tissue. Within the body, alpha particles result in greater cell damage than beta or gamma radiation because their energy is completely absorbed by the tissue. Beta particles are primarily an internal hazard, although in some cases of external exposure, very energetic beta particles can penetrate to living skin cells thus representing an external hazard as well. However, beta particles deposit less energy to tissue and therefore induce much less damage than alpha particles. Gamma radiation is primarily an external hazard because it can easily penetrate tissue and reach internal organs. However, only a small fraction of the incident energy is deposited in tissue and internal organs because these gamma rays continue on through the organism.

Thus, radiation exposure pathways can be separated into external and internal components and are dependent on the parameters used to define the exposure scenarios. External exposure occurs when the radioactive material is outside the body, and it is primarily a concern only for gamma radiation. Internal exposure occurs when the radioactive material enters the body by inhalation or ingestion. Inhaled material can be exhaled, expelled from the lungs to be either spit or swallowed and excreted, deposited in the lungs, or absorbed by the blood and relocated to other organs from which it is excreted over time. Some fraction of the ingested material will enter the bloodstream and be either excreted in the urine or feces or relocated to other organs and excreted over time; most insoluble ingested material is not absorbed into the blood but is excreted directly via feces. For internal exposures, alpha and beta particles are the dominant concern because their energy is absorbed in cells before the particles leave the body.

The cancer risk coefficients and DCFs given in Table 6-7 account for these factors as appropriate to the pathway of exposure. For internal exposures, the doses and risks are calculated by multiplying the amount inhaled or ingested (in pCi) by the appropriate risk coefficient or DCF. For external exposures, the cancer risks and radiation doses are calculated by multiplying the estimated radionuclide concentration and the amount of time that the individual is exposed to this radiation by the appropriate risk coefficient or DCF. Alternatively, measured gamma exposure rate measurements can be used, and the radiation dose (in mrem) calculated as the product of the estimated exposure rate and time of exposure. Such estimated doses can be converted to cancer risks by multiplying the dose by a risk factor of 6×10^{-7} cancers per mrem developed by the ICRP (ICRP 1991).

When evaluating the hazards associated with exposures to radionuclides, it is necessary to consider the risks associated with any additional radionuclides that may accompany them. For example, the radionuclides at the SLDA consist of isotopes of uranium, thorium, and radium, which also occur in nature in long decay chains. The presence of these decay chains was explicitly considered in this assessment. The cancer risk coefficients and DCFs given in Table 6-7 include the contributions of these additional short-lived decay products which may accompany the longer-lived parent radionuclides, as do the values incorporated into the RESRAD computer code (ANL 2001).

The estimated radiological risks and doses for the various receptors in the three EUs and on a site-wide basis are given in Tables 6-7 and 6-8. Table 6-7 summarizes the radiological carcinogenic risk estimates and the estimated radiation doses are given in Table 6-8. These estimates are summarized from the more detailed information included in Appendix R, which identify the contribution that each individual radionuclide makes to the calculated risks and doses.

As indicated in Table 6-7, the radiological risks range from 9×10^{-9} to 1×10^{-5} for the four scenarios in the three EUs and for site-wide exposures. The estimated risks for the two current-use scenarios are below the lower end of EPA's target risk range (1×10^{-6} to 1×10^{-4}) except for the Maintenance Worker in EU 2. The risk to this individual (3×10^{-6}) is at the lower end of this range and is associated with exposures to surface soil contaminated with plutonium and americium. The low risks for the two current-use scenarios reflect the generally low levels of radioactive contamination at accessible locations (as a result of the previous actions taken to remediate contaminated surface soil) and the relatively small amount of time that individuals would reasonably be expected to visit contaminated areas at this controlled site.

The estimated risks for the two future-use scenarios are also within or below the EPA target risk range. The estimated risks for the Construction Worker scenario are all below the lower end of the target risk range, and the risks for the Subsistence Farmer scenario are all within the EPA target risk range. The major contributor to the risk to the Subsistence Farmer is generally consumption of produce grown in contaminated soil. The maximum risk (1×10^{-5}) is a factor of ten below the level which would indicate a need for remedial action. These risks are low because there is very little contamination of soil outside the trenches, as indicated by the very low EPCs.

It is interesting to note that the estimated risks for the Maintenance Worker are comparable to, or higher than, the risks for the Construction Worker. This result is largely associated with the manner in which the EPCs were calculated for these two scenarios. The EPC for the Maintenance Worker was based solely on contaminated surface soil, while the EPC for the Construction Worker was based on the composite concentration through the entire depth of the samples (as reported in Table 6-4). The composite concentrations are lower than the surface soil concentrations for the site and, for EU 2, this difference is more than a factor of 50 for Am-241 and Pu-239. So even though the total time on-site for these two scenarios is comparable (see Table 6-5), the estimated risks for the Maintenance Worker were larger than for the Construction Worker. This result is largely due to the assumptions associated with development of the EPCs for these two scenarios.

The radiation doses are given in Table 6-8 and range from 0.03 to 100 mrem for the four scenarios in the three EUs and for site-wide exposures. As with the radiological cancer risk estimates, the maximum dose is associated with the Subsistence Farmer scenario in EU 2. The annual dose to the Subsistence Farmer in this EU is about 5 mrem/year, or about 20 percent of the annual dose limit (25 mrem/year) identified in the authorizing legislation for this site. This annual dose could have been estimated by simply calculating the SOR for the EPCs in this EU, and then multiplying this value by 25 mrem/year. Using information from Tables 6-1 and 6-4, the SOR is calculated to be 0.19 for the composite contaminant concentrations reported for EU 2, and multiplying this value by 25 mrem/year yields the estimated dose of 5 mrem/year. The annual dose for the Subsistence Farmer scenario in the other two EUs and for site-wide exposures is about 1 mrem/year.

The annual dose for the Maintenance Worker in EU 2 is estimated to be about 4 mrem/year. As noted previously, this result is largely due to the relatively high EPCs reported for americium-241 and plutonium-239 in surface soil in EU 2. The annual dose to the Construction Worker in this EU is estimated to be about 2 mrem/year. All other annual doses are estimated to be less than 1 mrem/year.

6.5.2 Noncarcinogenic Effects of Uranium

The potential for noncarcinogenic health effects from exposure to uranium was assessed by estimating the HI from oral intakes. An endpoint-specific HI of greater than 1 may indicate a potential for adverse health effects. Conversely, an HI of 1 or less is considered to indicate little potential for the occurrence of adverse health effects.

The estimated HIs for the four receptors in the three EUs and on a site-wide basis are given in Table 6-9. This table identifies the key information used to calculate the HIs including the uranium intakes, receptor body weight, averaging time, and RfD. The uranium intakes (in mg) were calculated from the activity intakes of the three uranium isotopes at the SLDA given in Appendix R (Tables R.1 through R.16). These activities were converted to mass using the specific activities for these three radionuclides (the conversion factors are indicated in footnote b of Table 6-9), and the total uranium intake was calculated as the sum of the intakes of the three individual isotopes. The details of this calculation are summarized in Table R.34.

The estimated HIs for the various receptors range from less than 0.001 to 0.010. These values are all much less than 1, which indicates little potential for noncarcinogenic health effects. The HIs were based on oral intakes of uranium, and the maximum HI occurs in EU 1 for the Subsistence Farmer. This is as expected, as the Subsistence Farmer scenario has the highest oral intakes of uranium (largely through consumption of produce grown in contaminated soil) and EU 1 has the highest concentration of uranium contamination.

6.6 Uncertainty Assessment

The evaluation of risks to human health presented in this BRA is based on existing characterization data and site-specific exposure assumptions and input parameters. It was necessary to make a number of assumptions to fill data gaps and predict realistic (but conservative) exposures and risks to hypothetical human receptors under current and future conditions. The uncertainties associated with the assumptions used in this assessment are discussed in Sections 6.6.1 through 6.6.3.

6.6.1 Uncertainties In Environmental Data

A considerable amount of data has been developed for the SLDA site to support this human health BRA. These data include historical information which was summarized in the SAP (USACE 2003a), and newly collected data which are presented in the first five chapters of this RI report. The historical data have a number of gaps as summarized in Appendices D through I of the SAP, and are of unknown quality. In contrast, the newly collected data were obtained in accordance with an approved QAPP (USACE 2003b). As such, the quantitative analyses in this BRA have been limited to the newly collected data. The newly collected data are consistent with the historical data (where comparisons can be made), and have gone through a rigorous review consistent with the QAPP. This consistency with historical information confirms that the site is adequately characterized for purposes of this risk assessment.

The focus of the characterization effort was to identify and quantify the radioactive contamination at SLDA, consistent with the authorizing legislation for cleanup of the site. Primary and secondary ROPCs were developed based on historical information prior to the start of site characterization activities, and the sampling program confirmed that the ROPCs are indeed those radionuclides present at the site at levels posing a potential risk to human health. The data collection program focused on the ten waste trenches, as these are the locations having the highest levels of radioactive contamination. While it is not possible to completely characterize the entire site, the site is considered adequately characterized for purposes of this BRA and any uncertainties in the environmental data are relatively minor and should not impact the results presented in this document.

6.6.2 Uncertainties In Exposure Assessment

The exposure assessment was developed using a number of site-specific considerations, including the development of EPCs, scenario assumptions and intake parameters, and primary exposure pathways. The uncertainties associated with these three elements of the exposure assessment are addressed as follows.

Factors that can contribute to the uncertainty in the EPCs include data availability, contaminant heterogeneity, and the potential impact of fate and transport over time. Site characterization activities focused on those areas of the site most likely to be contaminated based on historical information and previous site investigation activities. The EPCs for the current-use scenarios were based on measured values of radionuclides in surface and subsurface soil, so the uncertainties associated with the EPCs for these scenarios are considered to be low. A conservative estimate of the amount of airborne dust for the current-use scenarios was developed using a mass loading factor of 2.35×10^{-5} g/m^3.

The EPCs for the future-use scenarios were obtained from the previous RESRAD calculations conducted to develop the PRGs based on the Subsistence Farmer scenario. These values are considered to be reasonable but conservative approximations of the radionuclide concentrations that could be present in environmental media and foodstuffs in the future. This approach provides greater consistency between the PRGs and the estimates of the carcinogenic risks and radiation doses to other potential future receptors such as the hypothetical Construction Worker. Site-specific input parameters were used in these calculations to the extent possible, and NRC-recommended and RESRAD default values were used where site-specific information was not available. These parameters were reviewed by PADEP prior to use in developing the PRGs to ensure that they were reasonable approximations of conditions at the site. While use of computer modeling increases the uncertainty in the EPCs, the level of uncertainty is acceptable and does not significantly impact the overall results of this assessment because the risks and radiation doses estimated for future hypothetical receptors are very low. Since the hypothetical Construction Worker is assumed to be involved in soil excavation activities, the average concentration of airborne radionuclides is taken to be ten times higher than for the Subsistence Farmer scenario.

Some uncertainty is associated with the assumptions used to identify scenarios and intake parameters for the exposure assessment. Site-specific factors were used to identify a reasonable set of hypothetical receptors and to develop realistic scenario assumptions, including the extent of exposure. These assumptions incorporate information on current land use in the area and reasonable projections of future land use in the future. The site covers an area of 18 ha (44 acres) and a chain link fence surrounds the site. The ten waste disposal trenches cover about 0.49 ha (1.2 acres), or less than 3 percent of the site. The physical setting and land use in the vicinity of this relatively small site were key considerations in developing the exposure scenarios. The uncertainty associated with the current-use scenarios is low, but there is considerable uncertainty associated with the future-use scenarios. To address this uncertainty, use was made of a very conservative scenario (Subsistence Farmer) to provide a bounding estimate of the risks associated with future use of the site.

The intake parameters used in this BRA are generally based on EPA and NRC guidance and the scientific literature and are considered reasonable but conservative, so uncertainty related to underestimating risks is expected to be low. High-end values were used for several exposure factors which is expected to result in an overestimate of likely risks. The input parameters for the RESRAD calculations were developed in consultation with PADEP and are felt to be reasonable representations of site conditions. Conservative values were generally used for the input parameters since there is considerable uncertainty associated with them. This uncertainty is not expected to significantly affect the results presented in this BRA as the estimated risks and radiation doses are so low.

The PRGs were calculated assuming that the residual contamination was present in soil and extended from the surface to a depth of 4 m (13 ft). This is the approximate depth of the trenches in the upper trench area, which contains most of the radioactive contamination at the site. This is a conservative approach as the trenches are covered with clean soil to an approximate depth of 1.2 m (4 ft). This approach also addresses the possibility that actions could occur in the future under the Construction Worker and Subsistence Farmer scenarios in which subsurface contamination is brought to the surface and mixed with the clean overlying soil. While the assumption of uniform contamination through a depth of 4 m (13 ft) may underestimate the significance of the groundwater pathway in this assessment (as the residual contamination is actually closer to groundwater than assumed in these analyses), the water ingestion pathway is a minor contributor to the dose and risk for the Subsistence Farmer (see Tables R.29 through R.32 in Appendix R). The dominant exposure pathways for this hypothetical receptor are inhalation of radioactive contaminants and ingestion of produce grown in contaminated soil.

Using a more a realistic distribution of the current contamination pattern at the site would result in significantly higher PRGs (a non-conservative situation), as the dose-to-source ratios (mrem per pCi/g) would be largely limited to the groundwater-dependent exposure pathways. The water-dependent and water-independent pathways were considered separately in the RESRAD calculations, with the water-dependent pathways contributing less than 10 percent of the overall dose for the primary ROPCs, and for some radionuclides the contribution was less than 1 percent. Thus, while the approach used to develop the PRGs (as reflected in the intakes, doses and risks reported for the Subsistence Farmer scenario) may result in a slight underestimate in the contribution associated with the groundwater pathway, the net impact is small and the overall bias conservative in the reported doses and risks (and development of the PRGs).

The primary exposure pathways quantified in this assessment were determined on the basis of the CSM, characterization data, fate and transport considerations, and the scenario descriptions. The SLDA site is largely an open field surrounded by a chain link fence, with contaminated surface and subsurface soil being the environmental medium of most concern. The main exposure pathways are inhalation of contaminated dust, incidental ingestion of contaminated soil, and external gamma irradiation. A hypothetical Subsistence Farmer is addressed for future-use conditions, and additional pathways associated with ingestion of foodstuffs and groundwater are considered for this hypothetical individual. Consideration of these exposure pathways is standard practice in risk assessments, and EPA has developed a number of guidance documents for evaluating these types of exposures. There is little uncertainty associated with the exposure pathways assessed for the four hypothetical receptors in this risk assessment.

6.6.3 Uncertainties Related To Toxicity Information

Standard toxicity factors were used to estimate the health effects from hypothetical exposures to the radioactive contaminants at the SLDA. The health effects addressed in this BRA include the carcinogenic risks associated with internal and external exposures to radionuclides and the noncarcinogenic HI for uranium. The methods used to derive the toxicity factors are described in Section 6.4. The health risks associated with radiation exposure have been studied for many years and are considered well known at high doses. However, there is uncertainty when extrapolating these health risks to low doses such as those associated with exposures at the SLDA.

The risk coefficients and DCFs used in this assessment are based on the assumption that there is no threshold for health effects, i.e., that there is some risk of cancer at all exposure levels above zero, and that the dose-response relationship is linear in the low-dose portion of the curve. Under this assumption, the cancer risk coefficients and DCFs are constants, and the risks and doses are directly related to intake. In fact, a number of studies have been conducted which indicate that a threshold exists for radiation exposures, i.e., exposures below a certain level do not appear to result in cancer induction. Nevertheless, the use of risk factors based on the protective assumption of a linear no-threshold dose-response relationship is the default approach for estimating radiological risks and should result in a conservative estimate. The radiological risk coefficients and DCFs used in this assessment are generally accepted by the scientific community as representing reasonable but conservative projections of the hazards associated with radiation exposure.

The radiological cancer risks were estimated using risk coefficients developed by EPA, and these values are given in FGR 13 (EPA 1999b). These coefficients represent the estimated lifetime cancer risk per unit intake averaged over all ages and both genders and include the impact of competing risks. These risk coefficients were in part based on the extensive data file associated with human radiation toxicity including data on individuals who survived the atomic bombs at Hiroshima and Nagasaki; epidemiological studies of medical exposures to humans including the use of colloidal Th-232 (thorotrast) injected into patients as a radiographic contrast medium between 1928 and 1955; and studies of radium dial painters, radium chemists, and technicians exposed through medical procedures in the early 1900s. These studies are identified and discussed in FGR 13 and the references cited therein. These cancer risk coefficients have been used in numerous radiological risk assessments and provide a conservative but reasonable estimate of the risks associated with radiation exposure. The uncertainty associated with using these standard cancer risk coefficients to assess radiation toxicity is considered to be low.

Estimates of the radiation dose (TEDE) were made using standard DCFs given in FGR 11 (EPA 1988) and 12 (EPA 1993). These DCFs are based on the metabolic and anatomical model of an adult male, the ICRP reference man weighing 70 kg (about 150 pounds). The ICRP selected such a standardized individual for its dosimetry models because the main concern was worker protection and the majority of radiation workers are adult males. Although children are more susceptible to radiation exposure, i.e., the radiation doses are larger for children than adults for the same intake of radioactivity, such effects are significant only for very young children. The uncertainty associated with using DCFs developed for adults for the Adolescent Trespasser is relatively low, and does not significantly impact the radiation doses presented in this document. As described for the radiological cancer risk coefficients, these DCFs have been used in numerous assessments and evaluations for exposures to radiation and the uncertainty associated with their use is considered low.

In addition to the radiological cancer risks and doses, an estimate of the noncarcinogenic HI for uranium was included in this BRA. The HI was calculated by dividing the intake of uranium by the oral RfD. The oral RfD was developed by analyzing the biological effects of test animals given relatively large amounts of uranium. Although reliance on experimental animal data is widespread in general risk assessment practices, chemical absorption, distribution, metabolism, excretion (toxicokinetics), and toxic responses (toxicodynamics) can differ between humans and the species for which experimental toxicity data are available. Additional uncertainties in using animal data to predict potential effects in humans are introduced when routes of exposure in animal studies differ from human exposure routes, when the exposures in animal studies are short-term or subchronic, and when effects seen at relatively high exposure levels in animal studies are used to predict effects at much lower exposure levels found in the environment.

To compensate for uncertainties that arise from the use of animal data, regulatory agencies often base the RfD on the most sensitive animal species. Doses are then adjusted using safety or uncertainty factors (an uncertainty factor of 1,000 was used for the uranium RfD). This adjustment compensates for the lack of knowledge regarding interspecies extrapolation, and guards against the possibility of humans being more sensitive than the most sensitive animal specifies tested. This use of uncertainty factors is considered to be protective of human health. This results in more uncertainty that for the radiological cancer risk coefficients and DCFs, which are based (in part) on data for humans exposed to radiation. However the overall effect of this uncertainty does not negatively impact the results presented here as the HI for uranium exposures is well below the level of concern.

6.7 Identification of Radionuclides of Concern

Based on the results of the recent characterization program and evaluation of potential risks to human health and the environment, the ROCs are determined to be the eight primary ROPCs. While there were a few isolated values of some secondary ROPCs that exceeded the 95 percent UTL concentrations for background, these values did not exceed background by a significant amount (all of the values were less than twice background). As noted previously in Section 6.2.4, the 95 percent UTL does not reflect the full range of background concentrations, and it possible to observe occasional hits above the UTL and still be within the range of background. In addition, these elevated levels reported for the secondary ROPCs appear to be generally collocated with elevated levels of the primary ROPCs, so addressing the risks for the primary ROPCs would also result in addressing any secondary ROPCs that may be present.

Most of the radioactive contamination is associated with wastes buried in the upper trench area of the SLDA (associated with Trenches 1 through 9), and the major radionuclides in this portion of the site are the three uranium isotopes (U-234, U-235, and U-238), Th-232, and Ra-228. Of the three uranium isotopes, U-234 has the highest concentrations, which is indicative of enriched uranium. Very little contamination is associated with Trench 10, and this is the only area of the site that appears to be significantly contaminated with Am-241, Pu-239, and Pu-241. These results are consistent with historic information reported for the site.

While the sampling results provide evidence to support the contention that some radionuclides may only be present at specific areas of the site, all eight of the primary ROPCs will be retained as ROCs for all portions of the site. This will ensure that cleanup of the SLDA is conducted in a thorough manner and will result in conditions that are fully protective of human health and the environment.

6.8 Remedial Action Objectives

The overall objective of this project is to conduct remedial actions at the SLDA in accordance with Section 8143 of P.L.107-117, which directed the Secretary of the Army to cleanup radioactive waste at the site consistent with the July 5, 2001, MOU between NRC and USACE for coordination on cleanup and decommissioning of FUSRAP sites with NRC-licensed facilities. The MOU applies to USACE response actions meeting the decommissioning requirements given in 10 CFR 20.1402, i.e., for unrestricted future use. As stated in 10 CFR 20.1402, a site is considered acceptable for unrestricted use if the above-background residual radioactivity does not result in a TEDE to an average member of the critical group in excess of 25 mrem/yr, and that the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA). A Subsistence Farmer scenario was evaluated to represent exposures to the critical group for determining compliance with this requirement, and PRGs were developed using the probabilistic version of the RESRAD computer code consistent with NRC decommissioning guidance. These PRGs are provided in Table 6-1 and are being used as screening tools to better define the nature and extent of contamination.

Additional remedial action objectives include complying with other potential ARARs (in addition to the radiological requirements given in 10 CFR 20.1402), and conducting remedial actions in a manner that would minimize public and worker exposures to site-related contaminants. The ARARs for this project will be developed as part of the FS process, and will include input from PADEP and other state agencies. The complete list of remedial action objectives will be developed in the future in consultation with NRC, PADEP, and other stakeholders following completion of the RI report. These objectives will be factored into the evaluations to be performed as part of the FS.

6.9 Summary of Radiological Risk

This BRA was prepared consistent with EPA risk assessment guidance to support the determination of appropriate future actions at the SLDA site. The results of the human health risk assessment were developed according to four basic steps: identification of the contaminants of concern, development of exposure scenarios and input parameters, identification of the major toxic effects for the contaminants of concern, and presentation of the health risk characterization results. This assessment was limited to radioactive contaminants at the SLDA, consistent with the authorizing legislation for this site. The chemical toxic effects of these radioactive contaminants were considered in this assessment, specifically the chemical toxicity of uranium.

Eight primary ROPCs were identified for the SLDA based on historical information and site characterization activities. These radionuclides are: Am-241, Pu-239, Pu-241, Ra-228, Th-232, U-234, U-235, and U-238. As described in Sections 3.0 and 4.0, characterization activities were recently conducted to determine the concentrations of these radionuclides in soil, which is the primary impacted environmental medium at the site. The results of this characterization program were consistent with previously reported information; the radioactive contaminants are generally located in close vicinity of the ten waste trenches and have not migrated to groundwater. This program also confirmed that the concentrations of radionuclides in the previously disposed of wastes are significantly higher than the PRGs developed for soil at the site. These wastes as well as subsurface soil within the ten trenches were not quantitatively addressed in this BRA, as alternatives for managing these materials will be identified and evaluated in detail in the FS. However, as concentrations in the trenches are above the PRGs, potential future doses and cancer risks would be unacceptable.

Four hypothetical scenarios were developed to reflect reasonably likely patterns of human activity that might result in exposures to the radioactive contaminants at the SLDA. The two current-use scenarios (Maintenance Worker and Adolescent Trespasser) reflect possible exposures in the near term reflecting the current administrative controls at the site, and two future-use scenarios (Construction Worker and Subsistence Farmer) consider greater exposures that could occur in the future should these administrative controls be lost. These scenarios reflect a range of potential exposures and intakes, and provide useful information for guiding future decisions at this site. Patterns of activity were identified for these hypothetical individuals to determine the frequency and duration of exposures, the concentrations of radioactive contaminants to which these receptors could be exposed, and appropriate intake parameters. The Subsistence Farmer was evaluated as the conceivable, but unlikely and worst-case (bounding) scenario for the SLDA site.

The estimated radiological risks, radiation doses, and HIs associated with exposures for the four hypothetical scenarios considered in this BRA are given in Table 6-10. Separate estimates are given for each EU and for site-wide exposures. As shown in Table 6-10, the estimated risks range from 9×10^{-9} (Construction Worker in EU 2 and Adolescent Trespasser for site-wide exposures) to 1×10^{-5} (Subsistence Farmer in EU 1). The risks are all within or below EPA's target risk range of 1×10^{-6} to 1×10^{-4}. The maximum risk of 1×10^{-5} is a factor of ten below the level which would indicate a need for remedial action. These risks are low because there is very little contamination of soil outside the trenches, and the wastes in the trenches were not included in the development of EPCs for this BRA. In evaluating the results in Table 6-10, it is important to note that the EPCs for the two current-use scenarios were based on the surface soil concentrations, while the EPCs for the two future-use scenarios were based on the composite concentrations through the entire depth of the samples. The surface soil concentrations were larger than the composite values, especially in EU 2.

The estimated radiation doses given in Table 6-10 range from 0.03 mrem (Adolescent Trespasser in EU 1 and EU 3, and Construction Worker in EU 3) to 100 mrem (Subsistence Farmer in EU 2). As with the radiological cancer risk estimates, the maximum doses are associated with the Subsistence Farmer scenario, which formed the basis for development of the PRGs. The annual dose to the Subsistence Farmer ranges from less than 1 mrem/year (in EU 3) to approximately 5 mrem/year (in EU 2). The annual dose for the Maintenance Worker in EU 2 is estimated to be about 4 mrem/year, and the annual dose to the Construction Worker in this EU is estimated to be about 2 mrem/year. All other annual doses are estimated to be less than 1 mrem/year.

The estimated HIs for the various receptors range from less than 0.001 to 0.010. These values are all much less than 1, which indicates little potential for noncarcinogenic health effects.

The SLDA site presents very little risk to human health and the environment under current conditions. The site is currently vacant and surrounded by a security fence that is actively maintained. The site is routinely monitored and the open field is mowed several times a year, air at the site perimeter is being monitored, and there are a number of groundwater monitoring wells in the vicinity to determine the status of potential groundwater contamination. However, these conditions cannot be guaranteed in perpetuity, and over time the radionuclides in the trenches would be expected to gradually leach to groundwater. The SLDA is also susceptible to subsidence from collapse of the abandoned mine workings beneath the site. There is very little soil contamination at the SLDA outside the footprints of the ten trenches, and the little contamination that is present poses very little current and future risk.

7.0 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

The USACE is evaluating the need for remedial actions at SLDA under CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA). There are several sections of CERCLA and SARA that indicate a requirement to protect the environment, i.e., Sections 104, 105(a)(2), 121(b)(1), 121(c), and 121(d). An ecological risk assessment will support decisions concerning whether or not remedial actions at the site should occur in order to protect the environment and ecological receptors. The NCP indicated that an ecological risk assessment should be conducted along with a human health risk assessment in the RI stage of the CERCLA process. The NCP called for the identification and mitigation of environmental impacts (such as toxicity, bioaccumulation, death, reproductive impairment, growth impairment, and loss of critical habitat) at hazardous waste sites, and for the selection of remedial actions to protect the environment.

7.1 Scope and Objectives

An ecological risk assessment is a process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors. The process is used to systematically evaluate and organize data, information, assumptions, and uncertainties in order to help understand and predict the relationships between stressors and ecological effects in a way that is useful for environmental decision making (EPA 1998). The EPA has developed an eight-step process for conducting ecological risk assessments for Superfund (EPA 1997c). The first two steps are considered screening level steps, while the latter 6 steps are considered part of a baseline ecological risk assessment. A screening level ecological risk assessment (SLERA) relies on site data and conservative assumptions. If no potential for unacceptable ecological risks are identified at the end of the SLERA, then there is no need to conduct a complete baseline ecological risk assessment.

A screening level ecological risk assessment was performed in order to determine the potential for adverse ecological effects to occur from exposure to radionuclides at the SLDA, in the absence of remedial action. The risks due to toxic chemical effects of uranium exposure were also considered.

7.2 Procedural Framework

This SLERA was performed for radionuclides using the DOE's *Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota,* as outlined in their technical standard (DOE 2002b). The DOE graded approach includes screening methods, as well as methods for a more detailed analysis, akin to a baseline risk assessment, that may be used to evaluate whether or not dose limits appropriate for the protection of biota are exceeded at a radiologically contaminated site. These dose limits have been presented and discussed by the NCRP (NCRP 1991) and the International Atomic Energy Agency (IAEA 1992). The graded approach uses the biota dose limits, given below, to demonstrate that populations of plants and animals are adequately protected from the effects of ionizing radiation.

> Aquatic animals: The adsorbed dose to aquatic animals should not exceed 1 rad/d (10 mGy/d) from exposure to radiation or radioactive material releases into the aquatic environment.

> Terrestrial plants: The adsorbed dose to terrestrial plants should not exceed 1 rad/d (10 mGy/d) from exposure to radiation or radioactive material releases into the terrestrial environment.

> Terrestrial animals: The adsorbed dose to terrestrial animals should not exceed 0.1 rad/d (1 mGy/d) from exposure to radiation or radioactive material releases into the terrestrial environment.

The graded approach consists of a three-step process, which is designed to guide a user from an initial, conservative general screening to a more rigorous analysis using site-specific information (if needed). As such, the graded approach is akin to EPA's eight-step process for ecological risk assessments. The general screening step of the DOE graded approach is comparable to initial steps of a SLERA. If the general screening step is passed, there is no need to apply further steps within the graded approach. Each phase within the SLERA is discussed in terms of how the DOE graded approach is applied at that phase for ecological exposures to radionuclides. For evaluation of the toxic chemical effects of uranium, a standard SLERA was performed, through the refinement step 3A, according to EPA guidance (EPA 1997c).

7.3 Problem Formulation

Problem formulation involves a description of the environmental setting, an overview of the nature and extent of site contamination (in this case, limited to radioactive constituents and the chemical toxicity of uranium), and a presentation of the pathways linking contamination to ecological receptors. The ecological values to be protected (or assessment endpoints) are defined, as are the measurement endpoints that will be used in this screening-level assessment.

A general site description of the SLDA is found in Section 2.3 of this RI report. In addition, Chapter 3 of the Site Characterization Report prepared by the site owners (ARCO/B&W 1995) contains a more detailed description of the physical features of the site. This information was also used in this assessment.

The site is located on a hillside with upland terrain. The site has a vegetative cover of grassland and woodland plants. Dynamic processes such as soil erosion, mass wasting, gully erosion, and subsidence may affect the site. There is an intermittent stream (Dry Run) running to the northeast of the upper trenches. Several groundwater seeps are found on-site in the steep slope area immediately north of trenches 1 to 9 and above Dry Run. The seeps are not constant and go dry for extended periods. The seeps occur in notches near Dry Run where the topography intersects the seasonally high water table.

7.3.1 Conceptual Site Model

A screening level ecological conceptual site model for SLDA is presented in Figure 7-1. The mechanism for contamination at the site was through burial of radioactive wastes, and the source media is the trench wastes. Transport mechanisms included related site activities such as storage of materials on the surface, and excavation and re-burial of the wastes in the trenches. Other transport mechanisms are surface water seepage, and intrusion of biota into the trenches, such as plant roots or burrowing animals. The main environmental medium for ecological exposures was contaminated surface soil, and exposures could also occur through the food chain. Although Dry Run experiences periods of seasonal no-flow conditions, for the sake of conservatism in this screening level assessment, any radionuclide contamination in Dry Run sediments and surface water was evaluated for potential risks to aquatic receptors. Dry Run sediments were also included with surface soils for exposure to terrestrial receptors.

7.3.2 Identification of Constituents Of Potential Ecological Concern

The constituents of potential ecological concern (CPECs) are the same as the ROPCs for human receptors. As explained in Section 6.2 of this RI report, preliminary ROPCs were developed for the SLDA based on historical uses (specifically the radiological characteristics of the wastes buried in the trenches) and previous characterization activities. These preliminary ROPCs are discussed in Section 5.1, and are divided into primary and secondary ROPCs. The primary ROPCs are those radionuclides expected to be present at the site at concentrations posing a potential risk concern. Tables 7-1, 7-2, and 7-3 show the concentrations of primary ROPCs in surface soil, Dry Run, and Carnahan Run, respectively. The values for Dry Run and Carnahan Run reflect the first sampling event; the second phase (conducted in June 2004) had comparable results.

The primary ROPCs for the SLDA are: Am-241, Pu-239, Pu-241, Ra-228, Th 232, U-234, U-235, and U-238. Additional radionuclides may also be present, and these secondary ROPCs for the SLDA were: Cs-137, Co-60, Pu-238, Pu-240, Pu-242, Ra-226, and Th-230. As it was determined in the data evaluation for the human health BRA (Section 6.0), i.e., that only the primary ROPCs needed to be evaluated for the site, this SLERA also did not consider exposure to secondary ROPCs. Uranium was also considered for its chemical toxicological effects, as well as for its ionizing radiation properties.

7.3.3 Ecological Surveys And Description Of Habitats And Populations

Section 3.6 of the SLDA Draft Environmental Impact Statement (DEIS) prepared by the NRC describes the ecology of the site in detail (NRC 1997), and some of this information is also presented in Section 6.3.1 of this report. Most of the SLDA site is an open field that is mowed a few times a year, and vegetation in these areas is largely various species of grasses and annuals. About 4 ha (10 acres) are woodland, mainly in the vicinity of Dry Run near the northeast boundary and also in the southern and southeastern corners of the site. There are three small wetlands on the site, the largest of which runs along the length of Dry Run. About one-third of the soils on the property qualify as prime farm land. Wildlife at the site and nearby vicinity include a number of small mammals such as mice, voles, shrews, rabbits, squirrels, chipmunks, raccoons, skunks, and woodchucks. Whitetail deer are also common in this area. Typical reptiles in this area include box turtles and garter snakes. Various species of birds are expected to be present in both the open grass as well as the wooded areas, such as mourning doves, wild turkey, bobwhite quail, ruffled grouse, woodcock, and others. There are no permanent surface water bodies, and the intermittent flows in Dry Run do not support stable or well-developed aquatic communities, although some algae, vascular plants, and small invertebrates tolerant of extreme fluctuations between dry and wet conditions may thrive there. However, muskrats and mink may likely exist along streams near the site. There are no known threatened or endangered species at the site, other than for occasional transient species such as the southern bald eagle and American peregrine falcon, according to the various federal and state agencies contacted concerning the site (U.S. Fish and Wildlife Service, Pennsylvania Game Commission, Pennsylvania Fish and Boat Commission, Pennsylvania Department of Conservation and Natural Resources) (NRC 1997).

7.3.4 Selection Of Exposure Units And Receptor Species

The entire SLDA site was considered as a single terrestrial exposure unit. Terrestrial animals and plants may be exposed to surface soils at the site, down to 1.2 m (4 ft) below ground surface (bgs). Most burrowing animals and plant roots do not extend beyond this depth, so deeper soil and waste samples were not considered for exposure to ecological receptors. Because Dry Run is only an intermittent stream, Dry Run sediments will also be included as part of this surface soil exposure unit. Although it is obviously not the sole source of drinking water for animals at the site, Dry Run surface water results will be considered as part of this exposure unit.

For conservatism in this screening-level assessment, any radionuclide contamination in Dry Run sediments and surface water was evaluated as an aquatic exposure unit to assess potential risks to aquatic receptors. In addition, the surface water and sediments at Carnahan Run were considered as a separate aquatic exposure unit. For both these aquatic exposure units, riparian receptors (raccoons) were assumed to be present. No sediment or surface water screening levels were available for chemical toxic effects of uranium. The implications for this is discussed in the uncertainty section (Section 7.7.5) of this report.

For a screening level assessment, the DOE's graded approach begins by modeling doses to hypothetical terrestrial, riparian, and aquatic organisms. The dose limits were established to protect populations of biota within each type of ecological setting. The assumptions and parameters used in DOE's general screening phase of the graded approach are based on a maximally exposed individual within each type of exposure unit, representing a conservative approach for screening purposes. The choice of this hypothetical maximally exposed individual would be protective of actual ecological receptors present at the site. For aquatic exposure units, fish and crustacea such as crayfish are likely receptors in Carnahan run. Raccoons are riparian animals that are likely to be found at both the Carnahan Run and Dry Run exposure units. Various species of grasses, shrubs, and trees may be found on the SLDA site terrestrial exposure unit. Rabbits and hawks are two examples of terrestrial wildlife that may serve as ecological receptors for the terrestrial exposure unit.

7.3.5 Ecological Assessment and Measurement Endpoints

The protection of ecological resources, such as habitats and species of plants and animals, is a principal motivation for conducting SLERAs. Key aspects of ecological protection are presented as management goals, which are general goals established by legislation or agency policy and based on societal concern for the protection of certain environmental resources. The ecological management goal for the SLDA is the protection of terrestrial plant and animal populations, and aquatic plant and animal populations, from adverse effects due to the release or potential release of radionuclides associated with past site activities.

The measurement endpoint is comparison of radionuclide concentrations in each exposure unit, with biota concentration guidelines (BCGs), developed for the general screening phase of DOE's graded approach. A BCG is the limiting concentration of a radionuclide in soil, sediment, or water that would not cause dose limits for protection of populations of aquatic and terrestrial biota to be exceeded. The BCGs are analogous to DCGLs or PRGs that are developed to be protective of dose limits to humans (Section 6). Just as the SOR approach is used when multiple radionuclides are present to ensure that human dose limits are not exceeded, the SOR approach is also applied to BCGs when multiple radionuclides are present in the environment. The DOE's BCG calculator, release 2.0 (an Excel spreadsheet), will be used to compare site data with generic BCGs. The generic BCGs for terrestrial systems are listed in Table 7-5, while generic BCGs for aquatic systems are listed in Tables 7-6 and 7-7. Development of the BCGs is discussed more in Sections 7.4 and 7.5.

For screening-level evaluation of the chemical toxic effects of uranium, the soil screening level was based upon protection of terrestrial plants, and can be found in Table 7-8 (based on *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision,* Oak Ridge National Laboratory, by R.A. Efroymson, M.E. Will, G.W. Suter II, and A.C. Wooten).

7.3.6 **Summary of CPECs**

In summary, concentrations of the primary ROPCs Am-241, Pu-239, Pu-241, Ra-228, Th-232, U-234, U-235, and U-238 in surface soils (0 to 1.2 m [4 ft]), Dry Run sediments and surface water, and Carnahan Run sediments and surface water, were compared to DOE's general screening BCGs in each media. The SOR was used to ensure that dose limits protective of biota are not exceeded. If the maximum detected concentrations of radionuclides were less than the generic BCGs, and the SOR of BCGs was less than one, then it could be concluded that biota dose limits were not exceeded at the SLDA, and the site passed the SLERA. If, however, the generic BCGs were exceeded, then food uptake modeling was done as the ecological assessment proceeded to a more site-specific analysis.

Uranium was also considered a CPEC for its chemical toxicity. The maximum concentration of total uranium in surface soils (0 to 1.2 m [4 ft]), including Dry Run sediments, was compared to the soil screening level for total uranium. If the maximum concentration of total uranium exceeded the screening level (i.e., the ecological effects quotient was greater than one), then a refinement of the screening step was done, which involved comparing the EPC in the terrestrial soils ecological exposure unit to the screening level. If the refined screening resulted in an ecological effects quotient greater than one, then food uptake modeling was done as the ecological assessment proceeded to a more site-specific analysis.

7.4 Exposure Assessment

In the exposure assessment portion of a SLERA, the sources of contamination, receptors, and pathways of exposure were quantified.

7.4.1 Ecological Receptors and Exposure

As stated in Section 7.3.4, the DOE's generic BCGs were developed to protect a hypothetical maximally exposed individual (i.e., a representative terrestrial, aquatic, or riparian receptor) within each type of exposure unit. If these generic BCGs were not exceeded, then it was assumed that real ecological receptors would also be protected.

As explained in the DOE's technical standard (DOE 2002b), for external sources of radiation exposure, it was assumed that all of the ionizing radiation was deposited in the organisms (i.e., no pass-through and no self-shielding). This is conservative, and is tantamount to assuming that the radiosensitive tissues of concern (the reproductive tissues) lie on the surface of a very small organism. For external exposure to contaminated soil, the source was presumed to be infinite in extent. In the case of external exposure to contaminated sediment and water, the source was presumed to be semi-infinite in extent. The source medium to which the organisms were continuously exposed was assumed to contain uniform concentrations of radionuclides. These assumptions provided for appropriately conservative estimates of energy deposition in the organism from external sources of radiation exposure.

For internal sources of radiation exposure, estimates of the contribution to dose from internal radioactive material were conservatively made assuming that all of the decay energy is retained in the tissue of the organism. Progeny of radionuclides and their decay chains were also included. This provided an over-estimate of internal exposure, as the lifetime of many of the biota of interest was generally short compared to the time for the build up of progeny for certain radionuclides. The radionuclides were presumed to be homogeneously distributed in the tissues of the receptor organism. This was unlikely to under-estimate the actual dose to the tissues of concern (i.e., reproductive organs). A radiation weighing factor of 20 for alpha particles was used in calculating the BCGs for all organism types. This was conservative, especially if nonstochastic effects are most important in determining harm to biota. The true value may be a factor of 3 to 4 lower (DOE 2002b).

7.4.2 Quantification of Exposure

For the general screening phase of the DOE's graded approach, maximum detected concentrations of radionuclides measured in the first round of sampling for the recent RI field investigations were compared to the generic BCGs. As noted in Section 7.3.2, results from the second round of sampling were comparable to the first round of sampling. Inclusion of results from the second round of sampling would not change the conclusions reached in this evaluation. Only results from the recent site characterization activities were used, as analysis from previous investigations did not include as extensive an isotopic analysis of samples as was done in the current investigation. For further discussion of data evaluation, please see Section 6.2. If the maximum detected concentrations of radionuclides or uranium chemical exceeded their respective screening levels, then EPCs, as developed in Section 6.3.4, were compared to the screening level or BCGs.

7.4.3 Radionuclide Exposure Evaluation

Biota within each exposure unit were likely to be exposed to a range of radionuclide concentrations, and continual exposure to the maximum detected concentration was an overestimation of the true exposure. If the maximum detected concentrations of radionuclides were less than the BCGs, and the SOR of BCGs was less than one, then it could be concluded that biota dose limits had not been exceeded, and the site passed the SLERA.

The maximum detected concentrations of radionuclides within each exposure unit (terrestrial soils from 0 – 1.2 m [4 ft] bgs, aquatic exposures within Dry Run, and aquatic exposures within Carnahan Run) are presented in Tables 7-1 through 7-3.

7.4.4 Chemical Exposure Evaluation

The concentrations of total uranium (in mass units) were determined by converting isotopic uranium radioactivity concentrations to mg/kg, using the same conversion factors as presented in Appendix R, Section R.3. The conversions from radioactivity to mass are presented in Table 7-4.

7.4.5 Exposure Assessment Summary

The maximum detected concentrations of radionuclides within each exposure unit measured in the recent characterization program were compared to the generic BCGs, or chemical total uranium screening levels, to perform the SLERA. If the maximum detected concentrations exceeded the BCGs or the uranium soil screening level, then a comparison of the BCG or screening level to the EPC was made.

7.5 Effects Evaluation

7.5.1 Effects Evaluation For Radionuclides

The DOE's *Graded Approach For Evaluating Radiation Doses To Aquatic And Terrestrial Biota* was developed to address the growing concern that dose limits and standards established to protect human health may not always adequately protect ecological receptors from the ionizing effects of radiation. This assumption that protecting human health also protects biota, is most appropriate in cases where humans and other biota inhabit the same environment and have common routes of exposure, and less appropriate in cases where human access is restricted or pathways exist that are much more important for biota than for humans. The following excerpts from the DOE's technical standard explain the rationale establishing dose limits protective of aquatic and terrestrial biota (DOE 2002b).

At the request of DOE, the NCRP reviewed the literature on the effects of radiation on aquatic organisms and prepared a report on the then-current understanding of such effects (NCRP 1991). The report also provided guidance for protecting populations of aquatic organisms, concluding that a chronic dose of no greater than 1 rad/d (0.4 mGy/h) to the maximally exposed individual in a population of aquatic organisms would ensure protection of the population. The IAEA examined and summarized the conclusions regarding aquatic organisms of several previous reviews (IAEA 1992) as follows:

- Aquatic organisms are no more sensitive than other organisms; however, because they are poikilothermic animals, temperature can control the time of expression of radiation effects.
- The radiosensitivity of aquatic organisms increases with increasing complexity, that is, as organisms occupy successively higher positions on the phylogenetic scale.
- The radiosensitivity of many aquatic organisms changes with age, or, in the case of unhatched eggs, with the stage of development.
- Embryo development in fish and the process of gametogenesis appear to be the most radiosensitive stages of all aquatic organisms tested.

- The radiation-induced mutation rate for aquatic organisms appears to be between that for Drosophila (fruit flies) and mice.

Furthermore, the 1992 review found that the conclusions of an earlier IAEA review (IAEA 1976) were still supported; namely, that appreciable effects in aquatic populations would not be expected at doses lower than 1 rad/d (10 mGy/d) and that limiting the dose to the maximally exposed individuals to less than 1 rad/d would provide adequate protection of the population.

The IAEA (1992) summarized information about the effects of acute ionizing radiation on terrestrial organisms as follows:

- Reproduction (encompassing the processes from gametic formation through embryonic development) is likely to be the most limiting endpoint in terms of survival of the population.
- Lethal doses vary widely among different species, with birds, mammals, and a few tree species being the most sensitive among those considered.
- Acute doses of 10 rad (100 mGy) or less are very unlikely to produce persistent and measurable deleterious changes in populations or communities of terrestrial plants or animals.

The IAEA (1992) also summarized information about the effects of chronic radiation on terrestrial organisms:

- Reproduction (encompassing the processes from gametogenesis through embryonic development) is likely to be the most limiting endpoint in terms of population maintenance.
- Sensitivity to chronic radiation varies markedly among different taxa; certain mammals, birds, reptiles, and a few tree species appear to be the most sensitive.
- In the case of invertebrates, indirect responses to radiation-induced changes in vegetation appear more critical than direct effects.

- Irradiation at chronic dose rates of 1 rad/d (10 mGy/d) or less does not appear likely to cause observable changes in terrestrial plant populations.
- Irradiation at chronic dose rates of 0.1 rad/d (1 mGy/d) or less does not appear likely to cause observable changes in terrestrial animal populations. The assumed threshold for effects in terrestrial animals is less than that for terrestrial plants, primarily because some species of mammals and reptiles are considered to be more radiosensitive.
- Reproductive effects on long-lived species with low reproductive capacity may require further consideration.

The NCRP and IAEA concluded for aquatic organisms, and the IAEA concluded for terrestrial organisms, that the statement by the ICRP (ICRP 1977, ICRP 1991), "...if man is adequately protected, then other living things are also likely to be sufficiently protected" was reasonable within the limitations of the generic exposure scenarios examined.

Later studies and reviews by other international and national radiation protection agencies also supported the conclusions that dose limits of 1 rad/d is protective of populations of aquatic animals and terrestrial plants, and 0.1 rad/d is protective of populations of terrestrial animals (UNSCEAR 1996, Gentner 2002, Copplestone et al. 2001, CNSC-ACRP 2002). It should be noted that exposure below the recommended dose limits would not cause adverse effects at the population level, even though some individuals within the population might be adversely affected.

7.5.2 Effects Evaluation For Total Uranium Chemical Toxicity

The soil screening level for chemical toxicity of uranium was based on a phytotoxic endpoint, with reduced root weight being the critical effect (Efroymson et al., 1997). The mechanisms of uranium phytotoxicity involve inhibition of enzyme systems and possibly binding to nucleic acids. The minimal amount of radiation measured in the experimental plants has led researchers to the conclusion that toxic effects are the result of the element rather than radiation.

7.6 Risk Characterization for Ecological Receptors

7.6.1 Current Preliminary Risk Characterization for Radionuclides

The maximum detected concentrations of radionuclides in the top 1.2 m (4 ft) of soil measured across the site were compared to the generic BCGs for terrestrial systems. In addition, the maximum detected concentrations of radionuclides from Dry Run surface water samples were compared to the water BCGs for terrestrial systems. As seen in Table 7-5, the SOR for site wide soils is less than 1 (0.3), so biota dose limits have not been exceeded for the terrestrial exposure unit.

The maximum detected concentrations of radionuclides from Dry Run surface water and sediments were compared to generic BCGs for aquatic systems in Table 7-6. The SOR for this exposure unit is also less than 1 (0.4), and so biota dose limits have not been exceeded for this aquatic exposure unit.

The maximum detected concentrations of radionuclides from Carnahan Run surface water and sediments were compared to generic BCGs for aquatic systems in Table 7-7. The SOR for this exposure unit is also less than 1 (0.5), and so biota dose limits have not been exceeded for this aquatic exposure limit.

7.6.2 Future Preliminary Risk Characterization For Radionuclides

The ecological risk calculations performed for current conditions in Section 7.6.1 bound the risks for these receptors under future conditions. The EPCs for ecological receptors will decrease with time through radioactive decay and gradual dispersion in the environment through natural processes including leaching and migration to groundwater, surface water runoff, and erosion by wind and surface water. The results presented in Section 7.6.1 conservatively address ecological concerns for future times and, since the SOR is below 1, no unacceptable risks to potential ecological receptors are predicted to occur.

Of the two processes identified above, environmental dispersion is likely to be the major contributor to a reduction in EPCs with time. Most of the radionuclides at the SLDA have very long half-lives, and radioactive decay is significant for only two ROPCs over the 1,000 years considered in this assessment, i.e., Ra-228 and Pu-241. The concentration of Ra-228 (half-life of 5.8 years) would decrease by radioactive decay quite rapidly in the absence of its parent Th-232. However, Th-232 is present at the site and the concentrations of these two radionuclides in environmental media are comparable, which would indicate that Ra-228 is likely present in secular equilibrium with Th-232 at the site. Under these conditions, the concentration of Ra-228 will decrease by radioactive decay in accordance with the half-life of Th-232 (14 billion years). Hence, there would be no appreciable reduction in the concentration of Ra-228 due to radioactive decay over the next 1,000 years.

The half-life of Pu-241 is about 14 years, so the concentration of this radionuclide will decrease quite quickly by radioactive decay. This decrease in the Pu-241 concentrations is offset by the ingrowth of its decay product Am-241. As noted for the human health BRA, Am-241 (an alpha emitter) presents a greater risk to humans than Pu-241 (a beta emitter). The significance of the ingrowth of Am-241 is discussed in Section 7.7.3 in terms of the lack of a screening value for Pu-241. However, it can generally be concluded that time will tend to lower the ecological risk associated with Pu-241, largely due to dispersion by environmental processes.

All of the other six ROPCs at the SLDA have very long half-lives, and the concentrations of these radionuclides will not diminish significantly in the next 1,000 years. Radionuclide ingrowth was explicitly addressed in the human health BRA discussed in Chapter 6, and of these six radionuclides, radionuclide ingrowth is a concern only for U-235 (due to ingrowth of Pa-231 and Ac-227). While the contribution of these two U-235 decay products was considered in the human health assessment, this is not possible for this evaluation as screening values are not available for these two radionuclides. However, U-235 is a minor contributor to the ecological risk (see Tables 7-5, 7-6, and 7-7), so the results would not be significantly changed even if it were possible to account for the contribution of Pa-231 and Ac-227 in this assessment.

Based on these considerations, it is concluded that there is no need to quantify the ecological risk characterization for future conditions, which is conservatively addressed in Section 7.6.1.

7.6.3 Preliminary Risk Characterization For Total Uranium

As seen in Table 7-8, the maximum detected concentrations of total uranium exceeds the soil screening level, resulting in an ecological effects quotient greater than one. Therefore, a refinement of the screening step would seem to be warranted, in which a more realistic exposure assessment is used. However, it is not reasonable to assume that populations of plants across the site are only exposed to the maximum concentration of uranium. It is more reasonable to assume that on average, plants would be exposed to the site-wide EPC (see Table 7-4) of total uranium. The site-wide EPC for total uranium is less than the soil screening level, resulting in an ecological effects quotient of less than one (Table 7-8). Therefore, there is little potential for unacceptable risk to ecological receptors, due to the chemical toxic effects of uranium at SLDA.

7.6.4 Use of Characterization Results

A conservative screen of radionuclide concentrations recently measured in environmental media at the site against generic BCGs indicates that the ROPCs at SLDA do not pose a risk to ecological receptors. The SLERA was completed for radionuclides at the first, initial screening step. A refinement of the initial screening was necessary for total uranium. However, the EPC of total uranium is less than the chemical soil screening level. Therefore, no further evaluation of radionuclides or total uranium concentrations at the site with respect to their potential for posing ecological risks is warranted.

The USACE will consider environmental impacts from remedial action alternatives during preparation of the FS. However, the greatest environmental impacts from any remedial action alternative are likely to result from physical disturbances of the site, rather than exposure to radiological or total uranium contamination.

7.7 Uncertainties

There are uncertainties associated with every risk assessment, as not all the parameter values that need to be included in risk characterization can be completely characterized. In a SLERA, the assumptions used to estimate these values are designed to be conservative, so that the screening-level risk characterization overestimates the actual risk. Some of the assumptions and their impact on the uncertainty of the risk characterization are discussed below.

7.7.1 Problem Formulation

In problem formulation, the ecological receptors and the exposure routes linking sources of radiological contamination to receptors are identified. At the screening level, exposure routes and receptors are chosen to represent maximum potential exposure, of maximally exposed hypothetical individuals. For example, there are no true aquatic habitats on site, so there is some uncertainty with choosing BCGs developed to protect aquatic receptors. However, since Dry Run provides surface water at the site, it was assumed that some aquatic and riparian receptors could be exposed to contaminants at Dry Run for limited times of the year. Therefore, Dry Run sediments and surface waters were screened using generic BCGs developed to protect both terrestrial and aquatic ecosystems. By doing so, it is assured that all types of ecological receptors that could possibly exist or visit the site are protected.

7.7.2 Exposure Assessment

The assumptions used to estimate both external and internal doses for the generic screening step of the DOE's graded approach were presented in Section 7.4. There are obviously many uncertainties associated with these assumptions, but all of these assumptions are intended to protect a hypothetical maximally exposed individual from radioactive contaminants. As such, the assumptions overestimate the doses to a real ecological receptor, and are overly protective, which is appropriate at the first step in a screening-level assessment.

7.7.3 Effects Assessment

Various national and international radiation protection agencies agree that the dose limits set by the DOE (DOE 2002b) and used in this SLERA, are protective of populations of ecological receptors (see Section 7.5). Although there may be some uncertainty as to whether or not these limits may be protective of individuals within the population, the goal of the SLERA is to protect entire ecological populations, and not specific individuals, since no threatened and endangered species have been identified for SLDA.

The greatest uncertainty in the effects assessment is the lack of a screening value for Pu-241. However, it should be noted that the maximum detection of Pu-241 was 628 pCi/g, which is significantly less than the PRG of 890 pCi/g developed to be protective of human health using a Subsistence Farmer scenario (see Section 6.0). Since the human health PRG is based on a lower dose limit than the BCG for protection of terrestrial animals (25 mrem/year vs. 0.1 rad/day), and includes intensive exposure to soils, water, and ingestion of contaminated produce and animal products, it can be concluded that Pu-241 is not present at levels that would harm terrestrial animals.

Pu-241 decays by emitting a beta particle to Am-241, and it is exposures to Am-241 that represent the major human health concerns associated with Pu-241. The maximum Am-241 concentration is about 3 percent of the initial Pu-241 concentration, and this occurs about 73 years in the future. (This assumes no movement in the environment, such as would occur in a waste container.) The Pu-241 dose peaked at about 60 years for the Subsistence Farmer scenario in the RESRAD runs used to develop the PRGs (see Section 6.0 and Appendix R), and the Am-241 concentration was about 2.9 percent of the initial Pu-241 activity. Adding 3 percent of the maximum measured Pu-241 concentration (or about 19 pCi/g) to the Am-241 concentration given in Table 7-5 would increase the SOR value by only 0.005. Therefore, even if a BCG were available for Pu-241 in terrestrial systems, the SOR would only increase by a very small amount, and would still not exceed unity for all radionuclides in the terrestrial exposure unit. Since no Pu-241 was detected in either aquatic exposure unit (Tables 7-6 and 7-7), the lack of aquatic BCGs does not effect the risk characterization for the site.

7.7.4 Exposures To Deep Soils

Exposures to deep soils was not considered for either current or future ecological exposures. The biologically active zone is typically considered the top 0.6 m (2 ft), and, as stated in Section 7.4, most burrowing animals and plant roots do not extend beyond 1.2 m (4 ft). However, many plants do have root systems that can go deeper, and thus be directly exposed or potentially translocate contaminants to aboveground structures that could be eaten by terrestrial wildlife. Average rooting depths of perennial grasses and forbs have been reported to be in the 1.2 to 1.8 m (4 to 6 ft) range, with shrubs and trees roots going even deeper. Therefore, there is some uncertainty introduced by limiting the exposure in this SLERA to the top 1.2 m (4 ft) bgs, which would ignore exposure to contamination in the trenches that occurs deeper than 1.2 m (4 ft) bgs. However, while some plants do have roots that can contact deeper soils, any translocation probably would not result in aboveground tissue concentrations that could pose a potential risk to herbivores using the site. In fact, concentrations of radionuclides measured in vegetation on-site (discussed in Section 7.8) indicate that there is little uptake of radionuclides in plants. Therefore, the assumption limiting exposure to the top 1.2 m (4 ft) bgs is not unreasonable for this SLERA.

Future exposures to deep soils was also not considered in this SLERA. The soil erosion rate for the site was estimated to be 0.021 cm (0.0084 in.) per year (Section 5.2.2). At that rate, it would take more than 5,000 years for the top 1.2 m (4 ft) to erode away. Under NRC decommissioning guidance (NRC 1999, 2000a, 2002), which is the primary guidance for potential remedial action alternatives of the site, protectiveness is required through 1,000 years in the future. Therefore, it is reasonable to assume that the surface soil would not erode sufficiently in the time period under consideration to allow for exposure to more contaminated trench soils and wastes below 1.2 m (4 ft) bgs.

7.7.5 Lack of Ecological Screening Values for Uranium Chemical Toxicity In Sediment or Surface Water

The lack of screening levels for protection of ecological receptors from the chemical toxic effects of uranium does add some uncertainty to this SLERA. However, as Dry Run is only an intermittent stream, true aquatic communities would not be supportable on site. Therefore, concentrations of uranium in Dry Run sediments were included along with soils, for consideration in the terrestrial exposure unit. The average concentrations of uranium isotopes in Dry Run sediments are less than the uranium soil screening value. Carnahan Run contains negligible concentrations of uranium above background.

7.8 Weight-of-Evidence Analysis

The weight-of-evidence analysis involves consideration of other evidence, aside from the DOE's graded approach, that may be used in an ecological risk assessment. Another point of reference is the previous sampling and analysis of vegetation at the SLDA, which is described in Appendix I of the SLDA SAP (USACE 2003a). Among 16 vegetation samples taken across the site, only two samples had uranium concentrations that were slightly elevated above concentrations of radionuclides measured in background vegetation samples. This finding of apparent limited movement of radionuclides from the trenches into vegetations supports the ecological risk characterization conclusion.

7.9 Summary of Screening Level Ecological Risk Assessment

The DOE's *Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002b) was used as the basis for this SLERA. Maximum detected concentrations of radionuclides from one terrestrial exposure unit and two aquatic exposure units were compared to generic BCGs developed to protect ecological receptors from ionizing radiation. The SOR was used to ensure that the presence of multiple radionuclides did not create an exceedance of the dose limits. Since the SOR was below one in all three exposure units, it was concluded that no adverse ecological effects were occurring to biota exposed to radionuclides at the SLDA. It was also concluded that there is little potential for unacceptable risk to ecological receptors due to the chemical toxic effects of uranium at the site. No further ecological risk assessment is warranted as part of the RI. Because BCGs were not exceeded, further screening assessment employing food uptake models is not warranted. However, an evaluation of environmental impacts as part of the screening of the potential remedial action alternatives will be considered in the FS.

8.0 SUMMARY AND CONCLUSIONS

This RI report presents a detailed compilation and evaluation of contaminant and environmental data for the SLDA site. The report was prepared in accordance with EPA guidance and recommended format, consistent with the scope of this project. That is, the RI report is largely limited to an evaluation of the radioactive contaminants at the SLDA, as Section 8143 of P.L. 107-177 directed the Secretary of the Army to clean up *radioactive waste* at the site. Chemical contaminants at the site are addressed only if they are commingled with and cannot be separated from the radioactive contaminants. The chemical toxic effects of these radioactive contaminants were considered in the human health and ecological risk assessments, specifically the chemical toxicity of uranium. A limited amount of information on chemical contaminants was obtained to support disposal decisions for IDW. Historical information for chemical contaminants is generally included in this report for information purposes only.

Much of the information included in the RI report is data previously obtained for the site (the recently collected data were consistent with this historical information). The various sources of data were generally complementary, and they were synthesized in the RI report to develop a more thorough understanding of environmental conditions at the SLDA. However, since the historical data were incomplete and of unknown quality, the human health and ecological risk assessments were based on the newly collected data and did not make extensive use of historical information other than to confirm the reasonableness of these data.

The SLDA site has been adequately characterized for purposes of conducting this RI/FS. The historical data are presented in Section 2.2 and supporting appendices, and the environmental setting is given in Section 2.3. This information was used to develop the SAP for the on-site investigations, which were conducted from late August 2003 through January 2004 as described in Section 3.0. A second round of sediment, surface water, and groundwater sampling was performed in June 2004. The results of the site characterization program are presented in terms of the nature and extent of radioactive contamination (in Section 4.0), and contaminant fate and transport (in Section 5.0). These results are largely presented in tables and figures, including CSMs. The CSMs present conceptualized depictions of the movement of contaminants through environmental media, and identify mechanisms by which human and ecological receptors could be exposed to these contaminants. These CSMs were used to develop the human health the ecological BRAs, which are presented in Sections 6.0 and 7.0, respectively, of this report.

8.1 Summary

A summary of the site characterization results is given in terms of the nature and extent of contamination, fate and transport mechanisms, and the human health and ecological risk assessments. Detailed presentations of these topics are given in Sections 4.0 through 7.0, respectively, of this report.

8.1.1 Nature and Extent of Contamination

Radioactive contamination at the SLDA is a result of previous waste-disposal activities at the site that occurred from 1961 through 1970. The wastes were generally associated with activities conducted at the nearby Apollo nuclear fuel fabrication facility, and the primary radioactive contaminants are uranium and thorium. These disposals were done in accordance with existing AEC regulations in effect at that time, and BWXT (the current site owner) maintains the site in accordance with a license from NRC (SNM-2001).

Based on available records and discussions with individuals familiar with disposal operations at the SLDA, waste materials were placed into a series of pits that were constructed adjacent to one another. These pits give the appearance of linear trenches in geophysical surveys performed at the site, and they are depicted on site drawings as trenches. The SLDA site contains ten trenches which cover about 0.49 ha (1.2 acres) of the 18 ha (44 acre) site. Nine of the trenches (Trenches 1 through 9) are located in the southeastern portion of the site in a topographically elevated area and were reportedly excavated to the weathered shale bedrock. Trench 10 is located 300 m (1,000 ft) northwest of the upper trench area, and was excavated in coal strip mine spoils on the northwest side of a high wall of bedrock in a generally flat area of the site. Detailed records on the locations of these pits and waste disposal activities at the site are not available.

A wide variety of wastes were placed in the trenches in a highly heterogeneous manner. Following placement in the trenches, the waste materials were covered with about 1.2 m (4 ft) of clean soil, as specified in 10 CFR 20.304 (which was rescinded in 1981). The average waste thickness in Trenches 1 through 9 ranges from about 2.6 to 4.8 m (8.5 to 15.8 ft), and the average waste thickness in Trench 10 is 5.5 m (18.1 ft). The volume of potentially contaminated waste and soil in the ten trenches has been estimated to range from about 18,000 to 27,000 m^3 (23,500 to 36,700 yd^3). Much of this material may, however, be uncontaminated soil.

Most of the radioactive contamination at the site is associated with Trenches 1 through 9 in the upper trench area; historical information indicates that the wastes disposed of in Trench 10 were generally uncontaminated or only mildly contaminated equipment and construction debris. In actuality, there are only nine disposal trenches at the site, as Trench 3 in the upper trench area appears to have been a settling basin and not a disposal trench.

As previously stated, the primary radioactive contaminants in the previously disposed of wastes were uranium and thorium. The uranium-contaminated materials placed in the trenches are present in a wide range of enrichments, ranging from less than 0.2 percent (by weight) U-235 to greater than 45 percent U-235. The uranium isotopes of concern at the site are those associated with natural uranium (i.e., U-234, U-235, and U-238). The thorium disposed of at the SLDA was principally Th-232 and since more than 30 years has passed since disposal activities ceased, significant ingrowth of Ra-228 has occurred. The former Parks nuclear fuel fabrication facility was located adjacent to and northwest of the site (near Trench 10), and contaminated equipment from the Parks facility was reportedly stored in the area of Trench 10. Localized areas of surface soil by Trench 10 contain elevated concentrations of plutonium (Pu-239 and Pu-241) and Am-241; these transuranic radionuclides were not found at depth in the recent characterization program.

In 1965, Trenches 2, 4, and 5 in the upper trench area were excavated to investigate discrepancies in material accounts of disposed uranium. The materials removed from the trenches were placed on the ground and sorted. Some of the exhumed materials were placed back in the trenches and the remainder was shipped off site for disposal. Two soil remediation projects were later conducted (in 1986 and 1989) to remove surface soils containing elevated levels of uranium. These projects removed most of the contaminated surface soil at the site, and radiological surveys were conducted following the remedial actions to confirm the effectiveness of these actions. A gamma walkover survey was performed in the summer of 2003, which confirmed that contaminated surface soil is present in only a few isolated areas, and the concentrations of radionuclides at these locations are not high.

Previous evidence indicated that the contamination was largely limited to the wastes in the ten trenches, and the site characterization program focused on nearby environmental media to determine the extent to which these media had been impacted. A number of samples were also obtained from the trenches (solid materials and leachate) to further evaluate the radioactive characteristics of the wastes to determine if these materials pose a potential risk to human health and the environment, and to support waste-disposal analyses to be conducted in the FS. The data obtained by this limited intrusive sampling of the ten trenches were consistent with historical information.

The site characterization program confirmed that there is very little soil contamination outside the footprints of the trenches. Localized areas of contaminated soil are present (generally in the vicinity of Trench 10), and there are localized areas of contaminated sediment in Dry Run. The concentrations of radioactive contaminants in most soil samples were generally comparable to background. The maximum surface soil concentrations measured at the SLDA site were for Am-241 (320 pCi/g), Pu-239 (325 pCi/g), and Pu-241 (628 pCi/g) by Trench 10; the maximum subsurface soil concentration was for U-234 (508 pCi/g) in the upper trench area. The maximum sediment concentration in Dry Run was 29 pCi/g for U-234. The average concentrations of these radionuclides were much lower. Other than elevated concentrations of Am-241 and plutonium in isolated areas of surface soil by Trench 10, U-234 was generally the radionuclide that had the highest concentrations in soil, which is indicative of enriched uranium.

The surface water and sediment in Carnahan Run were determined to be uncontaminated, while low levels of radioactive contamination were identified at on-site locations in Dry Run and groundwater seeps in the upper trench area. This indicates that the radioactive wastes in the trenches (or previous site activities) may be impacting on-site surface water and sediment in Dry Run. Such impacts were not noted at off-site locations. Groundwater at the site, outside of perched areas within the trenches, does not appear to be contaminated, other than some localized areas in the upper trench area in the upper shallow bedrock water-bearing zone downgradient of Trenches 1 and 2. Some low levels of contamination were identified at this location, which may be associated with the radioactive wastes in these two trenches. However, the main contaminated environmental medium at the site (other than for the materials in the trenches) is soil, including sediment in Dry Run.

8.1.2 Contaminant Fate and Transport

The mechanisms and pathways by which the contaminants at the SLDA could be released from their current locations (generally within the ten trenches), move through environmental media, and potentially impact human and ecological receptors were evaluated in Section 5.0 of this report. Potential release mechanisms include wind erosion; surface water runoff, erosion, and deposition; and infiltration of water into the trenches with leaching of contaminants from the waste materials. These release mechanisms can act on the source media increasing contaminant mobility and enabling the radionuclides to migrate from their current locations to adjacent media (e.g., from the buried wastes to subsurface soil). The transport mechanisms affecting the migration of contaminants within and away from the SLDA include wind transport, surface water runoff, and groundwater flow.

Wind erosion is not a significant mechanism for contaminant releases from the site. The wastes are located about 1.2 m (4 ft) below the ground surface and are covered with clean soil. Most areas of the site having surface soil contamination were previously remediated, and surface vegetation limits the likelihood for airborne emissions of any remaining contaminated surface soil. The results of the recent site investigations indicate that contaminated surface soil is present in only a few isolated areas, and these areas are covered by vegetation (grasses) that is routinely mowed. The relatively low wind speeds and high moisture content of the soil in this area further limit the amount of fugitive dust generation. Radionuclide concentrations in air have been measured at the site perimeter since the fall of 2003 and these concentrations have been very low, confirming that wind erosion is not a significant release and transport mechanism.

Surface water runoff following a rain or snowmelt event is also not a significant pathway for contaminant transport from the SLDA. Most of the contamination is below ground and the site is covered with vegetation that limits the amount of soil erosion from surface water runoff. Small areas of contaminated surface soil are present at the site, but these are generally in areas where the terrain is flat (such as near Trench 10). Surface water and sediment in Dry Run were sampled in the recent characterization program. The surface water was determined to have very low levels of uranium contamination (below drinking water standards), and only localized areas having low levels of uranium contamination were identified in the sediment, supporting the conclusion that surface water runoff is not a major transport mechanism at the site.

Precipitation at the SLDA can run off the site, return to the atmosphere through evaporation or through plant uptake and transpiration, or infiltrate into soil. Water that infiltrates into soil can remain fixed in the unsaturated vadose zone soils or percolate to groundwater. Water percolating through contaminated soil or the waste trenches can result in the dissolution of water-soluble compounds, which can be transported to groundwater. Contaminant transport through groundwater is the most likely mechanism for radionuclides to move from the site and impact human and ecological receptors in the long term, since the wastes are located belowground and the groundwater table is high.

The upper trenches are intermittently saturated, especially during periods of heavy precipitation such as in winter and early spring when groundwater levels are elevated. However, the soil in this portion of the site contains a significant amount of clay particles (which are very effective at adsorbing positively charged ions such as the radionuclides in the waste materials), and there has been very little contaminant migration from these trenches. Although groundwater flow through the mine spoils by Trench 10 is more rapid, the wastes disposed of in this trench have very low levels of radioactive contamination.

The information developed for the RI report indicates that the radioactive contaminants in the previously disposed of wastes are confined to the immediate vicinity of the trenches. Sampling of air, surface water, sediment, and groundwater shows no elevated levels of radionclides migrating from the site (the contaminated surface water and sediment in Dry Run was measured within the site boundaries). However, these conditions are not expected to remain indefinitely, and over time the radionuclides in the trenches would be expected to gradually leach to percolating water and reach groundwater. The upper shallow bedrock water-bearing zone in the upper trench area is the groundwater system of most concern, and potential contamination of this zone was considered in development of the PRGs. The very complex hydrogeology of the site makes accurate prediction of contaminant transport through groundwater very difficult to perform. Groundwater monitoring is the only accurate means of determining groundwater conditions at the site.

8.1.3 Human Health Risk Assessment

The human health BRA was performed consistent with EPA risk assessment guidance to support the determination of appropriate actions for the site. The assessment was limited to the radioactive contaminants at the SLDA, in accordance with the authorizing legislation for the site. The chemical toxic effects of these radioactive contaminants were considered in this assessment, specifically for uranium, which is chemically toxic to the kidney.

Historical information indicated that it would be very difficult to obtain representative data on the physical forms and concentrations of radioactive contaminants in the buried wastes (i.e., a wide variety of radioactive wastes were placed in the trenches in a highly heterogeneous manner). The lack of detailed records on historical waste-disposal activities at the site made it prudent to minimize intrusive sampling in the trenches. A screening-level assessment of the risks associated with the materials in the ten trenches was performed largely based on historical information, and this assessment indicated that these materials pose a potential radiological risk to human health and should be addressed in more detail in the FS. The human health BRA did not address the materials within the trenches, but was limited to those areas of the site outside the footprints of the trenches but within the impacted area of the site. Surface soil above the ten trenches was included in the determination of EPCs for the risk assessment.

Preliminary ROPCs were developed for the SLDA based on historical uses (specifically, the radiological characteristics of the wastes buried in the trenches) and previous characterization activities. These preliminary ROPCs were divided into primary ROPCs and secondary ROPCs, and these designations were used to focus site characterization activities and develop the SAP.

The primary ROPCs are those radionuclides expected to be present at the site in concentrations posing a potential risk concern. The primary ROPCs for the SLDA site are: Am-241, Pu-239, Pu-241, Ra-228, Th-232, U-234, U-235, and U-238. Additional radionuclides were also considered likely to be present based on historical information and activities conducted at the adjacent Parks facility. These secondary ROPCs were determined to be: Co-60, Cs-137, Pu-238, Pu-240, Pu-242, Ra-226, and Th-230.

Elevated concentrations of the secondary radionuclides were detected very infrequently during site characterization activities, and the detections that did exceed background were not significantly elevated (all of the values were less than twice background). The secondary radionuclides were eliminated from quantitative assessment in the BRA based on the low frequency of detection and the reported low concentrations; the quantitative evaluation of risks in the BRA was limited to the eight primary ROPCs.

Four hypothetical scenarios were developed to reflect reasonably likely patterns of human activity that might result in exposures to the radioactive contaminants at the SLDA. Two current-use scenarios (Maintenance Worker and Adolescent Trespasser) consider possible exposures in the near term reflecting the current administrative controls at the site, and two future-use scenarios (Construction Worker and Subsistence Farmer) consider greater exposures that could occur in the future should these administrative controls be lost. The current-use scenarios addressed exposures to contaminated surface soil while the future-use scenarios addressed exposures to contaminated surface and subsurface soil. These four scenarios reflect a range of potential exposures and intakes to provide useful information to guide future decisions for the site. The Subsistence Farmer scenario was addressed as the conceivable, but unlikely and bounding scenario for the SLDA site.

Three EUs were developed to evaluate exposures at the site (see Figure 6-1), and human health risks were calculated for these four scenarios in these three EUs and also for site-wide exposures. The radiological cancer risks for the two current-use scenarios were calculated to be at or below the lower end of the EPA's target risk range of 1×10^{-6} to 1×10^{-4}, reflecting the generally low levels of radioactive contamination at accessible areas and the relatively small amount of time that these individuals would reasonably be expected to visit contaminated areas at this site. The estimated risks for the two future-use scenarios are also within or below the EPA target risk range. The maximum risk was calculated to be 1×10^{-5} for the Subsistence Farmer in the vicinity of Trench 10 (the major contributor to this risk was consumption of produce grown in contaminated soil). The annual radiation dose to the Subsistence Farmer was calculated to be 5 mrem/year, or about 20 percent of the annual dose limit of 25 mrem/year identified in the authorizing legislation for cleanup of this site (see Section 8.2.2). The estimated HIs for the various receptors ranged from less than 0.001 to 0.010, indicating little potential for noncarcinogenic health effects.

These results of the human health BRA indicate that the SLDA site presents very little risk to human health under current conditions. The site is currently vacant and surrounded by a security fence that is actively maintained. The site is routinely monitored and the open field is mowed several times a year, air at the site perimeter is being monitored, and there are several groundwater monitoring wells in the vicinity to determine the status of potential groundwater contamination. However, these conditions cannot be guaranteed in perpetuity and, over time, the radionuclides in the trenches would be expected to gradually leach to groundwater. The SLDA is also susceptible to subsidence from collapse of the abandoned mine workings beneath the site.

Current information indicates that there is very little soil contamination outside the footprints of the ten trenches, and the contamination that is present poses very little current and future risk. However, the previously disposed of wastes contain significant concentrations of radioactive contaminants (in excess of the PRGs developed for soil), and these materials could pose a potential risk to human health in the future. The carcinogenic risk to the Subsistence Farmer was calculated to be 3×10^{-3} using the results of the samples obtained from the trenches in the recent characterization program. This risk increases to 1×10^{-2} if the results are limited to the 13 samples that had field-screening evidence of waste. The HI exceeds one for both situations, and the corresponding annual doses are approximately 300 and 900 mrem/year, well in excess of the annual dose limit identified for cleanup of this site. These results confirm that the concentrations of radionuclides in the buried wastes are high enough to present a potential future risk to human health, and remedial action alternatives for these materials should be developed and evaluated in detail in the FS.

8.1.4 Screening-Level Ecological Risk Assessment

A screening-level ecological risk assessment was performed in order to determine the potential for adverse ecological effects to occur from exposures to radionuclides at the SLDA in the absence of remedial actions. The SLERA was performed using DOE's graded approach for ecological risk assessments, utilizing established biota dose limits. The dose limits used in the SLERA were 1 rad/d for aquatic animals, 1 rad/d for terrestrial plants, and 0.1 rad/d for terrestrial animals. These biota dose limits were developed by NCRP and IAEA. If the doses to hypothetically exposed ecological receptors do not exceed these limits, it can be concluded that populations of plants and animals are adequately protected from the potential effects of ionizing radiation.

The SLDA is covered with various species of grasses, shrubs, and trees, and the entire site was addressed as a single terrestrial EU. Since plants and animals can be exposed to soils down to a depth of about 1.2 m (4 ft), characterization data extending to this depth were used in this assessment. Most burrowing animals and plant roots do not extend beyond this depth, so deeper soil and waste samples were not considered. Dry Run sediments were also included in this terrestrial EU because Dry Run is an ephemeral stream. Two aquatic EUs were identified to address exposures (such as to riparian receptors) at Dry Run and Carnahan Run.

Radiation doses to hypothetical terrestrial, riparian, and aquatic organisms were modeled to develop BCGs for the various radionuclides at the SLDA. The BCG is the limiting concentration of a radionuclide in soil, sediment, or water that would not cause the protective dose limits (given above) to be exceeded. The BCGs were developed using conservative assumptions and are analogous to the DCGLs and PRGs developed for protection of human health. An SOR is calculated in cases where there are multiple radionuclides present in environmental media, in a manner identical to that used for human health evaluations.

The maximum detected concentrations of radionuclides in soil, sediment, and surface water were used to calculate the SORs for the three EUs. The SORs ranged from 0.3 to 0.5 for the three EUs, meaning that the biota dose limits are not exceeded. It was also concluded that there is little potential for unacceptable risks to ecological receptors due to the chemical toxic effects of uranium at the site. Since the results of this conservative assessment indicate that the radionuclides at the SLDA do not pose a potential risk to ecological receptors, no further evaluation of the potential risks to ecological receptors is warranted as part of the RI. Potential environmental impacts from implementing various remedial action alternatives will be addressed during preparation of the FS.

8.2 Conclusions

The major conclusions of the RI Report are given in the following discussion focusing on the identification of the ROCs at the site, the remedial action objectives, and data limitations and recommendations for future work.

8.2.1 Radionuclides of Concern

The ROCs for the SLDA are the eight primary ROPCs (i.e., Am-241, Pu-239, Pu-241, Ra-228, Th-232, U-234, U-235, and U-238). Elevated concentrations of secondary ROPCs were present in only a small percentage of the samples, and these concentrations did not exceed background by a significant amount (all of the values were less than twice background). In addition, the elevated levels reported for the secondary ROPCs appear to be generally collocated with elevated levels of the primary ROPCs (which would be expected based on the operating history of the site), so addressing the risks for the primary ROPCs would also result in addressing any secondary ROPCs that may be present.

Most of the radioactive contamination is associated with the upper trench area (in the wastes disposed of in Trenches 1 through 9), and the major radionuclides in this portion of the site are the three uranium isotopes (U-234, U-235, and U-238), Ra-228, and Th-232. Of the three uranium isotopes, U-234 has the highest concentration, which is indicative of enriched uranium. Very little contamination is associated with Trench 10, and this is the only area of the site that appears to be significantly contaminated with Am-241, Pu-239, and Pu-241. While the sampling results provide evidence to support the contention that some radionuclides may only be present at specific areas of the site, all eight of the primary ROPCs are being retained as ROCs for all portions of the site. This will ensure that cleanup of the SLDA is conducted in a thorough manner and will result in conditions that are fully protective of human health and the environment. However, this will continue to be investigated during the FS to determine if it is possible to reduce the number of ROCs at the upper trench area to five (Ra-228, Th-232, U-234, U-235, and U-238), and the number of ROCs by Trench 10 to three (Am-241, Pu-239, and Pu-241).

8.2.2 Remedial Action Objectives

The overall objective of this project is to conduct remedial actions at the SLDA in accordance with Section 8143 of P.L. 107-117, which directed the Secretary of the Army to cleanup radioactive waste at the site consistent with the July 5, 2001, MOU between NRC and USACE for coordination on cleanup and decommissioning of FUSRAP sites with NRC-licensed facilities. The MOU applies to response actions meeting the decommissioning requirements given in 10 CFR 20.1402 (i.e., for unrestricted future use). As noted in 10 CFR 20.1402, a site is considered acceptable for unrestricted use if the above-background residual radioactivity does not result in a TEDE for an average member of the critical group in excess of 25 mrem/year, and that the residual radioactivity has been reduced to levels that are ALARA. Conservative PRGs were developed for the SLDA, with a Subsistence Farmer scenario evaluated to represent exposures to the critical group for determining compliance with this requirement. The Subsistence Farmer was considered to be the bounding (but conceivable) scenario representing a reasonable future land use for this site. These PRGs are given in Table 6-1 and were developed with the concurrence of PADEP. As required by CERCLA and the NCP, Remedial Action Objectives will be developed based on compliance with the ARARs for this site.

Additional remedial action objectives include complying with other ARARs (as well as the radiological requirements given in 10 CFR 20.1402), and conducting remedial actions in a manner that would minimize public and worker exposures to site-related contaminants. The potential impacts to environmental receptors and other resources will be addressed during the FS as noted above. The ARARs for this project will be developed as part of the FS process, and will include input from PADEP and other state agencies. The complete list of remedial action objectives will be developed in the future in consultation with the NRC, PADEP, and other stakeholders following review and completion of the RI report. These objectives will be factored into the evaluations to be performed as part of the FS.

8.2.3 Data Limitations and Recommendations for Future Work

While the environmental conditions and radioactive contaminant concentrations at the site as summarized in the RI report are sufficient to properly assess remedial action alternatives in the FS, there are a number of data issues that will continue to be evaluated. These limitations are generally associated with the manner in which remedial actions would be implemented, and include uncertainties associated with the exact boundaries of the trenches and the volume of contaminated materials within the trenches. The total volume of waste and soil within the ten trenches has been estimated to range from 18,000 to 27,000 m^3 (23,500 to 36,700 yd^3), and much of this material is likely uncontaminated soil. Better estimates of the volumes of contaminated materials in the trenches will improve the accuracy of the cost estimates associated with the remedial action alternatives, and this information will continue to be developed during the FS.

The contaminant data obtained during the recent site characterization program were consistent with previous information, so there is very little uncertainty associated with the ROCs for the site. It is likely that certain radionuclides may only be present in sufficient concentrations (in excess of the PRGs) at certain locations of the site. Specifically, the radioactive contamination in the upper trench area is mainly associated with uranium, Ra-228, and Th-232, and Trench 10 contamination is mainly Am-241 and plutonium. Efforts will continue to determine if it is possible to limit the number of ROCs in specific portions of the site. This will expedite efforts to determine compliance with the cleanup criteria, which will be developed during preparation of the FS using the PRGs as a starting point.

Three EUs were used to evaluate the risks to human health in the BRA, and these EUs were developed considering the need to identify MARSSIM FSS units for future site closeout activities. Four Class 1 units, two Class 2 units, and one Class 3 unit were preliminarily identified for the site, as shown in Figure 6-1, using the recommendations given in MARSSIM on the contamination potential and sizes for these various units. The boundaries of these FSS units will continue to evolve throughout the RI/FS process. Identifying these units now on a preliminary basis should help expedite development of the FSS plan for site closeout in the future.

While groundwater contamination at the SLDA is very localized and most of the groundwater is currently uncontaminated, the site hydrogeology is very complex making it difficult to evaluate by use of standard groundwater modeling techniques. Monitoring of the various groundwater regimes was determined to be the most appropriate means to evaluate the potential movement of contaminants by this pathway. This monitoring will continue for the duration of the project in consultation with PADEP and other state and local agencies. As the project moves from the evaluation to field implementation phases, modifications to this monitoring program may be warranted. For example, removal of contaminated materials from the site may eliminate the need for future groundwater monitoring activities. Such decisions will be factored into the evaluation of alternatives in the FS and will incorporate input from PADEP and other state agencies and stakeholders.

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TABLES

TABLE 2-1
DESCRIPTION OF MATERIALS PLACED IN SLDA TRENCHES

Trench #	Dates of Activity	Description from the Site Characterization Report	Reported[1] Radiological Content	Description from ARCO Memo to Department of Justice (DOJ) (March 2000)[2]
Trench # 1	1961	61 drums and 5 bags of process waste 23 drums and 17 bags of trash 4 drums of beryllium waste miscellaneous debris	141.7 g U-235 Total Uranium = 4,526 g	Approximately 125,000 cubic feet (ft^3) of waste including process wastes, beryllium wastes, and scrap protective clothing (e.g. "dry active waste" DAW)
Trench # 2	1962	15,668 grams (g) of metal oxide powder 142.8 kilograms (kg) vapor blast [i.e. sand] 25 drums containing 1,075 kg of organic liquid Leached solids, including 399 pounds (lbs.) ash and 160 lbs. miscellaneous residue Leached residue In 1965 Trench #2 also received liquids during the exhumation of Trenches 4 & 5	4.41 g Uranium 156 g Uranium 152 g Uranium 616 g Uranium; 564 g U-235 289 g Uranium 564 g U-235 Total Uranium = 1,217.41 g	Approximately 110,000 cubic feet (ft^3) of waste including scrap metallic oxide powders, contaminated sand, process ash and residues, contaminated organic liquids, and DAW.
Trench # 3	1965 (best estimate)	ARCO/B&W believed this trench never received solid or liquid waste. Trench 3 is however thought to have functioned as a "catch basin" that received run-off from Trenches 2 and 4 when they were exhumed in 1965.		Excavated as a settling pond during 1965 exhumation. Approximately 5,000 ft^3 of contaminated soil exists in this area.
Trenches # 4 and #5	1963 - 1965 burial in 1963 no burial reported in 1964 exhumed in 1965	270 kg of scrap "solutions" (UO_2-BeO) 175 "birdcages" (shipping containers) used for UO2-BeO wastes 52 truck-loads of assorted process wastes, debris, and contaminated equipment The roof from the Apollo facility (burned in pit in early 1963) metal drums, stanchions, shipping container liners, strapping material, combustibles, etc.	37 g Uranium	Approximately 85,000 ft3 of waste (55,000 and 30,000 respectively). Materials from both trenches included uranium-beryllium scrap solutions, empty "birdcages" , assorted process wastes, debris, contaminated equipment, roof of Apollo facility, and DAW (Dry Active Waste).
Trench # 6	1965 - 1967 1965 1966 1967	150 drums each containing 5 g Th02 593 2-quart (qt) bottles of leached solids 75 2-qt bottles calcined filters 14 55-gallon drums containing 1,811 g U-235 200 to 300 drums and air filters from "Blue Building" at Apollo 40 55-gal drums containing scrap recovery wastes, including leached ashes and solids leached poly buckets and vials, scap metal, glass, and debris 22 drums process waste from CP-1 1 drum of 8-OH filter cake	750 g Th02 estimated, not previously reported 1,811 g U-235 3,162 g U-235; Total Uranium = 3,660.6 g 1,720 g U-235; Total Uranium = 787,800 g 570 g U-235; Total Uranium = 258,700 g Total U-235 = 5,911.9 g Total Uranium = 1,051,618 g	Approximately 110,000 cubic feet (ft^3) of scrap thorium oxide, scrap recovery waste such as ash and residues, filter cakes, DAW and zircalloy wastes.
Trench # 7	1968 - 1970 1968	large vacuum chamber one drum of zirc[onium]-beryllium 208,456.5 (units not specified) of raffinate, condensate, and filtrate from the high-enriched scrap recovery line 33 filters 97 55-gal drums of scrap recovery wastes and misc. wastes, including leached solids, vials, poly buckets, filter frames, residues and misc. scrap. Disposal boxes containing filter papers and 8-OH filter cake	913.5 g U 235 Total Uranium = 982.8 g 148.5 g U-235 Total Uranium = 152 g 2,301.5 g U-235 Total Uranium = 2,553 g 230 g U-235 Total Uranium = 130,000 g Total U-235 = 3690 g Total Uranium = 133690 g	Approximately 100,000 cubic feet (ft^3) of zirc-beryllium waste, scrap recovery wastes, filter paper, filter frames, 8-hydroxyquinoline filter cake, DAW, spent organic solutions, and a large vacuum chamber.

TABLE 2-1
DESCRIPTION OF MATERIALS PLACED IN SLDA TRENCHES

Trench #	Dates of Activity	Description from the Site Characterization Report	Reported[1] Radiological Content	Description from ARCO Memo to Department of Justice (DOJ) (March 2000)[2]
Trench # 7 (cont.)	1969	contaminated waste drums and filters, 14 truckloads of contaminated waste and filters		
		45 drums of leached samples, filters, debris, vials, buckets, and misc. scrap	586 g U-235 Total Uranium = 608 g	
		154 liters of stripped organic solution	2.37 g U-235 Total Uranium = 2.43 g	
		697 drums (C, D, E, and F series)	14,238 g U-235 Total Uranium = 15,310 g	
			Total U-235 = 14830 g Total Uranium: "not ascertained"	
	1970	14 boxes, 11 2-qt bottles, 66 buckets containing 231.933 kg scrap, and 2 filters - "shaken out"		
		25 drums of leached residues, miscellaneous scrap	1,058 g U-235 Total Uranium = 2,404 g	
		70 liters stripped organic solution		
		198,385 (no units specified) aqueous waste and contaminated oil	91 g U-235 Total Uranium = 2,833 g	
		210 boxes, 27 drums containing "relatively large quantity of U-235"	Total U-235 = 1150 g Total Uranium = 5240 g	
Trench # 8	1970	Discarded filtrate from ADU recovery, raffinates from scrap recovery and leached dissolver residues	543 g U-235 Total Uranium = 18,512 g	Approximately 30,000 cubic feet (ft^3) of scrap recovery wastes, contaminated soil, leached residues, scrap and DAW.
		22 drums of contaminated soil from sewer project at Apollo 25 drums of leached residues and scrap	322.1 g U-235 Total Uranium = 2,747.6 g	
			Total U-235 = 865.1 g Total Uranium = 21260 g	
Trench # 9	1968-1970	Contaminated soil from Trench #2 17 pieces of equipment several pieces of plywood from "Plutonium Facility drum field"	not listed	Approximately 55,000 cubic feet (ft^3) of contaminated soil, leached residues, scrap and DAW.
Trench # 10	1960-1971			Approximately 370,000 cubic feet (ft3) of material including, electrodes, DAW, filter cakes, barn debris, lightly contaminated equipment, and a truck. Much of the equipment placed in the trench was "uncontaminated (a barn, construction/demolition waste)
	1960	Electrodes, kimwipes and other lab waste, pipes, valves, tygon tubing, fuel tubing, feed sacks, and filter cake	308.2 g U-235 Total Uranium = 3,815 g Thorium: 0.03 g	
	1968	Slaughter house demolition waste, a barn foundation and quantities of soil from excavation work		
	1971	uncontaminated scrap (primarily old equipment) from an equipment storage and laydown area near Trench 10.		
		contaminated truck likely used for waste transport reportedly also placed in the trench		

[1]Descriptions of the waste and dates of activity were obtained from SLDA Site Characterization Report, Section 4.5, May 19, 1995
[2]Memo to the Department of Justice was issued by ARCO March 2000

TABLE 2-2

SUMMARY OF HISTORICAL SAMPLING COMPLETED AT SLDA

STUDY	YEAR	MATRIX	TYPE OF SAMPLE	NUMBER OF SAMPLES	ANALYSIS	SAMPLE IDENTIFICATION
B&W Environmental Monitoring	Initiated in 1972	Soil	Surface or Subsurface Soil	Unknown	Unknown	Unknown
B&W Environmental Monitoring	Initiated in 1972	Water	Surface Water	Unknown	Unknown	Unknown
B&W Environmental Monitoring	Initiated in 1972	Vegetation	Vegetation	Unknown	Unknown	Unknown
B&W Environmental Monitoring	Initiated in 1972	Air	TLD[1]	Unknown	Unknown	19-Jan
EG&G Aerial Survey	1981	Soil	Off-Site Background Surface Soil	10	Gamma Ray Exposure	Sample IDs were not presented
ORAU Survey	1981	Soil	Off-Site Background Surface Soil	6	U-235, U-238, Th-232, Ra-226, Cs-137 and Co-60	S121 through S126
ORAU Survey	1981	Soil	Surface Soil	120	U-235, U-238, Th-232, Ra-226, Cs-137 and Co-60	S1through S120
ORAU Survey	1981	Soil	Subsurface Soil	166	U-235, U-238, Th-232, Ra-226, Cs-137 and Co-60	Sample IDs were not presented
ORAU Survey	1981	Water	Groundwater	25	U-235, U-238, Th-232, Ra-226, Cs-137 and Co-60	Sample IDs were not presented
ORAU Survey	1981	Water	Surface Water	10	U-235, U-238, Th-232, Ra-226, Cs-137 and Co-60, Am-241, Pu-239	W1 through W10
ORAU Survey	1981	Vegetation	Vegetation	14	U-235, U-238, Th-232, Ra-226, Cs-137 and Co-60	V1 through V14
Supplemental ORAU	1982	Soil	Surface Soil	11	U-235 and U-238	1 through 11
Supplemental ORAU	1982	Soil	Subsurface Soil	5	U-235 and U-238	1 through 5
Post Remediation Survey	1986	Soil	Surface and Subsurface Soil	154	U-235 and U-238	9A-D through 20A-D, 30A-D through 34A-D, 43A-D through 47A-D, 58A-D through 60A-D, 68A-D through 71A-D, 79A-D through 82A-D, 92A-D, 93A-D, 100A-D, Grid Blocks 17, 46, 81 (various depths)
Post Remediation Survey	1989	Soil	Surface Soil	40	U-235 and U-238	50A-D, 157A-D, 158A-D, 163A-D, 168A D, 193A-D through 197A-D
Preliminary Assessment	1990	Water	Surface Water	1	TOX, Gross Alpha/Beta, Total/Dissolved Beryllium, Priority Pollutant VOCs	S-9
Preliminary Assessment	1990	Water	Seeps	3	TOX, Gross Alpha/Beta, Total/Dissolved Beryllium, Priority Pollutant VOCs	S-6, S-7, S-8
Site Characterization - Phase I	1990	Water	Groundwater	12	TOX, TOC, Major Cations/Anions, Total Dissolved PP Metals and PP VOCs	MW-1, MW-2, MW-2A, MW-3, MW-4, MW-5, MW-6, MW-7, MW-8, MW-9A, MW-10, MW-12S
Site Characterization - Phase I	1990	Water	Seeps	5	TOX, TOC, BE, Major Cation/Anions, PP Metals, PP VOCs, Gross Alpha/Beta	SS-1 through SS-5
Site Characterization - Phase I	1990	Water	Surface Water	2	TOX, TOC, BE, Major Cation/Anions, PP Metals, PP VOCs, Gross Alpha/Beta, Total Metals	S-1 and S-2
Site Characterization - Phase II	1991	Soil	Subsurface Soil	10	TCL VOCs, TCL SVOCs, TCL PCBs, CN, TBP, 8-OH	MW-11D, MW-12D, PZ-1, PZ-2, PZ- 3A, PZ-4,PZ-5,PZ-6A, PZ-7, PZ-8

TABLE 2-2

SUMMARY OF SAMPLING COMPLETED AT SLDA

STUDY	YEAR	MATRIX	TYPE OF SAMPLE	NUMBER OF SAMPLES	ANALYSIS	SAMPLE IDENTIFICATION
Site Characterization - Phase II	1991	Water	Groundwater	26	Water Quality Parameters, TCL VOCs, TCL BASE Neutrals/Acid Extractables, TCL PCBs, TAL Metals (Total and Dissolved), TBP, 8-OH, Metals BO, MO, TI, ZE (Total and Dissolved)	MW-1, MW-2, MW-2A, MW-3, MW-4, MW-5, MW-6, MW-7, MW-8, MW-9A, MW-10, MW-11D, MW-12S, MW-12D, MW-13, MW-14, MW-15, PZ-1, PZ-2,PZ-3A, PZ-4, PZ-5, PZ-6A, PZ-7, PZ-8, PZ9
Site Characterization - Phase II	1991	Water	Seeps	5	Water Quality Parameters, TCL VOCs, TCL SVOCs, TCL PCBs, TAL Metals (Total and Dissolved), TBP, 8-OH, Cyanide, Gross Alpha/Beta	SS-1 through SS-5
Site Characterization - Phase II	1991	Water	Surface Water	2	Water Quality Parameters, TCL VOCs, TCL SVOCs, TCL PCBs, TAL Metals (Total and Dissolved), TBP, 8-OH, Cyanide, Gross Alpha/Beta	S-1 and S-2
Site Characterization - Phase III	1992	Soil	Subsurface Soil	5	TCL VOCs, TAL Metals, Gross Alpha/Beta	MW-16, MW-16BC, MW-17, MW-18, MW-19
Site Characterization - Phase III	1992	Water	Groundwater	31	Water Quality Parameters, TCL VOCs, TAL Metals (Dissolved), TBP, 8-OH, Gross Alpha/Beta	MW-1, MW-2, MW-2A, MW-3, MW-4, MW-5, MW-6, MW-7, MW-8, MW-9A, MW-10, MW-11D, MW-12S, MW-12D, MW-13, MW-14, MW-15, MW-16, MW-16BC, MW-17, MW-18, MW-19, PZ-1, PZ-2,PZ-3A, PZ-4, PZ-5, PZ-6A, PZ-7, PZ-8, PZ9
	1992	Water	Groundwater Seep	5	Water Quality Parameters, TCL VOCs, select SVOCs, Dissolved TAL Metals, Gross Alpha/Beta	SS-1, SS-2, SS-3, SS-4, SS-5
	1992	Water	Surface Water	2	Water Quality Parameters, TCL VOCs, select SVOCs, Dissolved TAL Metals, Gross Alpha/Beta	S-1 and S-2
	1993	Water	Surface Water	1	Water Quality Parameters, TCL VOCs, select SVOCs, Dissolved TAL Metals, Gross Alpha/Beta	S-2
	1993	Water	Groundwater Seep	3	Water Quality Parameters, TCL VOCs, select SVOCs, Dissolved TAL Metals, Gross Alpha/Beta	SS-1, SS-4 and SS-5
Site Characterization - Phase IV	1993	Soil	Subsurface Soil	134	TCL VOCs, TCL SVOCs, TAL Metals	MW-23, MW-25, MW-26, MW-27 and Over 100 Other Sample IDs
Site Characterization - Phase IV	1993	Soil	Subsurface Soil	294	Total U	294 Sample IDs
Site Characterization - Phase IV	1993	Soil	Subsurface Soil	20	U-234, U-235, U-238, Total Isotopic U	05U11 (4-6), 02U12 (10-12), 05U10 (6-8), 02U12 (12-14), 03U06 (10-12), 01U27 (6-8), 01U23 (10-12), 07U05 (2-4), 01U15 (6-8), 08U11 (22-24), 01U30 (6-8), 01U09 (6-8), 01U31 (6-8), 01U13 (6-8), 02U13 (8-10), 01U06 (10-12), 02U02 (4-6), 02U13 (6-8), 10L13 (8-10), 02U08 (4-6)
Site Characterization - Phase IV	1993	Soil	Subsurface Soil	21	Am-241	10L04 (0-2), 10L04 (2-4), 10L07 (2-4), 10L07 (4-6), 10L07 (6-8), 10L16 (0-2), 10L17 (0-2), 10L18 (2-4), 10L18 (4-6), 10L18 (6-8), 10L18 (10-12), 10L18 (14-16), 10L24 (0-2), 10L24 (2-4), 10L24 (4-6) 10L24 (6-8), 10L24 (8-10), 10L25 (0-2), 10L25 (4-6), 10L25 (6-8), 10L25 (8-10)
Site Characterization - Phase IV	1993	Soil	Subsurface Soil	5	Pu-239/240, Pu-238, Pu-242, Am-241	10L07 (4-6), 10L07 (6-8), 10L18 (4-6), 10L24 (0-2), 10L25 (4-6)
Site Characterization - Phase IV	1993	Soil	Background Surface Soil	16	U, Th, Ra-226, Cs-137, Co-60, K-40, Am 241	Site 1 through Site 16

TABLE 2-2

SUMMARY OF SAMPLING COMPLETED AT SLDA

STUDY	YEAR	MATRIX	TYPE OF SAMPLE	NUMBER OF SAMPLES	ANALYSIS	SAMPLE IDENTIFICATION
Site Characterization - Phase IV	1993	Sediment	Sediment	7	Total U, Th-232, Ra-226, Cs-137, Co-60	SS-1 through SS-5, S-1 and S-2
Site Characterization - Phase IV	1993	Coal	Background Coal	8	Total U, Th-232, Ra-226, Cs-137, Co-60	MW-16 (91.2), MW-16 (105.9), MW-17 (27.8), MW-17 (30.8), MW-17 (50.6), MW-17 (75.1), MW-18 (45.7), MW-18 (92.7)
Site Characterization - Phase IV	1993	Water	Groundwater	43	Water Quality Parameters, TCL VOCs, TCL SVOCs, TAL Metals (Dissolved), TBP, 8-OH, Gross Alpha/Beta	MW-1, MW-2, MW-2A, MW-3, MW-4, MW-5, MW-6, MW-7, MW-8, MW-9A, MW-10, MW-11D, MW-12S, MW-12D, MW-13, MW-14, MW-15, MW-16, MW-16BC, MW-17, MW-18, MW-19, MW-20 through MW-29, MW-30A and MW-31, PZ-1, PZ-2, PZ-3A, PZ-4, PZ-5, PZ-6A, PZ-7, PZ-8, PZ-9
Site Characterization - Phase IV	1993	Vegetation	Vegetation	10	Total U, Total Th, K-40, Co-60, Cs-137, Ra-226	SITES 1, 2, 3, 5, 7, 8, 11, 13, 15, 16
Site Characterization - Supplemental	1994	Leachate	Leachate	31	NPDES Parameters Including BOD, CoD, ETC., PP VOCs, PP SVOCs, PP Metals, Gross Alpha/Beta, Total U	31 TWSP IDs
1995 Field Investigation	1995	Soil	Surface Soil	206	Am-241 and Total U	Over 200 Sample IDs
1995 Field Investigation	1995	Soil	Surface Soil	5	Am-241, Pu-241, TAL Metals, and TCL VOCs	BB-3, BC-5, BE-2, BG-12, BF-13
1995 Field Investigation	1995	Soil	Surface Soil	10	TAL Metals and TCL VOCs	BE-3, BD-4, BF-7, BF-8, BF-11, BE-12, BF-12, BE-14, BH-14, BG-17
1995 Field Investigation	1995	Soil	Subsurface Soil	10	TCL VOCs, TAL Metals, TBP, 8-OH, Total U	MW-37 through MW-46
1995 Field Investigation	1995	Sediment	Sediment	18	Total U, TCL VOCs, TCL SVOCs, TAL Metals, EDTA, 8-0H, TBP, Surfactants	S-1, S-2, SS-1, SS-2, SS-3, SS-4, SS-5, HA-1, HA-2, HA-3, HA-4
1995 Field Investigation	1995	Water	Surface Water	2	Gross Alpha/Beta, TAL Metals, Water Quality, Total U, Surfactants	Outfall, Under Bridge
1995 Field Investigation	1995	Sediment	Sediment	2	Gross Alpha/Beta, Total U, Surfactants, 8 OH, TBP	Outfall, Under Bridge
1995 Field Investigation	1995	Leachate	Unfiltered Liquids	12	Gross Alpha/Beta, Total U, Surfactants, TCL VOCs, TCL SVOCs, 8-OH, TBP, EDTA, TPH, TOC, BOD	TWSP 1-1 through 1-6, TWSP 2-1 through 2-4, TWSP 4-2, TWSP 8-2
1995 Field Investigation	1995	Leachate	Filtered Liquids	12	Gross Alpha/Beta, Total U, Am-241, Cs-137, Co-60, Major Cations/Anions, Nitrogen (2), Silicon, TDS, Metals	TWSP 1-1 through 1-6, TWSP 2-1 through 2-4, TWSP 4-2, TWSP 8-2
1995 Field Investigation	1995	Solids	Leachate	12	Total U, Surfactants, TCL VOCs, 8-OH, TBP, EDTA, TAL Metals	TWSP 1-1 through 1-6, TWSP 2-1 through 2-4, TWSP 4-2, TWSP 8-2
1995 Field Investigation	1995	Leachate	Filtered Leachate	5	U-234, U-235, U-238, Total U	TWSP 1-7, TWSP 2-1, TWSP 7-4, TWSP 7-5, TWSP 7-6
1995 Field Investigation	1995	Solids	Filtered Solids	5	U-234, U-235, U-238, Total U	TWSP 1-7, TWSP 2-1, TWSP 7-4, TWSP 7-5, TWSP 7-6
1995 Field Investigation	1995	Leachate	Unfiltered Leachate	30	Surfactants, TCL VOCs, 8-OH, TBP, EDTA, TPH	TWSP 1-7, 1-12, 2-5, 2-6, 2-7, 4-1, 5-1 through 5-5, 6-1 through 6-4, 7-1, through 7-6, 8-1, 9-1 through 9-5, 10-1 through 10 3
1995 Field Investigation	1995	Leachate	Filtered Leachate	28	Gross Alpha/Beta, Total U, Am-241, Cs-137, Co-60, Metals by ICP (30),	TWSP 1-7, 1-12, 2-5, 2-6, 2-7, 4-1, 5-1 through 5-5, 6-1 through 6-4, 7-1, through 7-6, 8-1, 9-1 through 9-3, 10-1 through 10 3
1995 Field Investigation	1995	Solids	Leachate	28	Gross Alpha/Beta, Total U, Total Thorium, Am-241, Ra-226, Co-60, Surfactants, TCL VOCs, 8-OH, TBP, EDTA, TAL Metals	TWSP 1-7, 1-12, 2-5, 2-6, 2-7, 4-1, 5-1 through 5-5, 6-1 through 6-4, 7-1, through 7-6, 8-1, 9-1 through 9-3, 10-1 through 10 3

TABLE 2-2

SUMMARY OF SAMPLING COMPLETED AT SLDA

STUDY	YEAR	MATRIX	TYPE OF SAMPLE	NUMBER OF SAMPLES	ANALYSIS	SAMPLE IDENTIFICATION
1995 Field Investigation	1995	Water	Groundwater	7	TCL VOCs, TCL SVOCs, 8-OH, TBP, Metals	MW-39, MW-8, MW-15, MW-38, MW-33, MW-7, MW-29
1995 Field Investigation	1995	Water	Groundwater	6	TCL VOCs, TCL SVOCs, 8-OH, TBP, Metals	MW-40 through MW-45
1995 Field Investigation	1995	Leachate	Unfiltered Leachate	10	Gross Alpha/ Beta	TWSP 4-1, TWSP 5-1 through TWSP 5-5, TWSP 6-1 through 6-4
1995 Field Investigation	1995	Solids	Filtered Leachate	10	Gross Alpha/ Beta	TWSP 4-1, TWSP 5-1 through TWSP 5-5, TWSP 6-1 through 6-4
Quarterly Groundwater Monitoring Program	1991-2002	Water	Groundwater, Surface Water and Seeps	Unable to Determine[2]	Gross Alpha/Beta, Total U	Varies[3]
Quarterly Monitoring Program	1992-2002	Water	Surface Water	Unable to Determine[2]	Gross Alpha/Beta, Total U	Trib 0, Trib 1, Trib 2, Trib 3, Trib 4, Trib 5, Trib 6,
Quarterly Monitoring Program	1992-2002	Sediment	Sediment	Unable to Determine[2]	Gross Alpha/Beta, Total U	Trib 0, Trib 1, Trib 2, Trib 3, Trib 4, Trib 5, Trib 6, HA-1, HA-2, HA-3, HA-4
Semi-Annual Groundwater Monitoring Program	1991-2002	Water	Groundwater, Surface Water and Seeps	Unable to Determine[2]	TCL VOCs, 8-OH and TBP	Varies[3]
ARCO/BWXT TWSP Quarterly Monitoring	1996-1997	Leachate	Unfiltered Leachate	Unable to Determine[2]	Gross Alpha/Beta	Varies[3]
2000 NRC/ORISE Investigation	2000	Soil	Surface Soil	4	U-235 and U-238	109, 111, 113, 114
2000 NRC/ORISE Investigation	2000	Soil	Subsurface Soil	3	U-235 and U-238	110, 112, 115

NOTES:

1 -- Thermoluminescent dosimeter
2 -- Unable to delineate between the various investigations and the quarterly/semi-annual groundwater monitoring programs.
3 -- Sample identifications are not listed since the program was modified over the years.

TABLE 2-3
SLDA DOWN-HOLE GAMMA INVESTIGATION SUMMARY
1993 AND 1995 INVESTIGATIONS

Parameters	Investigation: 1993 Site Characterization	Investigation: 1995 Field Investigation
No. of Sampling Points	36	22-4" plus the original 36-2" for a total of 58
TWSPs Diameter (inches) Installed	2	4
TWSP Construction Material	PVC	PVC
Gamma Activity Instrument	Small diameter sodium iodide (NaI) detector	3"x3", more sensitive NaI detector
Gamma-log data measurement Increments (ft)	1	1
Time Interval Counts (min)	1st 4 ft - 5 minute counts 5 ft to bottom - 20 minute counts	At 4 ft - 20 minute count 5 ft to bottom - 20 minute counts
Backgound Data	Obtained from steel piezometers and thought not to be a true representation of subsurface background due to the attenuation of lower energy gamma rays by the steel casing.	One two-inch and one four-inch diameter background TWSPs were installed within the site boundaries - proximate to the same geological formation(s) as the upper trenches.
Calibration Data	Energy efficiencies believed to have been overestimated and computer program not set-up properly - calibration was determined to be unreliable and of no value.	Custom-built unit to simulate actual TWSP installations in order to calibrate for naturally occuring uranium and thorium as well as gamma source. Better control and more reliable data.
Summary of Observations	Results provided indication of some down-hole gamma activity. Average U-235 concentration was reported to be 77.4 +/- 139.2 pCi/g.	Review of 1993 data showed that in several instances, data were improperly collected from the 2-inch TWSPs. The 1995 program concentrated on rectifying problems with the measurements within the 2-inch TWSPs and obtaining reliable measurements within the new 4-inch TWSPs. Approximately 25% of the measurements from 1993 were repeated in 1995. Average U-235 concentration from the 2-inch TWSPs was reported to be 29.3 +/- 33.5 pCi/g. The average U-235 concentration from the 4-inch TWSPs was reported to be 15.9 +/- 26.8 pCi/g. The 4-inch dectector system was able to identify picocurie quantities of uranium and thorium series daughter products but at "typical environmental levels." Neither Am-241 nor any other nuclides were detected.

TABLE 2-4

SUMMARY OF GEOTECHNICAL ANALYSIS OF SUBSURFACE SOILS

Boring Location	Depth Interval Composited (ft)	Specific Gravity	Net Water Content (%)	Atterberg Limits			Percent Gravel	Percent Sand	Percent Silt	Percent Clay	Classification*
				Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)					
MW-52	2 – 10	2.70	15.6	35.0	20.1	14.9	-	27.3	37.7	35.0	CL with sand
MW-54	2 – 10	2.75	11.5	22.8	15.7	7.1	-	43.4	29.8	26.8	Sandy CL-ML
MW-57	6 – 16	2.71	6.1	28.0	21.6	6.5	9.2	56.9	15.6	18.3	SC-SM
NWS-01	2 – 12	2.65	4.8	32.3	23.9	8.4	58.7	34.6	2.6	4.1	Sandy GP-GC
NWS-02	12 – 20	2.71	18.0	35.8	21.8	14.0	7.5	51.2	19.2	22.1	SC
NWS-03	10 – 18	2.78	26.9	28.6	20.0	8.6	-	45.2	16.5	38.3	Sandy CL

*Unified Soil Classification System:
CL = Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays
ML = Inorganic silts and very fine sands, silty or clayey fine sands with slight plasticity
SC = Clayey sands, poorly graded sand-clay mixtures
SM = Silty sands, poorly graded sand-silt mixtures
GC = Clayey gravels, poorly graded gravel-sand-clay mixtures
GP = poorly graded gravels, gravel-sand mixtures, little or no fines

TABLE 2-5

SLDA
SUMMARY OF PACKER PERMEABILITY TEST RESULTS

Packer Permeability Test Results Summary

Well ID	Hydrostratigraphic Zone Where Screened/Tested	Test Type	Ground Surface Elevation	Top of Test Interval[1]		Bottom of Test Interval		Total Test Interval	Test Interval Lithology	Hydraulic Conductivity	Hydraulic Conductivity	Direction
			ft msl	ft	elevation	ft	elevation	ft		cm/sec	ft/day	
MW-50	1S	Packer	899.1	No Test								
MW-51	1S	Packer	922.7	22.50	900.20	32.50	890.20	10.00	Fine Sandstone	**1.5×10^{-3}**	**4.28**	
MW-52	1S	Packer	921.9	21	900.90	31.00	890.90	10.00	Siltstone/Sandstone	2.9×10^{-4}	0.83	Horizontal
	1S	Packer	921.9	31	890.90	41.00	880.90	10.00	grades to silty Shale	**2.8×10^{-3}**	**7.98**	Horizontal
MW-53	2S	Packer	922.7	16	906.70	26	896.70	10	Fine Sandstone	7.5×10^{-4}	2.2	Horizontal
	2S	Packer	922.7	26	896.70	36	886.70	10	Fine Sandstone	1.2×10^{-3}	3.4	Horizontal
	2S	Packer	922.7	36	886.70	46	876.70	10	silty Shale	4.0×10^{-6}	0.01	Horizontal
	2S	Packer	922.7	46	876.70	56	866.70	10	black Shale	**4.1×10^{-4}**	**1.2**	Horizontal
	2S	Packer	922.7	57	865.70	67	855.70	10	black Shale	**2.9×10^{-4}**	**0.83**	Horizontal
MW-57	1S	Packer	945.6	27.5	918.10	37.5	908.10	10	Siltstone	4.6×10^{-5}	0.13	Horizontal
	1S	Packer	945.6	37.5	908.10	47.5	898.10	10	Siltstone	3.7×10^{-5}	0.11	Horizontal
	1S	Packer	945.6	47.5	898.10	57.5	888.10	10	Mudstone and Shale	8.7×10^{-6}	0.025	Horizontal
	2S	Packer	945.6	57.5	888.10	67.5	878.10	10	Sandstone and Shale	1.3×10^{-5}	0.04	Horizontal
	2S	Packer	945.6	67.5	878.10	77.5	868.10	10	Fine Sandstone	2×10^{-4}	0.57	Horizontal
	2S	Packer	945.6	77.5	868.10	87.5	858.10	10	Shale	6.8×10^{-6}	0.02	Horizontal
	2S	Packer	945.6	87.5	858.10	97.5	848.10	10	Shale	1.9×10^{-5}	0.05	Horizontal
	2S	Packer	946.6	97.5	849.10	107.5	839.10	10	Shale	1×10^{-5}	0.03	Horizontal
	UF	Packer	947.6	107.5	840.10	117.5	830.10	10	Coal	**1.4×10^{-4}**	**0.4**	Horizontal
MW-58	DB	Packer	836.7	25.8	810.90	35.8	800.90	10	Sandstone	**2.7×10^{-3}**	**7.7**	Horizontal
	DB	Packer	837.7	35.8	801.90	45.80	791.90	10	Shale	**3×10^{-6}**	**0.009**	Horizontal
	DB	Packer	838.7		No Test				Sandstone/Shale			Horizontal
	DB	Packer	839.7		No Test				Sandstone			Horizontal
	DB	Packer	840.7	65.8	774.90	75.80	764.90	10	Sandstone	9.75×10^{-6}	0.03	Horizontal
NWS-01A	1S	Packer	929.1	22	907.1	32	897.1	10	Shale, very broken, siltstone	1.58×10^{-4}	0.45	Horizontal
	1S	Packer	929.1	32	897.1	42	887.1	10	Siltstone	**1.8×10^{-4}**	**0.51**	Horizontal
	1S	Packer	929.1	42	887.1	52	877.1	10	Sandy Siltstone	5.6×10^{-4}	1.6	Horizontal

	2S	Packer	929.1	52	877.1	62	867.1	10	Sandy Siltstone	**5.0×10^{-4}**	**1.6**	Horizontal
	2S	Packer	929.1	62	867.1	72	857.1	10	Shale/Siltstone	5.6×10^{-5}	0.16	Horizontal
		Packer	929.1	72	857.1	82	847.1	10	Silty Shale	1.4×10^{-4}	0.4	Horizontal
		Packer	929.1	82	847.1	92	837.1	10	Shale	4.6×10^{-4}	1.3	Horizontal
		Packer	929.1	110	819.1	120	809.1	10	Siltstone/Mudstone with sandy Siltstone layers	1.5×10^{-6}	0.0043	Horizontal
		Packer	929.1	120	809.1	130	799.1	10	Siltstone	1×10^{-6}	0.0028	Horizontal
	DB	Packer	929.1	130	799.1	140	789.1	10	Shale	1×10^{-6}	0.0028	Horizontal
	DB	Packer	929.1	140	789.1	150	779.1	10	Shale	1×10^{-6}	0.0028	Horizontal
	DB	Packer	929.1	150	779.1	160	769.1	10	Silty Shale	**1.8×10^{-6}**	**0.0051**	Horizontal
	DB	Packer	929.1	160	769.1	170	759.1	10	(F-M) Sandstone	**2.1×10^{-6}**	**0.006**	Horizontal
NWS-02	1S	Packer	943.3	44	899.3	54	889.3	10	Claystone/Siltstone	**1.6×10^{-3}**	**4.5**	Horizontal
		Packer	943.3	54	889.3	64	879.3	10	Shaly Sandstone	1.7×10^{-6}	0.0048	Horizontal
		Packer	943.3	64	879.3	74	869.3	10	(F) Sandstone	1.4×10^{-6}	0.004	Horizontal
	2S	Packer	943.3	74	869.3	84	859.3	10	Siltstone and (v f) Sandstone	**1.8×10^{-5}**	**0.05**	Horizontal
		Packer	943.3	84	859.3	94	849.3	10	Shale	1×10^{-6}	0.0028	Horizontal
		Packer	943.3	94	849.3	104	839.3	10	Shale	1×10^{-6}	0.0028	Horizontal
		Packer	943.3	104	839.3	114	829.3	10	Shale	7.2×10^{-6}	0.02	Horizontal
		Packer	943.3	123	820.3	133	810.3	10	Silttstone	1.4×10^{-6}	0.004	Horizontal
		Packer	943.3	133	810.3	143	800.3	10	Silttstone	1×10^{-6}	0.0028	Horizontal
	DB	Packer	943.3	143	800.3	153	790.3	10	Siltstone and (v f) Sandstone	**1.2×10^{-6}**	**0.0034**	Horizontal
	DB	Packer	943.3	153	790.3	163	780.3	10	Shale	1×10^{-6}	0.0028	Horizontal
	DB	Packer	943.3	163	780.3	173	770.3	10	(F) Sandstone	1×10^{-6}	0.0028	Horizontal
NWS-03	1S	Packer	944.9	30	914.9	40	904.9	10	Claystone with siltstone	2.0×10^{-3}	5.7	Horizontal
	1S	Packer	944.9	40	904.9	50	894.9	10	Siltstone	1×10^{-6}	0.0028	Horizontal
	1S	Packer	944.9	50	894.9	60	884.9	10	Siltstone	**2.0×10^{-5}**	**0.057**	Horizontal
		Packer	944.9	60	884.9	70	874.9	10	(F) Sandstone grades to Shale	6.2×10^{-6}	0.018	Horizontal
	2S	Packer	944.9	70	874.9	80	864.9	10	(F) Sandstone with Shale interbeds	**2.5×10^{-5}**	**0.71**	Horizontal
	2S	Packer	944.9	80	864.9	90	854.9	10	Shale	1×10^{-6}	0.0028	Horizontal
		Packer	944.9	90	854.9	100	844.9	10	Shale	8.1×10^{-6}	0.023	Horizontal
		Packer	944.9	95	849.9	105	839.9	10	Shale	1×10^{-6}	0.0028	Horizontal
	DB	Packer	944.9	124	820.9	134	810.9	10	Claystone/Siltstone	4.3×10^{-5}	0.12	Horizontal

	DB	Packer	944.9	134	810.9	144	800.9	10	Grades to (F) Sandstone	1×10^{-6}	0.0028	Horizontal
	DB	Packer	944.9	144	800.9	154	790.9	10	(F) Sandstone	3.7×10^{-6}	0.01	Horizontal
	DB	Packer	944.9	154	790.9	164	780.9	10	(V F) Sandstone	**2.5×10^{-4}**	**0.71**	Horizontal
	DB	Packer	944.9	164	780.9	174	770.9	10	Shale	5×10^{-5}	0.14	Horizontal
NWS-04	1S	Packer	922.4	30	892.4	40	882.4	10	Silty Sandstone	**2.5×10^{-5}**	0.071	Horizontal
	1S	Packer	922.4	40	882.4	50	872.4	10	Shale with siltstone	1.8×10^{-4}	0.51	Horizontal
	2S	Packer	922.4	50	872.4	60	862.4	10	Shale with siltstone	**9.4×10^{-6}**	**0.027**	Horizontal
	2S	Packer	922.4	60	862.4	70	852.4	10	Shale	3.0×10^{-6}	0.0085	Horizontal
		Packer	922.4	70	852.4	80	842.4	10	Shale	1×10^{-6}	0.0028	Horizontal
		Packer	922.4	92	830.4	102	820.4	10	Siltstone grades to silty/sandy shale	1.8×10^{-6}	0.0051	Horizontal
		Packer	922.4	102	820.4	112	810.4	10	Silty Shale	2.9×10^{-6}	0.0082	Horizontal
		Packer	922.4	112	810.4	122	800.4	10	Silty Shale	4.4×10^{-6}	0.012	Horizontal
		Packer	922.4	122	800.4	132	790.4	10	Silty Shale	1×10^{-6}	0.0028	Horizontal
	DB	Packer	922.4	132	790.4	142	780.4	10	(F) Sandstone with Shale	**1.2×10^{-6}**	**0.0034**	Horizontal
	DB	Packer	922.4	142	780.4	152	770.4	10	Sandy shale	**4.5×10^{-6}**	**0.013**	Horizontal
		Packer	922.4	152	770.4	162	760.4	10	Siltstone and (f) sandstone	3.9×10^{-6}	0.011	Horizontal
		Packer	922.4	162	760.4	172	750.4	10	(F-M) Sandstone	1×10^{-6}	0.0028	Horizontal
		Packer	922.4	172	750.4	182	740.4	10	(M-C) Sandstone	2×10^{-6}	0.0057	Horizontal
NWS-05	1S	Packer	912.5	23	889.5	33	879.5	10	Fractured siltstone	**3.6×10^{-4}**	**1.02**	Horizontal
	1S	Packer	912.4	33	879.4	43	869.4	10	Siltstone	2.3×10^{-5}	0.065	Horizontal
	2S	Packer	912.4	43	869.4	53	859.4	10	Sandy Siltstone	**1.0×10^{-4}**	**0.28**	Horizontal
	2S	Packer	912.4	53	859.4	63	849.4	10	Shale	1×10^{-6}	0.0028	Horizontal
		Packer	912.4	82	830.4	92	820.4	10	Shale	3.5×10^{-6}	0.01	Horizontal
		Packer	912.4	92	820.4	102	810.4	10	Siltstone to shale	2.1×10^{-6}	0.006	Horizontal
	DB	Packer	912.4	102	810.4	112	800.4	10	Sandy Siltstone	6×10^{-6}	0.017	Horizontal
	DB	Packer	912.4	112	800.4	122	790.4	10	Sandy Siltstone	**5.6×10^{-5}**	**0.16**	Horizontal
	DB	Packer	912.4	122	790.4	132	780.4	10	Sandy Siltstone	2×10^{-6}	0.0057	Horizontal
	DB	Packer	912.4	132	780.4	142	770.4	10	Siltstone	3.6×10^{-6}	0.01	Horizontal
	DB	Packer	912.4	142	770.4	152	760.4	10	Sandstone	**6.8×10^{-4}**	**1.9**	Horizontal

Shaded areas indicate screened intervals.

TABLE 2-6

SLDA
SUMMARY OF SLUG TEST RESULTS

Slug Test Results Summary

Well ID	Hydrostratigraphic Zone Where Screened/Tested	Test Type	Ground Surface Elevation	Top of Test Interval[1]		Bottom of Test Interval		Total Test Interval	Test Interval Lithology	Hydraulic Conductivity	Hydraulic Conductivity	Direction
			ft msl	ft	elevation	ft	elevation	ft		cm/sec	ft/day	
MW-54	Mine Fill	Slug (F,R)	858.6	14.5	844.1	19.5	839.1	5	Mine Fill	1.85E-04	0.51	Horizontal
MW-56	Mine Fill	Slug (F,R)	859.4	16.0	843.4	26.0	833.4	10	Mine Fill	4.99E-04	1.41	Horizontal
MW-59	Overburden	Slug (F,R)	929.4	6.0	923.4	11.0	918.4	5	Silt and Clay, some (f) sand	3.82E-05	0.11	Horizontal
MW-64	Overburden	Slug (F,R)	943.9	9.0	934.9	19.0	924.9	10	(f-m) Sand, some silt and clay	5.74E-03	16.27	Horizontal
MW-69	Overburden	Slug (F,R)	945.5	10.0	935.5	20.0	925.5	10	(f) Sand and Silt, little clay	1.85E-03	5.24	Horizontal

TABLE 2-7
SUMMARY OF HORIZONTAL
HYDRAULIC GRADIENTS - SLDA

Hydrostratigraphic Unit	Well Locations	Groundwater Elevations (January 11, 2004)		dh (ft)	dl (ft)	Average K (ft/day)[1]	Effective Porosity[2]	Gradient	Direction	Apparent Groundwater Seepage Velocity (ft/day)[3]
Mine Fill	MW-56 to TWSP 10-04	841.13	837.70	3.43	170	0.95	0.20	0.020	Horizontal	0.10
Overburden	PZ-06A to TPZ-07	939.29	912.25	27.04	370	2.65	0.25	0.073	Horizontal	0.77
Overburden	PZ-07 to PZ-01	938.89	894.84	44.05	630	2.65	0.25	0.070	Horizontal	0.74
Overburden	PZ-09 to PZ-01	931.67	894.84	36.83	540	2.65	0.25	0.068	Horizontal	0.72
First Shallow Bedrock	MW-24 to TPZ-01	933.19	880.79	52.40	955	NA	NA	0.06	Horizontal	NA
First Shallow Bedrock	MW-24 to TPZ-02	933.19	891.03	42.16	750	NA	NA	0.06	Horizontal	NA
First Shallow Bedrock	MW-24 to MW-51	933.19	893.33	39.86	600	NA	NA	0.07	Horizontal	NA
First Shallow Bedrock	MW-24 to NWS-03-1	933.19	886.08	47.11	640	NA	NA	0.07	Horizontal	NA
							AVERAGE	**0.063**		
Second Shallow Bedrock	MW-52 to MW-11D	886.15	866.82	19.33	235	NA	NA	0.08	Horizontal	NA
Second Shallow Bedrock	MW-33 to MW-53	881.28	865.95	15.33	500	NA	NA	0.03	Horizontal	NA
							AVERAGE	**0.06**		
Upper Freeport	MW-01 to MW-31	838.01	834.66	3.35	1030	NA	NA	0.026	Horizontal	NA
Upper Freeport	NWS-05-3 to NWS-01A-3	838.77	831.96	6.81	680	NA	NA	0.010	Horizontal	NA
Upper Freeport	NWS-05-3 to MW-30A	838.77	829.85	8.92	980	NA	NA	0.009	Horizontal	NA
							AVERAGE	**0.02**		
Deep Bedrock	MW-58 to NWS-01A-4	832.87	749.09	83.78	1220	NA	NA	0.069	Horizontal	NA
Deep Bedrock	NWS-04-4 to NWS-01A-4	811.44	749.09	62.35	770	NA	NA	0.023	Horizontal	NA
	NWS-03-4 to NWS-01A	815.39	749.09	66.30	1100	NA	NA	0.019	Horizontal	NA
Deep Bedrock							**AVERAGE**	**0.04**		

Notes:

1. See Tables 2-5 and 2-6 for summary of K values
2. Effective porosity (e) estimated effective porosity (based on Fetter, 1980, pg 64)
3. Seepage velocity $\frac{K\,dh}{e\,(dl)}$

K average hydraulic conductivity in ft/day

dh - change in head

dl change in distance

dh/dl gradient

TABLE 2-8
COMPARISON OF GROUNDWATER ELEVATIONS AND SCREEN INTERVALS
FIRST SHALLOW BEDROCK WELLS - SLDA

Well	Zone Monitored	Groundwater Elevation	Top of Screen		Bottom of Screen		Center of Screen	Above (A) or Below (B) Top of Screen	Extent Above Screen
		1/11/2004	ft	elev	ft	elev	ft		ft
MW-7	1S	887.01	23.00	896.10	33.00	886.10	891.10	B	
MW-8	1S	918.49	24.00	905.30	34.00	895.30	900.30	A	13.19
MW-9A	1S	924.75	26.00	917.30	36.00	907.30	912.30	A	7.45
MW-12D	1S	889.39	22.00	894.40	32.00	884.40	889.40	B	
MW-13	1S	925.54	30.00	916.30	40.00	906.30	911.30	A	9.24
MW-14	1S	933.42	20.00	925.00	30.00	915.00	920.00	A	8.42
MW-15	1S	927.48	19.50	918.20	29.50	908.20	913.20	A	9.28
MW-24	1S	933.19	25.00	921.70	35.00	911.70	916.70	A	11.49
MW-25	1S	892.49	25.00	882.30	35.00	872.30	877.30	A	10.19
MW-26	1S	888.99	26.00	890.90	36.00	880.90	885.90	B	
MW-27	1S	891.35	25.00	902.30	35.00	892.30	897.30	B	
MW-29	1S	894.42	26.00	883.70	36.00	873.70	878.70	A	10.72
MW-32	1S	879.77	40.00	883.50	60.00	863.50	873.50	B	
MW-38	1S	901.52	50.00	891.70	60.00	881.70	886.70	A	9.82
MW-41	1S	893.01	25.00	885.60	35.00	875.60	880.60	A	7.41
MW-42	1S	881.68	30.00	884.50	40.00	874.50	879.50	B	
MW-44	1S	dry	42.00	886.90	52.00	876.90	881.90	B	
TPZ-01	1S	880.79	41.00	880.00	42.50	878.50	879.25	A	0.79
TPZ-02	1S	891.03	41.00	883.60	42.50	882.10	882.85	A	7.43
TPZ-03	1S	886.13	10.00	882.60	11.50	881.10	881.85	A	3.53
TPZ-04	1S	894.5	15.80	895.80	25.80	885.80	890.80	B	
TPZ-05	1S	893.92	21.00	893.80	31.00	883.80	888.80	A	0.12
MW-50	1S	864.64	24.80	874.30	34.80	864.30	869.30	B	
MW-51	1S	893.33	25.00	897.70	35.00	887.70	892.70	B	
MW-60	1S	883.77	37.00	892.13	47.00	882.13	887.13	B	
NWS-01A-1	1S	dry	38.00	891.10	48.00	881.10	886.10	B	
NWS-02-1	1S	na	45.00	898.30	55.00	888.30	893.30	B	
NWS-03-1	1S	886.08	53.00	891.90	63.00	881.90	886.90	B	
NWS-04-1	1S	dry	32.00	890.40	42.00	880.40	885.40	B	
NWS-05-1	1S	dry	25.00	887.50	35.00	877.50	882.50	B	
							AVERAGE		**7.79**
							MEDIAN		**8.83**

TABLE 2-8 (continued)

COMPARISON OF GROUNDWATER ELEVATIONS AND SCREEN INTERVALS
SECOND SHALLOW BEDROCK WELLS - SLDA

Well	Zone Monitored	Groundwater Elevation	Top of Screen		Bottom of Screen		Center of Screen	Above (A) or Below (B) Top of Screen	Extent Above Screen
		1/11/2004	ft	elev	ft	elev	ft		ft
MW-11D	2S	866.82	31.50	875.70	41.50	865.70	870.70	B	
MW-17	2S	861.84	41.00	870.50	51.00	860.50	865.50	B	
MW-33	2S	881.28	52.00	886.40	82.00	856.40	871.40	B	
MW-37	2S	dry	57.17	867.13	67.17	857.13	862.13	B	
MW-43	2S	874.62	35.00	879.30	45.00	869.30	874.30	B	
MW-45	2S	873.68	55.17	872.53	65.17	862.53	867.53	A	1.15
MW-52	1S	886.15	32.00	889.90	42.00	879.90	884.90	B	
MW-53	2S	865.95	48.50	874.20	58.50	864.20	869.20	B	
NWS-01A-2	2S	dry	54.00	875.10	64.00	865.10	870.10	B	
NWS-02-2	2S	NA	75.00	868.30	85.00	858.30	863.30	NA	
NWS-03-2	2S	868.68	70.00	874.90	80.00	864.90	869.90	B	
NWS-04-2	2S	dry	50.00	872.40	60.00	862.40	867.40	NA	
NWS-05-2	2S	dry	42.00	870.50	52.00	860.50	865.50	NA	

TABLE 2-9

SUMMARY OF VERTICAL GRADIENT DATA

Well Location	Unit Screened	Ground Elevation	Top of Screen		Bottom of Screen		Center of Screen		Water Level Elevation January 11, 2004	Gradient Direction
		ft	ft	elev	ft	elev	ft	elev	ft	
MW-47	SS	922.20	12.0	910.20	17.0	905.20	14.5	907.70	905.25	
MW-52	1S	921.90	32.0	889.90	42.0	879.90	37	884.90	886.15	down ↓
MW-34A	DB	924.30	165.0	759.30	185.0	739.30	175	749.30	dry	
MW-69	SS	945.50	10.0	935.50	20.0	925.50	15	930.50	934.46	down ↓
NWS-03-1	1S	944.90	53.0	891.90	63.0	881.90	58	886.90	886.08	
NWS-03-2	2S	944.90	70.0	874.90	80.0	864.90	75	869.90	868.68	
NWS-03-3	UF	944.90	110.0	834.90	118.0	826.90	114	830.90	829.95	
NWS-03-4	DB	944.90	154.0	790.90	164.0	780.90	159	785.90	815.39	
MW-11S	SS	907.10	5.00	902.10	10.0	897.10	7.5	899.60	899.10	down ↓
MW-29	1S	909.70	26	883.70	36	873.70	31	878.70	894.42	
MW-11D	2S	907.20	31.5	875.70	41.5	865.70	36.5	870.70	866.82	
PZ-09	SS	935.90	8	927.90	18	917.90	13	922.90	931.67	down ↓
MW-15	1S	937.70	19.5	918.20	29.5	908.20	24.5	913.20	927.48	
MW-33	2S	938.40	52	886.40	82	856.40	67	871.40	881.28	
MW-30A	UF	950.30	117	833.30	126	824.30	121.5	828.80	829.85	
MW-40	DB	937.30	169.65	767.65	189.65	747.65	179.65	757.65	806.57	
TPZ-4	1S	911.60	15.8	895.80	25.8	885.80	20.8	890.80	894.5	down ↓
MW-17	2S	911.50	41	870.50	51	860.50	46	865.50	861.84	
MW-35	DB	911.20	145	766.20	165	746.20	155	756.20	796.84	
NWS-05-3	UF	912.50	68.50	844.00	75.50	837.00	72.00	840.50	838.77	down ↓
NWS-05-4	DB	912.50	112	800.50	122	790.50	117	795.50	812.38	
NWS-05-5	DB	912.50	145	767.50	155	757.50	150	762.50	795.73	
MW-52	1S	921.90	32	889.90	42	879.90	37	884.90	886.15	down ↓
MW-32	2S	923.50	40	883.50	60	856.40	50	873.50	879.77	
MW-34A	DB	924.30	165	759.30	185	739.30	175	749.30	dry	

TABLE 2-10

SLDA SITE
2000 CENSUS DATA COMPARED TO 1990 CENSUS DATA

Place	2000 Population	Housing Units 2000	1990 Population	Housing Units 1990
Leechburg Borough	2,386	1,193	2,504	1,243
North Vandergrift – Pleasant View	1,355	604	1,431	619
Hyde Park Borough	513	231	542	241
Vandergrift	5,455	2,772	5,904	2,852
Totals	9,709	4,800	10,381	4,955

TABLE 3-1

SLDA REMEDIAL INVESTIGATION
VARIANCES FROM THE FIELD SAMPLING PLAN

Applicable Section	Plan Requirement	Variance
Section 3.1 - Task Descriptions	The plan called for measuring groundwater levels in all on-site wells prior to installation of new monitoring wells.	This task was not performed since ARCO provided groundwater level data collected by their consultant just prior to the RI work.
Section 5.4.1.1 - Soil Sampling Locations	The 101 proposed soil boring locations were called out in Figure 5-2.	One additional boring identified as SB-102R was advanced near SB-102 where elevated radiation levels were detected using the micro-R and FIDLER instruments. In addition, several of the soil boring locations were moved in the field due to adverse topography or trees. Typically, the adjustments were on the order of five to ten feet.
Section 5.4.1.2 - Discrete Sampling Requirements and Section 5.5.1.4 Discrete Surface Soil Sampling Locations	Section 5.4.1.2 indicated that if no elevated instrument measurements were detected during field screening, subsurface samples were to be collected from 4 to 6 feet, 8 to 10 feet, and 12 to 14 feet, or the bottom of the boring. If elevated field screening measurements were detected, one biased sample will be collected from the depth fraction with the highest measurement and the other two samples from directly above and directly below the biased sample. Section 5.5.1.4 indicated that at each subsurface soil sampling location, one surface soil sample was to be collected from ground surface to a depth of 0.5 feet.	At several boring locations, samples were collected from depths slightly different than those in the work plan. This was typically done when refusal was encountered at depths less than 14 feet, when sample recovery was lacking or when weathered shale bedrock was encountered. The following variances were implemented during the soil boring program: Sample SB-GB-001-10-12 was collected instead of a sample from the 12 to 14 foot interval since refusal was encountered at 12 feet. Samples SB-GB-005-8-10 and SB-GB-005-12-14 were not collected since refusal was encountered at 8 feet. Samples SB-GB-005-8-10 and SB-GB-005-12-14 were not collected since refusal was encountered at 8 feet. Samples SB-GB-006-8-10 and SB-GB-006-12-14 were not collected since refusal was encountered at 6.4 feet. Samples SB-GB-010-8-10 and SB-GB-010-12-14 were not collected since refusal was encountered at 6 feet. Sample SB-GB-011-8-10 was not collected since there was insufficient volume (recovery of 2 percent). Samples SB-GB-018-8-10 and SB-GB-018-12-14 were not collected since

Applicable Section	Plan Requirement	Variance
		weathered bedrock was encountered at 4 feet. Samples SB-GB-019-8-10 and SB-GB-019-12-14 were not collected since refusal was encountered at 7.8 feet. Samples SB-GB-020-8-10 and SB-GB-020-12-14 were not collected since refusal was encountered at 6.9 feet. Samples SB-GB-021-8-10 and SB-GB-021-12-14 were not collected since weathered shale was encountered between 7 and 11.1 feet (end of boring).Samples SB-GB-022-8-10 and SB-GB-022-12-14 were not collected since refusal w encountered at 6 feet. Sample SB-GB-023-8-10 was replaced with SB-GB-023-6-7.5 and sample SB-GB-023-12-14 was not collected since refusal was encountered at 7.5 feet. Sample SB-GB-024-8-10 was replaced with SB-GB-024-6-8.3 and sample SB-GB-024-12-14 was not collected since refusal was encountered at 9.3 feet. Sample SB-GB-025-4-6 was replaced with SB-GB-025-1-3 and samples SB-GB-025-8-10 and SB-GB-025-12-14 were not collected since refusal was encountered at 3 feet. Sample SB-GB-025-4-6 was replaced with SB-GB-025-1-3 and samples SB-GB-025-8-10 and SB-GB-025-12-14 were not collected since refusal was encountered at 3 feet. Sample SB-GB-027-4-6 was replaced with SB-GB-027-2-3.6 and samples SB-GB-027-8-10 and SB-GB-027-12-14 were not collected since refusal was encountered at 3.6 feet. Sample SB-GB-028-4-6 was replaced with SB-GB-028-4-6.5 and samples SB-GB-028-8-10 and SB-GB-028-12-14 were not collected since refusal was encountered at 6.5 feet. Sample SB-GB-029-8-10 was replaced with SB-GB-029-6-7.5 and sample SB-GB-029-12-14 was not collected since refusal was encountered at 7.5 feet. Sample SB-GB-030-8-10 was replaced with SB-GB-030-6-7.5 and sample SB-GB-030-12-14 was not collected since refusal was encountered at 8 feet. Sample SB-GB-031-8-10 was replaced with SB-GB-029-6-7.8 and sample SB-

Applicable Section	Plan Requirement	Variance
		GB-029-12-14 was not collected since refusal was encountered at 7.9 feet. Sample SB-GB-032-4-6 was replaced with SB-GB-032-1.5-3.5 and samples SB-GB-032-8-10 and SB-GB-032-12-14 were not collected since refusal was encountered at 4 feet. Sample SB-GB-033-4-6 was replaced with SB-GB-033-1-2.5 and samples SB-GB-033-8-10 and SB-GB-033-12-14 were not collected since refusal was encountered at 4 feet. Sample SB-GB-034-4-6 was replaced with SB-GB-034-3-5 and samples SB-GB-034-8-10 and SB-GB-034-12-14 were not collected since refusal was encountered at 6.5 feet. Sample SB-GB-035-8-10 was replaced with SB-GB-035-6-8 and sample SB-GB-030-12-14 was not collected since refusal was encountered at 9.7 feet and weathered rock was present between 8 and 9.7 feet. Sample SB-GB-036-12-14 was not collected since refusal was encountered at 12 feet. Sample SB-GB-037-12-14 was not collected since refusal was encountered at 12 feet. Samples SB-GB-038-8-10 and SB-GB-038-12-14 were not collected since refusal was encountered at 8 feet and weathered rock was present between 5.5 and 8 feet. Sample SB-GB-039-12-14 was not collected since refusal was encountered at 12 feet. Samples SB-GB-040-8-10 and SB-GB-040-12-14 were not collected since refusal was encountered at 7 feet. Samples SB-GB-041-8-10 and SB-GB-041-12-14 were not collected since refusal was encountered at 8 feet and weathered rock was present between 6 and 8 feet. Sample SB-GB-042-4-6 was replaced with SB-GB-042-4-5.5, sample SB-GB-042-8-10 was replaced with SB-GB-042-5.5-7.5 and sample SB-GB-042-12-14 was not collected since refusal was encountered at 8 feet. Samples SB-GB-043-8-10 and SB-GB-043-12-14 were not collected since refusal was encountered at 8 feet and weathered rock was present between 6 and 8 feet.

Applicable Section	Plan Requirement	Variance
		Sample SB-GB-044-4-6 was replaced with sample SB-GB-044-4-5.7 and samples SB-GB-044-8-10 and SB-GB-044-12-14 were not collected since bedrock was encountered at 5.7 feet. Sample SB-GB-045-4-6 was replaced with sample SB-GB-045-4-6.9 and samples SB-GB-045-8-10 and SB-GB-045-12-14 were not collected since bedrock was encountered at 6.9 feet. Sample SB-GB-046-12-14 was not collected since refusal was encountered at 12 feet. Sample SB-GB-047-8-10 was replaced with sample SB-GB-047-6-7.9 and sample SB-GB-047-12-14 was not collected since bedrock was encountered at 7.9 feet. Sample SB-GB-048-12-14 was not collected since refusal was encountered at 12 feet. Sample SB-GB-052-12-14 was replaced with sample SB-GB-052-10-12 since refusal was encountered at 12 feet. Sample SB-GB-060-12-14 was replaced with sample SB-GB-060-10-12 since refusal was encountered at 12.7 feet. Sample SB-GB-062-12-14 was replaced with sample SB-GB-062-10-12 since refusal was encountered at 12 feet. Sample SB-GB-063-12-14 was replaced with sample SB-GB-063-10-12 since refusal was encountered at 13 feet. Sample SB-GB-064-12-14 was not collected since refusal was encountered at 10.7 feet. Sample SB-GB-065-12-14 was replaced with sample SB-GB-065-10-12 since refusal was encountered at 12 feet. Sample SB-GB-066-4-6 was replaced with SB-GB-066-1-3 and samples SB-GB-066-8-10 and SB-GB-066-12-14 were not collected since refusal was encountered at 4 feet. Sample SB-GB-067-4-6 was replaced with SB-GB-067-1-3 and samples SB-GB-067-8-10 and SB-GB-067-12-14 were not collected since refusal was encountered at 4 feet. Sample SB-GB-068-4-6 was replaced with SB-GB-066-2-4 and samples SB-GB-066-8-10 and SB-GB-066-12-14 were not collected since refusal was encountered at 8 feet. Sample SB-GB-

Applicable Section	Plan Requirement	Variance
		069-4-6 was replaced with SB-GB-069-1-3 and samples SB-GB-069-8-10 and SB-GB-069-12-14 were not collected since refusal was encountered at 4 feet. Sample SB-GB-070-4-6 was replaced with SB-GB-070-1-3 and samples SB-GB-070-8-10 and SB-GB-070-12-14 were not collected since refusal was encountered at 4 feet. Sample SB-GB-071-8-10 was replaced with sample SB-GB-071-6-7.9 and sample SB-GB-071-12-14 was not collected since bedrock was encountered at 7.9 feet. Sample SB-GB-072-8-10 was replaced with sample SB-GB-072-6-7.3 and sample SB-GB-072-12-14 was not collected since bedrock was encountered at 7.3 feet. Sample SB-GB-073-4-6 was replaced with SB-GB-073-4-6.5 and samples SB-GB-073-8-10 and SB-GB-073-12-14 were not collected since bedrock was encountered at 7.5 feet. Sample SB-GB-074-8-10 was replaced with sample SB-GB-074-6-7.3 and sample SB-GB-074-12-14 was not collected since bedrock was encountered at 7.5 feet. Sample SB-GB-048-12-14 was not collected since refusal was encountered at 12 feet. Sample SB-GB-077-8-10 was replaced with sample SB-GB-077-6-8 since no recovery was present from the 8 to 12 foot interval. Sample SB-GB-078-12-14 was not collected since refusal was encountered at 11 feet. Sample SB-GB-079-12-14 was not collected since refusal was encountered at 12 feet. Sample SB-GB-080-12-14 was not collected since refusal was encountered at 12 feet. Sample SB-GB-081-12-14 was not collected since refusal was encountered at 12 feet. Sample SB-GB-082-12-14 was not collected since refusal was encountered at 12 feet. Sample SB-GB-083-12-14 was not collected since refusal was encountered at 10.3 feet. Sample SB-GB-084-12-14 was replaced with sample SB-GB-084-10-12 since refusal was encountered at 12 feet. Sample

Applicable Section	Plan Requirement	Variance
		SB-GB-086-12-14 was not collected since refusal was encountered at 12 feet. Sample SB-GB-087-12-14 was replaced with sample SB-GB-087-10-12 since refusal was encountered at 12 feet. Sample SB-GB-088-12-14 was replaced with sample SB-GB-088-10-12 since refusal was encountered at 12 feet. Sample SB-GB-089-4-6 was replaced with sample SB-GB-089-4-6.2 and samples SB-GB-089-8-10 and SB-GB-089-12-14 were not collected since bedrock was encountered at 6.5 feet. Samples SB-GB-090-8-10 and SB-GB-090-12-14 were not collected since bedrock was encountered at 6.7 feet. Samples SB-GB-091-8-10 and SB-GB-091-12-14 were not collected since bedrock was encountered at 7.2 feet. Sample SB-GB-097-4-6 was replaced with sample SB-GB-097-2-4 and samples SB-GB-097-8-10 and SB-GB-097-12-14 were not collected since bedrock was encountered at 4 feet. Sample SB-GB-098-4-6 was replaced with sample SB-GB-098-1-3 and samples SB-GB-098-8-10 and SB-GB-098-12-14 were not collected since bedrock was encountered at 4 feet. Sample SB-GB-099-4-6 was replaced with sample SB-GB-099-1-3 and samples SB-GB-099-8-10 and SB-GB-099-12-14 were not collected since bedrock was encountered at 4 feet. Sample SB-GB-100-4-6 was replaced with sample SB-GB-100-1-3 and samples SB-GB-100-8-10 and SB-GB-100-12-14 were not collected since bedrock was encountered at 4 feet. No samples were collected from boring SB-102; samples were collected from boring SB-102R instead.
Section 5.4.1.4 - Sample Collection and Field and Laboratory Analysis	The plan called for analysis of soil samples in accordance with Table 5-2.	Samples collected from borings SB-67, SB-68, SB-69, and SB-70 were collected from the immediate vicinity of where ARCO illustrated the location of MW-39 in CADD files forwarded from ARCO to the USACE. However, after the samples had been collected

Applicable Section	Plan Requirement	Variance
		and sent to the lab, the analysis was cancelled since the well is actually located some 200 feet to the southwest. Additional borings were not advanced around the actual location of well MW-39.
Section 5.4.2.1 - Drilling Methods	The plan called for the use of a Simco rig to advance soil borings where monitoring wells are not planned. In addition, the plan called for Simco borings to be backfilled with cement/bentonite grout and topped off with one foot of native soils.	Borings SB-089 and SB-090 were advanced using a CME-850 track rig due to access concerns with the Simco rig. Soil samples were retrieved using split spoons. Most of the Simco borings were backfilled to grade with the cement/bentonite grout, some were topped with native soils.
Section 5.5.1.2 - Sediment Sampling Locations from On-Site and Off-Site Drainage Channels	The plan called for collection of two sediment and surface water samples from the drainage swale adjacent to the site road near Trench 10.	Based upon a review of site hydrology during the course of the remedial investigation, it was determined that the drainage swale is not present. Therefore, the two sediment and surface water samples were not collected.
Section 5.6.1 - Surface Water and Seeps Rationale/Design	The plan calls for an inspection of Carnahan Run for the presence of seeps in addition to the "mine outfall" previously identified by ARCO. In addition, the plan has provisions to collect additional seep samples from the additional outfalls (although it is not a requirement of the plan).	The Carnahan Run reconnaissance was completed and two additional mine outfalls were identified. One of the outfalls located near Lee Lake was sampled in June 2004.
Section 5.6.2.1 - Sampling Methods for Surface Water and Seeps	The plan contains a detailed procedure for collection of groundwater seep samples which involves installation of a 1-inch diameter PVC screen into the creek bank.	Seep samples were collected directly from new 5-gallon buckets installed at each seep location. The buckets were perforated, cut off to a height of approximately 10 inches, and installed at each seep location. Seep samples were collected several days after the bucket was installed.
Section 5.7.1.1 - Trench Sample Locations	The proposed trench sample locations were shown on Figure 5-2. The plan calls for collection of soil samples from ground surface to 0.5 feet, 4 to 6 feet, 8-10 feet and 12-14 feet if there is no visual evidence of contamination and no elevated instrument readings.	Several of the trench boring locations were adjusted slightly to fall more closely to the centerline of the trench as illustrated on CADD files provided by ARCO. Sample SB-TR-010-006-12-14 was replaced with sample SB-TR-010-006-12-13.7 since refusal was encountered at 13.7 feet. Sample SB-TR-010-007-2-4 was replaced with sample SB-TR-

Applicable Section	Plan Requirement	Variance
		010-007-1-3 since refusal was encountered at 2.3 feet. Trench boring TR-010-007R was advanced approximately 10 feet from TR-010-007 and samples were collected in accordance with the protocols for a soil boring. Sample SB-TR-001-013-8-10 was replaced with SB-TR-001-013-6-8.5 and sample SB-TR-001-013-12-14 was not collected since refusal was encountered at 8.8 feet. Sample SB-TR-001-014-8-10 was replaced with SB-TR-001-014-7-9 and sample SB-TR-001-014-12-14 was not collected since refusal was encountered at 9.5 feet. Sample SB-TR-001-015-8-10 was replaced with SB-TR-001-015-8-9.5 and sample SB-TR-001-015-12-14 was not collected since refusal was encountered at 11.3 feet. Sample SB-TR-001-016-8-10 was replaced with SB-TR-001-016-8-9.5 and sample SB-TR-001-016-12-14 was not collected since refusal was encountered at 11.1 feet. Sample SB-TR-001-017-8-10 was replaced with SB-TR-001-017-6-8 and sample SB-TR-001-017-12-14 was not collected since refusal was encountered at 8 feet. Sample SB-TR-001-018-8-10 was replaced with SB-TR-001-018-6-8 and sample SB-TR-001-018-12-14 was not collected since refusal was encountered at 10 feet. Sample SB-TR-001-019-8-10 was replaced with SB-TR-001-019-8-9 and sample SB-TR-001-019-12-14 was not collected since refusal was encountered at 9 feet. Sample SB-TR-001-020-8-10 was replaced with SB-TR-002-020-8-10.2 and sample SB-TR-002-020-12-14 was not collected since refusal was encountered at 10.7 feet. Sample SB-TR-002-022-4-6 was replaced with SB-TR-002-022-4-5.9 and samples SB-TR-002-022-8-10 and SB-TR-002-022-12-14 were not collected since refusal was encountered at 5.9 feet. Sample SB-TR-003-029-8-10 was replaced by sample SB-TR-003-029-7-9 and sample SB-TR-003-029-12-14 was not collected since refusal was encountered

Applicable Section	Plan Requirement	Variance
		at 10 feet. Sample SB-TR-007-034-8-10 was replaced by sample SB-TR-007-034-8-10.9 and sample SB-TR-007-034-12-14 was not collected since refusal was encountered at 10.9 feet. Sample SB-TR-006-035-12-14 was not collected since refusal was encountered at 12 feet. Sample SB-TR-006-036-8-10 was replaced by sample SB-TR-006-036-8-11.2 and sample SB-TR-006-036-12-14 was not collected since refusal was encountered at 11.2 feet. Sample SB-TR-005-041-8-10 was replaced by sample SB-TR-005-041-6-7.7 and sample SB-TR-005-041-12-14 was not collected since refusal was encountered at 7.7 feet. Sample SB-TR-005-042-8-10 was replaced by sample SB-TR-005-042-8-10.6 and sample SB-TR-005-042-12-14 was not collected since refusal was encountered at 10.6 feet. Sample SB-TR-005-043-4-6 was replaced by sample SB-TR-005-043-4-4.9 and samples SB-TR-005-043-8-10 and SB-TR-005-043-12-14 were not collected since refusal was encountered at 4.9 feet.
Section 5.7.1.2 - Sample Collection and Field and Laboratory Analysis	The plan calls for soil samples collected from trench boring locations to be analyzed in accordance with Table 5-2.	At the request of the project team, several samples from borings that were deemed "soil borings" were achieved on-site and not analyzed.
Section 5.7.2 - Field Procedures	The plan called for trench borings to be backfilled with cement/bentonite grout and topped off with one foot of native soils.	Most of the trench borings were backfilled to grade with the cement/bentonite grout, some were topped with native soils.
Section 5.7.2.1 - Drilling Methods	The plan calls for placement of an 8 by 8 foot wooden frame covered with geotextile fabric on the ground surface for trench boring drilling.	The wooden frame was 4 foot square.
Section 6.4.1 - Sample Numbering System	The plan calls for "solid waste samples from trench borings" to be identified as TR (01 through 10)-01:6.0-8.0.	A unique convention was established to distinguish between waste and soil samples collected during the trench boring program. Soil samples were identified by placing the prefix SB- in front of the ID with the rest of the ID remaining the same.

Applicable Section	Plan Requirement	Variance
Section 7.0 - Sample Packaging and Shipping	The plan called for samples to shipped via overnight courier service. The plan called for applying custody seals on the cooler prior to shipment. The plan called for decontamination of soil sampling equipment with a 2-propanol and a 10% nitric acid solution in deionized water.	In general, samples specified for radionucide analysis were shipped via UPS or Fed-Ex second or third day delivery. Samples specified for chemical analyses were shipped overnight due to shorter holding time constraints. Custody seals were inadvertently omitted from being placed on the coolers shipped initially from the site. However, custody seals were placed on coolers shipped after these circumstances were discovered. After discussion with the USACE, it was decided that stainless steel sampling equipment could be decontaminated using Alconox and water only.

TABLE 3-2

SUMMARY OF SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED FOR BACKGROUND SAMPLES COLLECTED FROM GILPIN/LEECHBURG COMMUNITY PARK

Soil Boring Location	Soil Sample ID	Date Sampled	Analysis Completed: Primary ROPC[1]	Analysis Completed: Secondary ROPC[2]	Field Screening Results: Low Energy Gamma FIDLER (cts/min)	Field Screening Results: Fidler Bkg (cts/min)	Field Screening Results: Gamma (urem/hr)	Field Screening Results: VOC - PID (ppm)	Comments
BK-001	SO-BK-001-0-0.5	10/20/2003	X		13452		6	BG	
BK-001	SB-BK-001-2-4	10/20/2003	X		13643		6	BG	
BK-001	SO-FD-011-0-0.5	10/20/2003	X		13629		6	BG	Field Dup of Boring BK-001
BK-001	SB-FD-011-2-4	10/20/2003	X		13361		6	BG	Field Dup of Boring BK-001
BK-002	SO-BK-002-0-0.5	10/20/2003	X		13434		5	BG	
BK-002	SB-BK-002-2-4	10/20/2003	X		13839		6	BG	
BK-003	SO-BK-003-0-0.5	10/20/2003	X		13494		6	BG	
BK-003	SB-BK-003-2-4	10/20/2003	X		13723		6	BG	
BK-004	SO-BK-004-0-0.5	10/20/2003	X	X	13935		6	BG	
BK-004	SB-BK-004-2-4	10/20/2003	X	X	13755		6	BG	
BK-005	SO-BK-005-0-0.5	10/20/2003	X		13390		6	BG	
BK-005	SB-BK-005-2-4	10/20/2003	X		13016		6	BG	
BK-006	SO-BK-006-0-0.5	10/20/2003	X		13521		6	BG	
BK-006	SB-BK-006-2-4	10/20/2003	X		13339		6	BG	
BK-007	SO-BK-007-0-0.5	10/20/2003	X		13118		6	BG	
BK-007	SB-BK-007-2-4	10/20/2003	X		13063		6	BG	
BK-008	SO-BK-008-0-0.5	10/20/2003	X		13534		6	BG	
BK-008	SB-BK-008-2-4	10/20/2003	X		13434		6	BG	
BK-009	SO-BK-009-0-0.5	10/20/2003	X		13484		6	BG	
BK-009	SB-BK-009-2-4	10/20/2003	X		13895		6	BG	
BK-010	SO-BK-010-0-0.5	10/20/2003	X		13425		6	BG	
BK-010	SB-BK-010-2-4	10/20/2003	X		13351		6	BG	
BK-010	SO-FD-012-0-0.5	10/20/2003	X		13746		6	BG	Field Dup of Boring BK-010
BK-010	SB-FD-012-2-4	10/20/2003	X		13857		6	BG	Field Dup of Boring BK-010
BK-011	SO-BK-011-0-0.5	10/20/2003	X		14251		6	BG	
BK-011	SB-BK-011-2-4	10/20/2003	X		14238		6	BG	
BK-012	SO-BK-012-0-0.5	10/20/2003	X		13947		6	BG	
BK-012	SB-BK-012-2-4	10/20/2003	X		16678		6	BG	
BK-013	SO-BK-013-0-0.5	10/21/2003	X		16308		6	BG	
BK-013	SB-BK-013-2-4	10/21/2003	X		15811		6	BG	
BK-014	SO-BK-014-0-0.5	10/21/2003	X		16265		6	BG	
BK-014	SB-BK-014-2-4	10/21/2003	X						
BK-015	SO-BK-015-0-0.5	10/21/2003	X	X					
BK-015	SB-BK-015-2-4	10/21/2003	X	X					
BK-015	SB-FD-013-2-4	10/21/2003		X					Field Dup of Boring BK-015
BK-016	SO-BK-016-0-0.5	10/21/2003	X						
BK-016	SB-BK-016-2-4	10/21/2003	X						
BK-017	SO-BK-017-0-0.5	10/21/2003	X						
BK-017	SB-BK-017-2-4	10/21/2003	X						
BK-018	SO-BK-018-0-0.5	10/21/2003	X						
BK-018	SB-BK-018-2-4	10/21/2003	X						

1 -- Primary ROPC include U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. All samples were analyzed for the primary ROPC.
2 -- Secondary ROPC include Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, and Pu-242. Only 10% of the samples were analyzed for the secondary ROPC.

TABLE 3-3

SUMMARY OF SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED FOR WASTE SAMPLES COLLECTED FROM THE DISPOSAL TRENCHES (PROTOCOL NOS. 1 AND/OR 2)

Trench Boring Location	Waste Sample ID	Date Sampled	Analysis Completed: Primary ROPC[1]	Analysis Completed: Secondary ROPC[2]	Analysis Completed: TCLP, RCRA Parameters, PCB	Field Screening Results: Low Energy Gamma FIDLER (cts/min)	Field Screening Results: Fidler Bkg (cts/min)	Field Screening Results: Gamma (urem/hr)	Field Screening Results: VOC - PID (ppm)	Comments
TR-002-021	TR-002-021-11-12.5	11/19/2003	X			17790	14814	14	0	200 cpm Pancake
TR-002-023	TR-002-023-8-12	11/18-19/2003	X		X	41983	14628	22	0	
TR-002-024	TR-002-024-8-10	11/18/2003	X	X		26204	14628	12	0	
TR-002-025	TR-002-025-4-6	11/18/2003	X			13595	14628	12	0	
TR-004-039	TR-004-039-8-9.3	11/11/2003	X			11579	10414	10	0	
TR-004-040	TR-004-040-11-13	11/11-12/2003	X		X	13358	10414	10	0	250 cpm Pancake
TR-006-037	TR-006-037-15-16	11/10/2003	X	X		23247	11293	17	0	10000 cpm Pancake
TR-006-037	TR-006-037-11.8-16	11/22/2003			X	15788	14250	12	0	Waste- 17k through 23k Fidler, 800cpm Pancake
TR-006-038	TR-006-038-16-17.6	11/10/2003	X			12563	11293	11	0	150cpm Pancake
TR-007-031	TR-007-031-3.5-5.5	11/9/2003	X			19729	11504	11	0	
TR-007-033	TR-07-033-8-12	11/22/2003			X	20577	14568	13	0	
TR-007-033	TR-07-033-8-15.8	11/22/2003	X							10000 cpm Pancake
TR-008-030	SB-TR-008-030-14-16	11/8/2003			X (RCRA/PCB only)	11352	Not recorded	10	0	
TR-008-030	SB-TR-008-030-16-16.7	11/8/2003			X (TCLP only)	11447	Not recorded	10	1.2-2.4	VOC readings suspect
TR-009-026	TR-009-026-8-10	11/18/2003	X	X		14376	14628	12	0	
TR-009-027	TR-009-027-8-9.5	11/18/2003	X		X	15418	14628	12-14	0	600 cpm Pancake
TR-009-028	TR-009-028-5.5-7.8	11/13/2003	X			13064	12254	11	0	

1 -- Primary ROPC include U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. All samples were analyzed for the primary ROPC.

2 -- Secondary ROPC include Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, and Pu-242. Only 10% of the samples were analyzed for the secondary ROPC.

TABLE 3-4

SUMMARY OF SAMPLE IDENTIFICATION, SAMPLE DATE, ANALYSIS COMPLETED, AND FIELD SCREENING DATA FOR SAMPLES COLLECTED FROM TRENCH BORINGS THAT WERE SUBMITTED FOR LABORATORY TESTING

Trench Boring Location	Soil or Waste Sample ID	Date Sampled	Analysis Completed: Primary ROPC[1]	Secondary ROPC[2]	TCLP, RCRA Parameters PCB	Field Screening Results: Low Energy Gamma FIDLER (cts/min)	Fidler Bkg (cts/min)	Gamma (urem/hr)	VOC - PID (ppm)	Comments
TR-010-001	SO-TR-010-001-0.0.5	11/8/2003	X			12139	13103	8	0	
TR-010-001	SB-TR-010-001-4-6	11/8/2003	X			12573	13103	8	0	
TR-010-001	SB-TR-010-001-8-10	11/8/2003	X			12674	13103	8	0	
TR-010-002	SO-TR-010-002-0.0.5	11/8/2003	X			12634	13103	8	0	
TR-010-002	SB-TR-010-002-4-6	11/8/2003	X		X	12491	13103	8	0	
TR-010-002	SB-TR-010-002-8-10	11/8/2003	X			12802	13103	8	0	
TR-010-002	SB-TR-010-002-12-14	11/8/2003	X			12636	13103	8	0	
TR-010-003	SB-TR-010-003-8-12	11/7/2003	X			12283	12888	12	0	
TR-010-004	SB-TR-010-004-8-10	11/7/2003	X			12369	13059	12	0	
TR-010-005	SO-TR-010-005-0.0.5	11/6-7/03	X			12723	13059	11	0	
TR-010-005	SB-TR-010-005-4-6	11/6-7/03	X			12651	13059	11	0	
TR-010-005	SB-TR-010-005-8-10	11/6-7/03	X			12558	13059	11	0	
TR-010-005	SB-TR-010-005-12-14	11/6-7/03	X			12264	13059	11	0	
TR-010-006	SB-TR-010-006-8-10	11/6/2003	X			12584	13059	11	0	
TR-010-006	SB-TR-FD-001-8-10	11/7/2003	X			12343	12678	11	0	Field Dup of 006
TR-010-007R	SB-TR-010-007R-8-10	11/7/2003	X	X	X	12370	12502	12	0	
TR-010-010	SB-TR-010-010-8-10	11/6/2003	X			13287	13297	12	0	
TR-010-012	SB-TR-010-012-8-10	11/5/2003	X			14538	14692	13	0	
TR-001-013	SB-TR-001-013-6-8.5	11/21/2003	X		X	11951	11932	10	0	
TR-001-013	TR-FD-003-6-8.5	11/21/2003	X			11951	11932	10	0	Field Dup of 013
TR-001-014	SB-TR-01-014-7-9	11/21/2003	X			12487	11932	9	0	
TR-001-015	SB-TR-01-015-8-9.5	11/20/2003	X			12295	12208	10	0	
TR-001-017	SB-TR-01-017-6-8	11/20/2003	X			12209	11655	10	0	
TR-001-018	SB-TR-01-018-6-8	11/20/2003	X			12335	11655	10	0	
TR-001-018	SB-TR-FD-005-6-8	11/20/2003	X			12335	11655	10	0	Field Dup of 018
TR-001-017	SB-TR-FD-002-6-8	11/20/2003	X			12461	11655	10	0	Field Dup of 017
TR-001-019	SB-TR-01-019-8-9	11/20/2003	X			11772	11655	10	0	
TR-002-020	SB-TR-02-020-8-10.5	11/19/2003	X			15254	14814	12	0	
TR-002-022	SO-TR-02-022-0-0.5	11/19/2003	X			16139	14818	13	0	
TR-002-022	SB-TR-02-022-4-5.9	11/19/2003	X			16500	14818	13	0	
TR-003-029	SB-TR-03-029-7-9	11/13/2003	X			12641	12254	11	0	
TR-005-041	SB-TR-05-041-6-7.7	11/11-12/03	X		X	11184	10769	10	0	
TR-005-042	SB-TR-05-042-8-10.6	11/11/2003	X			11415	10769	10	0	
TR-006-035	SO-TR-006-035-8-10	11/10/2003	X			12667	12486	11	0	
TR-007-032	SO-TR-007-032-4-6	11/9/2003	X			11352	11504	11	0	
TR-007-032	SO-TR-007-032-8-10	11/9/2003	X			10885	11504	11	0	
TR-007-033	SO-TR-007-034-8-10.9	11/10/2003	X			11363	11504	11	0	

1 -- Primary ROPC include U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. All samples were analyzed for the primary ROPC.
2 -- Secondary ROPC include Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, and Pu-242. Only 10% of the samples were analyzed for the secondary ROPC.

TABLE 3-5							
SUMMARY OF SAMPLE IDENTIFICATION, SAMPLE DATE, AND FIELD SCREENING DATA COLLECTED FOR SAMPLES COLLECTED FROM TRENCH BORINGS THAT WERE NOT SUBMITTED FOR LABORATORY ANALYSIS							
			Field Screening Results				
Trench Boring Location	**Soil or Waste Sample ID**	**Date Sampled**	**Low Energy Gamma FIDLER (cts/min)**	**Fidler Bkg (cts/min)**	**Gamma (urem/hr)**	**VOC - PID (ppm)**	**Comments**
TR-010-001	SB-TR-010-001-12-14	11/8/2003	12529	13103	8	0	
TR-010-003	SO-TR-010-003-0.0.5	11/7/2003	12304	12888	12	0	
TR-010-003	SB-TR-010-003-4-6	11/7/2003	12489	12888	12	0	
TR-010-003	SB-TR-010-003-12-14	11/7/2003	12151	12888	12	0	
TR-010-004	SO-TR-010-004-0.0.5	11/7/2003	12103	13059	12	0	
TR-010-004	SB-TR-010-004-4-6	11/7/2003	12571	13059	12	0	
TR-010-004	SB-TR-010-004-12-14	11/7/2003	12368	13059	12	0	
TR-010-006	SO-TR-010-006-0.0.5	11/6/2003	12648	13059	11	0	
TR-010-006	SB-TR-010-006-4-6	11/6/2003	12581	13059	11	0	
TR-010-006	SB-TR-010-006-12-13.7	11/6/2003	12445	13059	11	0	
TR-010-006	SO-TR-FD-001-0-0.5	11/7/2003	12602	12678	11	0	Field Dup of 006
TR-010-006	SB-TR-FD-001-4-6	11/7/2003	12083	12678	11	0	Field Dup of 006
TR-010-006	SB-TR-FD-001-12-13.5	11/7/2003	12637	12678	11	0	Field Dup of 006
TR-010-007	SO-TR-010-007-0-0.5	11/6/2003	12956	13059	11	0	
TR-010-007	SB-TR-010-007-1-3	11/6/2003	12956	13059	11	0	
TR-010-007R	SO-TR-010-007R-0-0.5	11/7/2003	13398	12502	12	0	
TR-010-007R	SB-TR-010-007R-4-6	11/7/2003	12364	12502	12	0	
TR-010-007R	SB-TR-010-007R-12-14	11/7/2003	12316	12502	12	0	
TR-010-008	SO-TR-010-008-0.0.5	11/6/2003	12895	12785	11	0	
TR-010-008	SB-TR-010-008-4-6	11/6/2003	12552	12785	11	0	
TR-010-008	SB-TR-010-008-8-10	11/6/2003	12765	12785	11	0	
TR-010-008	SB-TR-010-008-12-14	11/6/2003	12519	12785	11	0	
TR-010-009	SO-TR-010-009-0.0.5	11/6/2003	12960	13297	13	0	
TR-010-009	SB-TR-010-009-4-6	11/6/2003	13104	13297	12	0	
TR-010-009	SB-TR-010-009-8-10	11/6/2003	12962	13297	12	0	
TR-010-009	SB-TR-010-009-12-14	11/6/2003	13182	13297	12	0	
TR-010-010	SO-TR-010-010-0.0.5	11/6/2003	13314	13297	12	0	
TR-010-010	SB-TR-010-010-4-6	11/6/2003	13107	13297	12	0	
TR-010-010	SB-TR-010-010-12-14	11/6/2003	13179	13297	12	0	
TR-010-011	SO-TR-010-011-0.0.5	11/5/2003	13548	13448	13	0	
TR-010-011	SB-TR-010-011-4-6	11/5/2003	13582	13448	13	0	
TR-010-011	SB-TR-010-011-8-10	11/5/2003	13623	13448	13	0	
TR-010-011	SB-TR-010-011-12-14	11/5/2003	13684	13448	13	0	
TR-010-012	SO-TR-010-012-0.0.5	11/5/2003	14464	14692	12	0	
TR-010-012	SB-TR-010-012-4-6	11/5/2003	14281	14692	13	0	
TR-010-012	SB-TR-010-012-12-14	11/5/2003	14558	14692	13	0	
TR-010-013	SO-TR-01-013-0-0.5	11/21/2003	12255	11932	9	0	
TR-010-013	SB-TR-01-013-4-6	11/21/2003	11536	11932	9	0	
TR-010-013	TR-FD-003-4-6	11/21/2003	11536	11932	9	0	
TR-010-014	SO-TR-01-014-0-0.5	11/21/2003	12357	11932	9	0	
TR-010-014	SB-TR-01-014-4-6	11/21/2003	12371	11932	9	0	
TR-010-015	SO-TR-01-015-0-0.5	11/20/2003	12238	12208	10	0	
TR-010-015	SB-TR-01-015-4-6	11/20/2003	12625	12208	10	0	
TR-010-016	SO-TR-01-016-0-0.5	11/20/2003	12649	11655	10	0	
TR-010-016	SB-TR-01-016-4-6	11/20/2003	12059	11655	10	0	
TR-010-016	SB-TR-01-016-8-9.5	11/20/2003	12673	11655	10	0	
TR-010-017	SO-TR-01-017-0-0.5	11/20/2003	12043	11655	10	0	
TR-010-017	SB-TR-01-017-4-6	11/20/2003	12209	11655	10	0	
TR-010-018	SO-TR-01-018-0-0.5	11/20/2003	12057	11655	10	0	
TR-010-018	SB-TR-01-018-4-6	11/20/2003	12129	11655	10	0	
TR-010-018	SB-TR-FD-005-4-6	11/21/2003	11869	11636	10	0	
TR-010-018	SB-TR-FD-005-6-8	11/21/2003	12025	11636	10	0	
TR-010-019	SO-TR-01-019-0-0.5	11/20/2003	12476	11655	10	0	
TR-010-019	SB-TR-01-019-4-6	11/20/2003	12365	11655	10	0	
TR-020-020	SO-TR-02-020-0-0.5	11/19/2003	14861	14814	12	0	
TR-020-020	SB-TR-02-020-4-6	11/19/2003	14653	14814	12	0	
TR-030-029	SO-TR-03-029-0-0.5	11/13/2003	13036	12254	11	0	
TR-030-029	SB-TR-03-029-4-6	11/13/2003	12825	12254	11	0	
TR-050-041	SO-TR-05-041-0-0.5	11/11/2003	11036	10769	10	0	
TR-050-041	SB-TR-05-041-4-6	11/11/2003	11184	10769	10	0	
TR-050-043	SO-TR-05-043-0-0.5	11/11/2003	10858	10769	10	0	

TABLE 3-5 SUMMARY OF SAMPLE IDENTIFICATION, SAMPLE DATE, AND FIELD SCREENING DATA COLLECTED FOR SAMPLES COLLECTED FROM TRENCH BORINGS THAT WERE NOT SUBMITTED FOR LABORATORY ANALYSIS							
			Field Screening Results				
Trench Boring Location	**Soil or Waste Sample ID**	**Date Sampled**	**Low Energy Gamma FIDLER (cts/min)**	**Fidler Bkg (cts/min)**	**Gamma (urem/hr)**	**VOC - PID (ppm)**	**Comments**
TR-050-043	SB-TR-05-043-4-4.9	11/11/2003	11215	10769	10	0	
TR-060-035	SO-TR-006-035-0-0.5	11/10/2003	12682	12486	11	0	
TR-060-035	SO-TR-006-035-4-6	11/10/2003	12658	12486	11	0	
TR-060-036	SO-TR-006-036-0-0.5	11/10/2003	12644	12486	11	0	
TR-060-036	SO-TR-006-036-4-6	11/10/2003	12538	12486	11	0	
TR-060-036	SO-TR-006-036-8-11.2	11/10/2003	12497	12486	11	0	
TR-060-036	SO-TR-FD-004-0-0.5	11/10/2003	12392	12486	11	0	Field Dup of 036
TR-060-036	SB-TR-FD-004-4-6	11/10/2003	12298	12486	11	0	Field Dup of 036
TR-060-036	SB-TR-FD-004-8-11.2	11/10/2003	12086	12486	11	0	Field Dup of 036
TR-070-032	SO-TR-007-032-0-0.5	11/9/2003	11378	11504	11	0	
TR-070-032	SO-TR-007-032-12-14	11/9/2003	11600	11504	11	0	
TR-070-033	TR-07-033-6-8	11/22/2003	17500	11504	11	0	Bottles received broken, analysis cancelled
TR-070-034	SO-TR-007-034-0-0.5	11/10/2003	11566	11504	11	0	
TR-070-034	SO-TR-007-034-4-6	11/10/2003	11240	11504	11	0	

TABLE 3-6

SUMMARY OF SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED FOR SAMPLES COLLECTED FROM SOIL BORINGS ADVANCED OUTSIDE THE DISPOSAL TRENCHES

			Analysis Completed		Field Screening Results				
Soil Boring Location	**Soil Sample ID**	**Date Sampled**	**Primary ROPC[1]**	**Secondary ROPC[2]**	**Low Energy Gamma FIDLER (cts/min)**	**Fidler Bkg (cts/min)**	**Gamma (urem/hr)**	**VOC - PID (ppm)**	**Comments**
GB-001	SO-GB-001-0-0.5	10/21/03	X		12,752	14,769	5	BG	
GB-001	SB-GB-001-4-6	10/21/03	X		13,531	14,769	5 - 6	BG	
GB-001	SB-GB-001-8-10	10/21/03	X		13,374	14,769	5	BG	
GB-001	SB-GB-001-10-12	10/21/03	X		13,374	14,769	5	BG	Refusal Encountered at 12'
GB-002	SO-GB-002-0-0.5	10/21/03	X		11,562	11,700	10	BG	
GB-002	SB-GB-002-4-6	10/21/03	X		11,555	11,700	11	BG	
GB-002	SB-GB-002-8-10	10/21/03	X		11,404	11,700	10	BG	
GB-002	SB-GB-002-12-14	10/21/03	X		11,520	11,700	11	BG	
GB-012	SO-GB-012-0-0.5	10/21/03	X		11,191	11,700	11	BG	
GB-012	SB-GB-012-4-6	10/21/03	X		11,249	11,700	10	BG	
GB-012	SB-GB-012-8-10	10/21/03	X		11,192	11,700	10	BG	
GB-012	SB-GB-012-12-14	10/21/03	X		10,970	11,700	11	BG	
GB-003	SO-GB-003-0-0.5	10/21/03	X	X	10,804	11,700	11	BG	
GB-003	SB-GB-003-4-6	10/21/03	X	X	10,871	11,700	11	BG	
GB-003	SB-GB-003-8-10	10/21/03	X	X	11,110	11,700	10	BG	
GB-003	SB-GB-003-12-14	10/21/03	X	X	10,915	11,700	10	BG	
GB-004	SO-GB-004-0-0.5	10/22/03	X		10,652	11,284	10	BG	
GB-004	SB-GB-004-4-6	10/22/03	X		10,710	11,284	10	BG	
GB-005	SO-GB-005-0-0.5	10/22/03	X		10,699	11,284	10	BG	
GB-005	SB-GB-005-4-6	10/22/03	X		10,697	11,284	10	BG	
GB-005	SO-FD-01-0-0.5	10/22/03	X		10,699	11,284	10	BG	Field Dup of 005
GB-005	SB-FD-01-4-6	10/22/03	X		10,697	11,284	10	BG	Field Dup of 005
GB-006	SO-GB-006-0-0.5	10/22/03	X		10,719	11,284	10	BG	
GB-006	SB-GB-006-4-6	10/22/03	X		10,575	11,284	10	BG	
GB-007	SO-GB-007-0-0.5	10/22/03	X		10,609	11,284	10	BG	
GB-007	SB-GB-007-4-6	10/22/03	X		10,508	11,284	10	BG	
GB-007	SB-GB-007-8-10	10/22/03	X		10,802	11,284	10	BG	
GB-007	SB-GB-007-12-14	10/22/03	X		10,546	11,284	10	BG	
GB-101	SO-GB-101-0-0.5	10/22/03	X		21,201	11,284	10	BG	
GB-101	SB-GB-101-4-6	10/22/03	X		10,909	11,284	10	BG	
GB-101	SB-GB-101-8-10	10/22/03	X		10,734	11,284	10	BG	
GB-101	SB-GB-101-12-14	10/22/03	X		10,340	11,284	10	BG	
GB-101	SO-FD-02-0-0.5	10/22/03	X		22,933	11,284	10	BG	Field Dup of 101
GB-101	SB-FD-02-4-6	10/22/03	X		10,909	11,284	10	BG	Field Dup of 101
GB-101	SB-FD-02-8-10	10/22/03	X		10,734	11,284	10	BG	Field Dup of 101
GB-101	SB-FD-02-12-14	10/22/03	X		10,340	11,284	10	BG	Field Dup of 101
GB-008	SO-GB-008-0-0.5	10/21/03	X		11,026	11,700	10	BG	
GB-008	SB-GB-008-4-6	10/21/03	X		11,089	11,700	10	BG	
GB-008	SB-GB-008-8-10	10/21/03	X		10,849	11,700	10	BG	
GB-008	SB-GB-008-12-14	10/21/03	X		10,702	11,700	10	BG	
GB-009	SO-GB-009-0-0.5	10/21/03	X		11,459	11,700	11	BG	
GB-009	SB-GB-009-4-6	10/21/03	X		11,109	11,700	11	BG	
GB-009	SB-GB-009-8-10	10/21/03	X		11,080	11,700	10.5	BG	
GB-009	SB-GB-009-12-14	10/21/03	X		11,039	11,700	10	BG	
GB-010	SO-GB-010-0-0.5	10/22/03	X		10,921	11,284	10	BG	
GB-010	SB-GB-010-4-6	10/22/03	X		11,085	11,284	10	BG	
GB-011	SO-GB-011-0-0.5	10/22/03	X		10,882	11,284	10	BG	
GB-011	SB-GB-011-4-6	10/22/03	X		10,593	11,284	10	BG	
GB-011	SB-GB-011-12-14	10/22/03	X		10,557	11,284	10	BG	
GB-102	SO-GB-102-0-0.5		X		10,809	11,284	10	BG	Cancelled (See Resample)

TABLE 3-6									
SUMMARY OF SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED FOR SAMPLES COLLECTED FROM SOIL BORINGS ADVANCED OUTSIDE THE DISPOSAL TRENCHES									
			Analysis Completed		**Field Screening Results**				
Soil Boring Location	**Soil Sample ID**	**Date Sampled**	**Primary ROPC[1]**	**Secondary ROPC[2]**	**Low Energy Gamma FIDLER (cts/min)**	**Fidler Bkg (cts/min)**	**Gamma (urem/hr)**	**VOC - PID (ppm)**	**Comments**
GB-102	SB-GB-102-4-6		X		10,885	11,284	10	BG	Cancelled (See Resample)
GB-102	SB-GB-102-8-10		X		10,769	11,284	10	BG	Cancelled (See Resample)
GB-102	SB-GB-102-12-14		X		10,662	11,284	10	BG	Cancelled (See Resample)
GB-013	SO-GB-013-0-0.5	10/22/03	X	X	10,885	11,284	10	BG	
GB-013	SB-GB-013-4-6	10/22/03	X	X	10,929	11,284	10	BG	
GB-013	SB-GB-013-8-10	10/22/03	X	X	10,812	11,284	10	BG	
GB-013	SB-GB-013-12-14	10/22/03	X	X	10,760	11,284	10	BG	
GB-014	SO-GB-014-0-0.5	10/22/03	X		10,648	11,284	10	BG	
GB-014	SB-GB-014-4-6	10/22/03	X		10,574	11,284	10	BG	
GB-014	SB-GB-014-8-10	10/22/03	X		10,726	11,284	10	BG	
GB-014	SB-GB-014-12-14	10/22/03	X		10,764	11,284	10	BG	
GB-015	SO-GB-015-0-0.5	10/23/03	X		12,656	12,767	12	BG	
GB-015	SB-GB-015-4-6	10/23/03	X		12,614	12,767	12	BG	
GB-015	SB-GB-015-8-10	10/23/03	X		12,622	12,767	12	BG	
GB-015	SB-GB-015-12-14	10/23/03	X		12,635	12,767	12	BG	
GB-016	SO-GB-016-0-0.5	10/23/03	X		12,450	12,767	12	BG	
GB-016	SB-GB-016-4-6	10/23/03	X		12,455	12,767	12	BG	
GB-016	SB-GB-016-8-10	10/23/03	X		12,410	12,767	12	BG	
GB-016	SB-GB-016-12-14	10/23/03	X		12,704	12,767	12	BG	
GB-017	SO-GB-017-0-0.5	10/23/03	X		12,496	12,767	12	BG	
GB-017	SB-GB-017-4-6	10/23/03	X		12,593	12,767	12	BG	
GB-017	SB-GB-017-8-10	10/23/03	X		12,181	12,767	12	BG	
GB-017	SB-GB-017-12-14	10/23/03	X		12,499	12,767	12	BG	
GB-094	SO-GB-094-0-0.5	10/23/03	X		12,201	12,767	12	BG	
GB-094	SB-GB-094-4-6	10/23/03	X		12,350	12,767	12	BG	
GB-094	SB-GB-094-8-10	10/23/03	X		12,541	12,767	12	BG	
GB-094	SB-GB-094-12-14	10/23/03	X		12,805	12,767	12	BG	
GB-095	SO-GB-095-0-0.5	10/23/03	X		12,311	12,767	12	BG	
GB-095	SB-GB-095-4-6	10/23/03	X		12,335	12,767	12	BG	
GB-095	SB-GB-095-8-10	10/23/03	X		12,442	12,767	12	BG	
GB-095	SB-GB-095-12-14	10/23/03	X		12,311	12,767	12	BG	
GB-100	SO-GB-100-0-0.5	10/25/03	X		12,351	11,959	11	BG	
GB-100	SB-GB-100-1-3	10/25/03	X		12,351	11,959	11	BG	
GB-099	SO-GB-099-0-0.5	10/25/03	X	X	11,935	11,959	10	BG	
GB-099	SB-GB-099-1-3	10/25/03	X	X	11,935	11,959	10	BG	
GB-066	SO-GB-066-0-0.5	10/25/03	X		12,182	11,959	11	BG	
GB-066	SB-GB-066-1-3	10/25/03	X		11,968	11,959	11	BG	
GB-066	SO-FD-03-0-0.5	10/25/03	X		12,182	11,959	11	BG	Field Dup of 066
GB-066	SB-FD-03-1-3	10/25/03	X		11,968	11,959	11	BG	Field Dup of 066
GB-097	SO-GB-097-0-0.5	10/25/03	X		11,868	11,959	11	BG	
GB-097	SB-GB-097-2-4	10/25/03	X		11,868	11,959	11	BG	
GB-098	SO-GB-098-0-0.5	10/25/03	X		11,997	11,959	11	BG	
GB-098	SB-GB-098-1-3	10/25/03	X		11,997	11,959	11	BG	
GB-067	SO-GB-067-0-0.5	10/25/03	X		11,484	11,959	11	BG	Location, Analysis
GB-067	SB-GB-067-1-3	10/25/03	X		11,484	11,959	11	BG	Cancelled, No
GB-069	SO-GB-069-0-0.5	10/25/03	X		11,525	11,959	11	BG	Location, Analysis
GB-069	SB-GB-069-1-3	10/25/03	X		11,525	11,959	11	BG	Cancelled, No
GB-070	SO-GB-070-0-0.5	10/25/03	X		11,792	11,959	11	BG	Location, Analysis
GB-070	SB-GB-070-1-3	10/25/03	X		11,792	11,959	11	BG	Cancelled, No
GB-068	SO-GB-068-0-0.5	10/25/03	X		11,422	11,959	11	BG	Location, Analysis

TABLE 3-6									
SUMMARY OF SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED FOR SAMPLES COLLECTED FROM SOIL BORINGS ADVANCED OUTSIDE THE DISPOSAL TRENCHES									
			Analysis Completed		Field Screening Results				
Soil Boring Location	Soil Sample ID	Date Sampled	Primary ROPC[1]	Secondary ROPC[2]	Low Energy Gamma FIDLER (cts/min)	Fidler Bkg (cts/min)	Gamma (urem/hr)	VOC - PID (ppm)	Comments
GB-068	SB-GB-068-2-4	10/25/03	X		11,422	11,959	11	BG	Cancelled, No
GB-096	SO-GB-096-0-0.5	10/23/03	X		10,925	12,767	10	BG	
GB-096	SB-GB-096-4-6	10/23/03	X		10,744	12,767	10	BG	
GB-096	SB-GB-096-8-10	10/23/03	X		10,683	12,767	10	BG	
GB-096	SB-GB-096-12-14	10/23/03	X		10,770	12,767	10	BG	
GB-057	SO-GB-057-0-0.5	10/23/03	X		10,920	10,743	10	BG	
GB-057	SB-GB-057-4-6	10/23/03	X		10,603	10,743	10	BG	
GB-057	SB-GB-057-8-10	10/23/03	X		10,710	10,743	10	BG	
GB-057	SB-GB-057-12-14	10/23/03	X		10,746	10,743	10	BG	
GB-058	SO-GB-058-0-0.5	10/23/03	X	X	10,808	10,743	10	BG	
GB-058	SB-GB-058-4-6	10/23/03	X	X	10,666	10,743	10	BG	
GB-058	SB-GB-058-8-10	10/23/03	X	X	10,501	10,743	10	BG	
GB-058	SB-GB-058-12-14	10/23/03	X	X	10,684	10,743	10	BG	
GB-059	SO-GB-059-0-0.5	10/23/03	X		10,774	10,743	10	BG	
GB-059	SB-GB-059-4-6	10/23/03	X		10,706	10,743	10	BG	
GB-059	SB-GB-059-8-10	10/23/03	X		11,034	10,743	10	BG	
GB-059	SB-GB-059-12-14	10/23/03	X		11,428	10,743	10	BG	
GB-060	SO-GB-060-0-0.5	10/24/03	X		11,592	12,175	12	BG	
GB-060	SB-GB-060-4-6	10/24/03	X		11,339	12,175	12	BG	
GB-060	SB-GB-060-8-10	10/24/03	X		11,643	12,175	12	BG	
GB-060	SB-GB-060-10-12	10/24/03	X		11,643	12,175	12	BG	Refusal Encountered at 12'
GB-060	SO-FD-04-0-0.5	10/24/03	X		11,592	12,175	12	BG	Field Dup of 060
GB-060	SB-FD-04-4-6	10/24/03	X		11,339	12,175	12	BG	Field Dup of 060
GB-060	SB-FD-04-8-10	10/24/03	X		11,643	12,175	12	BG	Field Dup of 060
GB-060	SB-FD-04-10-12	10/24/03	X		11,643	12,175	12	BG	Field Dup of 060, Refusal encounterd at 12'
GB-061	SO-GB-061-0-0.5	10/23/03	X		10,786	10,743	10	BG	
GB-061	SB-GB-061-4-6	10/23/03	X		10,694	10,743	10	BG	
GB-061	SB-GB-061-8-10	10/23/03	X		10,791	10,743	10	BG	
GB-061	SB-GB-061-12-14	10/23/03	X		11,151	10,743	10	BG	
GB-062	SO-GB-062-0-0.5	10/24/03	X		11,615	12,175	12	BG	
GB-062	SB-GB-062-4-6	10/24/03	X		11,745	12,175	11	BG	
GB-062	SB-GB-062-8-10	10/24/03	X		11,992	12,175	11	BG	
GB-062	SB-GB-062-10-12	10/24/03	X		11,992	12,175	11	BG	Refusal Encountered at 12'
GB-063	SO-GB-063-0-0.5	10/24/03	X		11,677	12,175	11	BG	
GB-063	SB-GB-063-4-6	10/24/03	X		11,627	12,175	11	BG	
GB-063	SB-GB-063-8-10	10/24/03	X		11,694	12,175	11	BG	
GB-063	SB-GB-063-10-12	10/24/03	X		11,694	12,175	11	BG	Refusal Encountered at 12'
GB-064	SO-GB-064-0-0.5	10/24/03	X		12,040	12,175	11	BG	
GB-064	SB-GB-064-4-6	10/24/03	X		11,486	12,175	11	BG	
GB-064	SB-GB-064-8-10	10/24/03	X		11,668	12,175	11	BG	
GB-065	SO-GB-065-0-0.5	10/24/03	X		11,758	12,175	11	BG	
GB-065	SB-GB-065-4-6	10/24/03	X		11,584	12,175	11	BG	
GB-065	SB-GB-065-8-10	10/24/03	X		11,956	12,175	11.5	BG	

TABLE 3-6									
SUMMARY OF SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED FOR SAMPLES COLLECTED FROM SOIL BORINGS ADVANCED OUTSIDE THE DISPOSAL TRENCHES									
			Analysis Completed		**Field Screening Results**				
Soil Boring Location	**Soil Sample ID**	**Date Sampled**	**Primary ROPC[1]**	**Secondary ROPC[2]**	**Low Energy Gamma FIDLER (cts/min)**	**Fidler Bkg (cts/min)**	**Gamma (urem/hr)**	**VOC - PID (ppm)**	**Comments**
GB-065	SB-GB-065-10-12	10/24/03	X		11,956	12,175	11.5	BG	Refusal Encountered at 12'
GB-056	SO-GB-056-0-0.5	10/24/03	X		11,476	12,092	10	BG	
GB-056	SB-GB-056-4-6	10/24/03	X		11,171	12,092	10	BG	
GB-056	SB-GB-056-8-10	10/24/03	X		11,463	12,092	10	BG	
GB-056	SB-GB-056-12-14	10/24/03	X		12,020	12,092	10	BG	
GB-084	SO-GB-084-0-0.5	10/24/03	X	X	11,900	11,988	11.5	BG	
GB-084	SB-GB-084-4-6	10/24/03	X	X	11,811	11,988	11	BG	
GB-084	SB-GB-084-8-10	10/24/03	X	X	11,694	11,988	11	BG	
GB-084	SB-GB-084-10-12	10/24/03	X	X	11,694	11,988	11	BG	Refusal Encountered at 12'
GB-085	SO-GB-085-0-0.5	10/24/03	X		11,330	11,988	12	BG	
GB-085	SB-GB-085-4-6	10/24/03	X		11,625	11,988	12	BG	
GB-085	SB-GB-085-8-10	10/24/03	X		11,448	11,988	12	BG	
GB-085	SB-GB-085-12-14	10/24/03	X		11,824	11,988	12	BG	
GB-086	SO-GB-086-0-0.5	10/24/03	X		11,483	11,988	11	BG	
GB-086	SB-GB-086-4-6	10/24/03	X		11,648	11,988	11	BG	
GB-086	SB-GB-086-8-10	10/24/03	X		12,225	11,988	11	BG	
GB-086	SB-GB-086-10-12	10/24/03	X		12,225	11,988	11	BG	Refusal Encountered at 12'
GB-087	SO-GB-087-0-0.5	10/25/03	X		12,286	12,689	11	BG	
GB-087	SB-GB-087-4-6	10/25/03	X		12,157	12,689	11	BG	
GB-087	SB-GB-087-8-10	10/25/03	X		12,482	12,689	11	BG	
GB-087	SB-GB-087-10-12	10/25/03	X		12,482	12,689	11	BG	Refusal Encountered at 12'
GB-088	SO-GB-088-0-0.5	10/25/03	X		12,359	12,689	11.5	BG	
GB-088	SB-GB-088-4-6	10/25/03	X		12,448	12,689	11.5	BG	
GB-088	SB-GB-088-8-10	10/25/03	X		12,436	12,689	11.5	BG	
GB-088	SB-GB-088-10-12	10/25/03	X		12,436	12,689	11.5	BG	Refusal Encountered at 12'
GB-093	SO-GB-093-0-0.5	10/25/03	X		13,293	13,412	11	BG	
GB-093	SB-GB-093-4-6	10/25/03	X		13,240	13,412	11	BG	
GB-093	SB-GB-093-8-10	10/25/03	X		13,521	13,412	11	BG	
GB-093	SB-GB-093-12-14	10/25/03	X		13,392	13,412	11	BG	
GB-093	SO-FD-05-0-0.5	10/25/03	X		13,293	13,412	11	BG	Field Dup of 093
GB-093	SB-FD-05-4-6	10/25/03	X		13,240	13,412	11	BG	Field Dup of 093
GB-093	SB-FD-05-8-10	10/25/03	X		13,521	13,412	11	BG	Field Dup of 093
GB-093	SB-FD-05-12-14	10/25/03	X		13,392	13,412	11	BG	Field Dup of 093
GB-092	SO-GB-092-0-0.5	10/25/03	X		13,285	13,412	11	BG	
GB-092	SB-GB-092-4-6	10/25/03	X		13,100	13,412	11	BG	
GB-092	SB-GB-092-8-10	10/25/03	X		13,025	13,412	11	BG	
GB-092	SB-GB-092-12-14	10/25/03	X		13,245	13,412	11	BG	
GB-083	SO-GB-083-0-0.5	10/26/03	X		12,351	12,594	12	BG	
GB-083	SB-GB-083-4-6	10/26/03	X		12,694	12,594	12	BG	
GB-083	SB-GB-083-8-10	10/26/03	X		12,678	12,594	12	BG	
GB-082	SO-GB-082-0-0.5	10/26/03	X		12,326	12,594	12	BG	
GB-082	SB-GB-082-4-6	10/26/03	X		12,449	12,594	12	BG	
GB-082	SB-GB-082-8-10	10/26/03	X		12,362	12,594	12	BG	

TABLE 3-6									
SUMMARY OF SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED FOR SAMPLES COLLECTED FROM SOIL BORINGS ADVANCED OUTSIDE THE DISPOSAL TRENCHES									
			Analysis Completed		**Field Screening Results**				
Soil Boring Location	**Soil Sample ID**	**Date Sampled**	**Primary ROPC[1]**	**Secondary ROPC[2]**	**Low Energy Gamma FIDLER (cts/min)**	**Fidler Bkg (cts/min)**	**Gamma (urem/hr)**	**VOC - PID (ppm)**	**Comments**
GB-079	SO-GB-079-0-0.5	10/26/03	X		12,883	12,594	12	BG	
GB-079	SB-GB-079-4-6	10/26/03	X		12,965	12,594	12	BG	
GB-079	SB-GB-079-8-10	10/26/03	X		13,362	12,594	12	BG	
GB-079	SO-FD-06-0-0.5	10/26/03	X		12,883	12,594	12	BG	Field Dup of 079
GB-079	SB-FD-06-4-6	10/26/03	X		12,965	12,594	12	BG	Field Dup of 079
GB-079	SB-FD-06-8-10	10/26/03	X		13,362	12,594	12	BG	Field Dup of 079
GB-081	SO-GB-081-0-0.5	10/26/03	X	X	12,229	12,594	12	BG	
GB-081	SB-GB-081-4-6	10/26/03	X	X	12,365	12,594	12	BG	
GB-081	SB-GB-081-8-10	10/26/03	X	X	12,309	12,594	12	BG	
GB-080	SO-GB-080-0-0.5	10/26/03	X		13,917	14,455	12	BG	
GB-080	SB-GB-080-4-6	10/26/03	X		13,409	14,455	12	BG	
GB-080	SB-GB-080-8-10	10/26/03	X		14,393	14,455	12	BG	
GB-078	SO-GB-078-0-0.5	10/26/03	X		14,286	14,455	12	BG	
GB-078	SB-GB-078-4-6	10/26/03	X		14,301	14,455	12	BG	
GB-078	SB-GB-078-8-10	10/26/03	X		14,560	14,455	12	BG	
GB-076	SO-GB-076-0-0.5	10/26/03	X		15,317	15,958	14	BG	
GB-076	SB-GB-076-4-6	10/26/03	X		15,086	15,958	14	BG	
GB-076	SB-GB-076-8-10	10/26/03	X		15,198	15,958	14	BG	
GB-077	SO-GB-077-0-0.5	10/27/03	X		15,855	15,675	14	BG	
GB-077	SB-GB-077-4-6	10/27/03	X		15,902	15,675	14	BG	
GB-077	SB-GB-077-8-10	10/27/03	X		15,902	15,675	14	BG	
GB-077	SB-GB-077-12-14	10/27/03	X		15,361	15,675	14	BG	
GB-021	SO-GB-021-0-0.5	10/26/03	X		18,063	18,062	17	BG	
GB-021	SB-GB-021-4-6	10/26/03	X		18,127	18,062	17	BG	
GB-075	SO-GB-075-0-0.5	10/26/03	X		17,292	17,956	17	BG	
GB-075	SB-GB-075-4-6	10/26/03	X		17,612	17,956	17	BG	
GB-075	SB-GB-075-8-10	10/26/03	X		17,638	17,956	17	BG	
GB-075	SB-GB-075-10-12	10/26/03	X		17,638	17,956	17	BG	Refusal Encountered at 12'
GB-053	SO-GB-053-0-0.5	10/27/03	X		15,716	15,895	14	BG	
GB-053	SB-GB-053-4-6	10/27/03	X		15,500	15,895	14	BG	
GB-053	SB-GB-053-8-10	10/27/03	X		15,500	15,895	14	BG	
GB-053	SB-GB-053-12-14	10/27/03	X		14,720	15,895	14	BG	
GB-054	SO-GB-054-0-0.5	10/27/03	X		14,305	14,006	12.5	BG	
GB-054	SB-GB-054-4-6	10/27/03	X		13,857	14,006	12.5	BG	
GB-054	SB-GB-054-8-10	10/27/03	X		13,713	14,006	12.5	BG	
GB-054	SB-GB-054-12-14	10/27/03	X		13,511	14,006	12.5	BG	
GB-055	SO-GB-055-0-0.5	10/27/03	X		12,517	12,721	11	BG	
GB-055	SB-GB-055-4-6	10/27/03	X		12,006	12,721	11	BG	
GB-055	SB-GB-055-8-10	10/27/03	X		12,288	12,721	11	BG	
GB-055	SB-GB-055-12-14	10/27/03	X		12,288	12,721	11	BG	
GB-051	SO-GB-051-0-0.5	10/28/03	X		12,665	12,989	10	BG	
GB-051	SB-GB-051-4-6	10/28/03	X		12,686	12,989	10	BG	
GB-051	SB-GB-051-8-10	10/28/03	X		12,316	12,989	10	BG	
GB-051	SB-GB-051-12-14	10/28/03	X		12,872	12,989	10	BG	
GB-050	SO-GB-050-0-0.5	10/27/03	X	X	12,004	12,721	11	BG	
GB-050	SB-GB-050-4-6	10/27/03	X	X	11,834	12,721	11	BG	
GB-050	SB-GB-050-8-10	10/27/03	X	X	12,309	12,721	11	BG	
GB-050	SB-GB-050-12-14	10/27/03	X	X	12,189	12,721	11	BG	
GB-052	SO-GB-052-0-0.5	10/27/03	X		12,227	12,551	11	BG	
GB-052	SB-GB-052-4-6	10/27/03	X		12,232	12,551	11	BG	
GB-052	SB-GB-052-8-10	10/27/03	X		12,226	12,551	11	BG	

TABLE 3-6									
SUMMARY OF SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED FOR SAMPLES COLLECTED FROM SOIL BORINGS ADVANCED OUTSIDE THE DISPOSAL TRENCHES									
			Analysis Completed		**Field Screening Results**				
Soil Boring Location	**Soil Sample ID**	**Date Sampled**	**Primary ROPC[1]**	**Secondary ROPC[2]**	**Low Energy Gamma FIDLER (cts/min)**	**Fidler Bkg (cts/min)**	**Gamma (urem/hr)**	**VOC - PID (ppm)**	**Comments**
GB-052	SB-GB-052-10-12	10/27/03	X		12,226	12,551	11	BG	Refusal Encountered at 12'
GB-049	SO-GB-049-0-0.5	10/28/03	X		13,096	12,989	10	BG	
GB-049	SB-GB-049-4-6	10/28/03	X		12,783	12,989	10	BG	
GB-049	SB-GB-049-8-10	10/28/03	X		12,611	12,989	10	BG	
GB-049	SB-GB-049-12-14	10/28/03	X		12,634	12,989	10	BG	
GB-049	SO-FD-07-0-0.5	10/28/03	X		13,096	12,989	10	BG	Field Dup of 049
GB-049	SB-FD-07-4-6	10/28/03	X		12,783	12,989	10	BG	Field Dup of 049
GB-049	SB-FD-07-8-10	10/28/03	X		12,611	12,989	10	BG	Field Dup of 049
GB-049	SB-FD-07-12-14	10/28/03	X		12,634	12,989	10	BG	Field Dup of 049
GB-048	SO-GB-048-0-0.5	10/28/03	X		12,581	12,989	10	BG	
GB-048	SB-GB-048-4-6	10/28/03	X		12,495	12,989	10	BG	
GB-048	SB-GB-048-8-10	10/28/03	X		12,195	12,989	10	BG	
GB-047	SO-GB-047-0-0.5	11/12/03	X		10,441	9,080	10	BG	
GB-047	SB-GB-047-4-6	11/12/03	X		10,499	9,080	10	BG	
GB-047	SB-GB-047-6-7.9	11/12/03	X		10,499	9,080	10	BG	
GB-046	SO-GB-046-0-0.5	10/28/03	X		12,767	12,989	10	BG	
GB-046	SB-GB-046-4-6	10/28/03	X		12,598	12,989	10	BG	
GB-046	SB-GB-046-8-10	10/28/03	X		12,277	12,989	10	BG	
GB-045	SO-GB-045-0-0.5	11/12/03	X		10,011	9,080	10	BG	
GB-045	SB-GB-045-4-6.9	11/12/03	X		10,156	9,080	10	BG	
GB-044	SO-GB-044-0-0.5	11/12/03	X		10,128	9,080	9	BG	
GB-044	SB-GB-044-4-5.7	11/12/03	X		10,306	9,080	9	BG	
GB-090	SO-GB-090-0-0.5	11/24/03	X						
GB-090	SB-GB-090-4-6	11/24/03	X						
GB-089	SO-GB-089-0-0.5		X						
GB-089	SB-GB-089-4-6.2		X						
GB-043	SO-GB-043-0-0.5	10/28/03	X		11,799	11,802	11	BG	
GB-043	SB-GB-043-4-6	10/28/03	X		12,191	11,802	11	BG	
GB-042	SO-GB-042-0-0.5	10/28/03	X		11,922	11,918	10.5	BG	
GB-042	SB-GB-042-4-5.5	10/28/03	X		11,810	11,918	10.5	BG	
GB-042	SB-GB-042-5.5-7	10/28/03	X		11,810	11,918	10.5	BG	Refusal Encountered at 7'
GB-041	SO-GB-041-0-0.5	10/28/03	X		No Data	11,918	No Data	No Data	
GB-041	SB-GB-041-4-6	10/28/03	X		11,883	11,918	10	BG	
GB-039	SO-GB-039-0-0.5	10/29/03	X		12,486	11,503	10	BG	
GB-039	SB-GB-039-4-6	10/29/03	X		12,402	11,530	10	BG	
GB-038	SO-GB-038-0-0.5	10/29/03	X		12,285	11,503	10	BG	
GB-038	SB-GB-038-4-6	10/29/03	X		12,405	11,503	10	BG	
GB-037	SO-GB-037-0-0.5	11/04/03	X		13,054	13,378	12	BG	
GB-037	SB-GB-037-4-6	11/04/03	X		13,013	13,378	12	BG	
GB-037	SB-GB-037-8-10	11/04/03	X		13,129	13,378	12	BG	
GB-036	SO-FD-014-0-0.5	11/04/03	X		12,560	13,378	12	BG	Field Dup of 036
GB-036	SO-GB-036-0-0.5	11/04/03	X		12,560	13,378	12	BG	
GB-036	SB-GB-036-4-6	11/04/03	X		12,686	13,378	12	BG	
GB-036	SB-GB-036-8-10	11/04/03	X		12,454	13,378	12	BG	
GB-040	SO-GB-040-0-0.5	11/24/03	X	X					
GB-040	SB-GB-040-4-6	11/24/03	X	X					
GB-035	SO-GB-035-0-0.5	11/23/03	X						
GB-035	SB-GB-035-4-6	11/23/03	X						
GB-035	SB-GB-035-6-8	11/23/03	X						
GB-034	SO-GB-034-0-0.5	11/23/03	X						

TABLE 3-6										
SUMMARY OF SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED FOR SAMPLES COLLECTED FROM SOIL BORINGS ADVANCED OUTSIDE THE DISPOSAL TRENCHES										
			Analysis Completed		**Field Screening Results**					
Soil Boring Location	**Soil Sample ID**	**Date Sampled**	**Primary ROPC[1]**	**Secondary ROPC[2]**	**Low Energy Gamma FIDLER (cts/min)**	**Fidler Bkg (cts/min)**	**Gamma (urem/hr)**	**VOC - PID (ppm)**	**Comments**
GB-034	SB-GB-034-3-5	11/23/03	X						
GB-033	SO-GB-033-0-0.5	11/23/03	X						
GB-033	SB-GB-033-1-2.5	11/23/03	X						
GB-032	SO-GB-032-0-0.5	11/23/03	X						
GB-032	SB-GB-032-1.5-3.5	11/23/03	X						
GB-031	SO-GB-031-0-0.5	11/23/03	X						
GB-031	SB-GB-031-4-6	11/23/03	X						
GB-031	SB-GB-031-6-7.8	11/23/03	X						
GB-074	SO-GB-074-0-0.5	11/24/03	X	X					
GB-074	SB-GB-074-4-6	11/24/03	X	X					
GB-074	SB-GB-074-6-7.3	11/24/03	X	X					
GB-071	SO-GB-071-0-0.5	11/23/03	X						
GB-071	SB-GB-071-4-6	11/23/03	X						
GB-071	SB-GB-071-6-7.9	11/23/03	X						
GB-071	SB-FD-08-4-6	11/23/03	X						Field Dup of 071
GB-071	SB-FD-08-6-7.9	11/23/03	X						Field Dup of 071
GB-073	SO-GB-073-0-0.5	11/23/03	X						
GB-073	SB-GB-073-4-6.5	11/23/03	X						
GB-073	SO-FD-09-0-0.5	11/23/03	X						Field Dup of 073
GB-073	SB-FD-09-4-6.5	11/23/03	X						Field Dup of 073
GB-072	SO-GB-072-0-0.5	11/23/03	X						
GB-072	SB-GB-072-4-6	11/23/03	X						
GB-072	SB-GB-072-6-7.3	11/23/03	X						
GB-030	SO-GB-030-0-0.5	11/23/03	X						
GB-030	SB-GB-030-4-6	11/23/03	X						
GB-030	SB-GB-030-6-7.5	11/23/03	X						
GB-030	SO-FD-10-0-0.5	11/23/03	X						Field Dup of 030
GB-030	SB-FD-10-4-6	11/23/03	X						Field Dup of 030
GB-030	SB-FD-10-6-7.5	11/23/03	X						Field Dup of 030
GB-029	SO-GB-029-0-0.5	11/23/03	X						
GB-029	SB-GB-029-4-6	11/23/03	X						
GB-029	SB-GB-029-6-7.5	11/23/03	X						
GB-028	SO-GB-028-0-0.5	11/23/03	X						
GB-028	SB-GB-028-4-6.5	11/23/03	X						
GB-020	SO-GB-020-0-0.5	11/04/03	X		12,323	13,378	12	BG	
GB-020	SB-GB-020-4-6	11/04/04	X		12,391	13,378	12	BG	
GB-091	SO-GB-091-0-0.5	11/04/03	X	X	11,784	12,603	12	BG	
GB-091	SB-GB-091-4-6	11/04/04	X	X	12,219	12,603	12	BG	
GB-019	SO-GB-019-0-0.5	11/04/03	X		12,034	12,057	12	BG	
GB-019	SB-GB-019-4-6	11/04/04	X		12,085	12,057	12	BG	
GB-018	SO-GB-018-0-0.5	11/04/03	X		12,197	12,057	12	BG	
GB-018	SB-GB-018-2-4	11/04/04	X		12,197	12,057	12	BG	
GB-025	SO-GB-025-0-0.5	11/04/03	X		11,478	11,132	11	BG	
GB-025	SB-GB-025-1-3	11/04/04	X		11,380	11,132	11	BG	
GB-026	SO-GB-026-0-0.5	11/04/03	X		11,411	11,132	11	BG	
GB-026	SB-GB-026-4-6	11/04/03	X		11,569	11,132	11	BG	
GB-026	SB-GB-026-6-7	11/04/03	X						
GB-027	SO-GB-027-0-0.5	11/04/03	X		11,366	11,132	11	BG	
GB-027	SB-GB-027-2-3.6	11/04/04	X		11,366	11,132	11	BG	
GB-024	SO-GB-024-0-0.5	11/23/03	X						
GB-024	SB-GB-024-4-6	11/23/03	X						
GB-024	SB-GB-024-6-8.3	11/23/03	X						

TABLE 3-6

SUMMARY OF SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED FOR SAMPLES COLLECTED FROM SOIL BORINGS ADVANCED OUTSIDE THE DISPOSAL TRENCHES

Soil Boring Location	Soil Sample ID	Date Sampled	Analysis Completed: Primary ROPC[1]	Analysis Completed: Secondary ROPC[2]	Field Screening Results: Low Energy Gamma FIDLER (cts/min)	Field Screening Results: Fidler Bkg (cts/min)	Field Screening Results: Gamma (urem/hr)	Field Screening Results: VOC - PID (ppm)	Comments
GB-023	SO-GB-023-0-0.5	11/04/03	X		11,002	11,132	11	BG	
GB-023	SB-GB-023-4-6	11/04/03	X		11,002	11,132	11	BG	
GB-023	SB-GB-023-6-7.5	11/04/03	X		11,002	11,132	11	BG	
GB-022	SO-GB-022-0-0.5	11/04/03	X		11,741	11,748	10	BG	
GB-022	SB-GB-022-4-6	11/04/04	X		11,741	11,748	10	BG	
GB-102R	SO-GB-102R-0-0.5	10/23/03	X		12,624	12,767	12	BG	Resample
GB-102R	SB-GB-102R-4-6	10/23/03	X		12,601	12,767	12	BG	Resample
GB-102R	SB-GB-102R-8-10	10/23/03	X		12,681	12,767	12	BG	Resample
GB-102R	SB-GB-102R-12-14	10/23/03	X		12,601	12,767	12	BG	Resample

1 -- Primary ROPC include U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. All samples were analyzed for the primary ROPC.

2 -- Secondary ROPC include Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, and Pu-242. Only 10% of the samples were analyzed for the secondary ROPC.

TABLE 3-7					
SUMMARY OF GROUNDWATER SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED FOR SAMPLES COLLECTED DURING THE DECEMBER 2003 SAMPLING EVENT					
			Analysis Completed		
Groundwater Monitoring Well	**Groundwater Sample ID**	**Date Sampled**	**Primary ROPC[1]**	**Secondary ROPC[2]**	**Comments**
MW-01	WG-MW-01	12/04/03	X		
MW-01	WG-FD-04	12/04/03	X		Field Dup of MW-01
MW-02	WG-MW-02	12/02/03	X		Pu-241 Reanalyzed
MW-02A	WG-MW-02A	12/02/03	X		
MW-03	WG-MW-03	12/03/03	X		
MW-05	WG-MW-05	12/01/03	X	X	
MW-06	WG-MW-06	12/03/03	X		
MW-07	WG-MW-07	12/03/03	X		
MW-08	WG-MW-08	12/03/03	X		
MW-09	WG-MW-09	12/03/03	X		
MW-11S	WG-MW-11S	12/04/03	X	X	
MW-12	WG-MW-12	12/05/03	X	X	
MW-12	WG-FD-06	12/05/03	X	X	Field Dup of MW-12
MW-13	WG-MW-13	12/03/03	X		
MW-14	WG-MW-14	12/02/03	X		
MW-15	WG-MW-15	12/02/03	X	X	
MW-16BC	WG-MW-16BC	12/04/03	X		
MW-19	WG-MW-19	12/03/03	X		
MW-22	WG-MW-22	12/02/03	X		
MW-23	WG-MW-23	12/03/03	X		
MW-25	WG-MW-25	12/04/03	X		
MW-26	WG-MW-26	12/05/03	X	X	
MW-26	WG-FD-07	12/05/03	X	X	Field Dup of MW-26
MW-29	WG-MW-29	12/05/03	X		
MW-30A	WG-MW-30A	12/02/03	X		Pu-241 Reanalyzed
MW-31	WG-MW-31	12/06/03	X		
MW-32	WG-MW-32	12/03/03	X		
MW-33	WG-MW-33	12/02/03	X		
MW-35	WG-MW-35	12/05/03	X		
MW-35	WG-FD-08	12/05/03	X		Field Dup of MW-35
MW-36	WG-MW-36	12/03/03	X	X	
MW-38	WG-MW-38	12/04/03	X		
MW-39	WG-MW-39	12/02/03	X		
MW-40	WG-MW-40	12/02/03	X		
MW-41	WG-MW-41	12/04/03	X		
MW-42	WG-MW-42	12/09/03	X		
MW-43	WG-MW-43	12/09/03	X		
MW-45	WG-MW-45	12/03/03	X		
MW-51	WG-MW-51	12/04/03	X		
MW-51	WG-FD-05	12/04/03	X		Field Dup of MW-51
MW-52	WG-MW-52	12/03/03	X		
MW-52	WG-FD-03	12/03/03	X		Field Dup of MW-52
MW-56	WG-MW-56	12/03/03	X		
MW-57	WG-MW-57	12/02/03	X		
MW-58	WG-MW-58	12/04/03	X		
Not Applicable	WG-RB-01-12-05-03	12/05/03	X	X	Rinsate Blank

1 -- Primary ROPC include U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. All samples were analyzed for the primary ROPC.

2 -- Secondary ROPC include Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, Pu-242, and gross alpha/beta. Only 10% of the samples were analyzed for the secondary ROPC.

TABLE 3-8

SUMMARY OF GROUNDWATER SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED FOR SAMPLES COLLECTED DURING THE JUNE 2004 SAMPLING EVENT

Groundwater Monitoring Well	Groundwater Sample ID	Date Sampled	Analysis Completed		Comments
			Primary ROPC[1]	Secondary ROPC[2]	
MW-01	WG-MW-01	06/08/04	X		
MW-02	WG-MW-02	06/10/04	X		
MW-02A	WG-MW-02A	06/12/04	X		
MW-05	WG-MW-05	06/09/04	X		
MW-06	WG-MW-06	06/09/04	X		
MW-07	WG-MW-07	06/10/04	X		
MW-08	WG-MW-08	06/09/04	X		
MW-09A	WG-MW-09A	06/09/04	X		
MW-12D	WG-MW-12D	06/12/04	X		
MW-12D	WG-FD-05	06/12/04	X		Field Dup of MW-12D
MW-13	WG-MW-13	06/08/04	X		
MW-14	WG-MW-14	06/08/04	X		
MW-15	WG-MW-15	06/09/04	X		
MW-16BC	WG-MW-16BC	06/12/04	X		
MW-19	WG-MW-19	06/08/04	X		
MW-22	WG-MW-22	06/10/04	X		
MW-23	WG-MW-23	06/08/04	X		
MW-24	WG-MW-24	06/08/04	X		
MW-24	WG-FD-01	06/08/04	X		Field Dup of MW-24
MW-25	WG-MW-25	06/09/04	X		
MW-26	WG-MW-26	06/10/04	X	X	
MW-26	WG-FD-04	06/10/04	X	X	Field Dup of MW-26
MW-29	WG-MW-29	06/11/04	X	X	
MW-30A	WG-MW-30A	06/14/04	X		
MW-31	WG-MW-31	06/13/04	X		
MW-32	WG-MW-32	06/12/04	X		
MW-33	WG-MW-33	06/09/04	X	X	
MW-35	WG-MW-35	06/12/04	X		
MW-36	WG-MW-36	06/09/04	X		
MW-38	WG-MW-38	06/09/04	X		
MW-39	WG-MW-39	06/10/04	X	X	
MW-40	WG-MW-40	06/12/04	X		
MW-41	WG-MW-41	06/12/04	X		
MW-43	WG-MW-43	06/11/04	X		
MW-51	WG-MW-51	06/12/04	X		
MW-52	WG-MW-52	06/10/04	X		
MW-56	WG-MW-56	06/08/04	X		
MW-58	WG-MW-58	06/09/04	X	X	
MW-59	WG-MW-59	06/10/04	X		
MW-64	WG-MW-64	06/08/04	X		
MW-64	WG-FD-02	06/08/04	X		Field Dup of MW-64
MW-69	MW-69	06/08/04	X		
MW-69	WG-FD-03	06/08/04	X		Field Dup of MW-69
NWS-01A	WG-NWS-01A-02	06/10/04	X		
NWS-01A	WG-NWS-01A-03	06/11/04	X		
NWS-01A	WG-NWS-01A-04	06/11/04	X		
NWS-03	WG-NWS-03-03	06/09/04	X		
NWS-05	WG-NWS-05-04	06/09/04	X		
Not Applicable	WG-RB-01-06-12-04	06/12/04	X	X	Rinsate Blank

1 -- Primary ROPC include U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. All samples were analyzed for the primary ROPC.
2 -- Secondary ROPC include Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, Pu-242, and gross alpha/beta. Only 10% of the samples were analyzed for the secondary ROPC.

TABLE 3-9

SUMMARY OF TEMPORARY WASTE SAMPLING POINT (TWSP) SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED

TWSP Location	Leachate Sample ID	Date Sampled	Analysis Completed: Primary ROPC[1]	Analysis Completed: Secondary ROPC[2]	Comments
TWSP-10-01	WL-10-01	12/03/03	X	X	
TWSP-10-01	WL-FD-01	12/03/03	X	X	Field Dup of WL-10-01
TWSP-10-02	WL-10-02	12/02/03	X		
TWSP-10-04	WL-10-04	12/02/03	X		
TWSP-10-07	WL-10-07	12/17/03	X		
TWSP-10-12	WL-10-12	12/02/03	X		
TWSP-01-01	WL-01-01	12/09/03	X		
TWSP-01-02	WL-01-02	12/08/03	X	X	
TWSP-01-03	WL-01-03	12/08/03	X		
TWSP-01-04	WL-01-04	12/06/03	X		
TWSP-01-05	WL-01-05	12/07/03	X		
TWSP-01-06	WL-01-06	12/06/03	X		
TWSP-01-06	WL-FD-05	12/06/03	X		Field Dup of WL-01-06
TWSP-01-07	WL-01-07	12/08/03	X		
TWSP-01-08	WL-01-08	12/09/03	X		
TWSP-01-09	WL-01-09	12/15/03	X		
TWSP-01-11	WL-01-11	12/07/03	X		
TWSP-01-12	WL-01-12	12/19/03	X		
TWSP-02-01	WL-02-01	12/06/03	X		
TWSP-02-02	WL-02-02	12/19/03	X		
TWSP-02-03	WL-02-03	12/05/03	X	X	
TWSP-02-04	WL-02-04	12/05/03	X		
TWSP-02-04	WL-FD-04	12/05/03	X		Field Dup of WL-02-04
TWSP-02-05	WL-02-05	12/06/03	X		
TWSP-02-06	WL-02-06	12/19/03	X		
TWSP-02-07	WL-02-07	12/05/03	X		
TWSP-03-01	WL-03-01	12/10/03	X	X	
TWSP-03-02	WL-03-02	12/07/03	X		
TWSP-04-01	WL-04-01	12/05/03	X		
TWSP-04-02	WL-04-02	12/05/03	X		
TWSP-05-01	WL-05-01	12/04/03	X		
TWSP-05-01	WL-FD-03	12/04/03	X		Field Dup of WL-05-01
TWSP-05-02	WL-05-02	12/04/03	X		
TWSP-05-03	WL-05-03	12/04/03	X	X	
TWSP-05-04	WL-05-04	12/04/03	X		
TWSP-05-05	WL-05-05	12/05/03	X		
TWSP-06-01	WL-06-01	12/04/03	X		
TWSP-06-02	WL-06-02	12/04/03	X		
TWSP-06-03	WL-06-03	12/04/03	X		
TWSP-06-04	WL-06-04	12/04/03	X		
TWSP-07-01	WL-07-01	12/04/03	X		
TWSP-07-02	WL-07-02	12/03/03	X		
TWSP-07-03	WL-07-03	12/03/03	X		
TWSP-07-04	WL-07-04	12/04/03	X		
TWSP-07-04	WL-FD-02	12/04/03	X		Field Dup of WL-07-04
TWSP-07-05	WL-07-05	12/03/03	X		
TWSP-07-06	WL-07-06	12/03/03	X		
TWSP-08-01	WL-08-01	12/03/03	X		
TWSP-08-02	WL-08-02	12/04/03	X		

1 -- Primary ROPC include U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. All samples were analyzed for the primary ROPC.
2 -- Secondary ROPC include Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, Pu-242, and gross alpha/beta. Only 10% of the samples were analyzed for the secondary ROPC.

TABLE 3-10						
SUMMARY OF SURFACE WATER AND GROUNDWATER SEEP SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED - DECEMBER 2003						
				Analysis Completed		
Sample Location	**Sample ID**	**Media**	**Date Sampled**	**Primary ROPC[1]**	**Secondary ROPC[2]**	**Comments**
Dry Run location WS-DR-01	WS-DR-01	Surface Water	12/6/2003	X		
Dry Run location WS-DR-02	WS-DR-02	Surface Water	12/6/2003	X		
Dry Run location WS-DR-03	WS-DR-03	Surface Water	12/6/2003	X		
Dry Run location WS-DR-04	WS-DR-04	Surface Water	12/6/2003	X		
Dry Run location WS-DR-04	WS-FD-01	Surface Water	12/6/2003	X		Field Dup of DR-04
Dry Run location WS-DR-05	WS-DR-05	Surface Water	12/6/2003	X	X	
Dry Run location WS-DR-06	WS-DR-06	Surface Water	12/6/2003	X		
Carnahan Run location WS-CR-01	WS-CR-01	Surface Water	12/7/2003	X		
Carnahan Run location WS-CR-02	WS-CR-02	Surface Water	12/7/2003	X		
Carnahan Run location WS-CR-03	WS-CR-03	Surface Water	12/7/2003	X		
Carnahan Run location WS-CR-04	WS-CR-04	Surface Water	12/7/2003	X		
Carnahan Run location WS-CR-05	WS-CR-05	Surface Water	12/7/2003	X		
Carnahan Run location WS-CR-06	WS-CR-06	Surface Water	12/7/2003	X		
Mine Outfall location along Carnahan Run SP-CR-01	SP-CR-01	Groundwater Seep	12/7/2003	X	X	Mine Outfall - orange
Dry Run location SP-DR-01	SP-DR-01	Groundwater Seep	12/7/2003	X		
Dry Run location SP-DR-01	SP-FD-01	Groundwater Seep	12/7/2003	X		Field Dup of SP-DR-01
Dry Run location SP-DR-02	SP-DR-02	Groundwater Seep	12/7/2003	X		
Dry Run location SP-DR-03	SP-DR-03	Groundwater Seep	12/7/2003	X		
Dry Run location SP-DR-04	SP-DR-04	Groundwater Seep	12/7/2003	X		
Dry Run location SP-DR-05	SP-DR-05	Groundwater Seep	12/6/2003	X		
Not Applicable	WS-RB-01	Rinsate Blank	12/7/2003	X	X	Rinsate Blank

1 -- Primary ROPC include U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. All samples were analyzed for the primary ROPC.

2 -- Secondary ROPC include Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, Pu-242, and gross alpha/beta. Only 10% of the samples were analyzed for the secondary ROPC.

TABLE 3-11

SUMMARY OF SURFACE WATER AND GROUNDWATER SEEP SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED - JUNE 2004

Sample Location	Sample ID	Media	Date Sampled	Analysis Completed: Primary ROPC[1]	Analysis Completed: Secondary ROPC[2]	Comments
Dry Run location WS-DR-01	WS-DR-01	Surface Water	06/14/04	X		
Dry Run location WS-DR-02	WS-DR-02	Surface Water	06/12/04	X		
Dry Run location WS-DR-02	WS-FD-01	Surface Water	06/12/04	X		Field Dup of WS-DR-02
Dry Run location WS-DR-03	WS-DR-03	Surface Water	06/12/04	X		
Dry Run location WS-DR-04	WS-DR-04	Surface Water	06/12/04	X		
Dry Run location WS-DR-05	WS-DR-05	Surface Water	06/12/04	X		
Dry Run location WS-DR-06	WS-DR-06	Surface Water	06/12/04	X		
Carnahan Run location WS-CR-01	WS-CR-01	Surface Water	06/13/04	X		
Carnahan Run location WS-CR-02	WS-CR-02	Surface Water	06/13/04	X		
Carnahan Run location WS-CR-03	WS-CR-03	Surface Water	06/13/04	X		
Carnahan Run location WS-CR-04	WS-CR-04	Surface Water	06/13/04	X		
Carnahan Run location WS-CR-04	WS-FD-02	Surface Water	06/13/04	X		Field Dup of WS-CR-04
Carnahan Run location WS-CR-05	WS-CR-05	Surface Water	06/13/04	X		
Carnahan Run location WS-CR-06	WS-CR-06	Surface Water	06/13/04	X		
Mine Outfall location along Carnahan Run SP-CR-01	SP-CR-01	Groundwater Seep	06/13/04	X		Mine Outfall - orange
Carnahan Run location SP-CR-02	SP-CR-02	Groundwater Seep	06/13/04	X		
Dry Run location SP-DR-01	SP-DR-01	Groundwater Seep	06/12/04	X	X	
Dry Run location SP-DR-03	SP-DR-03	Groundwater Seep	06/12/04	X		
Dry Run location SP-DR-04	SP-DR-04	Groundwater Seep	06/12/04	X		
Dry Run location SP-DR-05	SP-DR-05	Groundwater Seep	06/12/04	X	X	

1 -- Primary ROPC include U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. All samples were analyzed for the primary ROPC.

2 -- Secondary ROPC include Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, Pu-242, and gross alpha/beta. Only 10% of the samples were analyzed for the secondary ROPC.

TABLE 3-12						
SUMMARY OF SEDIMENT SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED - DECEMBER 2003						
				Analysis Completed		
Sample Location	Sample ID	Media	Date Sampled	Primary ROPC[1]	Secondary ROPC[2]	Comments
Dry Run location SE-DR-01	SE-DR-01	Sediment	12/6/2003	X		
Dry Run location SE-DR-02	SE-DR-02	Sediment	12/6/2003	X		
Dry Run location SE-DR-03	SE-DR-03	Sediment	12/6/2003	X		
Dry Run location SE-DR-04	SE-DR-04	Sediment	12/6/2003	X		
Dry Run location SE-DR-04	SE-FD-01	Sediment	12/6/2003	X		Field Dup of SE-DR-04
Dry Run location SE-DR-05	SE-DR-05	Sediment	12/6/2003	X	X	
Dry Run location SE-DR-06	SE-DR-06	Sediment	12/6/2003	X		
Carnahan Run location SE-CR-01	SE-CR-01	Sediment	12/7/2003	X		
Carnahan Run location SE-CR-02	SE-CR-02	Sediment	12/7/2003	X		
Carnahan Run location SE-CR-02	SE-FD-02	Sediment	12/7/2003	X		Field Dup of SE-CR-02
Carnahan Run location SE-CR-03	SE-CR-03	Sediment	12/7/2003	X	X	
Carnahan Run location SE-CR-04	SE-CR-04	Sediment	12/7/2003	X		
Carnahan Run location SE-CR-05	SE-CR-05	Sediment	12/7/2003	X		
Carnahan Run location SE-CR-06	SE-CR-06	Sediment	12/7/2003	X		

1 -- Primary ROPC include U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. All samples were analyzed for the primary ROPC.

2 -- Secondary ROPC include Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, and Pu-242. Only 10% of the samples were analyzed for the secondary ROPC.

TABLE 3-13

SUMMARY OF SEDIMENT SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED - JUNE 2004

Sample Location	Sample ID	Media	Date Sampled	Analysis Completed Primary ROPC[1]	Analysis Completed Secondary ROPC[2]	Comments
Dry Run location SE-DR-01	SE-DR-01	Sediment	06/12/04	X		
Dry Run location SE-DR-02	SE-DR-02	Sediment	06/12/04	X		
Dry Run location SE-DR-03	SE-DR-03	Sediment	06/12/04	X	X	
Dry Run location SE-DR-03	SE-FD-01	Sediment	06/12/04	X	X	Field Dup of SE-DR-03
Dry Run location SE-DR-04	SE-DR-04	Sediment	06/12/04	X		
Dry Run location SE-DR-05	SE-DR-05	Sediment	06/12/04	X	X	
Dry Run location SE-DR-06	SE-DR-06	Sediment	06/12/04	X		
Carnahan Run location SE-CR-01	SE-CR-01	Sediment	06/13/04	X		
Carnahan Run location SE-CR-02	SE-CR-02	Sediment	06/13/04	X		
Carnahan Run location SE-CR-03	SE-CR-03	Sediment	06/13/04	X		
Carnahan Run location SE-CR-04	SE-CR-04	Sediment	06/13/04	X		
Carnahan Run location SE-CR-05	SE-CR-05	Sediment	06/13/04	X		
Carnahan Run location SE-CR-06	SE-CR-06	Sediment	06/13/04	X		
Not Applicable	SE-RB-01-061304	Rinse Blank	06/13/04	X	X	

1 -- Primary ROPC include U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. All samples were analyzed for the primary ROPC.

2 -- Secondary ROPC include Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, and Pu-242. Only 10% of the samples were analyzed for the secondary ROPC.

TABLE 3-14						
SUMMARY OF AIR SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED						
			Date	Analysis Completed		
Sample Location	**Sample ID**	**Media**	**Sampled**	**Suite 1[1]**	**Suite 2[2]**	**Comments**
Weekly Perimeter Air Monitoring Samples						
ASL-01	ASL-01	Filter	08/26/03	X	X (Am-241)	
ASL-02	ASL-02	Filter	08/26/03	X	X (Am-241)	
ASL-03	ASL-03	Filter	08/26/03	X	X (Am-241)	
ASL-04	ASL-04	Filter	08/26/03	X	X (Am-241)	
ASL-05	ASL-05	Filter	08/26/03	X	X (Am-241)	
ASL-01	ASL-01-090203	Filter	09/02/03	X		
ASL-02	ASL-02-090203	Filter	09/02/03	X		
ASL-03	ASL-03-090203	Filter	09/02/03	X		
ASL-04	ASL-04-090203	Filter	09/02/03	X		
ASL-05	ASL-05-090203	Filter	09/02/03	X		
ASL-01	ASL-01-090903	Filter	09/09/03	X	X (Iso-Th)	
ASL-02	ASL-02-090903	Filter	09/09/03	X	X (Iso-Th)	
ASL-03	ASL-03-090903	Filter	09/09/03	X	X (Iso-Th)	
ASL-04	ASL-04-090903	Filter	09/09/03	X	X (Iso-Th)	
ASL-05	ASL-05-090903	Filter	09/09/03	X	X (Iso-Th)	
ASL-01	ASL-01-091603	Filter	09/16/03	X		
ASL-02	ASL-02-091603	Filter	09/16/03	X		
ASL-03	ASL-03-091603	Filter	09/16/03	X		
ASL-04	ASL-04-091603	Filter	09/16/03	X		
ASL-05	ASL-05-091603	Filter	09/16/03	X		
ASL-01	ASL-01-092303	Filter	09/23/03	X	X (Am-241)	
ASL-02	ASL-02-092303	Filter	09/23/03	X	X (Am-241)	
ASL-03	ASL-03-092303	Filter	09/23/03	X	X (Am-241)	
ASL-04	ASL-04-092303	Filter	09/23/03	X	X (Am-241)	
ASL-05	ASL-05-092303	Filter	09/23/03	X	X (Am-241)	
Not Applicable	ASL-06-092403	Filter	09/23/03	X	X (Am-241)	Filter Blank
ASL-01	ASL-01-093003	Filter	09/30/03	X		
ASL-02	ASL-02-093003	Filter	09/30/03	X		
ASL-03	ASL-03-093003	Filter	09/30/03	X		
ASL-04	ASL-04-093003	Filter	09/30/03	X		
ASL-05	ASL-05-093003	Filter	09/30/03	X		
Not Applicable	ASL-06-093003	Filter	09/30/03	X		Filter Blank
NWS-03	NWS-03-0	Filter	09/30/03	X		Nested Well Sample - GW Installation Work Area
ASL-01	ASL-1-100703	Filter	10/07/03	X	X (Iso-Th)	
ASL-02	ASL-2-100703	Filter	10/07/03	X	X (Iso-Th)	
ASL-03	ASL-3-100703	Filter	10/07/03	X	X (Iso-Th)	
ASL-04	ASL-4-100703	Filter	10/07/03	X	X (Iso-Th)	
ASL-05	ASL-5-100703	Filter	10/07/03	X	X (Iso-Th)	
ASL-01	ASL-01-101403	Filter	10/14/03	X		
ASL-02	ASL-02-101403	Filter	10/14/03	X		
ASL-03	ASL-03-101403	Filter	10/14/03	X		
ASL-04	ASL-04-101403	Filter	10/14/03	X		
ASL-05	ASL-05-101403	Filter	10/14/03	X		
Not Applicable	ASL-06-101403	Filter	10/14/03	X		Filter Blank
ASL-01	ASL-01-102103	Filter	10/21/03	X	X (Am-241)	
ASL-02	ASL-02-102103	Filter	10/21/03	X	X (Am-241)	
ASL-03	ASL-03-102103	Filter	10/21/03	X	X (Am-241)	
ASL-04	ASL-04-102103	Filter	10/21/03	X	X (Am-241)	
ASL-05	ASL-05-102103	Filter	10/21/03	X	X (Am-241)	

TABLE 3-14						
SUMMARY OF AIR SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED						
			Date	Analysis Completed		
Sample Location	**Sample ID**	**Media**	**Sampled**	**Suite 1[1]**	**Suite 2[2]**	**Comments**
ASL-01	ASL-01-102803	Filter	10/28/03	X		
ASL-02	ASL-02-102803	Filter	10/28/03	X		
ASL-03	ASL-03-102803	Filter	10/28/03	X		
ASL-04	ASL-04-102803	Filter	10/28/03	X		
ASL-05	ASL-05-102803	Filter	10/28/03	X		
ASL-01	ASL-1-110403	Filter	11/04/03	X	X (Iso-Th)	
ASL-02	ASL-2-110403	Filter	11/04/03	X	X (Iso-Th)	
ASL-03	ASL-3-110403	Filter	11/04/03	X	X (Iso-Th)	
ASL-04	ASL-4-110403	Filter	11/04/03	X	X (Iso-Th)	
ASL-05	ASL-5-110403	Filter	11/04/03	X	X (Iso-Th)	
ASL-01	ASL-01-111103	Filter	11/11/03	X		
ASL-02	ASL-02-111103	Filter	11/11/03	X		
ASL-03	ASL-03-111103	Filter	11/11/03	X		
ASL-04	ASL-04-111103	Filter	11/11/03	X		
ASL-05	ASL-05-111103	Filter	11/11/03	X		
Not Applicable	ASL-06-111103	Filter	11/11/03	X		Filter Blank
ASL-01	ASL-01-111803	Filter	11/18/03	X	X (Am-241)	
ASL-02	ASL-02-111803	Filter	11/18/03	X	X (Am-241)	
ASL-03	ASL-03-111803	Filter	11/18/03	X	X (Am-241)	
ASL-04	ASL-04-111803	Filter	11/18/03	X	X (Am-241)	
ASL-05	ASL-05-111803	Filter	11/18/03	X	X (Am-241)	
ASL-01	ASL-01-112503	Filter	11/25/03	X		
ASL-02	ASL-02-112503	Filter	11/25/03	X		
ASL-03	ASL-03-112503	Filter	11/25/03	X		
ASL-04	ASL-04-112503	Filter	11/25/03	X		
ASL-05	ASL-05-112503	Filter	11/25/03	X		
ASL-01	ASL-1-120203	Filter	12/02/03	X	X (Iso-Th)	
ASL-02	ASL-2-120203	Filter	12/02/03	X	X (Iso-Th)	
ASL-03	ASL-3-120203	Filter	12/02/03	X	X (Iso-Th)	
ASL-04	ASL-4-120203	Filter	12/02/03	X	X (Iso-Th)	
ASL-05	ASL-5-120203	Filter	12/02/03	X	X (Iso-Th)	
ASL-01	ASL-01-120903	Filter	12/09/03	X		
ASL-02	ASL-02-120903	Filter	12/09/03	X		
ASL-03	ASL-03-120903	Filter	12/09/03	X		
ASL-04	ASL-04-120903	Filter	12/09/03	X		
ASL-05	ASL-05-120903	Filter	12/09/03	X		
Not Applicable	ASL-06-120903	Filter	12/09/03	X		Filter Blank
Monthly Perimeter Air Monitoring Samples						
ASL-01	ASL-01-010604	Filter	01/06/04	X		plus Am-241 and iso-Th
ASL-02	ASL-02-010604	Filter	01/06/04	X		plus Am-241 and iso-Th
ASL-03	ASL-03-010604	Filter	01/06/04	X		plus Am-241 and iso-Th
ASL-04	ASL-04-010604	Filter	01/06/04	X		plus Am-241 and iso-Th
ASL-05	ASL-05-010604	Filter	01/06/04	X		plus Am-241 and iso-Th
ASL-01	ASL-01-021004	Filter	02/10/04	X		plus Am-241 and iso-Th
ASL-02	ASL-02-021004	Filter	02/10/04	X		plus Am-241 and iso-Th
ASL-03	ASL-03-021004	Filter	02/10/04	X		plus Am-241 and iso-Th
ASL-04	ASL-04-021004	Filter	02/10/04	X		plus Am-241 and iso-Th
ASL-05	ASL-05-021004	Filter	02/10/04	X		plus Am-241 and iso-Th
ASL-01	ASL-01-031004	Filter	03/10/04	X		plus Am-241 and iso-Th
ASL-02	ASL-02-031004	Filter	03/10/04	X		plus Am-241 and iso-Th

TABLE 3-14						
SUMMARY OF AIR SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED						
			Date	**Analysis Completed**		
Sample Location	**Sample ID**	**Media**	**Sampled**	**Suite 1**[1]	**Suite 2**[2]	**Comments**
ASL-03	ASL-03-031004	Filter	03/10/04	X		plus Am-241 and iso-Th
ASL-04	ASL-04-031004	Filter	03/10/04	X		plus Am-241 and iso-Th
ASL-05	ASL-05-031004	Filter	03/10/04	X		plus Am-241 and iso-Th
ASL-01	ASL-01-040604	Filter	04/06/04	X		plus Am-241 and iso-Th
ASL-02	ASL-02-040604	Filter	04/06/04	X		plus Am-241 and iso-Th
ASL-03	ASL-03-040604	Filter	04/06/04	X		plus Am-241 and iso-Th
ASL-04	ASL-04-040604	Filter	04/06/04	X		plus Am-241 and iso-Th
ASL-05	ASL-05-040604	Filter	04/06/04	X		plus Am-241 and iso-Th
ASL-01	ASL-01-050404	Filter	05/04/04	X		plus Am-241 and iso-Th
ASL-02	ASL-02-050404	Filter	05/04/04	X		plus Am-241 and iso-Th
ASL-03	ASL-03-050404	Filter	05/04/04	X		plus Am-241 and iso-Th
ASL-04	ASL-04-050404	Filter	05/04/04	X		plus Am-241 and iso-Th
ASL-05	ASL-05-050404	Filter	05/04/04	X		plus Am-241 and iso-Th
ASL-01	ASL-01-060804	Filter	06/08/04	X		plus Am-241 and iso-Th
ASL-02	ASL-02-060804	Filter	06/08/04	X		plus Am-241 and iso-Th
ASL-03	ASL-03-060804	Filter	06/08/04	X		plus Am-241 and iso-Th
ASL-04	ASL-04-060804	Filter	06/08/04	X		plus Am-241 and iso-Th
ASL-05	ASL-05-060804	Filter	06/08/04	X		plus Am-241 and iso-Th
Not Applicable	ASL-06-060804	Filter	06/08/04	X		plus Am-241 and iso-Th, Filter Blank
ASL-01	ASL-01-070804	Filter	07/08/04	X		plus Am-241 and iso-Th
ASL-02	ASL-02-070804	Filter	07/08/04	X		plus Am-241 and iso-Th
ASL-03	ASL-03-070804	Filter	07/08/04	X		plus Am-241 and iso-Th
ASL-04	ASL-04-070804	Filter	07/08/04	X		plus Am-241 and iso-Th
ASL-05	ASL-05-070804	Filter	07/08/04	X		plus Am-241 and iso-Th
Not Applicable	ASL-06-070804	Filter	07/08/04	X		plus Am-241 and iso-Th, Filter Blank
ASL-01	ASL-01-081204	Filter	08/12/04	X		plus Am-241 and iso-Th
ASL-02	ASL-02-081204	Filter	08/12/04	X		plus Am-241 and iso-Th
ASL-03	ASL-03-081204	Filter	08/12/04	X		plus Am-241 and iso-Th
ASL-04	ASL-04-081204	Filter	08/12/04	X		plus Am-241 and iso-Th
ASL-05	ASL-05-081204	Filter	08/12/04	X		plus Am-241 and iso-Th
Breathing Zone Samples						
Geologist's Sholder During Trench Borings	BZ-001A	Filter	11/05/03	X		Total Beryllium
Geologist's Shoulder During Trench Borings	BZ-002P	Filter	11/05/03	X		Total Beryllium
Geologist's Sholder During Trench Borings	BZ-003	Filter	11/06/03	X		Total Beryllium
Geologist's Sholder During Trench Borings	BZ-004	Filter	11/07/03	X		Total Beryllium
Geologist's Sholder During Trench Borings	BZ-005A	Filter	11/08/03	X		Total Beryllium
Geologist's Sholder During Trench Borings	BZ-006P	Filter	11/08/03	X		Total Beryllium

TABLE 3-14						
SUMMARY OF AIR SAMPLE IDENTIFICATION, SAMPLE DATE, AND ANALYSIS COMPLETED						
			Date	**Analysis Completed**		
Sample Location	**Sample ID**	**Media**	**Sampled**	**Suite 1[1]**	**Suite 2[2]**	**Comments**
Geologist's Sholder During Trench Borings	BZ-007	Filter	11/09/03	X		Total Beryllium
Geologist's Sholder During Trench Borings	BZ-008	Filter	11/10/03	X		Total Beryllium
Geologist's Sholder During Trench Borings	BZ-009	Filter	11/11/03	X		Total Beryllium
Geologist's Sholder During Trench Borings	BZ-010	Filter	11/17/03	X		Total Beryllium
Geologist's Sholder During Trench Borings	BZ-011A	Filter	11/18/03	X		Total Beryllium
Geologist's Sholder During Trench Borings	BZ-012P	Filter	11/18/03	X		Total Beryllium
Geologist's Sholder During Trench Borings	BZ-013	Filter	11/19/03	X		Total Beryllium
Geologist's Sholder During Trench Borings	BZ-014	Filter	11/20/03	X		Total Beryllium
Geologist's Sholder During Trench Borings	BZ-015	Filter	11/21/03	X		Total Beryllium
Geologist's Sholder During Trench Borings	BZ-016	Filter	11/22/03	X		Total Beryllium
Geologist's Sholder During Trench Borings	BZ-017	Filter	12/16/03	X		Filter Blank - Total Beryllium

1 -- For perimeter air monitoring, Suite 1 consisted of gross alpha/beta, gamma spec (Co-60, Cs-137), Ra-226 (radon emnantion), Ra-228 (lucas cell), and isotopic uranium (U-234, U-235, U-238). For breathing zone (BZ) samples, Suite 1 consisted of total beryllium (NIOSH 7300).

2 -- Suite 2 consisted of gross alpha/beta, gamma spec (Co-60, Cs-137), Ra-226 (radon emnantion), Ra-228 (lucas cell), and Am-241 (or isotopic thorium - Th-230 and Th-232).

TABLE 3-15

ANALYTICAL METHODS USED DURING THE REMEDIAL INVESTIGATION SLDA

PARAMETER*	SOLID MATRIX		AQUEOUS MATRIX		AIR MATRIX		REFERENCE
	Preparation Method Number	Analysis Method Number	Preparation Method Number	Analysis Method Number	Preparation Method Number	Analysis Method Number	
Americium-241 (aqueous and air only), Isotopic Plutonium (soil and water only), Thorium and Uranium (Alpha Spectroscopy)	DOE EML HASL 300 Series	DOE EML HASL 300 Series	DOE EML HASL 300 Series	DOE EML HASL 300 Series	DOE EML HASL 300 Series	DOE EML HASL 300 Series	1
Plutonium-241 (Liquid Scintillation Counting)	DOE EML HASL 300 Pu-11-RC-Mod	DOE EML HASL 300 Pu-11-RC-Mod	DOE EML HASL 300 Pu-11-RC-Mod	DOE EML HASL 300 Pu-11-RC-Mod	Not Applicable	Not Applicable	1
Radium-226 and Radium-228 (Gamma Spectrometry)**	DOE EML HASL 300 Sec. 4.5.3.2	DOE EML HASL 300 Sec. 4.5.3.2	Not Applicable	Not Applicable	Not Applicable	Not Applicable	1
Americium-241 (solid only), Cobalt-60, and Cesium-137 (Gamma Spectrometry)**	EPA 901.1	EPA 901.1	EPA 901.1	EPA 901.1	EPA 901.1	EPA 901.1	2
Radium-226 (Radon Emanation)	Not Applicable	Not Applicable	EPA 903.1	EPA 903.1	EPA 903.1	EPA 903.1	2
Radium-228 (Gas-Flow Proportional Counting)	Not Applicable	Not Applicable	EPA 904.0/SW9320	EPA 904.0/SW9320	EPA 904.0/SW9320	EPA 904.0/SW9320	2, 3
Gross Alpha/Beta Activity (Gas-Flow Proportional Counting)	Not Applicable	Not Applicable	EPA 900.0	EPA 900.0	EPA 900.0	EPA 900.0	2
Toxicity Characteristic Leaching Procedure (TCLP)	1311/8260B/ 3510C/8151A/ 3010A/7470A	8260B/8270C/ 8081A/8151A/ 6010C/7471A	1311/8260B/ 3510C/8151A/ 3010A/7470A	8260B/8270C/ 8081A/8151A/ 6010C/7470A	Not Applicable	Not Applicable	3
Polychlorinated Biphenyls (PCB)	3540C	8082	3510C	8082	Not Applicable	Not Applicable	3
RCRA Characteristics (Reactivity, Ignitability, and Corrosivity)	SW-846 Chap. 7, Sec. 7.3/ 1010/9045C	SW-846 Chap. 7, Sec. 7.3/ 1030/9045C	SW-846 Chap. 7, Sec. 7.3/ 1010/9040B	SW-846 Chap. 7, Sec. 7.3/ 1010/9040B	Not Applicable	Not Applicable	3
Priority Pollutant Analyses	Not Applicable	Not Applicable	8260B/ 3510C/ 3010A/7470A	8260B/8270C/ 8081A/ 6010C/7470A	Not Applicable	Not Applicable	3
Total Copper, Iron, Manganese, Nickel, and Zinc	3050A	6010C	Not Applicable	Not Applicable	Not Applicable	Not Applicable	3
Geotechnical Testing	Not Applicable	ASTM D2216/D421 and D422/D4318/D1895B/D792	Not Applicable	Not Applicable	Not Applicable	Not Applicable	4

References:

1. DOE, *EML HASL 300 Series,* 28th Edition (2/97).

2. USEPA, *Prescribed Procedures for Measurement of Radioactivity in Drinking Water,* EPA 600/4-80-032, August 1980.
3. USEPA, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Integrated Manual,* Final Update III, June 1997.
4. American Society of Testing and Materials (ASTM).

Notes:

* - The primary ROPC are U-234, U-235, U-238, Pu-239, Pu-241, Ra-228, Th-232, and Am-241. All samples will be analyzed for the primary ROPC. The secondary ROPC are Cs-137, Co-60, Th-230, Ra-226, Pu-238, Pu-240, and Pu-242. Only 10% of the samples are analyzed for the secondary ROPC. Air samples will only be analyzed for Am-241, Co-60, Cs-137, Ra-226, Ra-228, isotopic thorium, and isotopic uranium.
**- For gamma spectroscopy, all identified radionuclides will be reported by the laboratory.

ISOTOPIC PLUTONIUM INCLUDES PU-238, PU-239, PU-240, AND PU-242 BY HASL 300 METHOD PU-11-RC-MODIFIED

ISOTOPIC THORIUM INCLUDES TH-230 AND TH-232 BY HASL 300 METHOD TH-01-RC-MODIFIED

Isotopic uranium includes U-234, U-235, and U-238 by HASL 300 Method U-02-RC-Modified.

TABLE 3-16
PERCENT COMPLETENESS ANALYSIS FOR RI SAMPLING PROGRAM
SLDA

Matrix	Proposed No. of Samples*	Actual No. of Samples*	Difference Between Proposed and Actual**	No. of Data Points Obtained***	No. of Data Points Rejected***	Data Percent Completeness
Background Soil						
Surface Soil	20	20	0	108	4	96.3
Subsurface Soil	20	20	0	116	4	96.6
Soil - Lower Trench Area						
Surface Soil	33	29	-4	258	12	95.3
Subsurface Soil	99	61	-38	558	46	91.8
Soil - Upper Trench Area						
Surface Soil	67	67	0	585	18	96.9
Subsurface Soil	200	129	-71	1120	31	97.2
Trench Contents						
Trench 1	7	8	1	64	1	98.4
Trench 2	5	7	2	62	1	98.4
Trench 3	1	1	0	8	0	100.0
Trench 4	2	2	0	16	0	100.0
Trench 5	15	2	-13	16	0	100.0
Trench 6	4	3	-1	31	2	93.5
Trench 7	4	5	1	40	0	100.0
Trench 8	1	0	-1	0	NA	NC
Trench 9	3	3	0	31	0	100.0
Trench 10	12	18	6	151	1	99.3
Leachate	65	49	-16	434	16	96.3
Groundwater			0			
Round 1	109	55	-54	496	48	90.3
Round 2****	109	49	-60	399	20	95.0
Surface Water/Seeps			0			
Round 1	16	20	4	174	3	98.3
Round 2****	16	20	4	178	2	98.9
Sediment			0			
Round 1	14	14	0	126	0	100.0
Round 2****	14	14	0	139	0	100.0

Notes:

* - No. of samples includes field duplicates.
** - For soils, the number of samples decreased because refusal was encountered during boring operations; for trench contents, the number of samples decreased because waste was not encountered; and for groundwaters and leachates, the number of samples decreased because either the monitoring wells and standpipes were dry or there was insufficient sample volume for collection.
*** - No. of data points is for primary and secondary ROPC only.
**** - Data validated by USACE.
NA - Not Applicable
NC - Not Calculable

TABLE 4-1
STATISTICAL SUMMARY OF BACKGROUND SURFACE SOIL RESULTS
SLDA

Parameter	Units	PRG*	No. of Usable Results	No. of Detections	Range of Detections				Dist	Location of Max Value	Upper Tolerance Limit
					Min	Max	Avg	StdDev			
Primary Radionuclides											
Americium 241	pCi/g	27.7	17	-	-	-	-	-	-	-	0.131
Plutonium 239	pCi/g	32.6	16	-	-	-	-	-	-	-	0.085
Plutonium 241	pCi/g	892	18	-	-	-	-	-	-	-	7.189
Radium 228	pCi/g	1.69	18	18	0.92	1.4	1.1	0.11	Non-Normal	BK-018	1.415
Thorium 232	pCi/g	1.35	18	18	0.74	1.3	1.1	0.16	Normal	BK-002	1.522
Uranium 234	pCi/g	96.4	18	18	0.72	1.3	0.94	0.19	Normal	BK-018	1.469
Uranium 235 (alpha)	pCi/g	34.6	18	3	0.17	0.19	0.067	0.054	Non-Normal	BK-008	0.329
Uranium 235 (gamma)	pCi/g	34.6	18	-	-	-	-	-	-	-	0.164
Uranium 238	pCi/g	123	18	18	0.74	1.3	0.98	0.14	Normal	BK-016	1.366
Secondary Radionuclides											
Cesium 137	pCi/g	-	18	18	0.18	0.79	0.45	0.19	Normal	BK-011	0.979
Cobalt 60	pCi/g	-	18	-	-	-	-	-	-	-	0.035
Plutonium 238	pCi/g	-	2	-	-	-	-	-	-	-	0.141
Plutonium 242	pCi/g	-	1	-	-	-	-	-	-	-	
Radium 226	pCi/g	-	18	18	0.72	1.3	0.99	0.14	Normal	BK-017	1.320
Thorium 230	pCi/g	-	2	2	1.2	1.2	1.2	0.042	-	BK-004	2.808
Other Radionuclides											

*PRG- Preliminary Remediation Goal.

Concentration Exceeds PRG

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: BKG_SUR_SO_RN
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatDevCrit1_UTL
2/16/2005
WHERE [SITEID] = '3' AND [SAMPNO] <> '3' AND [MATRIX] = 'SO' AND VAL([SED]) <= VAL(0.5) AND [LOCID] LIKE 'BK*';

TABLE 4-1
STATISTICAL SUMMARY OF BACKGROUND SURFACE SOIL RESULTS
SLDA

Parameter	Units	PRG*	No. of Usable Results	No. of Detections	Range of Detections				Dist	Location of Max Value	Upper Tolerance Limit
					Min	Max	Avg	StdDev			
Other Radionuclides											
Beryllium 7	pCi/g	-	18	-	-	-	-	-	-	-	0.304
Bismuth 212	pCi/g	-	18	16	0.55	0.87	0.64	0.2	Non-Normal	BK-004	2.103
Lead 212	pCi/g	-	18	18	0.99	1.5	1.2	0.12	Non-Normal	BK-018	1.495
Lead 214	pCi/g	-	18	18	0.84	1.5	1.1	0.17	Normal	BK-016	1.607
Potassium 40	pCi/g	-	18	18	8.8	13	10	0.9	Normal	BK-018	12.99
Thorium 234	pCi/g	-	18	7	0.95	2.2	1.0	0.65	Normal	BK-010	2.877
Field Screening											
Low Energy Gamma Fiddler	cts/min	-	14	14	13000	16000	14000	1000	Non-Normal	BK-013	
Gamma	urem/hr	-	14	14	6.0	6.0	6.0	0.00E+00	Normal	BK-014	

*PRG- Preliminary Remediation Goal.

(oval symbol) Concentration Exceeds PRG

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: BKG_SUR_SO_RN
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatDevCrit1_UTL
2/16/2005
WHERE [SITEID] = '3' AND [SAMPNO] <> '3' AND [MATRIX] = 'SO' AND VAL([SED]) <= VAL(0.5) AND [LOCID] LIKE 'BK*';

TABLE 4-2
STATISTICAL SUMMARY OF BACKGROUND SUBSURFACE SOIL RESULTS
SLDA

Parameter	Units	PRG*	No. of Usable Results	No. of Detections	Range of Detections				Dist	Location of Max Value	Upper Tolerance Limit
					Min	Max	Avg	StdDev			
Primary Radionuclides											
Americium 241	pCi/g	27.7	17	-	-	-	-	-	-	-	0.121
Plutonium 239	pCi/g	32.6	17	-	-	-	-	-	-	-	0.083
Plutonium 241	pCi/g	892	18	-	-	-	-	-	-	-	7.055
Radium 228	pCi/g	1.69	18	18	1.2	1.7	1.4	0.11	Normal	BK-004	1.746
Thorium 232	pCi/g	1.35	18	17	1.1	1.8	1.4	0.36	Non-Normal	BK-002	6.474
Uranium 234	pCi/g	96.4	18	18	0.72	1.3	1.1	0.14	Normal	BK-017	1.594
Uranium 235 (alpha)	pCi/g	34.6	18	4	0.17	0.27	0.076	0.076	Non-Normal	BK-008	0.550
Uranium 235 (gamma)	pCi/g	34.6	18	-	-	-	-	-	-	-	0.208
Uranium 238	pCi/g	123	18	18	0.71	1.4	1.1	0.18	Normal	BK-008	1.554
Secondary Radionuclides											
Cesium 137	pCi/g	-	17	-	-	-	-	-	-	-	0.039
Cobalt 60	pCi/g	-	18	-	-	-	-	-	-	-	0.032
Plutonium 238	pCi/g	-	2	-	-	-	-	-	-	-	0.667
Plutonium 242	pCi/g	-	2	-	-	-	-	-	-	-	0.379
Radium 226	pCi/g	-	18	18	0.82	1.3	1.0	0.15	Normal	BK-017	1.471
Thorium 230	pCi/g	-	2	2	1.1	1.2	1.1	0.074	-	BK-015	3.900
Other Radionuclides											

*PRG- Preliminary Remediation Goal.

(oval) Concentration Exceeds PRG

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: BKG_SUB_SO_RN
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatDevCrit1_UTL
2/16/2005
WHERE [SITEID] = '3' AND [SAMPNO] <> '3' AND [MATRIX] = 'SO' AND VAL([SED]) > VAL(0.5) AND [LOCID] LIKE 'BK*';

TABLE 4-2
STATISTICAL SUMMARY OF BACKGROUND SUBSURFACE SOIL RESULTS
SLDA

Parameter	Units	PRG*	No. of Usable Results	No. of Detections	Range of Detections				Dist	Location of Max Value	Upper Tolerance Limit
					Min	Max	Avg	StdDev			
Other Radionuclides											
Beryllium 7	pCi/g	-	18	-	-	-	-	-	-	-	0.283
Bismuth 212	pCi/g	-	18	17	0.75	1.2	0.95	0.24	Non-Normal	BK-018	2.675
Lead 212	pCi/g	-	18	18	1.4	2.0	1.6	0.15	Non-Normal	BK-004	2.086
Lead 214	pCi/g	-	18	18	0.99	1.5	1.2	0.14	Normal	BK-008	1.592
Potassium 40	pCi/g	-	18	18	11	21	16	2.5	Normal	BK-008	22.93
Thorium 234	pCi/g	-	18	7	1.4	2.8	1.3	0.83	Normal	BK-017	3.600
Field Screening											
Low Energy Gamma Fiddler	cts/min	-	13	13	13000	17000	14000	1100	Non-Normal	BK-012	
Gamma	urem/hr	-	13	13	6.0	6.0	6.0	0.00E+00	Normal	BK-013	

*PRG- Preliminary Remediation Goal.

Concentration Exceeds PRG

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: BKG_SUB_SO_RN
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatDevCrit1_UTL
2/16/2005
WHERE [SITEID] = '3' AND [SAMPNO] <> '3' AND [MATRIX] = 'SO' AND VAL([SED]) > VAL(0.5) AND [LOCID] LIKE 'BK*';

Table 4-3
Summary of Background Surface Soil Values for the SLDA Site

Surface Soil Radionuclide	Background Value (pCi/g)
Americium-241	0.000
Beryllium-7	0.000
Bismuth 212	0.867
Cesium-137	0.791
Cobalt-60	0.000
Lead-212	1.470
Lead-214	1.460
Plutonium-238	0.000
Plutonium-239 (alpha)	0.000
Plutonium-241	0.000
Plutonium-242	0.000
Potassium-40	12.700
Radium-226	1.320
Radium-228	1.415
Thorium-230	1.240
Thorium-232	1.310
Thorium-234	2.230
Uranium-234 (alpha)	1.320
Uranium-235 (alpha)	0.190
Uranium-235 (gamma)	0.000
Uranium-238	1.250

NOTES:

1. A background value of zero was given if the nuclide was not detected in any of the samples.
2. If a nuclide was detected in one or more samples, one half the method detection limit was used in the UTL calculation for samples where that nuclide was not detected.
3. The background value is the lower of either the upper tolerance limit and the maximum value detected.
4. For data not exhibiting normal distributions, the UTL was calculated using the log of the data.
5. Duplicate samples were averaged with the parent sample.
6. Only two samples were collected and analyzed for plutonium-238, plutonium-242, and thorium-230 since they are considered secondary ROPC. Results associated with one of the plutonium-242 analyses was rejected. Therefore, the background values for these nuclides was based on results of only one or two sample analyses.

Table 4-4
Summary of Background Subsurface Soil Values for the SLDA Site

Subsurface Soil Radionuclide	Background Value (pCi/g)
Americium-241	0.000
Beryllium-7	0.000
Bismuth 212	1.240
Cesium-137	0.000
Cobalt-60	0.000
Lead-212	2.000
Lead-214	1.460
Plutonium-238	0.000
Plutonium-239 (alpha)	0.000
Plutonium-241	0.000
Plutonium-242	0.000
Potassium-40	20.800
Radium-226	1.320
Radium-228	1.660
Thorium-230	1.155
Thorium-232	1.770
Thorium-234	2.770
Uranium-234 (alpha)	1.280
Uranium-235 (alpha)	0.269
Uranium-235 (gamma)	0.208
Uranium-238	1.410

NOTES:

1. A background value of zero was given if the nuclide was not detected in any of the samples.
2. If a nuclide was detected in one or more samples, one half the method detection limit was used in the UTL calculation for samples where that nuclide was not detected.
3. The background value is the lower of either the upper tolerance limit and the maximum value detected.
4. For data not exhibiting normal distributions, the UTL was calculated using the log of the data.
5. Duplicate samples were averaged with the parent sample.
6. Only two samples were collected and analyzed for plutonium-238, plutonium-242, and thorium-230 since they are considered secondary ROPC. Results associated with one of the plutonium-242 analyses was rejected. Therefore, the background values for these nuclides was based on results of only one or two sample analyses.

TABLE 4-5
STATISTICAL SUMMARY OF SURFACE SOIL ANALYTICAL RESULTS
SLDA

Parameter	Units	Criteria (1)	Criteria (2)	Criteria (3)	No. of Usable Results	No. of Detections	Range of Detections					Dist	No. of Exceed.			Max Value	
							Min	Max	Avg	StdDev	UCL95		Crit. (1)	Crit. (2)	Crit. (3)	Location	Depth
Primary Radionuclides																	
Americium 241	pCi/g	0	-	27.7	247	130	0.140	319.5	7.08	30.09	3.65	Non-Normal	130	130	4	GB-101	0-0.5
Plutonium 239	pCi/g	0	-	32.6	96	19	0.145	325.0	24.21	74.20	1.23	Non-Normal	19	19	2	GB-102R	0-0.5
Plutonium 241	pCi/g	0	-	892	93	8	24.40	628.0	117.8	209.0	9.78	Non-Normal	8	8	0	GB-102R	0-0.5
Radium 228	pCi/g	1.415	2.83	3.11	102	102	0.797	2.23	1.24	0.208	1.27	Non-Normal	13	0	0	GB-051	0-0.5
Thorium 232	pCi/g	1.31	2.62	2.66	110	110	0.447	1.76	1.19	0.239	1.23	Normal	34	0	0	GB-012	0-0.5
Uranium 234	pCi/g	1.32	2.64	97.72	102	102	0.569	71.30	4.95	8.25	5.52	Non-Normal	70	45	0	GB-084	0-0.5
Uranium 235 (alpha)	pCi/g	0.19	0.38	34.79	102	57	0.150	3.97	0.599	0.632	0.487	Non-Normal	52	28	0	GB-084	0-0.5
Uranium 235 (gamma)	pCi/g	0	-	34.6	297	93	0.080	236.0	5.56	29.42	0.450	Non-Normal	93	93	2	114/115	0-0.5
Uranium 238	pCi/g	1.25	2.5	124.25	296	194	0.435	278.0	4.27	20.59	2.09	Non-Normal	133	52	1	113	0-0.5
Isotopic Uranium (total)	pCi/g	2.76	5.52	-	102	102	1.03	92.27	6.87	10.36	7.35	Non-Normal	63	36	0	GB-084	0-0.5
Uranium (total)	pCi/g	2.76	5.52	-	207	207	0.740	13.77	3.99	2.60	4.16	Non-Normal	151	22	0	BC-14	0-0.5
Secondary Radionuclides																	
Cesium 137	pCi/g	0.791	1.582	-	113	83	0.010	1.16	0.214	0.191	0.237	Non-Normal	2	0	0	GB-025	0-0.5
Cobalt 60	pCi/g	0	-	-	111	7	0.010	0.470	0.112	0.166	0.024	Non-Normal	7	7	0	S095	0-0.5

Criteria (1)- Background concentrations for surface soil.

Criteria (2)- Two times background concentrations for surface soil.

Criteria (3)- Preliminary Remediation Goal plus Background for Surface soil.

(Oval) Concentration Exceeds Criteria 1

(Box) Concentration Exceeds Criteria (2)

Border Concentration Exceeds Criteria (3)

Advanced Selection: SURF_SO_RN
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStat95StdDevCrit3NE
10/19/2004
WHERE [SITEID] = '1' AND [MATRIX] = 'SO' AND ([LOCID] <> 'DRUMMED SOIL' AND [LOCID] NOT LIKE 'BK*') AND [PRCCODE] LIKE 'RN*' AND VAL([SED]) <= '0.5' AND ([SAMPNO] <> '3' AND [SAMPNO] <> '4');

TABLE 4-5
STATISTICAL SUMMARY OF SURFACE SOIL ANALYTICAL RESULTS
SLDA

Parameter	Units	Criteria (1)	Criteria (2)	Criteria (3)	No. of Usable Results	No. of Detections	Range of Detections					Dist	No. of Exceed.			Max Value	
							Min	Max	Avg	StdDev	UCL95		Crit. (1)	Crit. (2)	Crit. (3)	Location	Depth
Secondary Radionuclides																	
Plutonium 238	pCi/g	0	-	-	9	-	-	-	-	-	-	-	0	0	0	-	
Plutonium 242	pCi/g	0	-	-	9	-	-	-	-	-	-	-	0	0	0	-	
Radium 226	pCi/g	1.32	2.64	-	114	114	0.660	1.59	0.966	0.142	0.988	Normal	2	0	0	GB-051	0-0.5
Thorium 230	pCi/g	1.24	2.48	-	10	10	0.955	1.53	1.36	0.234	1.54	Non-Normal	7	0	0	GB-084	0-0.5
Other Radionuclides																	
Beryllium 7	pCi/g	0	-	-	102	-	-	-	-	-	-	-	0	0	0	-	
Bismuth 212	pCi/g	0.867	1.734	-	102	97	0.516	2.05	0.896	0.224	0.906	Normal	45	1	0	GB-009	0-0.5
Lead 212	pCi/g	1.47	2.94	-	102	102	0.885	2.63	1.40	0.251	1.44	Non-Normal	30	0	0	GB-051	0-0.5
Lead 214	pCi/g	1.46	2.92	-	102	102	0.821	1.82	1.15	0.161	1.18	Normal	5	0	0	GB-051	0-0.5
Potassium 40	pCi/g	12.7	25.4	-	106	106	5.72	26.20	14.63	3.80	15.24	Normal	72	1	0	GB-094	0-0.5
Thorium (total)	pCi/g	4.78	9.56	-	4	4	1.94	2.38	2.15	0.209	2.39	Normal	0	0	0	SITE # 13	0.5-0.5
Thorium 234	pCi/g	2.23	4.46	-	102	34	1.04	20.70	3.17	4.31	1.49	Non-Normal	11	3	0	GB-020	0-0.5
Radionuclides Ratios																	
U234 / U238 Ratio	pCi/g	-	-	-	102	102	0.692	10.24	2.94	2.56	2.641	Normal	0	0	0	GB-089	0-0.5

Criteria (1)- Background concentrations for surface soil.

Criteria (2)- Two times background concentrations for surface soil.

Criteria (3)- Preliminary Remediation Goal plus Background for Surface soil.

(Oval) Concentration Exceeds Criteria 1

(Rectangle) Concentration Exceeds Criteria (2)

Border Concentration Exceeds Criteria (3)

Advanced Selection: SURF_SO_RN
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStat95StdDevCrit3NE
10/19/2004
WHERE [SITEID] = '1' AND [MATRIX] = 'SO' AND ([LOCID] <> 'DRUMMED SOIL' AND [LOCID] NOT LIKE 'BK*') AND [PRCCODE] LIKE 'RN*' AND VAL([SED]) <= '0.5' AND ([SAMPNO] <> '3' AND [SAMPNO] <> '4');

TABLE 4-5
STATISTICAL SUMMARY OF SURFACE SOIL ANALYTICAL RESULTS
SLDA

Parameter	Units	Criteria (1)	Criteria (2)	Criteria (3)	No. of Usable Results	No. of Detections	Range of Detections					Dist	No. of Exceed.			Max Value	
							Min	Max	Avg	StdDev	UCL95		Crit. (1)	Crit. (2)	Crit. (3)	Location	Depth
Radionuclides Ratios																	
U235 (alpha) Ratio / U238 Ratio	pCi/g	-	-	-	102	62	0.088	1.02	0.357	0.222	.233	Normal	0	0	0	GB-062	0-0.5

Criteria (1)- Background concentrations for surface soil.

Criteria (2)- Two times background concentrations for surface soil.

Criteria (3)- Preliminary Remediation Goal plus Background for Surface soil.

Concentration Exceeds Criteria 1

Concentration Exceeds Criteria (2)

Border Concentration Exceeds Criteria (3)

TABLE 4-6
STATISTICAL SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
GREATER THAN 0.5 FEET AND LESS THAN AND EQUAL TO 4 FEET BELOW GROUND SURFACE
SLDA

Parameter	Units	Criteria (1)	Criteria (2)	Criteria (3)	No. of Samples	No. of Detections	Range of Detections				Dist	No. of Exceed.			Max Value	
							Min	Max	Avg	StdDev		Crit. (1)	Crit. (2)	Crit. (3)	Location	Depth
Primary Radionuclides																
Americium 241	pCi/g	0	0	27.7	40	10	0.019	34	1.3	5.4	Non-Normal	10	10	1	10L24	0-2
Plutonium 239	pCi/g	0	0	32.6	11	2	0.0003	69	6.3	21	Non-Normal	2	2	1	10L24	0-2
Plutonium 241	pCi/g	0	0	892	9	-	-	-	-	-	-	0	0	0	-	
Radium 228	pCi/g	1.66	3.32	3.35	10	10	1.2	1.6	1.4	0.18	Normal	0	0	0	GB-066	1-3
Thorium 232	pCi/g	1.77	3.54	3.12	30	30	0.78	2.3	1.5	0.31	Normal	4	0	0	MW-37	2-4
Uranium 234	pCi/g	1.28	2.56	97.68	11	11	0.54	150	14	44	Non-Normal	2	1	1	07U05	2-4
Uranium 235 (alpha)	pCi/g	0.269	0.538	34.87	11	1	5.0	5.0	0.51	1.5	Non-Normal	1	1	0	07U05	2-4
Uranium 235 (gamma)	pCi/g	0.208	0.416	34.81	28	5	0.78	31	2.0	6.3	Non-Normal	5	5	0	114/115	0.5-1
Uranium 238	pCi/g	1.41	2.82	124.41	29	19	0.55	15	2.3	3.4	Non-Normal	9	6	0	046	1-1.5
Isotopic Uranium (total)	pCi/g	2.96	5.92	-	11	11	1.2	160	16	48	Non-Normal	2	1	0	07U05	2-4
Uranium (total)	pCi/g	2.96	5.92	-	67	67	2.1	130	19	27	Non-Normal	62	46	0	01U20	4-4
Secondary Radionuclides																
Cesium 137	pCi/g	0	0	-	28	9	0.03	0.3	0.05	0.059	Non-Normal	9	9	0	MW-41	0-2

Criteria (1)- Background concentrations for subsurface soil.

Criteria (2)- Two times background concentrations for subsurface soil.

Criteria (3)- Preliminary Remediation Goal plus Background for Subsurface soil.

(ellipse) Concentration Exceeds Criteria 1

(box) Concentration Exceeds Criteria (2)

Border Concentration Exceeds Criteria (3)

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: SUBSOIL_RN_0.5-4
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit3NE
2/16/2005
WHERE ([MATRIX] = 'SO' AND [PRCCODE] LIKE 'RN*') AND VAL([SBD]) >= 0 AND (VAL([SED]) <= 4 AND VAL([SED]) > 0.5) AND ([SAMPNO] <> '3'AND [SAMPNO] <> '4') AND ([SITEID] <> '2' AND [SITEID] <> '3');

TABLE 4-6
STATISTICAL SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
GREATER THAN 0.5 FEET AND LESS THAN AND EQUAL TO 4 FEET BELOW GROUND SURFACE
SLDA

Parameter	Units	Criteria (1)	Criteria (2)	Criteria (3)	No. of Samples	No. of Detections	Range of Detections				Dist	No. of Exceed.			Max Value	
							Min	Max	Avg	StdDev		Crit. (1)	Crit. (2)	Crit. (3)	Location	Depth
Secondary Radionuclides																
Cobalt 60	pCi/g	0	0	-	30	1	0.03	0.03	0.024	0.006	Normal	1	1	0	MW-40	2-4
Plutonium 238	pCi/g	0	0	-	2	1	2.1	2.1	1.1	1.4	-	1	1	0	10L24	0-2
Plutonium 242	pCi/g	0	0	-	2	-	-	-	-	-	-	0	0	0	-	
Radium 226	pCi/g	1.32	2.64	-	30	30	0.73	1.5	1.0	0.15	Non-Normal	1	0	0	MW-37	2-4
Thorium 230	pCi/g	1.155	2.31	-	1	1	1.2	1.2	1.2	-	-	1	0	0	GB-099	1-3
Other Radionuclides																
Beryllium 7	pCi/g	0	0	-	10	-	-	-	-	-	-	0	0	0	-	
Bismuth 212	pCi/g	1.24	2.48	-	10	9	0.68	1.2	0.96	0.32	Non-Normal	0	0	0	GB-097	2-4
Lead 212	pCi/g	2	4	-	10	10	1.3	1.9	1.6	0.18	Normal	0	0	0	GB-066	1-3
Lead 214	pCi/g	1.46	2.92	-	10	10	0.98	1.3	1.2	0.11	Normal	0	0	0	GB-033	1-2.5
Plutonium (alpha)	pCi/g	-	-	-	2	-	-	-	-	-	-	0	0	0	-	
Potassium 40	pCi/g	20.8	41.6	-	10	10	10	23	17	4.0	Normal	2	0	0	GB-018	2-4
Thorium 234	pCi/g	2.77	5.54	-	10	4	0.71	2.5	1.1	0.77	Non-Normal	0	0	0	GB-097	2-4

Criteria (1)- Background concentrations for subsurface soil.

Criteria (2)- Two times background concentrations for subsurface soil.

Criteria (3)- Preliminary Remediation Goal plus Background for Subsurface soil.

(Ellipse) Concentration Exceeds Criteria 1

(Box) Concentration Exceeds Criteria (2)

Border Concentration Exceeds Criteria (3)

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: SUBSOIL_RN_0.5-4
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit3NE
2/16/2005
WHERE ([MATRIX] = 'SO' AND [PRCCODE] LIKE 'RN*') AND VAL([SBD]) >= 0 AND (VAL([SED]) <= 4 AND VAL([SED]) > 0.5) AND ([SAMPNO] <> '3'AND [SAMPNO] <> '4') AND ([SITEID] <> '2' AND [SITEID] <> '3');

TABLE 4-6
STATISTICAL SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
GREATER THAN 0.5 FEET AND LESS THAN AND EQUAL TO 4 FEET BELOW GROUND SURFACE
SLDA

Parameter	Units	Criteria (1)	Criteria (2)	Criteria (3)	No. of Samples	No. of Detections	Range of Detections				Dist	No. of Exceed.			Max Value	
							Min	Max	Avg	StdDev		Crit. (1)	Crit. (2)	Crit. (3)	Location	Depth
Radionuclides Ratios																
U234 / U238 Ratio	pCi/g	-	-	-	11	11	0.87	23	3.0	6.7	Normal	0	0	0	07U05	2-4
U235 (alpha) Ratio / U238 Ratio	pCi/g	-	-	-	11	1	0.78	0.78	0.78	0.00E+00	Normal	0	0	0	07U05	2-4

Criteria (1)- Background concentrations for subsurface soil.

Criteria (2)- Two times background concentrations for subsurface soil.

Criteria (3)- Preliminary Remediation Goal plus Background for Subsurface soil.

Concentration Exceeds Criteria 1

Concentration Exceeds Criteria (2)

Border Concentration Exceeds Criteria (3)

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: SUBSOIL_RN_0.5-4
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit3NE
2/16/2005
WHERE ([MATRIX] = 'SO' AND [PRCCODE] LIKE 'RN*') AND VAL([SBD]) >= 0 AND (VAL([SED]) <= 4 AND VAL([SED]) > 0.5) AND ([SAMPNO] <> '3'AND [SAMPNO] <> '4') AND ([SITEID] <> '2' AND [SITEID] <> '3');

TABLE 4-7
STATISTICAL SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
GREATER THAN 4 FEET AND LESS THAN AND EQUAL TO 10 FEET BELOW GROUND SURFACE
SLDA

Parameter	Units	Criteria (1)	Criteria (2)	Criteria (3)	No. of Samples	No. of Detections	Range of Detections				Dist	No. of Exceed.			Max Value	
							Min	Max	Avg	StdDev		Crit. (1)	Crit. (2)	Crit. (3)	Location	Depth
Primary Radionuclides																
Americium 241	pCi/g	0	0	27.7	210	16	0.12	38	0.55	2.9	Non-Normal	16	16	1	10L07	4-6
Plutonium 239	pCi/g	0	0	32.6	166	13	0.12	88	1.1	8.1	Non-Normal	13	13	2	10L07	4-6
Plutonium 241	pCi/g	0	0	892	162	3	14	24	5.7	2.1	Non-Normal	3	3	0	GB-008	4-6
Radium 228	pCi/g	1.66	3.32	3.35	174	174	0.68	2.2	1.4	0.31	Normal	30	0	0	GB-019	4-6
Thorium 232	pCi/g	1.77	3.54	3.12	202	201	0.34	2.6	1.4	0.42	Normal	34	0	0	MW-46	8-10
Uranium 234	pCi/g	1.28	2.56	97.68	180	180	0.41	510	10	45	Non-Normal	66	31	6	GB-043	4-6
Uranium 235 (alpha)	pCi/g	0.269	0.538	34.87	180	53	0.058	47	0.71	3.8	Non-Normal	28	18	1	GB-043	4-6
Uranium 235 (gamma)	pCi/g	0.208	0.416	34.81	174	17	0.11	11	0.26	0.98	Non-Normal	15	11	0	GB-043	4-6
Uranium 238	pCi/g	1.41	2.82	124.41	180	179	0.37	37	1.8	3.4	Non-Normal	46	12	0	GB-043	4-6
Isotopic Uranium (total)	pCi/g	2.96	5.92	-	180	180	0.94	590	13	51	Non-Normal	52	24	0	GB-043	4-6
Uranium (total)	pCi/g	2.96	5.92	-	131	131	1.8	630	35	83	Non-Normal	116	80	0	02U08	8-8
Secondary Radionuclides																
Cesium 137	pCi/g	0	0	-	193	8	0.0503	0.26	0.023	0.027	Non-Normal	8	8	0	GB-023	6-7.5

Criteria (1)- Background concentrations for subsurface soil.

Criteria (2)- Two times background concentrations for subsurface soil.

Criteria (3)- Preliminary Remediation Goal plus Background for Subsurface soil.

(ellipse) Concentration Exceeds Criteria 1

(box) Concentration Exceeds Criteria (2)

Border Concentration Exceeds Criteria (3)

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: SUBSOIL_RN_4-10
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit3NE
2/16/2005
WHERE ([MATRIX] = 'SO' AND [PRCCODE] LIKE 'RN*') AND VAL([SBD]) >= 4 AND (VAL([SED]) <= 10 AND VAL([SED]) > 4) AND ([SAMPNO] <> '3'AND [SAMPNO] <> '4') AND ([SITEID] <> '2' AND [SITEID] <> '3');

TABLE 4-7
STATISTICAL SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
GREATER THAN 4 FEET AND LESS THAN AND EQUAL TO 10 FEET BELOW GROUND SURFACE
SLDA

Parameter	Units	Criteria (1)	Criteria (2)	Criteria (3)	No. of Samples	No. of Detections	Range of Detections				Dist	No. of Exceed.			Max Value	
							Min	Max	Avg	StdDev		Crit. (1)	Crit. (2)	Crit. (3)	Location	Depth
Secondary Radionuclides																
Cobalt 60	pCi/g	0	0	-	200	-	-	-	-	-	-	0	0	0	-	
Plutonium 238	pCi/g	0	0	-	21	4	0.6	3.2	0.34	0.75	Non-Normal	4	4	0	10L07	4-6
Plutonium 242	pCi/g	0	0	-	17	-	-	-	-	-	-	0	0	0	-	
Radium 226	pCi/g	1.32	2.64	-	202	202	0.47	1.8	0.97	0.22	Normal	14	0	0	GB-080	8-10
Thorium 230	pCi/g	1.155	2.31	-	17	17	0.47	2.4	1.2	0.42	Non-Normal	9	1	0	GB-081	8-10
Other Radionuclides																
Beryllium 7	pCi/g	0	0	-	170	-	-	-	-	-	-	0	0	0	-	
Bismuth 212	pCi/g	1.24	2.48	-	174	171	0.49	1.7	0.93	0.26	Normal	24	0	0	GB-037	8-10
Lead 212	pCi/g	2	4	-	174	174	0.88	2.6	1.6	0.34	Normal	17	0	0	GB-037	8-10
Lead 214	pCi/g	1.46	2.92	-	174	174	0.60	2.1	1.2	0.24	Normal	17	0	0	GB-080	8-10
Plutonium (alpha)	pCi/g	-	-	-	1	-	-	-	-	-	-	0	0	0	-	
Potassium 40	pCi/g	20.8	41.6	-	174	174	5.2	30	17	6.0	Normal	55	0	0	GB-019	4-6
Thorium 234	pCi/g	2.77	5.54	-	174	55	0.89	19	1.3	1.7	Non-Normal	10	3	0	GB-043	4-6

Criteria (1)- Background concentrations for subsurface soil.

Criteria (2)- Two times background concentrations for subsurface soil.

Criteria (3)- Preliminary Remediation Goal plus Background for Subsurface soil.

(oval) Concentration Exceeds Criteria 1

(box) Concentration Exceeds Criteria (2)

Border Concentration Exceeds Criteria (3)

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: SUBSOIL_RN_4-10
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit3NE
2/16/2005
WHERE ([MATRIX] = 'SO' AND [PRCCODE] LIKE 'RN*') AND VAL([SBD]) >= 4 AND (VAL([SED]) <= 10 AND VAL([SED]) > 4) AND ([SAMPNO] <> '3'AND [SAMPNO] <> '4') AND ([SITEID] <> '2' AND [SITEID] <> '3');

TABLE 4-7
STATISTICAL SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
GREATER THAN 4 FEET AND LESS THAN AND EQUAL TO 10 FEET BELOW GROUND SURFACE
SLDA

Parameter	Units	Criteria (1)	Criteria (2)	Criteria (3)	No. of Samples	No. of Detections	Range of Detections				Dist	No. of Exceed.			Max Value	
							Min	Max	Avg	StdDev		Crit. (1)	Crit. (2)	Crit. (3)	Location	Depth
Radionuclides Ratios																
U234 / U238 Ratio	pCi/g	-	-	-	180	180	0.32	54	2.4	5.8	Normal	0	0	0	GB-023	4-6
U235 (alpha) Ratio / U238 Ratio	pCi/g	-	-	-	180	57	5.034	4.3	0.44	0.61	Normal	0	0	0	GB-023	4-6

Criteria (1)- Background concentrations for subsurface soil.

Criteria (2)- Two times background concentrations for subsurface soil.

Criteria (3)- Preliminary Remediation Goal plus Background for Subsurface soil.

Concentration Exceeds Criteria 1

Concentration Exceeds Criteria (2)

Border Concentration Exceeds Criteria (3)

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: SUBSOIL_RN_4-10
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit3NE
2/16/2005
WHERE ([MATRIX] = 'SO' AND [PRCCODE] LIKE 'RN*') AND VAL([SBD]) >= 4 AND (VAL([SED]) <= 10 AND VAL([SED]) > 4) AND ([SAMPNO] <> '3'AND [SAMPNO] <> '4') AND ([SITEID] <> '2' AND [SITEID] <> '3');

TABLE 4-8
STATISTICAL SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
GREATER THAN 10 FEET BELOW GROUND SURFACE
SLDA

Parameter	Units	Criteria (1)	Criteria (2)	Criteria (3)	No. of Samples	No. of Detections	Range of Detections				Dist	No. of Exceed.			Max Value	
							Min	Max	Avg	StdDev		Crit. (1)	Crit. (2)	Crit. (3)	Location	Depth
Primary Radionuclides																
Americium 241	pCi/g	0	0	27.7	61	3	0.24	13	0.33	1.6	Non-Normal	3	3	0	GB-101	12-14
Plutonium 239	pCi/g	0	0	32.6	40	2	0.801	3.0	0.14	0.48	Non-Normal	2	2	0	GB-101	12-14
Plutonium 241	pCi/g	0	0	892	38	1	27	27	6.2	3.6	Non-Normal	1	1	0	GB-052	10-12
Radium 228	pCi/g	1.66	3.32	3.35	45	45	0.37	2.1	1.3	0.45	Normal	9	0	0	GB-093	12-14
Thorium 232	pCi/g	1.77	3.54	3.12	60	59	0.28	2.8	1.5	0.64	Normal	16	0	0	MW-37	10-12
Uranium 234	pCi/g	1.28	2.56	97.68	48	48	0.37	90	6.7	21	Non-Normal	15	6	0	01U23	10-12
Uranium 235 (alpha)	pCi/g	0.269	0.538	34.87	48	14	0.13	3.5	0.36	0.87	Non-Normal	8	4	0	01U23	10-12
Uranium 235 (gamma)	pCi/g	0.208	0.416	34.81	45	1	0.29	0.29	0.1	0.04	Non-Normal	1	0	0	GB-011	12-14
Uranium 238	pCi/g	1.41	2.82	124.41	48	48	0.23	11	1.4	1.7	Non-Normal	13	4	0	03U06	10-12
Isotopic Uranium (total)	pCi/g	2.96	5.92	-	48	48	0.709	100	8.4	24	Non-Normal	15	5	0	03U06	10-12
Uranium (total)	pCi/g	2.96	5.92	-	130	130	2.4	120	13	18	Non-Normal	124	73	0	04U03	12-12
Secondary Radionuclides																
Cesium 137	pCi/g	0	0	-	56	2	0.03	0.13	0.021	0.016	Non-Normal	2	2	0	MW-43	10-12

Criteria (1)- Background concentrations for subsurface soil.

Criteria (2)- Two times background concentrations for subsurface soil.

Criteria (3)- Preliminary Remediation Goal plus Background for Subsurface soil.

(oval) Concentration Exceeds Criteria 1

(box) Concentration Exceeds Criteria (2)

Border Concentration Exceeds Criteria (3)

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: SUBSOIL_RN_10+
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit3NE
2/16/2005
WHERE ([MATRIX] = 'SO' AND [PRCCODE] LIKE 'RN*') AND VAL([SBD]) >=10 AND VAL([SeD]) >10 AND ([SAMPNO] <> '3'AND [SAMPNO] <> '4') AND ([SITEID] <> '2' AND [SITEID] <> '3') AND [PARVQ] <> 'R';

TABLE 4-8
STATISTICAL SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
GREATER THAN 10 FEET BELOW GROUND SURFACE
SLDA

Parameter	Units	Criteria (1)	Criteria (2)	Criteria (3)	No. of Samples	No. of Detections	Range of Detections				Dist	No. of Exceed.			Max Value	
							Min	Max	Avg	StdDev		Crit. (1)	Crit. (2)	Crit. (3)	Location	Depth
Secondary Radionuclides																
Cobalt 60	pCi/g	0	0	-	60	-	-	-	-	-	-	0	0	0	-	
Plutonium 238	pCi/g	0	0	-	4	-	-	-	-	-	-	0	0	0	-	
Plutonium 242	pCi/g	0	0	-	4	1	0.15	0.15	0.085	0.05	Normal	1	1	0	GB-050	12-14
Radium 226	pCi/g	1.32	2.64	-	60	60	0.30	2.3	1.0	0.35	Normal	7	0	0	GB-092	12-14
Thorium 230	pCi/g	1.155	2.31	-	5	5	0.52	1.4	1.0	0.32	Non-Normal	2	0	0	GB-050	12-14
Other Radionuclides																
Beryllium 7	pCi/g	0	0	-	44	-	-	-	-	-	-	0	0	0	-	
Bismuth 212	pCi/g	1.24	2.48	-	45	43	0.27	1.5	0.9	0.35	Normal	6	0	0	GB-050	12-14
Lead 212	pCi/g	2	4	-	45	45	0.406	2.2	1.5	0.49	Normal	5	0	0	GB-093	12-14
Lead 214	pCi/g	1.46	2.92	-	45	45	0.35	2.7	1.2	0.46	Normal	7	0	0	GB-092	12-14
Potassium 40	pCi/g	20.8	41.6	-	45	45	3.6	28	17	7.6	Normal	19	0	0	GB-094	12-14
Thorium 234	pCi/g	2.77	5.54	-	45	15	0.66	4.1	1.1	0.86	Non-Normal	3	0	0	GB-092	12-14
Radionuclides Ratios																

Criteria (1)- Background concentrations for subsurface soil.

Criteria (2)- Two times background concentrations for subsurface soil.

Criteria (3)- Preliminary Remediation Goal plus Background for Subsurface soil.

(Ellipse) Concentration Exceeds Criteria 1

(Box) Concentration Exceeds Criteria (2)

Border Concentration Exceeds Criteria (3)

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: SUBSOIL_RN_10+
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit3NE
2/16/2005
WHERE ([MATRIX] = 'SO' AND [PRCCODE] LIKE 'RN*') AND VAL([SBD]) >=10 AND VAL([SeD]) >10 AND ([SAMPNO] <> '3'AND [SAMPNO] <> '4') AND ([SITEID] <> '2' AND [SITEID] <> '3') AND [PARVQ] <> 'R';

TABLE 4-8
STATISTICAL SUMMARY OF SUBSURFACE SOIL ANALYTICAL RESULTS
GREATER THAN 10 FEET BELOW GROUND SURFACE
SLDA

Parameter	Units	Criteria (1)	Criteria (2)	Criteria (3)	No. of Samples	No. of Detections	Range of Detections				Dist	No. of Exceed.			Max Value	
							Min	Max	Avg	StdDev		Crit. (1)	Crit. (2)	Crit. (3)	Location	Depth
Radionuclides Ratios																
U234 / U238 Ratio	pCi/g	-	-	-	48	48	0.78	17	2.0	3.4	Normal	0	0	0	08U11	10-12
U235 (alpha) Ratio / U238 Ratio	pCi/g	-	-	-	48	15	6.3	0.66	0.25	0.18	Normal	0	0	0	01U23	10-12

Criteria (1)- Background concentrations for subsurface soil.

Criteria (2)- Two times background concentrations for subsurface soil.

Criteria (3)- Preliminary Remediation Goal plus Background for Subsurface soil.

Concentration Exceeds Criteria 1

Concentration Exceeds Criteria (2)

Border Concentration Exceeds Criteria (3)

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: SUBSOIL_RN_10+
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit3NE
2/16/2005
WHERE ([MATRIX] = 'SO' AND [PRCCODE] LIKE 'RN*') AND VAL([SBD]) >=10 AND VAL([SeD]) >10 AND ([SAMPNO] <> '3'AND [SAMPNO] <> '4') AND ([SITEID] <> '2' AND [SITEID] <> '3') AND [PARVQ] <> 'R';

TABLE 4-9
SHALLOW LAND DISPOSAL AREA
ESTIMATED TRENCH VOLUME

TRENCH NUMBER	NUMBER OF BORINGS[1]	AVERAGE DEPTH TO BEDROCK (feet below ground surface)	TRENCH SURFACE AREA[2] (square feet)	ESTIMATED TRENCH VOLUME (cubic feet)
1	32	12.3	10,471.5	128,799.5
2	31	14.2	7,802.4	110,794.1
3	8	10.7	794.1	8,496.9
4	10	14.9	1,961.5	29,226.4
5	12	14.4	3,496.6	50,351.0
6	5	15.6	5,431.8	84,736.1
7	12	14.7	4,444.1	65,328.3
8	13	15.3	1,296.2	19,831.9
9	8	13.8	2,693.5	37,170.3
10	29	21.3	12,240.2	260,716.3
TOTAL	160	--	50,631.9	795,450.6
TOTAL CUBIC YARDS	--	--	--	29,461.1

Notes:
[1] The number of borings refers to the borings advanced during the Site Characterization perimeter boring program.
[2] The trench surface area data are from SCR Table 5-10.

TABLE 4-10
RATIONALE FOR INCLUDING CERTAIN SUBSURFACE SOIL BORINGS IN TRENCH CHARACTERIZATION

BORING ID	DATE	SITE LOCATION	DISCUSSION	CONCLUSION
01U06	1993	Southeast side of Trench #1	Boring log describes misc. waste encountered between 6 ft and 10 ft. Elevated SAGA readings (14,000 to 16,000 cpm) compared to background levels (4,000 cpm).	Boring advanced within trench limits, samples collected from 8-10 and 10-11.42 feet below ground surface are considered representative of trench contents.
01U09	1993	Northeast side of Trench #1	Boring log describes encountering an obstruction at 5.9 ft including aluminum piping.	Boring advanced within trench limits, samples collected from 4-6, 6-8, and 8-10 feet below ground surface are considered representative of trench contents.
01U13	1993	Northeast corner of Trench #1	Boring log describes encountering paper debris between 8 ft and 12 ft. Elevated SAGA readings of 15,000 cpm.	Boring advanced within trench limits, samples collected from 6-8, 8-10, and 10-12 feet below ground surface are considered representative of trench contents.
01U15	1993	Northeast side of Trench #1	Boring log describes encountering "grease-like" material and misc. fill between 4 ft and 8 ft. Elevated SAGA readings of 18,000 cpm. Boring located within trench boundary as determined by various geophysical surveys.	Boring advanced within trench limits, samples collected from 2-4 and 4-6 feet below ground surface are considered representative of trench contents.
02U02	1993	Southeast side of Trench #2	Boring log describes encountering plastic debris between 2.5 ft and 7.5 ft. Elevated SAGA readings of 9,000 cpm. Boring located within trench boundary as determined by various geophysical surveys.	Boring advanced within trench limits, samples collected from 4-6 and 6-8 feet below ground surface are considered representative of trench contents.
02U04	1993	Northeast corner of Trench #2	Boring log describes encountering white plastic fragments between 4 ft and 6 ft. Elevated SAGA readings of 8,000 cpm. Boring located within trench boundary as determined by various geophysical surveys.	Boring advanced within trench limits, sample collected from 2-4 feet below ground surface is considered representative of trench contents.
02U12	1993	North-central side of Trench #2	Boring log describes encountering glass, plastic and metal debris at approximately 7 ft. Elevated SAGA readings of 8,000 cpm.	Boring advanced within trench limits, samples collected from 6-8, 8-10, and 10-12 feet below ground surface are considered representative of trench contents.
02U13	1993	North-central side of Trench #2	Boring log describes encountering cardboard, metal debris at approximately 8 ft. Elevated SAGA readings of 7,000 cpm.	Boring advanced within trench limits, samples collected from 4-6, 6-8, 8-10, and 10-12 feet below ground surface are considered representative of trench contents.

TABLE 4-10
RATIONALE FOR INCLUDING CERTAIN SUBSURFACE SOIL BORINGS IN TRENCH CHARACTERIZATION

BORING ID	DATE	SITE LOCATION	DISCUSSION	CONCLUSION
03U03	1993	North side of Trench #3	Boring log describes encountering wood debris at approximately 8 ft. Elevated SAGA readings of 8,000 cpm, and elevated HNu readings of 15 ppm.	Not included since no evidence of waste material was detected in boring.
03U04	1993	North side of Trench #3	Boring log describes encountering wood debris at approximately 8 ft. Elevated SAGA readings of 8,000 cpm, and elevated HNu readings of 15 ppm.	Boring advanced within trench limits, sample collected from 8-10 feet below ground surface is considered representative of trench contents.
03U06	1993	Center of Trench #3	Boring located within trench boundary as determined by various geophysical surveys.	Not included since no evidence of waste material was detected in boring.
05U04	1993	Southeast corner of Trench #5	Boring log describes encountering white "grease-like" material and misc. fill at approximately 6 ft. Elevated SAGA readings of 2,000,000 cpm. Boring located within trench boundary as determined by various geophysical surveys.	Boring advanced within trench limits, however samples were not collected where waste was encountered or elevated field screening measurements were noted. Therefore, samples collected from 2-4 and 4-6 feet were not considered representative of trench contents.
05U05	1993	Southeast corner of Trench #5	Boring log describes encountering misc. "trench" material and misc. fill at approximately 5 ft. Elevated SAGA readings of 2,000,000 cpm. Boring located within trench boundary as determined by various geophysical surveys.	Boring advanced within trench limits, sample collected from 4-6 feet below ground surface is considered representative of trench contents.
06U01	1993	Southeast corner of Trench #6	Boring log describes encountering a void between 4 ft and 5.4 ft. No sample recovered between 4 ft and 10 ft. Misc. debris also encountered between 4 ft and 12 ft. Boring located within trench boundary as determined by various geophysical surveys.	Boring advanced within trench limits, sample collected from 10-12 feet below ground surface is considered representative of trench contents.
06U04	1993	Southeast corner of Trench #6	Boring log describes encountering plastic piping at approximately 6.2 ft. Boring located within trench boundary as determined by various geophysical surveys.	Not included since debris was encountered at a shallow depth (not greater than 4 feet) and no elevated readings obtained.
07U05	1993	Northern area between Trenches #6 and #7	Boring log describes encountering misc. debris between approximately 4 ft and 12 ft. Elevated SAGA readings of 8,000 cpm.	Boring advanced within trench limits, samples collected from 4-6, 6-8, and 10-12 feet below ground surface are considered representative of trench contents.

TABLE 4-10
RATIONALE FOR INCLUDING CERTAIN SUBSURFACE SOIL BORINGS IN TRENCH CHARACTERIZATION

BORING ID	DATE	SITE LOCATION	DISCUSSION	CONCLUSION
07U06	1993	Northern area between Trenches #6 and #7	Boring log describes encountering misc. debris between approximately 2 ft and 4 ft. No samples were recovered between 4 ft and 8 ft.	Not included since debris was encountered at a shallow depth and no elevated readings obtained.
07U07	1993	Northeastern side of Trench #7	Boring log describes encountering metal debris between approximately 4 and 6 ft. Elevated SAGA readings of 7,000 cpm. Drilling halted at 10 ft due to elevated LEL readings.	Not included since debris was encountered at a shallow depth and no elevated readings obtained
08U06	1993	Center of Trench #8	Boring log described water entering the borehole at approximately 18 ft and rose to within 2 ft of the ground surface. Elevated LEL readings recorded at the top of the augers at the 18 ft depth. Drilling was halted. Wood fragments also noted in the drill	Not included since no evidence of waste material or elevated readings detected in boring.
B18	1981	Center of Trench #1	Boring located within trench boundary as determined by various geophysical surveys. No boring logs available to review from the 1981 investigation.	Not included since no logs are available.
B26	1981	Within southeastern portion of Trench #7	Boring located within trench boundary as determined by various geophysical surveys. No boring logs available to review from the 1981 investigation.	Not included since no logs are available.
10L04	1993	Northwest side of Trench #10 in extended area of the trench	Boring log describes encountering plastic/fiberglass fragments and concrete debris between approximately 2 ft. and 3 ft. Boring located within trench boundary as determined by various geophysical surveys	Not included since debris was encountered at shallow depth (not greater than 4 feet) and no elevated readings obtained.
10L05	1993	Northwest side of Trench #10 in extended area of the trench	Boring located within trench boundary as determined by various geophysical surveys	Not included since no evidence of waste material or elevated readings detected in boring.
10L07	1993	Northwest side of Trench #10 in extended area of the trench	Boring located within trench boundary as determined by various geophysical surveys	Not included since no evidence of waste material or elevated readings detected in boring.
10L13	1993	Northwestern corner of Trench #10	Boring log describes encountering plastic debris between approximately 14 ft. and 16 ft.	Boring advanced within trench limits, sample collected from 8-10 feet below ground surface is considered representative of trench contents.
10L16	1993	Northwest side of Trench #10 in extended area of the trench	Boring log describes encountering plastic "wrap" debris at approximately 2 ft. Boring located within trench boundary as determined by various geophysical surveys	Not included since debris was encountered at shallow depth and no elevated readings obtained.

TABLE 4-10
RATIONALE FOR INCLUDING CERTAIN SUBSURFACE SOIL BORINGS IN TRENCH CHARACTERIZATION

BORING ID	DATE	SITE LOCATION	DISCUSSION	CONCLUSION
10L17	1993	Northwest side of Trench #10 in extended area of the trench	Boring log describes encountering concrete debris at approximately 2 ft. Boring located within trench boundary as determined by various geophysical surveys	Not included since debris was encountered at a shallow depth and no elevated readings obtained.
10L18	1993	Northwest side of Trench #10 in extended area of the trench	Boring log describes encountering metal debris between approximately 4 to 6 ft., 16 to 18 ft. and 22 to 24 ft. Boring located within trench boundary as determined by various geophysical surveys	Not included since debris was encountered at a shallow depth and no elevated readings obtained.
10L25	1993	Northwest side of Trench #10 in extended area of the trench	Boring located within trench boundary as determined by various geophysical surveys	Not included since no debris was encountered and no elevated readings obtained.
10L26	1993	Northwest side of Trench #10 in extended area of the trench	Boring log describes encountering plastic, concrete, and metal debris between approximately 4 and 6 ft. Boring located within trench boundary as determined by various geophysical surveys	Not included since debris was encountered at a shallow depth (not greater than 4 feet) and no elevated readings obtained.
10L27	1993	Northwest side of Trench #10 in extended area of the trench	Boring located within trench boundary as determined by various geophysical surveys	Not included since no debris was encountered and no elevated readings were obtained.
10L28	1993	Northwest side of Trench #10 in extended area of the trench	Boring log indicated that elevated SAGA reading of 9,000 cpm was detected from 3 to 3.5 ft. Boring located within trench boundary as determined by various geophysical surveys	Not included since no debris was encountered and elevated readings were obtained at shallow depth.
10L29	1993	Northwest side of Trench #10 in extended area of the trench	Boring located within trench boundary as determined by various geophysical surveys	Not included since no debris was encountered and no elevated readings obtained.
B06	1981	Within southwestern portion of Trench #10	Boring located within trench boundary as determined by various geophysical surveys. No boring logs available to review from this 1981 investigation.	Not included at this time, but requires additional evaluation

TABLE 4-11
Boring Location, Sample Interval and Sample Designation Corresponding To Samples Collected from Borings Advanced Into the Waste

Boring Location	Sample Interval (feet below ground)	Waste or Soil
01U06	8-10	Waste
	10-11.42	Trench Soil
01U09	4-6	Waste
	6-8	Trench Soil
	8-10	Unknown
01U13	6-8	Trench Soil
	8-10	Waste
	10-12	Trench Soil
01U15	2-4	Waste
	4-6	Waste
02U02	4-6	Waste
	6-8	Waste
02U04	2-4	Trench Soil
02U12	6-8	Waste
	8-10	Waste
	10-12	Trench Soil
02U13	4-6	Waste
	6-8	Waste
	8-10	Trench Soil
	10-12	Trench Soil
03U04	8-10	Waste
05U05	4-6	Waste
06U01	10-12	Waste
07U05	4-6	Waste
	6-8	Waste
	10-12	Waste
10L13	8-10	Trench Soil

Notes:
1. Data taken from the Site Characterization Report prepared by ARCO (ARCO/B&W, 1995).
2. Boring locations are illustrated in Figures 4-3 and 4-4.

TABLE 4-12

Boring Identification and Sample Depths of Waste or Contaminated Soils Encountered in the Disposal Trenches During Previous Investigations and the RI		
Investigation	**Boring Identification**	**Sample Depth (Feet)**
Site Characterization Conducted by ARCO/B&W	01U06	8 - 10
Site Characterization Conducted by ARCO/B&W	01U06	10 - 11.42
Site Characterization Conducted by ARCO/B&W	01U09	4 - 6
Site Characterization Conducted by ARCO/B&W	01U09	6 - 8
Site Characterization Conducted by ARCO/B&W	01U09	8 - 10
Site Characterization Conducted by ARCO/B&W	01U13	6 - 8
Site Characterization Conducted by ARCO/B&W	01U13	8 - 10
Site Characterization Conducted by ARCO/B&W	01U13	10 - 12
Site Characterization Conducted by ARCO/B&W	01U15	2 - 4
Site Characterization Conducted by ARCO/B&W	01U15	4 - 6
Site Characterization Conducted by ARCO/B&W	02U02	4 - 6
Site Characterization Conducted by ARCO/B&W	02U02	6 - 8
Site Characterization Conducted by ARCO/B&W	02U04	2 - 4
Site Characterization Conducted by ARCO/B&W	02U12	6 - 8
Site Characterization Conducted by ARCO/B&W	02U12	8 - 10
Site Characterization Conducted by ARCO/B&W	02U12	10 - 12
Site Characterization Conducted by ARCO/B&W	02U13	4 - 6
Site Characterization Conducted by ARCO/B&W	02U13	6 - 8
Site Characterization Conducted by ARCO/B&W	02U13	8 - 10
Site Characterization Conducted by ARCO/B&W	02U13	10 - 12
Site Characterization Conducted by ARCO/B&W	03U04	8 - 10
Site Characterization Conducted by ARCO/B&W	05U05	4 - 6
Site Characterization Conducted by ARCO/B&W	06U01	10 - 12
Site Characterization Conducted by ARCO/B&W	07U05	4 - 6
Site Characterization Conducted by ARCO/B&W	07U05	6 - 8
Site Characterization Conducted by ARCO/B&W	07U05	10 - 12
Site Characterization Conducted by ARCO/B&W	10L13	8 - 10
Remedial Investigation Conducted by USACE	TR-02-021	11 - 12.5
Remedial Investigation Conducted by USACE	TR-02-023	8 - 12
Remedial Investigation Conducted by USACE	TR-02-024	8 - 10
Remedial Investigation Conducted by USACE	TR-02-025	4 - 6
Remedial Investigation Conducted by USACE	TR-04-039	8 - 9.3
Remedial Investigation Conducted by USACE	TR-04-040	11 - 13
Remedial Investigation Conducted by USACE	TR-06-037	15 - 16
Remedial Investigation Conducted by USACE	TR-06-038	16 - 17.6
Remedial Investigation Conducted by USACE	TR-07-031	3.5 - 5.5
Remedial Investigation Conducted by USACE	TR-07-033	8 - 15.8
Remedial Investigation Conducted by USACE	TR-09-026	8 - 10
Remedial Investigation Conducted by USACE	TR-09-027	8 - 9.5
Remedial Investigation Conducted by USACE	TR-09-028	5.5 - 7.8

TABLE 4-13

Summary Of Field Screening Conducted on Waste Samples Analyzed for Radionuclides				
Boring Location	**Depth (Feet)**	**Sample FIDLER Meter Reading (cts/min)**	**Background FIDLER Meter Reading (cts/min)**	**Observations in Soil Boring**
TR02-25	4 to 6	13,595	14,628	Waste-like materials: wood, nails, cinders, rubber tubing, thin mil plastic.
TR02-24	8 to 10	26,204	14,628	Brown paper and wood.
TR02-23	8 to 12	41,983	14,628	Glass, white damp filter type material, very fibrous insulation.
TR02-21	11 to 12.5	17,790	14,814	Wood and thick mil plastic.
TR04-40	11 to 13	13,358	10,414	Wood, plastic, paint chips, thin black fibers.
TR04-39	8 to 9.3	11,579	10,414	Soil type is different from upper soils, but similar to TR04-40 at depths of 11 to 13 feet.
TR-06-38	17 to 17.6	12,563	11,293	Black felt-like fibers.
TR-06-37	15 to 16	23,247	11,293	Filter paper.
TR07-33	8 to 15.8	20,577	14,568	Waste particle board.
TR07-31	3.5 to 5.5	19,729	11,504	Black fibrous material.
TR09-28	5.5 to 7.8	13,064	12,254	Black fibers.
TR09-27	8 to 9.5	15,418	14,628	Filter paper, latex rubber and wood pieces.
TR09-26	8 to 10	14,376	14,628	Wood fragments.

TABLE 4-14
STATISTICAL SUMMARY OF RADIOLOGICAL CONSTITUENTS DETECTED IN WASTE
SLDA

Parameter	Units	Criteria (1)	Criteria (2)	Criteria (3)	No. of Samples	No. of Detections	Range of Detections				Dist	No. of Exceed.			Max Value	
							Min	Max	Avg	StdDev		Crit. (1)	Crit. (2)	Crit. (3)	Location	Depth
Primary Radionuclides																
Americium 241	pCi/g	0	0	27.7	13	-	-	-	-	-	-	0	0	0	-	
Plutonium 239	pCi/g	0	0	32.6	12	-	-	-	-	-	-	0	0	0	-	
Plutonium 241	pCi/g	0	0	892	13	-	-	-	-	-	-	0	0	0	-	
Radium 228	pCi/g	1.66	3.32	3.35	13	13	0.97	4.3	1.6	0.84	Non-Normal	4	1	1	TR-02-023	8-12
Thorium 232	pCi/g	1.77	3.54	3.12	13	12	0.67	2.6	1.5	0.6	Normal	3	0	0	TR-02-023	8-12
Uranium 234	pCi/g	1.28	2.56	97.68	23	23	12	2200	500	580	Non-Normal	23	23	16	TR-04-040	11-13
Uranium 235 (alpha)	pCi/g	0.269	0.538	34.87	22	22	1.2	220	34	51	Non-Normal	22	22	5	TR-04-040	11-13
Uranium 235 (gamma)	pCi/g	0.208	0.416	34.81	13	13	0.70	72	24	26	Normal	13	13	3	TR-04-040	11-13
Uranium 238	pCi/g	1.41	2.82	124.41	23	23	1.5	580	63	150	Non-Normal	23	19	2	TR-07-033	8-15.8
Isotopic Uranium (total)	pCi/g	2.96	5.92	-	23	23	15	2500	600	680	Non-Normal	23	23	0	TR-04-040	11-13
Uranium (total)	pCi/g	2.96	5.92	-	26	26	9.8	1100	160	280	Non-Normal	26	26	0	01U06	8-10
Secondary Radionuclides																
Cesium 137	pCi/g	0	0	-	12	8	0.14	0.66	0.21	0.2	Non-Normal	8	8	0	TR-06-037	15-16

Criteria (1)- Background concentrations for subsurface soil.

Criteria (2)- Two times background concentrations for subsurface soil.

Criteria (3)- Preliminary Remediation Goal plus Background for Subsurface soil.

(oval) Concentration Exceeds Criteria 1

(box) Concentration Exceeds Criteria (2)

Border Concentration Exceeds Criteria (3)

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: ST_RN
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit3NE
2/17/2005
WHERE [MATRIX] LIKE 'ST' AND [PRCCODE] LIKE '*RN*';

TABLE 4-14
STATISTICAL SUMMARY OF RADIOLOGICAL CONSTITUENTS DETECTED IN WASTE
SLDA

Parameter	Units	Criteria (1)	Criteria (2)	Criteria (3)	No. of Samples	No. of Detections	Range of Detections				Dist	No. of Exceed.			Max Value	
							Min	Max	Avg	StdDev		Crit. (1)	Crit. (2)	Crit. (3)	Location	Depth
Secondary Radionuclides																
Cobalt 60	pCi/g	0	0	-	13	-	-	-	-	-	-	0	0	0	-	
Plutonium 238	pCi/g	0	0	-	3	-	-	-	-	-	-	0	0	0	-	
Plutonium 242	pCi/g	0	0	-	2	-	-	-	-	-	-	0	0	0	-	
Radium 226	pCi/g	1.32	2.64	-	13	13	0.84	1.6	1.2	0.22	Normal	3	0	0	TR-06-037	15-16
Thorium 230	pCi/g	1.155	2.31	-	3	3	1.3	2.2	1.6	0.53	Non-Normal	3	0	0	TR-09-026	8-10
Other Radionuclides																
Beryllium 7	pCi/g	0	0	-	13	-	-	-	-	-	-	0	0	0	-	
Bismuth 212	pCi/g	1.24	2.48	-	13	12	0.60	2.9	1.1	0.59	Non-Normal	3	1	0	TR-02-023	8-12
Lead 212	pCi/g	2	4	-	13	13	1.1	5.1	1.9	0.99	Non-Normal	1	1	0	TR-02-023	8-12
Lead 214	pCi/g	1.46	2.92	-	13	13	1.0	1.7	1.4	0.21	Normal	4	0	0	TR-06-037	15-16
Potassium 40	pCi/g	20.8	41.6	-	13	13	8.8	25	17	3.7	Normal	1	0	0	TR-02-023	8-12
Thorium 234	pCi/g	2.77	5.54	-	13	11	2.9	460	50	120	Non-Normal	11	10	0	TR-07-033	8-15.8
Radionuclides Ratios																

Criteria (1)- Background concentrations for subsurface soil.

Criteria (2)- Two times background concentrations for subsurface soil.

Criteria (3)- Preliminary Remediation Goal plus Background for Subsurface soil.

(oval) Concentration Exceeds Criteria 1

(rectangle) Concentration Exceeds Criteria (2)

Border Concentration Exceeds Criteria (3)

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: ST_RN
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit3NE
2/17/2005
WHERE [MATRIX] LIKE 'ST' AND [PRCCODE] LIKE '*RN*';

TABLE 4-14
STATISTICAL SUMMARY OF RADIOLOGICAL CONSTITUENTS DETECTED IN WASTE
SLDA

Parameter	Units	Criteria (1)	Criteria (2)	Criteria (3)	No. of Samples	No. of Detections	Range of Detections				Dist	No. of Exceed.			Max Value	
							Min	Max	Avg	StdDev		Crit. (1)	Crit. (2)	Crit. (3)	Location	Depth
Radionuclides Ratios																
U234 / U238 Ratio	pCi/g	-	-	-	23	23	0.33	180	32	39	Normal	0	0	0	02U13	11-13
U235 (alpha) Ratio / U238 Ratio	pCi/g	-	-	-	23	22	5.5	5.2	1.4	1.2	Normal	0	0	0	02U13	11-13

Criteria (1)- Background concentrations for subsurface soil.

Criteria (2)- Two times background concentrations for subsurface soil.

Criteria (3)- Preliminary Remediation Goal plus Background for Subsurface soil.

Concentration Exceeds Criteria 1

Concentration Exceeds Criteria (2)

Border Concentration Exceeds Criteria (3)

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: ST_RN
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit3NE
2/17/2005
WHERE [MATRIX] LIKE 'ST' AND [PRCCODE] LIKE '*RN*';

TABLE 4-15
STATISTICAL SUMMARY OF TRENCH SAMPLE CHEMICAL ANALYTICAL DATA
SLDA

Parameter	Units	No. of Samples	No. of Detections	Range of Detections			Location of Max Value	Depth Of Max
				Min	Max	Avg		
TCLP Volatile Organic Compounds								
Trichloroethene	MG/L	10	1	0.0098	0.0098	0.0026	TR-08-030	16-16.7
TCLP Semivolatile Organic Compounds								
Pentachlorophenol	MG/L	10	1	0.048	0.048	0.016	TR-06-037	11.8-16
TCLP Metals								
Barium	MG/L	10	10	0.24	2.8	1.2	TR-10-002	4-6
Cadmium	MG/L	10	2	0.004	0.006	0.0025	TR-10-002	4-6
Chromium	MG/L	10	4	0.004	0.0098	0.0052	TR-10-002	4-6
Lead	MG/L	10	5	0.03	0.05	0.027	TR-09-027	8-9.5
Mercury	MG/L	10	1	0.001	0.001	0.00031	TR-07-033	8-12
Silver	MG/L	10	2	0.006	0.008	0.0061	TR-10-002	4-6
RCRA Characteristics								
Corrosivity	S.U.	10	10	6.1	7.6	6.7	TR-10-007R	8-10
Flash Point	DEG F	10	10	0.00E+00	0.00E+00	200	TR-10-007R	8-10
Reactive Releasable Cyanide	UG/KG	10	1	9.0	9.0	3.9	TR-09-027	8-9.5
Reactive Releasable Sulfide	MG/KG	10	8	27	160	68	TR-05-041	6-8

Only Detected Results Reported.

Minimum and maximum values are reported for detection data o

Average values were calculated using one-half the detection limit for non-detected data.

TABLE 4-16
STATISTICAL SUMMARY OF LEACHATE ANALYTICAL RESULTS (DECEMBER 2003)
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241 (alpha)	pCi/L	44	-	-	-	-	-	-
Americium 241 (gamma)	pCi/L	6	-	-	-	-	-	-
Plutonium 239	pCi/L	44	1	1.2	1.2	0.23	0.2	TWSP 05-03
Plutonium 241	pCi/L	33	-	-	-	-	-	-
Radium 228 (beta)	pCi/L	44	23	1.2	16	2.5	2.9	TWSP 05-04
Radium 228 (gamma)	pCi/L	6	-	-	-	-	-	-
Thorium 232	pCi/L	44	12	0.59	9.8	0.8	1.6	TWSP 03-02
Uranium 234	pCi/L	44	44	1.2	24000	1600	4700	TWSP 01-06
Uranium 235 (alpha)	pCi/L	44	35	0.29	2500	160	480	TWSP 02-01
Uranium 235 (gamma)	pCi/L	6	2	76	750	140	300	TWSP 02-01
Uranium 238	pCi/L	44	38	1.2	2300	110	370	TWSP 01-06
Secondary Radionuclides								
Cesium 137	pCi/L	6	-	-	-	-	-	-
Cobalt 60	pCi/L	6	-	-	-	-	-	-
Gross Alpha	pCi/L	6	6	40	31000	5900	12000	TWSP 02-01
Gross Beta	pCi/L	6	6	43	1700	430	640	TWSP 02-01
Plutonium 238	pCi/L	6	-	-	-	-	-	-
Plutonium 242	pCi/L	5	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-16
STATISTICAL SUMMARY OF LEACHATE ANALYTICAL RESULTS (DECEMBER 2003)
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections				Location of Max Value
				Min	Max	Avg	StdDev	
Secondary Radionuclides								
Radium 226 (alpha)	pCi/L	6	5	1.1	3.1	1.4	0.93	TWSP 02-01
Radium 226 (gamma)	pCi/L	6	1	13	13	4.6	4.3	TWSP 02-01
Thorium 230	pCi/L	6	5	1.3	9.1	3.1	3.2	TWSP 02-01
Other Radionuclides								
Beryllium 7	pCi/L	6	-	-	-	-	-	-
Bismuth 212	pCi/L	6	-	-	-	-	-	-
Lead 212	pCi/L	6	1	13	13	4.5	4.2	TWSP 02-01
Lead 214	pCi/L	6	1	11	11	4.3	3.4	TWSP 02-01
Potassium 40	pCi/L	6	1	99	99	29	34	TWSP 02-01
Thorium 234	pCi/L	6	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-17
STATISTICAL SUMMARY OF HISTORICAL LEACHATE ANALYTICAL RESULTS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Thorium 232	pCi/L	1	-	-	-	-	-	-
Uranium 234	pCi/L	5	5	400	3500	1800	1300	TWSP 01-07
Uranium 235	pCi/L	5	5	12	110	53	40	TWSP 01-07
Uranium 238	pCi/L	5	4	1.9	140	58	68	TWSP 07-06
Uranium (total)	pCi/L	34	17	400	21000	2100	5300	TWSP 03-02
Secondary Radionuclides								
Gross Alpha	pCi/L	28	28	0.58	7900	930	1900	TWSP 01-06
Gross Beta	pCi/L	28	28	3.1	960	120	250	TWSP 01-06
Thorium 230	pCi/L	1	-	-	-	-	-	-
Other Radionuclides								
Radium	pCi/L	1	1	0.37	0.37	0.37	-	TWSP 01-07
Thorium (total)	pCi/L	1	-	-	-	-	-	-
Thorium 228	pCi/L	1	-	-	-	-	-	-
Filtered Primary Radionuclides								
Americium 241 (0.45u)	pCi/L	28	-	-	-	-	-	-
Uranium 235 (0.45u)	pCi/L	35	13	6.8	770	46	140	TWSP 01-06
Filtered Secondary Radionuclides								
Cesium 137 (0.45u)	pCi/L	5	5	5.0	85	25	34	TWSP 01-06

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-17
STATISTICAL SUMMARY OF HISTORICAL LEACHATE ANALYTICAL RESULTS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections				Location of Max Value
				Min	Max	Avg	StdDev	
Filtered Secondary Radionuclides								
Cobalt 60 (0.45u)	pCi/L	1	1	89	89	89	-	TWSP 04-02
Gross Alpha (0.45u)	pCi/L	40	40	5.6	16000	1200	3000	TWSP 01-06
Gross Beta (0.45u)	pCi/L	40	40	5.3	2000	130	350	TWSP 01-06
Filtered Other Radionuclides								
Total Uranium (0.45u)	pCi/L	35	15	230	18000	1300	3900	TWSP 01-06

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevNoCrit
2/17/2005
WHERE [MATRIX] = 'WL' AND [LOGDATE] < #8/26/2003# AND [PRCCODE] LIKE '*RN*';

TABLE 4-18
STATISTICAL SUMMARY OF RI ON-SITE SURFACE WATER ANALYTICAL RESULTS (DECEMBER 2003 AND JUNE 2004)
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241 (alpha)	pCi/L	20	-	-	-	-	-	-
Americium 241 (gamma)	pCi/L	3	-	-	-	-	-	-
Plutonium 239	pCi/L	19	-	-	-	-	-	-
Plutonium 241	pCi/L	21	-	-	-	-	-	-
Radium 228 (beta)	pCi/L	21	8	1.1	1.9	1.1	0.46	SP-DR-03
Radium 228 (gamma)	pCi/L	3	-	-	-	-	-	-
Thorium 232	pCi/L	21	-	-	-	-	-	-
Uranium 234	pCi/L	21	12	0.43	21	3.1	5.3	SP-DR-01
Uranium 235 (alpha)	pCi/L	21	3	0.38	1.6	0.25	0.32	SP-DR-01
Uranium 235 (gamma)	pCi/L	3	-	-	-	-	-	-
Uranium 238	pCi/L	21	3	0.62	0.86	0.26	0.24	SP-DR-01
Secondary Radionuclides								
Cesium 137	pCi/L	3	-	-	-	-	-	-
Cobalt 60	pCi/L	3	-	-	-	-	-	-
Gross Alpha	pCi/L	3	2	2.9	13	5.5	6.3	SP-DR-01
Gross Beta	pCi/L	3	1	9.8	9.8	4.4	4.6	SP-DR-01
Plutonium 238	pCi/L	3	-	-	-	-	-	-
Plutonium 242	pCi/L	3	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-18
STATISTICAL SUMMARY OF RI ON-SITE SURFACE WATER ANALYTICAL RESULTS (DECEMBER 2003 AND JUNE 2004)
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Secondary Radionuclides								
Radium 226 (alpha)	pCi/L	3	-	-	-	-	-	-
Radium 226 (gamma)	pCi/L	3	2	1.5	22	8.0	12	WS/SE-DR-05
Thorium 230	pCi/L	3	3	0.95	0.99	0.97	0.024	WS/SE-DR-05
Other Radionuclides								
Beryllium 7	pCi/L	3	-	-	-	-	-	-
Bismuth 212	pCi/L	3	-	-	-	-	-	-
Lead 212	pCi/L	3	-	-	-	-	-	-
Lead 214	pCi/L	3	-	-	-	-	-	-
Potassium 40	pCi/L	3	-	-	-	-	-	-
Thorium 234	pCi/L	3	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-19
STATISTICAL SUMMARY OF HISTORICAL ON-SITE SURFACE WATER ANALYTICAL RESULTS
SLDA

Parameter	Units	No. of Samples	No. of Detections	Range of Detections			Location of Max Value	
				Min	Max	Avg		
Primary Radionuclides								
Americium 241	pCi/L	4	-	-	-	-	-	
Plutonium 239	pCi/L	2	1	0.014	0.014	0.027	W02	
Radium 228	pCi/L	5	-	-	-	-	-	
Thorium 232	pCi/L	3	-	-	-	-	-	
Uranium 234	pCi/L	8	6	27	850	350	TRIB 2	
Uranium 235	pCi/L	21	8	1.4	31	8.6	TRIB 2	
Uranium 238	pCi/L	14	9	1.3	2500	420	W03	
Uranium (total)	pCi/L	20	6	49	930	190	TRIB 2	
Secondary Radionuclides								
Cesium 137	pCi/L	15	1	50	50	6.6	W06	
Cobalt 60	pCi/L	8	-	-	-	-	-	
Gross Alpha	pCi/L	235	195	0.024	2700	34	TRIB 2	
Gross Beta	pCi/L	235	228	0.4	1300	16	TRIB 2	
Radium 226	pCi/L	13	9	0.2	30	9.1	TRIB 6	
Thorium 230	pCi/L	2	2	0.68	1.5	1.1	TRIB 6	
Other Radionuclides								
Thorium 228	pCi/L	2	-	-	-	-	-	
Uranium 236	pCi/L	3	3	0.17	4.0	1.7	TRIB 2	

Minimum and maximum values are reported for detection data o

Average values were calculated using one-half the detection limit for non-detected data.

TABLE 4-19
STATISTICAL SUMMARY OF HISTORICAL ON-SITE SURFACE WATER ANALYTICAL RESULTS
SLDA

Parameter	Units	No. of Samples	No. of Detections	Range of Detections			Location of Max Value	
				Min	Max	Avg		
Filtered Secondary Radionuclides								
Gross Alpha (0.45u)	pCi/L	8	7	0.19	5.2	2.0	TRIB 5	
Gross Alpha (1.0u)	pCi/L	1	-	-	-	-	-	
Gross Beta (0.45u)	pCi/L	8	7	2.8	20	6.2	TRIB 0	
Gross Beta (1.0u)	pCi/L	1	-	-	-	-	-	

Minimum and maximum values are reported for detection data o

Average values were calculated using one-half the detection limit for non-detected data.

TABLE 4-20
STATISTICAL SUMMARY OF RI OFF-SITE SURFACE WATER ANALYTICAL RESULTS (DECEMBER 2003 AND JUNE 2004)
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241 (alpha)	pCi/L	15	-	-	-	-	-	-
Americium 241 (gamma)	pCi/L	1	-	-	-	-	-	-
Plutonium 239	pCi/L	15	-	-	-	-	-	-
Plutonium 241	pCi/L	13	-	-	-	-	-	-
Radium 228 (beta)	pCi/L	15	5	1.5	2.6	1.2	0.69	WS/SE-CR-05
Radium 228 (gamma)	pCi/L	1	-	-	-	-	-	-
Thorium 232	pCi/L	15	-	-	-	-	-	-
Uranium 234	pCi/L	15	-	-	-	-	-	-
Uranium 235 (alpha)	pCi/L	15	-	-	-	-	-	-
Uranium 235 (gamma)	pCi/L	1	-	-	-	-	-	-
Uranium 238	pCi/L	15	-	-	-	-	-	-
Secondary Radionuclides								
Cesium 137	pCi/L	1	-	-	-	-	-	-
Cobalt 60	pCi/L	1	-	-	-	-	-	-
Gross Alpha	pCi/L	1	-	-	-	-	-	-
Gross Beta	pCi/L	1	1	7.3	7.3	7.3	-	SP-CR-01
Plutonium 238	pCi/L	1	-	-	-	-	-	-
Plutonium 242	pCi/L	1	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: _TABLE 4-20
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevNoCrit
2/17/2005
WHERE [LOCID] LIKE "*CR*" AND [MATRIX] = 'WS';

TABLE 4-20
STATISTICAL SUMMARY OF RI OFF-SITE SURFACE WATER ANALYTICAL RESULTS (DECEMBER 2003 AND JUNE 2004)
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Secondary Radionuclides								
Radium 226 (alpha)	pCi/L	1	1	0.81	0.81	0.81	-	SP-CR-01
Radium 226 (gamma)	pCi/L	1	-	-	-	-	-	-
Thorium 230	pCi/L	1	-	-	-	-	-	-
Other Radionuclides								
Beryllium 7	pCi/L	1	-	-	-	-	-	-
Bismuth 212	pCi/L	1	-	-	-	-	-	-
Lead 212	pCi/L	1	-	-	-	-	-	-
Lead 214	pCi/L	1	-	-	-	-	-	-
Potassium 40	pCi/L	1	-	-	-	-	-	-
Thorium 234	pCi/L	1	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: _TABLE 4-20
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevNoCrit
2/17/2005
WHERE [LOCID] LIKE "*CR*" AND [MATRIX] = 'WS';

TABLE 4-21
STATISTICAL SUMMARY OF HISTORICAL OFF-SITE SURFACE WATER ANALYTICAL RESULTS
SLDA

Parameter	Units	No. of Samples	No. of Detections	Range of Detections			Location of Max Value	
				Min	Max	Avg		
Primary Radionuclides								
Thorium 232	pCi/L	4	1	100	100	40	W09	
Uranium 235	pCi/L	6	-	-	-	-	-	
Uranium 238	pCi/L	4	3	1100	2500	1400	W08	
Secondary Radionuclides								
Cesium 137	pCi/L	4	-	-	-	-	-	
Cobalt 60	pCi/L	4	1	30	30	13	W10	
Gross Alpha	pCi/L	2	2	5.2	19	12	OUTFALL	
Gross Beta	pCi/L	2	2	5.8	13	9.5	OUTFALL	
Radium 226	pCi/L	1	1	0.6	0.6	0.6	W10	
Filtered Secondary Radionuclides								
Gross Alpha (0.45u)	PCi/L	2	2	0.23	0.41	0.32	UNDER BRIDGE	
Gross Alpha (1.0u)	PCi/L	2	2	0.36	0.64	0.5	UNDER BRIDGE	
Gross Alpha (2.5u)	PCi/L	2	2	0.78	4.0	2.4	UNDER BRIDGE	
Gross Beta (0.45u)	PCi/L	2	2	0.67	1.5	1.1	UNDER BRIDGE	
Gross Beta (1.0u)	PCi/L	2	2	6.5	6.7	6.6	UNDER BRIDGE	
Gross Beta (2.5u)	PCi/L	2	2	2.3	13	7.7	UNDER BRIDGE	

Minimum and maximum values are reported for detection data only.

Average values were calculated using one-half the detection limit for non-detected data.

N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatNoCrit
Printed: 2/17/2005 1:46:57 PM
WHERE [MATRIX] = 'WS' AND [LOGDATE] < #8/26/2003# AND [PRCCODE] LIKE '*RN*' AND [SAMPNO] <> '3' AND [SITEID] = '3';

TABLE 4-22
STATISTICAL SUMMARY OF RI ON-SITE SEDIMENT ANALYTICAL RESULTS (DECEMBER 2003 AND JUNE 2004
SLDA

Parameter	Units	Criteria*	No. of Usable Results	No. of Detections	Range of Detections				No. Exceed	Dist	Location of Max Value
					Min	Max	Avg	StdDev			
Primary Radionuclides											
Americium 241	pCi/g	27.7	12	-	-	-	-	-	0	-	-
Plutonium 239	pCi/g	32.6	12	-	-	-	-	-	0	-	-
Plutonium 241	pCi/g	892	12	-	-	-	-	-	0	-	-
Radium 228	pCi/g	3.11	12	12	0.83	1.5	1.1	0.25	0	Normal	WS/SE-DR-02
Thorium 232	pCi/g	2.66	12	12	0.67	1.5	1.1	0.24	0	Normal	WS/SE-DR-01
Uranium 234	pCi/g	97.72	12	12	0.76	29	11	11	0	Normal	WS/SE-DR-04
Uranium 235 (alpha)	pCi/g	34.79	12	9	0.091	3.2	0.93	1.0	0	Non-Normal	WS/SE-DR-03
Uranium 235 (gamma)	pCi/g	34.6	12	7	0.19	1.2	0.39	0.37	0	Non-Normal	WS/SE-DR-04
Uranium 238	pCi/g	124.25	12	12	0.73	2.1	1.3	0.45	0	Normal	WS/SE-DR-04
Secondary Radionuclides											
Cesium 137	pCi/g	-	12	11	0.072	0.24	0.13	0.055	0	Normal	WS/SE-DR-06
Cobalt 60	pCi/g	-	12	-	-	-	-	-	0	-	-
Plutonium 238	pCi/g	-	2	-	-	-	-	-	0	-	-
Plutonium 242	pCi/g	-	2	-	-	-	-	-	0	-	-
Radium 226	pCi/g	-	12	12	0.53	1.0	0.81	0.15	0	Normal	WS/SE-DR-02
Thorium 230	pCi/g	-	2	2	1.0	1.1	1.1	0.064	0	-	WS/SE-DR-05

*Criteria- Preliminary Remediation Goal plus Background for Surface soil.

Concentration Exceeds Criteria

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit1NE
Printed: 2/17/2005 1:49:01 PM
WHERE [LOCID] LIKE '*DR*' AND [MATRIX] = 'SE';

TABLE 4-22
STATISTICAL SUMMARY OF RI ON-SITE SEDIMENT ANALYTICAL RESULTS (DECEMBER 2003 AND JUNE 2004
SLDA

Parameter	Units	Criteria*	No. of Usable Results	No. of Detections	Range of Detections				No. Exceed	Dist	Location of Max Value
					Min	Max	Avg	StdDev			
Other Radionuclides											
Beryllium 7	pCi/g	-	12	-	-	-	-	-	0	-	-
Bismuth 212	pCi/g	-	12	10	0.56	0.90	0.66	0.23	0	Non-Normal	WS/SE-DR-01
Lead 212	pCi/g	-	12	12	0.88	1.7	1.1	0.3	0	Normal	WS/SE-DR-01
Lead 214	pCi/g	-	12	12	0.601	1.1	0.93	0.15	0	Normal	WS/SE-DR-01
Potassium 40	pCi/g	-	12	12	6.9	23	12	6.0	0	Normal	WS/SE-DR-01
Thorium 234	pCi/g	-	12	7	1.0	1.8	1.1	0.46	0	Normal	WS/SE-DR-05

*Criteria- Preliminary Remediation Goal plus Background for Surface soil.

Concentration Exceeds Criteria

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-23
STATISTICAL SUMMARY OF HISTORICAL ON-SITE SEDIMENT ANALYTICAL RESULTS
SLDA

Parameter	Units	Criteria*	No. of Usable Results	No. of Detections	Range of Detections				No. Exceed	Dist	Location of Max Value
					Min	Max	Avg	StdDev			
Primary Radionuclides											
Americium 241	pCi/g	27.7	39	1	0.1	0.1	0.12	0.074	0	Non-Normal	SS-02
Thorium 232	pCi/g	2.66	39	39	0.58	2.6	1.1	0.4	0	Non-Normal	SS-01
Uranium 234	pCi/g	97.72	32	21	4.9	160	18	30	1	Non-Normal	TRIB 7
Uranium 235	pCi/g	34.79	39	28	0.15	7.3	0.75	1.2	0	Non-Normal	TRIB 7
Uranium 238	pCi/g	124.25	32	26	0.79	6.6	1.8	1.3	0	Non-Normal	TRIB 7
Uranium (total)	pCi/g	-	277	274	1.1	170	15	14	0	Non-Normal	TRIB 7
Secondary Radionuclides											
Cesium 137	pCi/g	-	46	38	0.04	0.49	0.15	0.11	0	Non-Normal	TRIB 2
Cobalt 60	pCi/g	-	39	-	-	-	-	-	0	-	-
Gross Alpha	pCi/g	-	8	8	13	200	53	63	0	Non-Normal	TRIB 7
Gross Beta	pCi/g	-	8	8	10	19	15	2.8	0	Normal	TRIB 7
Radium 226	pCi/g	-	39	39	0.48	1.9	0.86	0.24	0	Non-Normal	SS-01

*Criteria- Preliminary Remediation Goal plus Background for Surface soil.

(oval) Concentration Exceeds Criteria

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit1NE
Printed: 2/17/2005 2:01:22 PM
WHERE [MATRIX] = 'SE' AND [LOGDATE] < #8/26/2003# AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND ([SAMPNO] <> '3' AND [SAMPNO]<> '4');

TABLE 4-24
STATISTICAL SUMMARY OF RI OFF-SITE SEDIMENT ANALYTICAL RESULTS (DECEMBER 2003 AND JUNE 2004)
SLDA

Parameter	Units	Criteria*	No. of Usable Results	No. of Detections	Range of Detections				No. Exceed	Dist	Location of Max Value
					Min	Max	Avg	StdDev			
Primary Radionuclides											
Americium 241	pCi/g	27.7	12	-	-	-	-	-	0	-	-
Plutonium 239	pCi/g	32.6	12	-	-	-	-	-	0	-	-
Plutonium 241	pCi/g	892	12	-	-	-	-	-	0	-	-
Radium 228	pCi/g	3.11	12	12	0.98	1.3	1.1	0.078	0	Normal	WS/SE-CR-02
Thorium 232	pCi/g	2.66	12	12	0.80	1.3	1.0	0.13	0	Normal	WS/SE-CR-05
Uranium 234	pCi/g	97.72	12	12	0.62	1.5	0.97	0.26	0	Normal	WS/SE-CR-01
Uranium 235 (alpha)	pCi/g	34.79	12	4	0.065	0.16	0.091	0.041	0	Normal	WS/SE-CR-04
Uranium 235 (gamma)	pCi/g	34.6	12	1	0.33	0.33	0.1	0.074	0	Non-Normal	WS/SE-CR-05
Uranium 238	pCi/g	124.25	12	12	0.53	1.2	0.81	0.22	0	Normal	WS/SE-CR-01
Secondary Radionuclides											
Cesium 137	pCi/g	-	12	4	0.024	0.049	0.021	0.012	0	Non-Normal	WS/SE-CR-01
Cobalt 60	pCi/g	-	12	-	-	-	-	-	0	-	-
Plutonium 238	pCi/g	-	1	-	-	-	-	-	0	-	-
Plutonium 242	pCi/g	-	1	-	-	-	-	-	0	-	-
Radium 226	pCi/g	-	12	12	0.66	1.4	0.89	0.18	0	Non-Normal	WS/SE-CR-01
Thorium 230	pCi/g	-	1	1	1.1	1.1	1.1	-	0	-	WS/SE-CR-03

*Criteria- Preliminary Remediation Goal plus Background for Surface soil.

(oval) Concentration Exceeds Criteria

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit1NE
Printed: 2/17/2005 2:07:09 PM
WHERE [MATRIX] = 'SE' AND [LOCID] LIKE '*CR*';

TABLE 4-24
STATISTICAL SUMMARY OF RI OFF-SITE SEDIMENT ANALYTICAL RESULTS (DECEMBER 2003 AND JUNE 2004)
SLDA

Parameter	Units	Criteria*	No. of Usable Results	No. of Detections	Range of Detections				No. Exceed	Dist	Location of Max Value
					Min	Max	Avg	StdDev			
Other Radionuclides											
Beryllium 7	pCi/g	-	12	-	-	-	-	-	0	-	-
Bismuth 212	pCi/g	-	12	12	0.59	0.96	0.72	0.12	0	Normal	WS/SE-CR-06
Lead 212	pCi/g	-	12	12	1.0	1.5	1.2	0.17	0	Normal	WS/SE-CR-02
Lead 214	pCi/g	-	12	12	0.84	1.5	1.1	0.21	0	Non-Normal	WS/SE-CR-01
Potassium 40	pCi/g	-	12	12	11	16	14	1.2	0	Normal	WS/SE-CR-02
Thorium 234	pCi/g	-	12	1	0.807	0.807	0.58	0.18	0	Normal	WS/SE-CR-01

*Criteria- Preliminary Remediation Goal plus Background for Surface soil.

(oval) Concentration Exceeds Criteria

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevCrit1NE
Printed: 2/17/2005 2:07:09 PM
WHERE [MATRIX] = 'SE' AND [LOCID] LIKE '*CR*';

TABLE 4-25
STATISTICAL SUMMARY OF HISTORICAL OFF-SITE SEDIMENT ANALYTICAL RESULTS
SLDA

Parameter	Units	Criteria*	No. of Usable Results	No. of Detections	Range of Detections				Dist	Location of Max Value
					Min	Max	Avg	StdDev		
Primary Radionuclides										
Uranium 235	pCi/g	34.79	2	2	0.1	0.13	0.12	0.021	-	UNDER BRIDGE
Uranium (total)	pCi/g	-	2	2	3.1	3.8	3.4	0.49	-	UNDER BRIDGE

*Criteria- Preliminary Remediation Goal plus Background for Surface soil.

Concentration Exceeds Criteria

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-26

HYDRAULIC LOCATION OF MONITORING WELLS AND PIEZOMETERS RELATIVE TO THE WASTE DISPOSAL AREAS SLDA REMEDIAL INVESTIGATION

Location	Zone	Up (U) or Down (D) Gradient from Disposal Areas	Sampled in December 2003	Sampled in June 2004
MW-11S	OB	D	Y	N-DRY
PZ-01	OB	D	N	N
PZ-02	OB	D	N	N
PZ-03A	OB	D	N	N
PZ-04	OB	D	N	N
PZ-05	OB	D	N	N
PZ-06A	OB	D	N	N
PZ-07	OB	U	N	N
PZ-08	OB	U	N	N
PZ-09	OB	U	N	N
MW-47	OB	U	N - DRY	N - DRY
MW-59	OB	U	Y	Y
MW-64	OB	U	Y	Y
MW-69	OB	U	Y	Y
MW-74	OB	U	N - DRY	N - DRY
MW-7	1S	U/cross gradient	Y	Y
MW-8	1S	U	Y	Y
MW-9A	1S	U	Y	Y
MW-12D	1S	D	Y	Y
MW-13	1S	U	Y	Y
MW-14	1S	U	Y	Y
MW-15	1S	U	Y	Y
MW-24	1S	U	Y	Y
MW-25	1S	D	Y	Y
MW-26	1S	D	Y	Y
MW-27	1S	D	N - DRY	N - DRY
MW-29	1S	D	Y	Y
MW-32	1S	U	Y	Y
MW-38	1S	U	Y	Y
MW-41	1S	D	Y	Y
MW-42	1S	D	Y	N - DRY
MW-44	1S	D	N - DRY	N - DRY
MW-50	1S	D	N - DRY	N - DRY
MW-51	1S	D	Y	Y
MW-60	1S	D	N*	N - DRY
NWS-01A-1	1S	D	N**	N - DRY
NWS-02-1	1S	U	N**	N - DRY
NWS-03-1	1S	U	N**	N - DRY
NWS-04-1	1S	D	N**	N - DRY
NWS-05-1	1S	D	N**	N - DRY

N* Well not installed yet
N** FLUTe monitoring system not sampled
N*** Obstruction in well
OB Overburden
1S First shallow bedrock
2S Second shallow bedrock
UF Upper Freeport
DB Deep Bedrock

TABLE 4-26

HYDRAULIC LOCATION OF MONITORING WELLS AND PIEZOMETERS RELATIVE TO THE WASTE DISPOSAL AREAS SLDA REMEDIAL INVESTIGATION

Location	Zone	Up (U) or Down (D) Gradient from Disposal Areas	Sampled in December 2003	Sampled in June 2004
MW-11D	2S	D	N - DRY	N - DRY
MW-17	2S	D	N - DRY	N - DRY
MW-33	2S	U	Y	Y
MW-37	2S	D	N - DRY	N - DRY
MW-43	2S	D	Y	Y
MW-45	2S	U	Y	N - DRY
MW-52	2S	U	Y	Y
MW-53	2S	D	N - DRY	N - DRY
MW-61	2S	U	N*	N - DRY
NWS-01A-2	2S	U	N**	Y
NWS-02-2	2S	U	N**	N - DRY
NWS-03-2	2S	U	N**	N - DRY
NWS-04-2	2S	D	N**	N - DRY
NWS-05-2	2S	D	N**	N - DRY
MW-1	UF	U	Y	Y
MW-2A	UF	D	Y	Y
MW-3	UF	D	Y	N - DRY
MW-5	UF	U	Y	Y
MW-6	UF	U	Y	Y
MW-16	UF	D	N - DRY	N - DRY
MW-20	UF	D	N - DRY	N - DRY
MW-21	UF	D	N - DRY	N - DRY
MW-30A	UF	D	Y	Y
MW-31	UF	D	Y	Y
MW-39	UF	D	Y	Y
MW-46	UF	D	N***	N***
MW-54	UF	U	Y	N - DRY
MW-56	UF	U	Y	Y
MW-57	UF	D	Y	N - DRY
MW-62	UF	D	N*	N - DRY
NWS-01A-3	UF	D	N*	Y
NWS-02-3	UF	D	N*	N - DRY
NWS-03-3	UF	D	N*	Y
NWS-04-3	UF	D	N*	N - DRY
NWS-05-3	UF	D/cross gradient	N*	N - DRY

N* Well not installed yet
N** FLUTe monitoring system not sampled
N*** Obstruction in well
OB Overburden
1S First shallow bedrock
2S Second shallow bedrock
UF Upper Freeport
DB Deep Bedrock

TABLE 4-26

HYDRAULIC LOCATION OF MONITORING WELLS AND PIEZOMETERS RELATIVE TO THE WASTE DISPOSAL AREAS SLDA REMEDIAL INVESTIGATION

Location	Zone	Up (U) or Down (D) Gradient from Disposal Areas	Sampled in December 2003	Sampled in June 2004
MW-2	DB	U	Y	Y
MW-16BC	DB	U	Y	Y
MW-19	DB	U	Y	Y
MW-22	DB	D	Y	Y
MW-23	DB	U	Y	Y
MW-34A	DB	D	N - DRY	N - DRY
MW-35	DB	U	Y	Y
MW-36	DB	U	Y	Y
MW-40	DB	D	Y	Y
MW-58	DB	U	Y	Y
NWS-01A-4	DB	D	N**	Y
NWS-02-4	DB	U	N**	N - DRY
NWS-03-4	DB	U	N**	N - DRY
NWS-04-4	DB	U	N**	N - DRY
NWS-05-4	DB	U	N**	Y
NWS-05-5	DB2	U	N**	N - DRY

N* Well not installed yet
N** FLUTe monitoring system not sampled
N*** Obstruction in well
OB Overburden
1S First shallow bedrock
2S Second shallow bedrock
UF Upper Freeport
DB Deep Bedrock

TABLE 4-27
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
UPGRADIENT OVERBURDEN WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241 (alpha)	pCi/L	4	-	-	-	-	-	-
Plutonium 239	pCi/L	5	-	-	-	-	-	-
Plutonium 241	pCi/L	3	-	-	-	-	-	-
Radium 228 (beta)	pCi/L	5	2	1.5	1.6	1.1	0.42	MW-69
Thorium 232	pCi/L	4	-	-	-	-	-	-
Uranium 234	pCi/L	5	-	-	-	-	-	-
Uranium 235 (alpha)	pCi/L	5	-	-	-	-	-	-
Uranium 238	pCi/L	4	-	-	-	-	-	-
Secondary Radionuclides								
Plutonium 238	pCi/L	2	-	-	-	-	-	-
Plutonium 242	pCi/L	1	-	-	-	-	-	-

Advanced Selection: _TABLE 4-27
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Minimum and maximum values are reported for detection data only.

WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = 'SS' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-59' OR [LOCID] = 'MW-64' OR [LOCID] = 'MW-69');

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-28
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
DOWNGRADIENT OVERBURDEN WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241 (alpha)	pCi/L	1	-	-	-	-	-	-
Americium 241 (gamma)	pCi/L	1	-	-	-	-	-	-
Plutonium 239	pCi/L	1	-	-	-	-	-	-
Radium 228 (beta)	pCi/L	1	-	-	-	-	-	-
Radium 228 (gamma)	pCi/L	1	-	-	-	-	-	-
Thorium 232	pCi/L	1	-	-	-	-	-	-
Uranium 234	pCi/L	1	-	-	-	-	-	-
Uranium 235 (alpha)	pCi/L	1	-	-	-	-	-	-
Uranium 235 (gamma)	pCi/L	1	-	-	-	-	-	-
Uranium 238	pCi/L	1	-	-	-	-	-	-
Secondary Radionuclides								
Cesium 137	pCi/L	1	-	-	-	-	-	-
Cobalt 60	pCi/L	1	-	-	-	-	-	-
Gross Alpha	pCi/L	1	1	2.7	2.7	2.7	-	MW-11S
Gross Beta	pCi/L	1	-	-	-	-	-	-
Plutonium 238	pCi/L	1	-	-	-	-	-	-
Plutonium 242	pCi/L	1	-	-	-	-	-	-
Radium 226 (alpha)	pCi/L	1	1	1.3	1.3	1.3	-	MW-11S

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-28
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
DOWNGRADIENT OVERBURDEN WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Secondary Radionuclides								
Radium 226 (gamma)	pCi/L	1	-	-	-	-	-	-
Thorium 230	pCi/L	1	-	-	-	-	-	-
Other Radionuclides								
Beryllium 7	pCi/L	1	-	-	-	-	-	-
Bismuth 212	pCi/L	1	-	-	-	-	-	-
Lead 212	pCi/L	1	-	-	-	-	-	-
Lead 214	pCi/L	1	-	-	-	-	-	-
Potassium 40	pCi/L	1	1	48	48	48	-	MW-11S
Thorium 234	pCi/L	1	-	-	-	-	-	-

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Minimum and maximum values are reported for detection data only.

WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = 'SS' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-11S');

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-29
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
UPGRADIENT FIRST SHALLOW BEDROCK ZONE WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241 (alpha)	pCi/L	13	-	-	-	-	-	-
Americium 241 (gamma)	pCi/L	1	-	-	-	-	-	-
Plutonium 239	pCi/L	15	-	-	-	-	-	-
Plutonium 241	pCi/L	14	-	-	-	-	-	-
Radium 228 (beta)	pCi/L	14	4	1.4	2.6	1.1	0.57	MW-08
Radium 228 (gamma)	pCi/L	1	-	-	-	-	-	-
Thorium 232	pCi/L	14	-	-	-	-	-	-
Uranium 234	pCi/L	14	-	-	-	-	-	-
Uranium 235 (alpha)	pCi/L	14	-	-	-	-	-	-
Uranium 235 (gamma)	pCi/L	1	-	-	-	-	-	-
Uranium 238	pCi/L	15	1	0.17	0.17	0.14	0.071	MW-38
Secondary Radionuclides								
Cesium 137	pCi/L	1	-	-	-	-	-	-
Cobalt 60	pCi/L	1	-	-	-	-	-	-
Gross Alpha	pCi/L	1	1	130	130	130	-	MW-15
Gross Beta	pCi/L	1	1	170	170	170	-	MW-15
Plutonium 238	pCi/L	1	-	-	-	-	-	-
Plutonium 242	pCi/L	1	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: _TABLE 4-28
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevNoCrit
2/17/2005
WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = '1S' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-08' OR [LOCID] = 'MW-09A' OR [LOCID] = 'MW-13' OR [LOCID] = 'MW-14' OR [LOCID] = 'MW-15' OR [LOCID] = 'MW-24' OR [LOCID] = 'MW-32' OR [LOCID] = 'MW-38');

TABLE 4-29
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
UPGRADIENT FIRST SHALLOW BEDROCK ZONE WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Secondary Radionuclides								
Radium 226 (alpha)	pCi/L	1	1	3.5	3.5	3.5	-	MW-15
Radium 226 (gamma)	pCi/L	1	-	-	-	-	-	-
Thorium 230	pCi/L	1	1	0.87	0.87	0.87	-	MW-15
Other Radionuclides								
Beryllium 7	pCi/L	1	-	-	-	-	-	-
Bismuth 212	pCi/L	1	-	-	-	-	-	-
Lead 212	pCi/L	1	-	-	-	-	-	-
Lead 214	pCi/L	1	-	-	-	-	-	-
Potassium 40	pCi/L	1	1	87	87	87	-	MW-15
Thorium 234	pCi/L	1	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: _TABLE 4-28
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevNoCrit
2/17/2005

WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = '1S' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-08' OR [LOCID] = 'MW-09A' OR [LOCID] = 'MW-13' OR [LOCID] = 'MW-14' OR [LOCID] = 'MW-15' OR [LOCID] = 'MW-24' OR [LOCID] = 'MW-32' OR [LOCID] = 'MW-38');

TABLE 4-30
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
DOWNGRADIENT FIRST SHALLOW BEDROCK ZONE WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241 (alpha)	pCi/L	13	-	-	-	-	-	-
Americium 241 (gamma)	pCi/L	4	-	-	-	-	-	-
Plutonium 239	pCi/L	13	-	-	-	-	-	-
Plutonium 241	pCi/L	11	-	-	-	-	-	-
Radium 228 (beta)	pCi/L	13	8	1.3	2.5	1.4	0.59	MW-42
Radium 228 (gamma)	pCi/L	4	-	-	-	-	-	-
Thorium 232	pCi/L	11	1	1.6	1.6	0.28	0.41	MW-29
Uranium 234	pCi/L	13	3	0.501	2.7	0.45	0.68	MW-29
Uranium 235 (alpha)	pCi/L	13	1	0.95	0.95	0.22	0.22	MW-29
Uranium 235 (gamma)	pCi/L	4	-	-	-	-	-	-
Uranium 238	pCi/L	13	1	0.37	0.37	0.2	0.13	MW-41
Secondary Radionuclides								
Cesium 137	pCi/L	4	-	-	-	-	-	-
Cobalt 60	pCi/L	4	-	-	-	-	-	-
Gross Alpha	pCi/L	4	-	-	-	-	-	-
Gross Beta	pCi/L	4	1	3.1	3.1	2.2	0.6	MW-26
Plutonium 238	pCi/L	4	-	-	-	-	-	-
Plutonium 242	pCi/L	4	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = '1S' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-12D' OR [LOCID] = 'MW-25' OR [LOCID] = 'MW-26' OR [LOCID] = 'MW-29' OR [LOCID] = 'MW-41' OR [LOCID] = 'MW-42' OR [LOCID] = 'MW-51');

TABLE 4-30
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
DOWNGRADIENT FIRST SHALLOW BEDROCK ZONE WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Secondary Radionuclides								
Radium 226 (alpha)	pCi/L	4	2	0.801	4.4	2.8	1.7	MW-12D
Radium 226 (gamma)	pCi/L	4	2	6.5	7.6	3.6	3.9	MW-12D
Thorium 230	pCi/L	4	-	-	-	-	-	-
Other Radionuclides								
Beryllium 7	pCi/L	4	-	-	-	-	-	-
Bismuth 212	pCi/L	4	-	-	-	-	-	-
Lead 212	pCi/L	4	-	-	-	-	-	-
Lead 214	pCi/L	4	-	-	-	-	-	-
Potassium 40	pCi/L	4	-	-	-	-	-	-
Thorium 234	pCi/L	4	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: _TABLE 4-30
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevNoCrit
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WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = '1S' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-12D' OR [LOCID] = 'MW-25' OR [LOCID] = 'MW-26' OR [LOCID] = 'MW-29' OR [LOCID] = 'MW-41' OR [LOCID] = 'MW-42' OR [LOCID] = 'MW-51');

TABLE 4-31
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
UPGRADIENT SECOND SHALLOW BEDROCK ZONE WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241 (alpha)	pCi/L	5	-	-	-	-	-	-
Americium 241 (gamma)	pCi/L	1	-	-	-	-	-	-
Plutonium 239	pCi/L	5	-	-	-	-	-	-
Plutonium 241	pCi/L	5	-	-	-	-	-	-
Radium 228 (beta)	pCi/L	5	2	1.4	1.4	1.0	0.38	MW-33
Radium 228 (gamma)	pCi/L	1	-	-	-	-	-	-
Thorium 232	pCi/L	5	-	-	-	-	-	-
Uranium 234	pCi/L	5	2	0.49	4.9	1.2	2.0	MW-45
Uranium 235 (alpha)	pCi/L	5	-	-	-	-	-	-
Uranium 235 (gamma)	pCi/L	1	-	-	-	-	-	-
Uranium 238	pCi/L	5	2	0.36	2.1	0.61	0.85	MW-45
Secondary Radionuclides								
Cesium 137	pCi/L	1	-	-	-	-	-	-
Cobalt 60	pCi/L	1	-	-	-	-	-	-
Gross Alpha	pCi/L	1	-	-	-	-	-	-
Gross Beta	pCi/L	1	1	4.5	4.5	4.5	-	MW-33
Plutonium 238	pCi/L	1	-	-	-	-	-	-
Plutonium 242	pCi/L	1	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = '2S' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-33' OR [LOCID] = 'MW-45' OR [LOCID] = 'MW-52' OR [LOCID] = 'MW-61' OR [LOCID] = 'NWS-02-02' OR [LOCID] = 'NWS-03-02');

TABLE 4-31
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
UPGRADIENT SECOND SHALLOW BEDROCK ZONE WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Secondary Radionuclides								
Radium 226 (alpha)	pCi/L	1	-	-	-	-	-	-
Radium 226 (gamma)	pCi/L	1	1	0.96	0.96	0.96	-	MW-33
Thorium 230	pCi/L	1	-	-	-	-	-	-
Other Radionuclides								
Beryllium 7	pCi/L	1	-	-	-	-	-	-
Bismuth 212	pCi/L	1	-	-	-	-	-	-
Lead 212	pCi/L	1	-	-	-	-	-	-
Lead 214	pCi/L	1	-	-	-	-	-	-
Potassium 40	pCi/L	1	-	-	-	-	-	-
Thorium 234	pCi/L	1	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = '2S' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-33' OR [LOCID] = 'MW-45' OR [LOCID] = 'MW-52' OR [LOCID] = 'MW-61' OR [LOCID] = 'NWS-02-02' OR [LOCID] = 'NWS-03-02');

TABLE 4-32
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
DOWNGRADIENT SECOND SHALLOW BEDROCK ZONE WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241 (alpha)	pCi/L	2	-	-	-	-	-	-
Plutonium 239	pCi/L	2	-	-	-	-	-	-
Plutonium 241	pCi/L	2	-	-	-	-	-	-
Radium 228 (beta)	pCi/L	2	-	-	-	-	-	-
Thorium 232	pCi/L	2	-	-	-	-	-	-
Uranium 234	pCi/L	2	2	0.701	1.5	1.1	0.56	MW-43
Uranium 235 (alpha)	pCi/L	2	-	-	-	-	-	-
Uranium 238	pCi/L	2	1	0.33	0.33	0.21	0.17	MW-43

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

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WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = '2S' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-43' OR [LOCID] = 'MW-11D' OR [LOCID] = 'MW-37' OR [LOCID] = 'MW-17' OR [LOCID] = 'MW-53' OR [LOCID] = 'NWS-04-02' OR [LOCID] = 'NWS-05-02');

TABLE 4-33
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
UPGRADIENT UPPER FREEPORT COAL ZONE WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241 (alpha)	pCi/L	9	-	-	-	-	-	-
Americium 241 (gamma)	pCi/L	1	-	-	-	-	-	-
Plutonium 239	pCi/L	8	-	-	-	-	-	-
Plutonium 241	pCi/L	7	-	-	-	-	-	-
Radium 228 (beta)	pCi/L	9	3	1.9	2.0	1.2	0.55	MW-56
Radium 228 (gamma)	pCi/L	1	-	-	-	-	-	-
Thorium 232	pCi/L	8	1	1.8	1.8	0.39	0.56	MW-54
Uranium 234	pCi/L	9	1	0.62	0.62	0.2	0.17	MW-54
Uranium 235 (alpha)	pCi/L	9	-	-	-	-	-	-
Uranium 235 (gamma)	pCi/L	1	-	-	-	-	-	-
Uranium 238	pCi/L	9	-	-	-	-	-	-
Secondary Radionuclides								
Cesium 137	pCi/L	1	-	-	-	-	-	-
Cobalt 60	pCi/L	1	-	-	-	-	-	-
Gross Alpha	pCi/L	1	-	-	-	-	-	-
Gross Beta	pCi/L	1	1	3.3	3.3	3.3	-	MW-05
Plutonium 238	pCi/L	1	-	-	-	-	-	-
Plutonium 242	pCi/L	1	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: _TABLE 4-33
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevNoCrit
2/17/2005
WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = 'UF' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-01' OR [LOCID] = 'MW-05' OR [LOCID] = 'MW-06' OR [LOCID] = 'MW-54' OR [LOCID] = 'MW-56');

TABLE 4-33
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
UPGRADIENT UPPER FREEPORT COAL ZONE WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Secondary Radionuclides								
Radium 226 (alpha)	pCi/L	1	1	0.69	0.69	0.69	-	MW-05
Radium 226 (gamma)	pCi/L	1	-	-	-	-	-	-
Thorium 230	pCi/L	1	-	-	-	-	-	-
Other Radionuclides								
Beryllium 7	pCi/L	1	-	-	-	-	-	-
Bismuth 212	pCi/L	1	-	-	-	-	-	-
Lead 212	pCi/L	1	-	-	-	-	-	-
Lead 214	pCi/L	1	-	-	-	-	-	-
Potassium 40	pCi/L	1	-	-	-	-	-	-
Thorium 234	pCi/L	1	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: _TABLE 4-33
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevNoCrit
2/17/2005
WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = 'UF' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-01' OR [LOCID] = 'MW-05' OR [LOCID] = 'MW-06' OR [LOCID] = 'MW-54' OR [LOCID] = 'MW-56');

TABLE 4-34
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
DOWNGRADIENT UPPER FREEPORT COAL ZONE WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241 (alpha)	pCi/L	10	-	-	-	-	-	-
Americium 241 (gamma)	pCi/L	1	-	-	-	-	-	-
Plutonium 239	pCi/L	8	-	-	-	-	-	-
Plutonium 241	pCi/L	8	-	-	-	-	-	-
Radium 228 (beta)	pCi/L	10	1	1.4	1.4	0.86	0.24	MW-31
Radium 228 (gamma)	pCi/L	1	-	-	-	-	-	-
Thorium 232	pCi/L	10	2	5.3	6.0	1.3	2.3	MW-30A
Uranium 234	pCi/L	10	2	0.39	7.8	0.98	2.4	MW-57
Uranium 235 (alpha)	pCi/L	10	-	-	-	-	-	-
Uranium 235 (gamma)	pCi/L	1	-	-	-	-	-	-
Uranium 238	pCi/L	10	1	4.9	4.9	0.66	1.5	MW-57
Secondary Radionuclides								
Cesium 137	pCi/L	1	-	-	-	-	-	-
Cobalt 60	pCi/L	1	-	-	-	-	-	-
Gross Alpha	pCi/L	1	-	-	-	-	-	-
Gross Beta	pCi/L	1	1	3.8	3.8	3.8	-	MW-39
Plutonium 238	pCi/L	2	-	-	-	-	-	-
Plutonium 242	pCi/L	1	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = 'UF' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-02A' OR [LOCID] = 'MW-30A' OR [LOCID] = 'MW-31' OR [LOCID] = 'MW-39' OR [LOCID] = 'MW-57' OR [LOCID] = 'NWS-01A-03' OR [LOCID] = 'NWS-03-03' OR [LOCID] = 'MW-03' OR [LOCID] = 'MW-16'

TABLE 4-34
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
DOWNGRADIENT UPPER FREEPORT COAL ZONE WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Secondary Radionuclides								
Radium 226 (alpha)	pCi/L	1	-	-	-	-	-	-
Radium 226 (gamma)	pCi/L	1	-	-	-	-	-	-
Thorium 230	pCi/L	1	1	0.53	0.53	0.53	-	MW-39
Other Radionuclides								
Beryllium 7	pCi/L	1	-	-	-	-	-	-
Bismuth 212	pCi/L	1	-	-	-	-	-	-
Lead 212	pCi/L	1	-	-	-	-	-	-
Lead 214	pCi/L	1	-	-	-	-	-	-
Potassium 40	pCi/L	1	-	-	-	-	-	-
Thorium 234	pCi/L	1	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = 'UF' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-02A' OR [LOCID] = 'MW-30A' OR [LOCID] = 'MW-31' OR [LOCID] = 'MW-39' OR [LOCID] = 'MW-57' OR [LOCID] = 'NWS-01A-03' OR [LOCID] = 'NWS-03-03' OR [LOCID] = 'MW-03' OR [LOCID] = 'MW-16'

TABLE 4-35
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
UPGRADIENT DEEP BEDROCK ZONE WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241 (alpha)	pCi/L	14	-	-	-	-	-	-
Americium 241 (gamma)	pCi/L	2	-	-	-	-	-	-
Plutonium 239	pCi/L	13	-	-	-	-	-	-
Plutonium 241	pCi/L	11	-	-	-	-	-	-
Radium 228 (beta)	pCi/L	15	6	1.1	5.1	1.6	1.5	MW-36
Radium 228 (gamma)	pCi/L	3	-	-	-	-	-	-
Thorium 232	pCi/L	16	-	-	-	-	-	-
Uranium 234	pCi/L	16	7	0.28	1.2	0.4	0.28	MW-36
Uranium 235 (alpha)	pCi/L	16	-	-	-	-	-	-
Uranium 235 (gamma)	pCi/L	2	-	-	-	-	-	-
Uranium 238	pCi/L	16	1	0.52	0.52	0.18	0.13	MW-23
Secondary Radionuclides								
Cesium 137	pCi/L	2	-	-	-	-	-	-
Cobalt 60	pCi/L	2	-	-	-	-	-	-
Gross Alpha	pCi/L	2	-	-	-	-	-	-
Gross Beta	pCi/L	2	-	-	-	-	-	-
Plutonium 238	pCi/L	2	-	-	-	-	-	-
Plutonium 242	pCi/L	1	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

Advanced Selection: _TABLE 4-35
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevNoCrit
2/17/2005

WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = 'DB' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-02' OR [LOCID] = 'MW-16BC' OR [LOCID] = 'MW-19' OR [LOCID] = 'MW-23' OR [LOCID] = 'MW-35' OR [LOCID] = 'MW-36' OR [LOCID] = 'MW-58' OR [LOCID] = 'NWS-05-04');

TABLE 4-35
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
UPGRADIENT DEEP BEDROCK ZONE WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Secondary Radionuclides								
Radium 226 (alpha)	pCi/L	2	1	1.1	1.1	1.8	0.93	MW-36
Radium 226 (gamma)	pCi/L	2	-	-	-	-	-	-
Thorium 230	pCi/L	2	1	1.1	1.1	0.61	0.62	MW-36
Other Radionuclides								
Beryllium 7	pCi/L	2	-	-	-	-	-	-
Bismuth 212	pCi/L	2	-	-	-	-	-	-
Lead 212	pCi/L	2	-	-	-	-	-	-
Lead 214	pCi/L	2	-	-	-	-	-	-
Potassium 40	pCi/L	2	-	-	-	-	-	-
Thorium 234	pCi/L	2	-	-	-	-	-	-

Advanced Selection: _TABLE 4-35
N:\11171431.00000\GIS\dB\Program\STAT_97.mdb Report: rptStatStdDevNoCrit
2/17/2005

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = 'DB' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-02' OR [LOCID] = 'MW-16BC' OR [LOCID] = 'MW-19' OR [LOCID] = 'MW-23' OR [LOCID] = 'MW-35' OR [LOCID] = 'MW-36' OR [LOCID] = 'MW-58' OR [LOCID] = 'NWS-05-04');

TABLE 4-36
STATISTICAL SUMMARY OF RI GROUNDWATER ANALYTICAL RESULTS
DOWNGRADIENT DEEP BEDROCK ZONE WELLS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241 (alpha)	pCi/L	5	-	-	-	-	-	-
Plutonium 239	pCi/L	5	-	-	-	-	-	-
Plutonium 241	pCi/L	4	-	-	-	-	-	-
Radium 228 (beta)	pCi/L	5	2	1.2	3.1	1.3	1.1	MW-22
Thorium 232	pCi/L	5	-	-	-	-	-	-
Uranium 234	pCi/L	4	-	-	-	-	-	-
Uranium 235 (alpha)	pCi/L	5	-	-	-	-	-	-
Uranium 238	pCi/L	5	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

WHERE ([LOGDATE] >= #8/1/2003# AND [MATRIX] = 'WG' AND SDG = 'DB' AND [PRCCODE] LIKE '*RN*' AND [SITEID] = '1' AND [SAMPNO] <> '3' AND [SAMPNO] <> '4') AND ([LOCID] = 'MW-22' OR [LOCID] = 'MW-40' OR [LOCID] = 'NWS-01A-04');

TABLE 4-37

Quarterly Gross Alpha and Gross Beta Groundwater Sampling Statistics
By ARCO/BWXT - April 1991 Through June 2002 - SLDA

Location	Zone	Up (U) or Down (D) Gradient	Analysis	Mean	Std Dev	Confidence	95% UCL	Median	Max	# Events	Min
MW-1	UF	U	ALPHA	1.69	1.81	0.61	2.30	1.00	9.60	34	0.00
			BETA	4.33	4.09	1.37	5.71	3.85	24.90	34	0.50
MW-2	DB	U	ALPHA	3.64	3.38	1.15	4.80	3.00	14.60	33	0.00
			BETA	11.17	11.61	3.96	15.13	9.14	68.80	33	0.50
MW-2A	UF	D	ALPHA	1.44	2.57	0.88	2.41	1.00	14.56	33	0.20
			BETA	5.27	3.24	1.11	6.89	4.90	16.79	33	0.50
MW-3	UF	D	ALPHA	27.88	32.11	12.85	38.91	19.77	137.39	27	0.00
			BETA	24.49	24.53	9.81	33.78	15.70	105.73	27	2.45
MW-4 (2)	NA	NA	ALPHA	7.30	4.44	2.05	9.36	7.10	16.00	18	0.00
			BETA	195.83	77.00	35.57	231.40	181.95	382.99	18	105.23
MW-5	UF	U	ALPHA	1.37	1.41	0.54	1.37	0.98	3.17	26	0.32
			BETA	3.82	3.54	1.36	5.20	3.45	19.80	26	0.20
MW-6	UF	U	ALPHA	2.58	4.12	1.38	3.27	1.06	17.96	35	0.00
			BETA	6.48	9.28	3.12	9.65	4.31	54.30	35	0.29
MW-7	1S	U	ALPHA	2.17	1.69	0.58	2.77	1.80	7.70	33	0.00
			BETA	4.64	3.87	1.32	5.97	4.20	24.40	33	0.94
MW-8	1S	U	ALPHA	8.62	1.38	0.47	1.65	0.90	5.86	33	0.00
			BETA	3.99	3.60	1.23	5.31	3.00	21.38	33	0.50
MW-9A	1S	U	ALPHA	1.26	1.63	0.65	1.91	0.52	7.64	24	0.02
			BETA	2.67	2.20	0.88	3.55	1.93	9.86	24	0.50
MW-10 (2)	NA	NA	ALPHA	2.05	1.50	0.68	2.73	1.72	5.56	19	0.05
			BETA	5.95	4.63	2.08	8.03	5.60	22.00	19	0.80
MW-11S	SS	D	ALPHA	0.66	1.16	0.66	1.32	0.41	3.23	12	0.00
			BETA	2.16	1.30	0.74	2.89	1.95	5.80	12	0.87
MW-11D	2S	D	ALPHA	4.52	3.67	1.44	5.96	3.60	19.18	25	0.50
			BETA	5.04	5.67	2.22	7.26	5.60	20.94	25	1.70
MW-12D	1S	D	ALPHA	1.44	1.43	0.50	1.94	1.30	4.10	31	0.08
			BETA	5.72	5.42	1.91	7.63	3.80	26.60	31	0.00
MW-13	1S	U	ALPHA	1.98	5.43	1.88	3.86	1.15	30.50	30	0.06
			BETA	3.98	5.81	2.01	5.99	2.40	32.42	30	0.89
MW-14	1S	U	ALPHA	1.77	2.68	0.93	2.69	1.00	13.00	32	0.07
			BETA	3.11	2.87	0.99	4.11	2.25	14.70	32	0.20

TABLE 4-37

Quarterly Gross Alpha and Gross Beta Groundwater Sampling Statistics By ARCO/BWXT - April 1991 Through June 2002 - SLDA

Location	Zone	Up (U) or Down (D) Gradient	Analysis	Mean	Std Dev	Confidence	95% UCL	Median	Max	# Events	Min
MW-15	1S	U	ALPHA	1.50	2.52	0.87	2.38	1.00	10.78	32	0.08
			BETA	3.96	2.19	0.76	4.72	3.32	10.53	32	0.50
MW-16	UF	D	ALPHA	NS	NS	NS	NS	NS	NS	NS	NS
			BETA	NS	NS	NS	NS	NS	NS	NS	NS
MW-16BC	DB	U	ALPHA	2.94	4.76	1.83	4.77	2.03	17.69	26	0.09
			BETA	9.83	5.05	1.94	11.77	10.28	21.01	26	1.90
MW-17	2S	D	ALPHA	3.85	3.21	1.26	5.11	3.65	14.43	25	0.00
			BETA	10.83	6.29	2.46	13.30	7.86	27.79	25	5.10
MW-18 (1)	NA	NA	ALPHA	NS	NS	NS	NS	NS	NS	NS	NS
			BETA	NS	NS	NS	NS	NS	NS	NS	NS
MW-19	DB	U	ALPHA	2.25	2.66	1.02	3.27	1.98	8.39	26	0.00
			BETA	6.06	6.96	2.67	8.74	5.20	35.56	26	0.27
MW-20	UF	D	ALPHA	8.32	4.99	2.30	10.62	8.25	17.17	18	0.40
			BETA	12.56	5.30	2.45	15.01	12.25	22.53	18	3.60
MW-21	UF	D	ALPHA	NS	NS	NS	NS	NS	NS	NS	NS
			BETA	NS	NS	NS	NS	NS	NS	NS	NS
MW-22	DB	D	ALPHA	6.34	18.18	7.27	13.62	2.34	89.88	24	0.00
			BETA	8.55	6.47	2.59	11.14	8.37	20.90	24	3.24
MW-23	DB	U	ALPHA	5.33	3.21	1.28	6.61	4.98	18.10	24	1.49
			BETA	8.63	2.83	1.13	9.77	8.10	17.90	24	4.46
MW-24	1S	U	ALPHA	0.98	0.82	0.33	1.31	1.00	2.50	24	0.00
			BETA	4.82	12.40	4.96	9.78	2.08	62.48	24	0.20
MW-25	1S	D	ALPHA	1.54	1.69	0.68	2.22	1.43	5.30	24	0.04
			BETA	4.55	3.64	1.46	6.01	3.42	18.00	24	1.40
MW-26	1S	D	ALPHA	1.37	1.12	0.45	1.81	1.33	3.93	24	0.17
			BETA	6.06	9.61	3.84	9.90	3.63	48.30	24	0.77
MW-27	1S	D	ALPHA	18.45	33.79	27.04	45.49	4.05	86.17	6	1.00
			BETA	29.09	30.48	24.39	53.47	14.26	81.16	6	5.10
MW-28 (2)	NA	NA	ALPHA	5.76	2.41	2.11	7.87	6.40	8.83	5	2.92
			BETA	8.17	2.71	2.37	10.55	6.50	11.17	5	5.83
MW-29	1S	D	ALPHA	6.43	8.68	3.40	9.84	4.58	47.45	25	2.70
			BETA	8.40	13.21	5.18	13.58	4.51	66.30	25	0.76
MW-30A	UF	D	ALPHA	3.81	5.69	2.38	6.19	2.68	16.57	22	0.20

TABLE 4-37

Quarterly Gross Alpha and Gross Beta Groundwater Sampling Statistics By ARCO/BWXT - April 1991 Through June 2002 - SLDA

Location	Zone	Up (U) or Down (D) Gradient	Analysis	Mean	Std Dev	Confidence	95% UCL	Median	Max	# Events	Min
			BETA	44.95	14.34	5.99	50.94	43.30	84.61	22	12.81
MW-31	UF	D	ALPHA	5.87	9.03	3.69	9.56	3.70	34.40	23	0.46
			BETA	18.89	24.39	9.97	28.86	11.38	126.20	23	4.98
MW-32	1S	U	ALPHA	1.47	0.94	0.39	1.85	1.30	3.40	23	0.10
			BETA	4.89	2.45	1.00	5.89	3.97	12.30	23	2.70
MW-33	2S	U	ALPHA	3.14	2.15	0.92	4.06	2.50	7.00	21	0.60
			BETA	7.85	8.05	3.44	11.29	5.23	38.00	21	1.11
MW-34A	DB	D	ALPHA	4.13	8.73	3.49	7.63	2.69	43.91	24	0.02
			BETA	11.80	17.83	7.13	18.93	5.23	65.30	24	0.18
MW-35	DB	U	ALPHA	3.98	4.91	1.96	5.94	2.40	17.70	24	0.35
			BETA	14.38	18.28	7.31	21.69	8.25	77.10	24	0.73
MW-36	DB	U	ALPHA	3.01	1.98	0.79	3.80	2.71	8.42	24	0.00
			BETA	10.01	10.59	4.24	14.25	7.00	51.80	24	3.23
MW-37	2S	D	ALPHA	NS	NS	NS	NS	NS	NS	NS	NS
			BETA	NS	NS	NS	NS	NS	NS	NS	NS
MW-38	1S	U	ALPHA	1.16	1.09	0.59	1.76	0.90	3.30	13	0.09
			BETA	3.07	1.01	0.55	3.62	3.20	4.62	13	0.20
MW-39	UF	D	ALPHA	3.45	5.45	2.96	6.41	1.90	14.70	13	0.36
			BETA	16.30	9.36	5.09	21.38	17.10	42.75	13	2.81
MW-40	DB	D	ALPHA	2.91	2.57	1.40	4.31	2.60	8.22	13	0.74
			BETA	4.91	3.20	1.74	6.65	3.70	12.69	13	1.70
MW-41	1S	D	ALPHA	2.83	2.17	1.18	4.01	2.30	8.21	13	0.43
			BETA	6.30	6.46	3.51	9.81	4.37	27.30	13	2.92
MW-42	1S	D	ALPHA	4.13	3.46	1.81	5.94	3.75	14.80	14	1.00
			BETA	14.49	18.74	9.82	24.30	8.20	77.30	14	5.18
MW-43	2S	D	ALPHA	1.86	1.34	0.76	2.61	1.57	4.20	12	0.47
			BETA	10.31	19.60	11.09	21.40	4.19	72.19	12	2.60
MW-44	1S	D	ALPHA	6.69	4.10	2.15	8.84	5.91	17.30	14	1.60
			BETA	12.17	15.43	8.08	20.25	6.68	58.50	14	3.60
MW-45	2S	U	ALPHA	4.03	2.65	1.50	5.53	3.72	8.50	12	1.14
			BETA	45.22	52.78	29.86	75.08	24.17	197.90	12	9.99
MW-46	UF	D	ALPHA	5.45	3.67	4.16	9.61	4.88	9.38	3	2.10
			BETA	26.82	22.60	25.57	52.39	20.02	52.04	3	8.40

TABLE 4-37

Quarterly Gross Alpha and Gross Beta Groundwater Sampling Statistics
By ARCO/BWXT - April 1991 Through June 2002 - SLDA

Location	Zone	Up (U) or Down (D) Gradient	Analysis	Mean	Std Dev	Confidence	95% UCL	Median	Max	# Events	Min
PZ-1	SS	D	ALPHA	7.09	15.17	5.26	12.34	3.35	86.89	32	0.47
			BETA	5.22	8.98	3.11	8.33	2.10	46.63	32	0.50
PZ-2	SS	D	ALPHA	4.85	7.22	2.89	7.74	2.45	33.44	24	0.01
			BETA	6.72	7.83	3.13	9.86	3.58	35.33	24	0.50
PZ-3	SS	D	ALPHA	3.01	3.21	1.28	4.29	2.58	15.30	20	0.00
			BETA	8.57	11.62	4.65	13.22	5.75	60.90	20	0.95
PZ-4	SS	D	ALPHA	NS	NS	NS	NS	NS	NS	NS	NS
			BETA	NS	NS	NS	NS	NS	NS	NS	NS
PZ-5	SS	D	ALPHA	NS	NS	NS	NS	NS	NS	NS	NS
			BETA	NS	NS	NS	NS	NS	NS	NS	NS
PZ-6A	SS	D	ALPHA	2.72	7.57	2.62	5.34	0.73	37.27	28	0.00
			BETA	3.09	3.99	1.38	4.48	1.96	22.53	28	0.86
PZ-7	SS	U	ALPHA	0.93	0.96	0.33	1.26	0.65	3.83	30	0.00
			BETA	2.24	1.22	0.42	2.66	2.00	7.39	30	0.62
PZ-8	SS	U	ALPHA	1.39	2.69	0.93	2.32	0.74	11.99	30	0.00
			BETA	3.12	3.66	1.27	4.39	2.20	18.10	30	1.00
PZ-9	SS	U	ALPHA	1.99	6.57	2.28	4.26	0.88	37.76	30	0.04
			BETA	2.89	4.78	1.66	4.55	2.14	28.69	30	0.50

General Note - One half the method detection limit was used in cases where the parameter was not detected.
Results include data from April 1991 through June 2000
NS - Not Sampled
NA - Not applicable due to only one (1) sample analysis.
(1) - MW-18 not sampled due to a bailer lodged in the well casing.
(2) - Well abandoned after installation of new wells during 1995 field work.
SS Subsoil
1S First Shallow Bedrock Zone
2S Second Shallow Bedrock Zone
UF Upper Freeport Coal
DB Deep Bedrock Zone

TABLE 4-38

NUMBER OF TIMES
MAXIMUM GROSS ALPHA OR GROSS BETA CONCENTRATION
EXCEEDED THE DRINKING WATER MCL

Well Location	Maximum Gross Alpha Concentration >15 pCi/L	Date	Maximum Gross Beta Concentration >50 pCi/l	Date	Hydrostratigraphic Unit	Up (U) or Down (D) Gradient from Disposal Area
MW-2	-		1	8/25//97	DB	**U**
MW-3	-		1	3/26/1992	UF	D
MW-6	1	11/3/1994	1	6/2/1998	UF	**U**
MW-11D	1	7/1/1991	-		2S	D
MW-13	1	7/1/1991	-		1S	**U**
MW-16BC	1	5/2/1995	-		DB	**U**
MW-20	3		-		UF	D
MW-22	1	5/15/1997	-		DB	D
MW-23	1	11/7/1995	-		DB	**U**
MW-24	-		1	2/24/1994	1S	**U**
MW-27	2		1	2/20/1996	1S	D
MW-29	1	5/3/1995	1	11/16/1998	1S	D
MW-30A	1	8/27/1996	2		UF	D
MW-31	1	8/11/1998	1	6/11/1998	UF	D
MW-34A	1	2/1/1995	2		DB	D
MW-35	1	8/12/1998	2		DB	**U**
MW-36	-		1	6/12/1998	DB	**U**
MW-42	-		1	11/16/1998	1S	D
MW-43	-		1	5/20/1997	2S	D
MW-44	1	11/17/1998	1	11/17/1998	1S	D
MW-45	-		2		2S	**U**
MW-46	-		1	8/23/1996	UF	D
PZ-01	3		1	8/23/1996	SS	D
PZ-02	2		-		SS	D
PZ-03A	1	8/27/1996	1	6/16/1992	SS	D
PZ-06A	1	7/1/1991	-		SS	D
PZ-09	1	7/1/1991	-		SS	**U**

Dates shown only for one time exceedence
SS Subsoil
1S First Shallow Bedrock
2S Second Shallow Bedrock
UF Upper Freeport
DB Deep Bedrock

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TABLE 4-39

STATISTICAL SUMMARY OF GROUNDWATER CHEMICAL ANALYTICAL RESULTS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections				Location of Max Value
				Min	Max	Avg	StdDev	
Volatile Organic Compounds								
1,1,1-Trichloroethane	UG/L	627	67	0.600	204.0	61.36	84.63	MW-27
1,1,2-Trichloroethane	UG/L	627	1	38.00	38.00	38.00	-	PZ-02
1,1-Dichloroethane	UG/L	625	132	1.00	773.3	79.96	180.6	MW-27
1,1-Dichloroethene	UG/L	626	29	1.00	30.16	12.52	11.10	MW-27
1,2-Dichloroethane	UG/L	582	7	1.00	46.80	9.90	16.45	PZ-01
1,2-Dichloroethene (cis)	UG/L	101	19	1.70	349.6	70.89	184.7	PZ-01
1,2-Dichloroethene (total)	UG/L	447	83	0.500	478.8	101.0	204.4	PZ-01
1,2-Dichloroethene (trans)	UG/L	180	12	3.00	874.6	243.0	653.6	PZ-01
1,3-Dichloropropene (cis)	UG/L	583	1	10.00	10.00	10.00	-	MW-17
1,3-Dichloropropene (trans)	UG/L	583	1	15.00	15.00	15.00	-	MW-12D
2-Hexanone	UG/L	584	2	9.50	9.50	9.50	0.00E+00	MW-33
4-Methyl-2-pentanone	UG/L	584	1	0.600	0.600	0.600	-	MW-16BC
Acetone	UG/L	583	47	0.400	18.00	7.78	5.77	MW-45
Benzene	UG/L	626	29	0.500	6.00	2.20	1.37	MW-41
Bromodichloromethane	UG/L	583	5	2.00	4.00	2.90	1.01	MW-27
Carbon disulfide	UG/L	581	11	0.700	3.70	2.42	1.84	MW-02
Carbon tetrachloride	UG/L	583	1	2.30	2.30	2.30	-	PZ-06A
Chloroethane	UG/L	583	10	1.00	7.78	5.12	4.71	PZ-01

Only Detected Results Reported.

TABLE 4-39

STATISTICAL SUMMARY OF GROUNDWATER CHEMICAL ANALYTICAL RESULTS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections				Location of Max Value
				Min	Max	Avg	StdDev	
Volatile Organic Compounds								
Chloroform	UG/L	583	23	0.700	13.00	7.44	4.91	MW-17
Chloromethane	UG/L	626	2	10.00	11.00	10.50	0.707	PZ-01
Dibromochloromethane	UG/L	583	1	1.00	1.00	1.00	-	MW-40
Ethylbenzene	UG/L	583	1	1.00	1.00	1.00	-	MW-02A
Methyl ethyl ketone (2-Butanone)	UG/L	583	3	0.600	5.15	4.27	4.80	MW-45
Methylene chloride	UG/L	584	21	0.500	51.00	5.05	11.87	MW-01
Toluene	UG/L	584	62	0.600	26.80	3.39	5.99	MW-29
Trichloroethene	UG/L	627	92	1.00	97.46	40.97	36.13	PZ-02
Vinyl chloride	UG/L	627	46	1.00	168.4	82.31	172.5	PZ-01
Xylene (total)	UG/L	584	12	0.400	4.00	1.49	1.15	MW-02A
Semivolatile Organic Compounds								
8-Hydroxyquinoline	UG/L	515	4	1.30	130.0	68.83	70.83	MW-08
bis(2-Ethylhexyl)phthalate	UG/L	48	11	6.00	630.0	68.56	186.3	MW-40
Di-n-butylphthalate	UG/L	48	24	3.20	32.00	13.76	7.14	MW-42
Di-n-octylphthalate	UG/L	48	1	42.00	42.00	42.00	-	MW-40
Tributylphosphate	UG/L	515	38	0.520	1,050	327.4	1,469	PZ-01
Metals								
Aluminum	MG/L	30	30	0.300	27.00	6.46	8.04	MW-13

Only Detected Results Reported.

TABLE 4-39

STATISTICAL SUMMARY OF GROUNDWATER CHEMICAL ANALYTICAL RESULTS

SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections				Location of Max Value
				Min	Max	Avg	StdDev	
Metals								
Antimony	MG/L	30	5	0.003	0.070	0.019	0.029	PZ-08
Arsenic	MG/L	31	15	0.001	0.166	0.028	0.052	MW-30A
Barium	MG/L	31	31	0.020	1.12	0.395	0.342	MW-33
Beryllium	MG/L	31	8	0.001	0.020	0.006	0.006	MW-03
Cadmium	MG/L	31	15	0.005	0.030	0.011	0.007	MW-03
Calcium	MG/L	30	29	9.00	279.0	58.82	60.84	MW-36
Chromium	MG/L	31	19	0.007	0.190	0.049	0.048	MW-04
Cobalt	MG/L	30	7	0.011	0.130	0.050	0.043	MW-03
Copper	MG/L	30	22	0.010	0.220	0.043	0.046	MW-03
Iron	MG/L	31	31	0.600	140.0	27.67	34.01	MW-03
Lead	MG/L	31	25	0.001	0.041	0.010	0.010	PZ-08
Magnesium	MG/L	30	29	0.481	55.00	15.16	12.43	MW-02
Manganese	MG/L	31	31	0.040	3.43	0.675	0.777	MW-36
Mercury	MG/L	31	11	0.0002	0.0005	0.0003	0.0001	MW-04
Nickel	MG/L	30	16	0.017	0.900	0.140	0.224	PZ-01
Potassium	MG/L	30	23	1.00	450.0	24.59	92.86	MW-04
Selenium	MG/L	31	6	0.001	0.003	0.002	0.0006	MW-36
Silver	MG/L	31	2	0.010	0.010	0.010	0.00E+00	PZ-07

Only Detected Results Reported.

TABLE 4-39

STATISTICAL SUMMARY OF GROUNDWATER CHEMICAL ANALYTICAL RESULTS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections				Location of Max Value
				Min	Max	Avg	StdDev	
Metals								
Sodium	MG/L	30	26	2.00	173.0	25.57	49.65	MW-35
Thallium	MG/L	30	4	0.002	0.004	0.003	0.0010	MW-07
Vanadium	MG/L	30	8	0.022	0.080	0.053	0.018	PZ-07
Zinc	MG/L	31	27	0.010	0.850	0.097	0.160	MW-03
Zirconium	MG/L	25	3	10.00	22.00	14.33	6.66	MW-10
Miscellaneous Parameters								
Alkalinity, Bicarbonate (as CaCO3)	MG/L	25	24	1.00	340.0	117.2	97.54	PZ-03A
Alkalinity, Total (as CaCO3)	MG/L	67	62	1.00	449.7	138.8	129.6	MW-04
Ammonia (as N)	MG/L	24	9	0.100	1.70	0.489	0.609	MW-03
Chloride	MG/L	36	36	1.10	26.00	5.68	5.78	PZ-03A
Cyanide	MG/L	24	3	0.010	0.030	0.020	0.010	MW-10
Fluoride	MG/L	36	36	0.020	1.50	0.213	0.260	MW-11D
Nitrate-Nitrite	MG/L	24	5	0.200	1.60	0.600	0.616	MW-11S
Nitrate-Nitrogen	MG/L	11	2	0.500	0.900	0.700	0.283	MW-06
Orthophosphate	MG/L	25	21	0.010	0.550	0.080	0.124	MW-04
pH	S.U.	40	40	2.60	8.30	6.43	1.16	MW-04
pH (Field)	S.U.	502	502	1.90	9.89	6.98	1.59	MW-14
pH (Lab)	S.U.	431	431	1.85	10.53	7.13	1.35	MW-45

Only Detected Results Reported.

TABLE 4-39
STATISTICAL SUMMARY OF GROUNDWATER CHEMICAL ANALYTICAL RESULTS
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections				Location of Max Value
				Min	Max	Avg	StdDev	
Miscellaneous Parameters								
Redox Potential (Field)	mV	17	17	10.00	230.0	141.6	68.76	PZ-07
Redox Potential (Lab)	mV	12	12	350.0	692.0	475.7	79.47	MW-03
Silicon	MG/L	25	25	4.00	39.00	13.04	9.77	MW-13
Specific Conductance	µmhos/cm	52	52	80.00	2,900	576.1	707.6	MW-03
Specific Conductance(Field)	µmhos/cm	503	503	7.89	616.0	581.2	545.0	MW-12D
Specific Conductance(Lab)	µmhos/cm	431	431	4.80	3,767	489.3	596.6	MW-04
Sulfate (as SO4)	MG/L	36	33	6.00	955.0	177.9	287.7	MW-03
Temperature	DEG C	232	232	9.70	15.34	14.12	2.97	MW-39
Temperature (Field)	DEG C	311	311	6.00	13.29	12.31	2.37	MW-25
Temperature (Lab)	DEG C	17	17	9.50	21.30	18.04	4.56	MW-13
Total Dissolved Solids	MG/L	481	479	1.00	441.1	318.2	445.5	PZ-09
Total Organic Carbon (TOC)	MG/L	100	98	0.280	15.00	3.60	3.82	MW-16BC
Total Organic Halogens	UG/L	11	1	38.00	38.00	38.00	-	MW-10
Total Suspended Solids	MG/L	483	477	1.00	2.20E+04	729.2	1,817	MW-28
Turbidity	NTU	120	120	0.990	6,000	533.8	1,053	MW-36

Only Detected Results Reported.

TABLE 4-40

SUMMARY OF GROUNDWATER CHEMCAL DATA EXCEEDENCES

Parameter	Wells Where Parameter Detected	Hydro-Stratigraphic Zone	Maximum Value Detected	PA Act II Standard*
Volatile Organics			ug/L	ug/L
Benzene	MW-41	1S	6	5
1,1,1-Trichloroethane	MW-27	1S	390	200
	MW-44	1S	260	
	PZ-02	SS	38	
1,1,2-Trichloroethane	PZ-02	SS	38	27
1,1-Dichloroethane	MW-10	Abandoned	69	27
	MW-12D	1S	85	
	MW-27	1S	1100	
	MW-28	1S	140	
	MW-44	1S	280	
	PZ-01	SS	450	
	PZ-02	SS	83	
	PZ-03A	SS	300	
	PZ-06A	SS	69	
1,1-Dichloroethene	MW-27	1S	45	7
	MW-28	1S	11	
	MW-44	1S	22	
	PZ-06A	SS	12	
1,2-Dichloroethane	MW-27	1S	6.7	5
	PZ-01	SS	46.8	
1,2-Dichloroethene (cis)	PZ-01	SS	810	70
1,2-Dichloroethene (trans)	PZ-01	SS	2300	100
1,3-Dichloropropene (cis)	MW-17	2S	10	6.6
1,3-Dichloropropene (trans)	MW-12D	1S	15	6.6
Trichloroethene	MW-12D	1S	26	5
	MW-26	1S	44	
	MW-29	1S	74	
	PZ-01	SS	140	
	PZ-02	SS	150	
Vinyl chloride	MW-10	Abandoned	130	2
	MW-12D	1S	43	
	MW-25	1S	6.8	
	PZ-01	SS	880	
	PZ-02	SS	4	
	PZ-06A	SS	7.7	
Semivolatile Organics				
bis(2-Ethylhexyl)phthalate	MW-32	1S	12	6
	MW-35	DB	22	
	MW-38	1S	6.1	
	MW-39	UF	6.6	
	MW-40	DB	630	
	MW-41	1S	6.5	
	MW-42	1S	13	
	MW-43	2S	10	
	MW-44	1S	24	
	MW-45	2S	18	
Pentachlorophenol	MW-24	1S	15	1

TABLE 4-40

SUMMARY OF GROUNDWATER CHEMCAL DATA EXCEEDENCES

Parameter	Wells Where Parameter Detected	Hydro-Stratigraphic Zone	Maximum Value Detected	PA Act II Standard*
Metals				
Aluminum	MW-01	UF	0.4	0.2
	MW-02	DB	0.3	
	MW-02A	UF	2.2	
	MW-03	UF	19	
	MW-04	Abandoned	1.7	
	MW-05	UF	0.9	
	MW-06	UF	1.3	
	MW-07	1S	0.3	
	MW-08	1S	0.4	
	MW-09A	1S	0.7	
	MW-10	Abandoned	0.5	
	MW-11S	SS	11	
	MW-11D	2S	11	
	MW-12D	1S	1.2	
	MW-13	1S	27	
	MW-14	1S	0.4	
	MW-15	1S	2.2	
	MW-32	1S	0.706	
	MW-33	2S	5.66	
	MW-34A	DB	1.6	
	MW-35	DB	2.27	
	MW-36	DB	2.8	
	PZ-01	SS	15	
	PZ-02	SS	5.8	
	PZ-03A	SS	4.9	
	PZ-06A	SS	12	
	PZ-07	SS	20	
	PZ-08	SS	18	
	PZ-09	SS	24	
Antimony	MW-35	DB	0.0085	0.006
	PZ-08	SS	0.07	
Arsenic	MW-03	UF	0.14	0.05
	MW-30A	UF	0.166	
Beryllium	MW-02	DB	0.007	0.004
	MW-03	UF	0.02	
	MW-36	DB	0.0102	
	PZ-01	SS	0.005	
Cadmium	MW-02	DB	0.017	0.005
	MW-02A	UF	0.007	
	MW-03	UF	0.03	
	MW-11S	SS	0.007	
	MW-33	2S	0.0064	
	MW-36	DB	0.0123	
	PZ-01	SS	0.013	
	PZ-06A	SS	0.008	
	PZ-07	SS	0.019	
	PZ-08	SS	0.019	
	PZ-09	SS	0.01	
Chromium	MW-04	UF	0.19	0.1
	MW-35	DB	0.154	

TABLE 4-40

SUMMARY OF GROUNDWATER CHEMCAL DATA EXCEEDENCES

Parameter	Wells Where Parameter Detected	Hydro-Stratigraphic Zone	Maximum Value Detected	PA Act II Standard*
Iron	MW-01	UF	0.7	0.3
	MW-02	DB	98	
	MW-02A	UF	5.1	
	MW-03	UF	140	
	MW-04	UF	4.7	
	MW-05	UF	4.8	
	MW-06	UF	11	
	MW-07	1S	0.6	
	MW-08	1S	1.5	
	MW-09A	1S	1.8	
	MW-10	Abandoned	1.9	
	MW-11D	2S	35	
	MW-11S	SS	36	
	MW-12D	1S	3.5	
	MW-13	1S	56	
	MW-14	1S	4.5	
	MW-15	1S	3.1	
	MW-30A	UF	18.3	
	MW-32	1S	2.17	
	MW-33	2S	37.7	
	MW-34A	DB	1.47	
	MW-35	DB	3.19	
	MW-36	DB	46.8	
	PZ-01	SS	56	0.3
	PZ-02	SS	21	
	PZ-03A	SS	16	
	PZ-06A	SS	44	
	PZ-07	SS	69	
	PZ-08	SS	66	
	PZ-09	SS	67	
Lead	MW-02A	UF	0.006	0.005
	MW-03	UF	0.01	
	MW-11D	2S	0.014	
	MW-11S	SS	0.018	
	MW-33	2S	0.0072	
	MW-35	DB	0.0087	
	MW-36	DB	0.0209	
	PZ-01	SS	0.027	0.005
	PZ-02	SS	0.007	
	PZ-03A	SS	0.007	
	PZ-06A	SS	0.019	
	PZ-07	SS	0.023	
	PZ-08	SS	0.041	
	PZ-09	SS	0.019	

TABLE 4-40

SUMMARY OF GROUNDWATER CHEMCAL DATA EXCEEDENCES

Parameter	Wells Where Parameter Detected	Hydro-Stratigraphic Zone	Maximum Value Detected	PA Act II Standard*
Manganese	MW-02	DB	1.9	0.05
	MW-02A	UF	0.14	
	MW-03	UF	1.9	
	MW-04	UF	0.16	
	MW-05	UF	0.94	
	MW-06	UF	1.1	
	MW-07	1S	0.1	
	MW-08	1S	0.06	
	MW-09A	1S	0.09	
	MW-10	1S	0.22	
	MW-10	1S	0.16	
	MW-11D	2S	0.53	
	MW-11S	SS	0.83	
	MW-12D	1S	0.3	
	MW-13	1S	0.6	
	MW-14	1S	0.28	
	MW-15	1S	0.16	
	MW-30A	UF	0.571	
	MW-32	1S	0.114	
	MW-33	2S	1.08	
	MW-34A	DB	0.166	
	MW-35	DB	0.0754	
	MW-36	DB	3.43	
	PZ-01	SS	1.8	
	PZ-02	SS	0.37	
	PZ-03A	SS	0.31	
	PZ-06A	SS	0.5	
	PZ-07	SS	0.62	
	PZ-08	SS	1.9	
	PZ-09	SS	0.48	
Nickel	MW-02	DB	0.17	0.1
	MW-03	UF	0.42	
Thallium	MW-07	1S	0.004	0.002
	MW-09A	1S	0.003	

TABLE 4-41
STATISTICAL SUMMARY OF AIR SAMPLE RESULTS FOR ASL-01
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241	uCi/mL	10	-	-	-	-	-	-
Americium 241 (alpha)	uCi/mL	8	-	-	-	-	-	-
Americium 241 (gamma)	uCi/mL	8	-	-	-	-	-	-
Radium 228	uCi/mL	24	7	7.93E-16	2.29E-15	2.3	8.8	ASL-01
Thorium 232	uCi/mL	11	-	-	-	-	-	-
Uranium 234	uCi/mL	22	1	10.0	10.0	4.5	2.1	ASL-01
Uranium 235	uCi/mL	1	-	-	-	-	-	-
Uranium 235 (alpha)	uCi/mL	24	-	-	-	-	-	-
Uranium 235 (gamma)	uCi/mL	14	-	-	-	-	-	-
Uranium 238	uCi/mL	23	-	-	-	-	-	-
Secondary Radionuclides								
Cesium 137	uCi/mL	24	-	-	-	-	-	-
Cobalt 60	uCi/mL	24	-	-	-	-	-	-
Gross Alpha	uCi/mL	24	15	3.56E-16	7.52E-15	2.2	1.2	ASL-01
Gross Beta	uCi/mL	24	24	9.07E-15	3.43E-14	1.83E-14	6.60E-15	ASL-01
Radium 226	uCi/mL	24	10	8.54E-16	0.29	2.0	7.4	ASL-01
Thorium 230	uCi/mL	12	5	1.61E-16	9.09E-15	1.35E-15	2.56E-15	ASL-01
Other Radionuclides								

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-41
STATISTICAL SUMMARY OF AIR SAMPLE RESULTS FOR ASL-01
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Other Radionuclides								
Beryllium 7	uCi/mL	15	15	3.65E-14	1.00E-13	6.86E-14	1.92E-14	ASL-01
Bismuth 212	uCi/mL	15	-	-	-	-	-	-
Lead 212	uCi/mL	15	-	-	-	-	-	-
Lead 214	uCi/mL	15	-	-	-	-	-	-
Potassium 40	uCi/mL	15	-	-	-	-	-	-
Thorium 234	uCi/mL	15	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-42
STATISTICAL SUMMARY OF AIR SAMPLE RESULTS FOR ASL-02
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241	uCi/mL	10	-	-	-	-	-	-
Americium 241 (alpha)	uCi/mL	6	-	-	-	-	-	-
Americium 241 (gamma)	uCi/mL	8	-	-	-	-	-	-
Radium 228	uCi/mL	24	8	4.32E-16	2.71E-15	1.3	7.2	ASL-02
Thorium 232	uCi/mL	12	-	-	-	-	-	-
Uranium 234	uCi/mL	24	2	2.51E-16	1.17E-15	3.5	1.7	ASL-02
Uranium 235	uCi/mL	1	-	-	-	-	-	-
Uranium 235 (alpha)	uCi/mL	24	-	-	-	-	-	-
Uranium 235 (gamma)	uCi/mL	14	-	-	-	-	-	-
Uranium 238	uCi/mL	23	-	-	-	-	-	-
Secondary Radionuclides								
Cesium 137	uCi/mL	24	-	-	-	-	-	-
Cobalt 60	uCi/mL	23	-	-	-	-	-	-
Gross Alpha	uCi/mL	24	17	3.66E-16	1.02E-14	4.9	1.9	ASL-02
Gross Beta	uCi/mL	24	24	1.19E-14	3.73E-14	1.96E-14	6.55E-15	ASL-02
Radium 226	uCi/mL	24	10	1.64E-15	8.48E-15	2.58E-15	2.16E-15	ASL-02
Thorium 230	uCi/mL	12	2	3.87E-16	5.15E-15	8.09E-16	1.40E-15	ASL-02
Other Radionuclides								

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-42
STATISTICAL SUMMARY OF AIR SAMPLE RESULTS FOR ASL-02
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Other Radionuclides								
Beryllium 7	uCi/mL	15	15	4.86E-14	9.75E-14	7.35E-14	1.72E-14	ASL-02
Bismuth 212	uCi/mL	15	-	-	-	-	-	-
Lead 212	uCi/mL	15	-	-	-	-	-	-
Lead 214	uCi/mL	15	-	-	-	-	-	-
Potassium 40	uCi/mL	15	1	1.76E-14	1.76E-14	0.65	2.7	ASL-02
Thorium 234	uCi/mL	15	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-43
STATISTICAL SUMMARY OF AIR SAMPLE RESULTS FOR ASL-03
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241	uCi/mL	10	-	-	-	-	-	-
Americium 241 (alpha)	uCi/mL	8	-	-	-	-	-	-
Americium 241 (gamma)	uCi/mL	8	-	-	-	-	-	-
Radium 228	uCi/mL	24	6	5.10E-16	2.47E-15	2.2	8.5	ASL-03
Thorium 232	uCi/mL	12	-	-	-	-	-	-
Uranium 234	uCi/mL	23	2	9.74E-16	2.01E-15	4.1	2.0	ASL-03
Uranium 235	uCi/mL	1	-	-	-	-	-	-
Uranium 235 (alpha)	uCi/mL	23	1	2.84E-16	2.84E-16	4.1	0.02	ASL-03
Uranium 235 (gamma)	uCi/mL	14	-	-	-	-	-	-
Uranium 238	uCi/mL	22	1	2.33E-15	2.33E-15	4.3	0.02	ASL-03
Secondary Radionuclides								
Cesium 137	uCi/mL	24	-	-	-	-	-	-
Cobalt 60	uCi/mL	24	-	-	-	-	-	-
Gross Alpha	uCi/mL	24	17	3.64E-16	1.03E-14	6.4	0.025	ASL-03
Gross Beta	uCi/mL	24	24	1.17E-14	4.17E-14	2.17E-14	7.29E-15	ASL-03
Radium 226	uCi/mL	24	4	3.08E-15	1.02E-14	2.21E-15	1.91E-15	ASL-03
Thorium 230	uCi/mL	12	5	4.16E-16	4.83E-15	1.07E-15	1.40E-15	ASL-03
Other Radionuclides								

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-43
STATISTICAL SUMMARY OF AIR SAMPLE RESULTS FOR ASL-03
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Other Radionuclides								
Beryllium 7	uCi/mL	15	15	4.45E-14	6.8	0.8	2.3	ASL-03
Bismuth 212	uCi/mL	15	-	-	-	-	-	-
Lead 212	uCi/mL	15	1	5.77E-15	5.77E-15	0.064	0.26	ASL-03
Lead 214	uCi/mL	15	-	-	-	-	-	-
Potassium 40	uCi/mL	15	-	-	-	-	-	-
Thorium 234	uCi/mL	15	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-44
STATISTICAL SUMMARY OF AIR SAMPLE RESULTS FOR ASL-04
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241	uCi/mL	10	-	-	-	-	-	-
Americium 241 (alpha)	uCi/mL	8	-	-	-	-	-	-
Americium 241 (gamma)	uCi/mL	8	-	-	-	-	-	-
Radium 228	uCi/mL	24	9	5.99E-16	2.89E-15	1.23E-15	7.41E-16	ASL-04
Thorium 232	uCi/mL	12	-	-	-	-	-	-
Uranium 234	uCi/mL	24	1	6.76E-15	6.76E-15	3.5	1.7	ASL-04
Uranium 235	uCi/mL	1	-	-	-	-	-	-
Uranium 235 (alpha)	uCi/mL	24	1	5.83E-15	5.83E-15	1.1	5.4	ASL-04
Uranium 235 (gamma)	uCi/mL	14	-	-	-	-	-	-
Uranium 238	uCi/mL	24	2	7.82E-16	3.16E-15	3.5	1.7	ASL-04
Secondary Radionuclides								
Cesium 137	uCi/mL	23	-	-	-	-	-	-
Cobalt 60	uCi/mL	24	-	-	-	-	-	-
Gross Alpha	uCi/mL	24	16	3.04E-16	9.59E-15	5.2	2.0	ASL-04
Gross Beta	uCi/mL	24	24	1.23E-14	3.93E-14	2.01E-14	6.65E-15	ASL-04
Radium 226	uCi/mL	24	8	1.02E-15	9.17E-15	2.42E-15	1.96E-15	ASL-04
Thorium 230	uCi/mL	12	4	1.34E-15	4.86E-15	1.31E-15	1.65E-15	ASL-04
Other Radionuclides								

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-44
STATISTICAL SUMMARY OF AIR SAMPLE RESULTS FOR ASL-04
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Other Radionuclides								
Beryllium 7	uCi/mL	15	14	5.28E-14	1.08E-13	7.45E-14	2.59E-14	ASL-04
Bismuth 212	uCi/mL	15	-	-	-	-	-	-
Lead 212	uCi/mL	15	-	-	-	-	-	-
Lead 214	uCi/mL	15	-	-	-	-	-	-
Potassium 40	uCi/mL	15	-	-	-	-	-	-
Thorium 234	uCi/mL	15	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-45
STATISTICAL SUMMARY OF AIR SAMPLE RESULTS FOR ASL-05
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241	uCi/mL	10	-	-	-	-	-	-
Americium 241 (alpha)	uCi/mL	8	-	-	-	-	-	-
Americium 241 (gamma)	uCi/mL	8	-	-	-	-	-	-
Radium 228	uCi/mL	24	10	5.21E-16	3.62E-15	2.2	7.1	ASL-05
Thorium 232	uCi/mL	11	-	-	-	-	-	-
Uranium 234	uCi/mL	22	-	-	-	-	-	-
Uranium 235	uCi/mL	1	-	-	-	-	-	-
Uranium 235 (alpha)	uCi/mL	21	-	-	-	-	-	-
Uranium 235 (gamma)	uCi/mL	14	-	-	-	-	-	-
Uranium 238	uCi/mL	23	-	-	-	-	-	-
Secondary Radionuclides								
Cesium 137	uCi/mL	23	-	-	-	-	-	-
Cobalt 60	uCi/mL	24	-	-	-	-	-	-
Gross Alpha	uCi/mL	24	19	2.34E-16	8.26E-15	1.51E-15	1.76E-15	ASL-05
Gross Beta	uCi/mL	24	24	9.80E-15	3.62E-14	1.95E-14	6.09E-15	ASL-05
Radium 226	uCi/mL	24	10	1.09E-15	1.29E-14	2.9	0.1	ASL-05
Thorium 230	uCi/mL	12	7	3.33E-16	8.80E-15	1.83E-15	2.66E-15	ASL-05
Other Radionuclides								

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-45
STATISTICAL SUMMARY OF AIR SAMPLE RESULTS FOR ASL-05
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Other Radionuclides								
Beryllium 7	uCi/mL	15	15	4.09E-14	1.05E-13	7.26E-14	1.54E-14	ASL-05
Bismuth 212	uCi/mL	15	-	-	-	-	-	-
Lead 212	uCi/mL	15	-	-	-	-	-	-
Lead 214	uCi/mL	15	-	-	-	-	-	-
Potassium 40	uCi/mL	15	-	-	-	-	-	-
Thorium 234	uCi/mL	15	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-46
STATISTICAL SUMMARY OF AIR SAMPLE RESULTS FOR ASL-01 THROUGH ASL-05
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Primary Radionuclides								
Americium 241	uCi/mL	50	-	-	-	-	-	-
Americium 241 (alpha)	uCi/mL	38	-	-	-	-	-	-
Americium 241 (gamma)	uCi/mL	40	-	-	-	-	-	-
Radium 228	uCi/mL	120	40	4.32E-16	3.62E-15	1.3	6.6	ASL-05
Thorium 232	uCi/mL	58	-	-	-	-	-	-
Uranium 234	uCi/mL	115	6	2.51E-16	10.0	4.8	2.4	ASL-01
Uranium 235	uCi/mL	5	-	-	-	-	-	-
Uranium 235 (alpha)	uCi/mL	116	2	2.84E-16	5.83E-15	3.2	0.016	ASL-04
Uranium 235 (gamma)	uCi/mL	70	-	-	-	-	-	-
Uranium 238	uCi/mL	115	3	7.82E-16	3.16E-15	2.9	1.6	ASL-04
Secondary Radionuclides								
Cesium 137	uCi/mL	118	-	-	-	-	-	-
Cobalt 60	uCi/mL	119	-	-	-	-	-	-
Gross Alpha	uCi/mL	120	84	2.34E-16	1.03E-14	3.6	1.7	ASL-03
Gross Beta	uCi/mL	120	120	9.07E-15	4.17E-14	2.00E-14	6.62E-15	ASL-03
Radium 226	uCi/mL	120	42	8.54E-16	0.29	10	5.9	ASL-01
Thorium 230	uCi/mL	60	23	1.61E-16	9.09E-15	1.27E-15	1.97E-15	ASL-01
Other Radionuclides								

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 4-46
STATISTICAL SUMMARY OF AIR SAMPLE RESULTS FOR ASL-01 THROUGH ASL-05
SLDA

Parameter	Units	No. of Usable Results	No. of Detections	Range of Detections*				Location of Max Value
				Min	Max	Avg	StdDev	
Other Radionuclides								
Beryllium 7	uCi/mL	75	74	3.65E-14	6.8	0.17	1.1	ASL-03
Bismuth 212	uCi/mL	75	-	-	-	-	-	-
Lead 212	uCi/mL	75	1	5.77E-15	5.77E-15	0.093	0.29	ASL-03
Lead 214	uCi/mL	75	-	-	-	-	-	-
Potassium 40	uCi/mL	75	1	1.76E-14	1.76E-14	0.75	2.8	ASL-02
Thorium 234	uCi/mL	75	-	-	-	-	-	-

Minimum and maximum values are reported for detection data only.

Average and standard deviation values were calculated using one-half the detection limit for non-detected data.

TABLE 6-1
PRELIMINARY REMEDIATION GOALS (PRGs)
FOR THE PRIMARY ROPCs AT THE SLDA

Radionuclide	PRG (pCi/g) [a]
Americium-241	27.7
Plutonium-239	32.6
Plutonium-241	892
Radium-228	1.69
Thorium-232	1.35
Uranium-234	96.4
Uranium-235	34.6
Uranium-238	123

[a] The PRGs represent radionulclide concentrations in soil in excess of background levels.

TABLE 6-2

BACKGROUND CONCENTRATIONS OF THE PRIMARY AND SECONDARY ROPCs AT THE SLDA[a]

Radionuclide	Soil Concentration (pCi/g)		
	Surface	Subsurface	Composite
Primary ROPCs			
Americium-241[b]	0.0	0.0	0.0
Plutonium-239[b]	0.0	0.0	0.0
Plutonium-241[b]	0.0	0.0	0.0
Radium-228	1.42	1.66	1.61
Thorium-232	1.31	1.77	1.68
Uranium-234	1.32	1.28	1.29
Uranium-235	0.19	0.27	0.25
Uranium-238	1.25	1.41	1.38
Secondary ROPCs			
Cesium-137[b]	0.79	0.0	0.16
Cobalt-60[b]	0.0	0.0	0.0
Plutonium-238[b]	0.0	0.0	0.0
Plutonium-240[b,c]	0.0	0.0	0.0
Plutonium-242[b]	0.0	0.0	0.0
Radium-226	1.32	1.32	1.32
Thorium-230	1.24	1.16	1.18

[a] The background soil concentrations for surface and subsurface soil are the maximum measured values, as these values exceeded the 95% UTL with 95% coverage of the measured concentrations as described in the text. The background soil samples were collected at 18 locations at Galpin/Leechburg Community Park. The surface value represents the concentration in the top 15 cm (6 in.) of soil, and the subsurface value represents the value from 60 cm (2 ft) to 1.2 m (4 ft) below the surface. The composite represents the weighted average value for surface and subsurface soil. All values are given to two decimal places.

[b] The concentrations of these radionuclides (which are not naturally occurring) were below the minimum detectable concentrations. The background values for these radionuclides were taken to be 0.0 pCi/g. The surface soil concentration for cesium-137 represents the fallout contribution from previous atmospheric tests of nuclear weapons.

[c] Pu-240 was not reported separately by the analytical laboratory, but was combined with Pu-239 and reported as Pu-239/240. Since the reported background values for Pu-239/240 were zero, the background concentration of Pu-240 is zero.

TABLE 6-3
PRIMARY EXPOSURE PATHWAYS EVALUATED FOR THE SLDA SITE[a]

		Current-Use Scenarios		*Future-Use Scenarios*	
Medium	Exposure Route	Maintenance Worker	Adolescent Trespasser	Construction Worker	Subsistence Farmer
Air	Inhalation	×	×	×	×
Surface soil	Gamma irradiation	×	×	×	×
	Incidental ingestion	×	×	×	×
Subsurface soil	Gamma irradiation	×	×	×	×
	Incidental ingestion			×	×
Sediment	Gamma irradiation		×	×	×
	Incidental ingestion		×	×	×
Surface water	Incidental ingestion		×	×	×
Groundwater	Incidental ingestion			×	×
	Ingestion				×
Produce	Ingestion				×
Beef and poultry	Ingestion				×
Dairy products	Ingestion				×
Fish	Ingestion				×

[a] The two current-use scenarios address hypothetical receptors who could reasonably be exposed to site contaminants in the next several years based on existing site conditions and access restrictions. The two future-use scenarios address hypothetical receptors who could be exposed to site contaminants within the next 1,000 years and assume loss of institutional controls. While the two current-use receptors are not directly exposed to subsurface soil, gamma rays emitted from radionuclides in subsurface soil can penetrate through the overlying soil and impact these individuals. Hence, the gamma irradiation pathway for subsurface soil is indicated for these two hypothetical receptors. Also, exposures to contaminated surface water are indicated for completeness, but are not addressed quantitatively in this risk assessment as nearby surface water bodies have been determined to either be uncontaminated (Carnahan Run) or contain very low levels of contamination (Dry Run) in the recent site characterization program.

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Background Surface (0-6")																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	17	17	-	-	0.05-0.19	0.06	-	-	-	-	-	-	28	0.00	-	-	
Plutonium 239	pCi/g	16	16	-	-	0.03-0.13	0.04	-	-	-	-	-	-	33	0.00	-	-	
Plutonium 241	pCi/g	18	18	-	-	8.44-13.2	5.33	-	-	-	-	-	-	890	0.00	-	-	
Radium 228	pCi/g	18	0	0.92-1.42	BK-018	0.06-0.19	1.07	1.07	0.11	No	1.12E+00	No	-	1.7	1.42	-	-	
Thorium 232	pCi/g	18	0	0.74-1.31	BK-002	0.02-0.12	1.06	1.06	0.16	Yes	1.13E+00	No	-	1.4	1.31	-	-	
Uranium 234	pCi/g	18	0	0.72-1.32	BK-018	0.03-0.31	0.94	0.94	0.19	Yes	1.02E+00	No	-	96	1.32	-	-	
Uranium 235 (alpha)	pCi/g	18	15	0.17-0.19	BK-008	0.04-0.17	0.07	0.18	0.05	No	9.27E-02	No	-	35	0.19	-	-	
Uranium 238	pCi/g	18	0	0.74-1.25	BK-016	0.04-0.13	0.98	0.98	0.14	Yes	1.03E+00	No	-	120	1.25	-	-	
Secondary ROPC																		
Cesium 137	pCi/g	18	0	0.18-0.79	BK-011	0.02-0.06	0.45	0.45	0.19	Yes	5.25E-01	No	-	-	0.79	-	-	
Cobalt 60	pCi/g	18	18	-	-	0.02-0.06	0.02	-	-	-	-	-	-	-	0.00	-	-	
Plutonium 238	pCi/g	2	2	-	-	0.07-0.08	0.04	-	-	-	-	-	-	-	0.00	-	-	Two values
Plutonium 242	pCi/g	1	1	-	-	0.07-0.07	0.03	-	-	-	-	-	-	-	0.00	-	-	One value
Radium 226	pCi/g	18	0	0.72-1.32	BK-017	0.03-0.1	0.99	0.99	0.14	Yes	1.04E-00	No	-	-	1.32	-	-	
Thorium 230	pCi/g	2	0	1.18-1.24	BK-004	0.06-0.07	1.21	1.21	0.04	-	-	-	-	-	1.24	-	-	Two values
Background Subsurface (2' - 4')																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	17	17	-	-	0.03-0.18	0.06	-	-	-	-	-	-	28	0.00	-	-	
Plutonium 239	pCi/g	17	17	-	-	0.06-0.13	0.05	-	-	-	-	-	-	33	0.00	-	-	
Plutonium 241	pCi/g	18	18	-	-	9.48-13.6	5.42	-	-	-	-	-	-	890	0.00	-	-	
Radium 228	pCi/g	18	0	1.2-1.66	BK-004	0.06-0.2	1.44	1.44	0.11	Yes	1.48E+00	No	-	1.7	1.66	-	-	
Thorium 232	pCi/g	18	1	1.1-1.77	BK-002	0.02-0.29	1.43	1.51	0.36	No	2.06E+00	Yes	-	1.4	1.77	-	-	
Uranium 234	pCi/g	18	0	0.72-1.28	BK-017	0.07-0.33	1.08	1.08	0.14	Yes	1.14E-00	No	-	96	1.28	-	-	
Uranium 235 (alpha)	pCi/g	18	14	0.17-0.27	BK-008	0.04-0.22	0.08	0.21	0.08	No	1.22E-01	No	-	35	0.27	-	-	
Uranium 238	pCi/g	18	0	0.71-1.41	BK-008	0.04-0.22	1.05	1.05	0.18	Yes	1.12E-00	No	-	120	1.41	-	-	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Background Subsurface (2' - 4')																		
Soil																		
Secondary ROPC																		
Cesium 137	pCi/g	17	17	-	-	0.02-0.08	0.02	-	-	-	-	-	-	-	0.00	-	-	
Cobalt 60	pCi/g	18	18	-	-	0.02-0.06	0.02	-	-	-	-	-	-	-	0.00	-	-	
Plutonium 238	pCi/g	2	2	-	-	0.07-0.12	0.05	-	-	-	-	-	-	-	0.00	-	-	Two values
Plutonium 242	pCi/g	2	2	-	-	0.12-0.14	0.07	-	-	-	-	-	-	-	0.00	-	-	Two values
Radium 226	pCi/g	18	0	0.82-1.32	BK-016	0.03-0.09	1.04	1.04	0.15	Yes	1.10E+00	No	-	-	1.32	-	-	
Thorium 230	pCi/g	2	0	1.05-1.16	BK-015	0.11-0.13	1.10	1.10	0.07	-	-	-	-	-	1.16	-	-	Two values

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
EU 1 Current Use [Area in Vicinity of Trenches 1-9 Surface (Depths 0-6")]																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	58	58	-	-	0.03-0.41	0.07	-	-	-	-	-	0.00	28	0.00	0	0.00	
Plutonium 239	pCi/g	57	57	-	-	0.03-0.16	0.04	-	-	-	-	-	0.00	33	0.00	0	0.00	
Plutonium 241	pCi/g	58	57	25.4-25.4	GB-055	5.87-13.3	5.45	25.40	2.79	No	5.72E+00	No	5.72	890	0.00	1	5.72	
Radium 228	pCi/g	62	0	0.8-2.23	GB-051	0.05-0.25	1.27	1.27	0.24	No	1.32E+00	No	1.32	1.7	1.42	14	0.00	
Thorium 232	pCi/g	62	0	0.45-1.73	GB-043	0.02-0.15	1.22	1.22	0.25	No	1.29E+00	No	1.29	1.4	1.31	21	0.00	
Uranium 234	pCi/g	62	0	0.57-71.3	GB-084	0.04-0.38	6.73	6.73	10.03	No	8.72E+00	No	8.72	96	1.32	51	7.40	
Uranium 235 (alpha)	pCi/g	62	19	0.07-3.97	GB-084	0.04-0.29	0.48	0.66	0.65	No	7.76E-01	No	0.78	35	0.19	38	0.59	
Uranium 238	pCi/g	62	0	0.44-17.0	GB-084	0.03-0.31	1.78	1.78	2.21	No	1.90E+00	No	1.90	120	1.25	31	0.65	
Secondary ROPC																		
Cesium 137	pCi/g	61	24	0.03-1.16	GB-025	0.01-0.06	0.17	0.26	0.23	No	2.66E-01	No	0.27	-	0.79	2	0.00	
Cobalt 60	pCi/g	60	60	-	-	0.02-0.07	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 238	pCi/g	6	6	-	-	0.04-0.27	0.07	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 242	pCi/g	5	5	-	-	0.03-0.19	0.04	-	-	-	-	-	0.00	-	0.00	0	0.00	
Radium 226	pCi/g	62	0	0.72-1.59	GB-051	0.03-0.11	1.00	1.00	0.14	No	1.03E+00	No	1.03	-	1.32	1	0.00	
Thorium 230	pCi/g	6	0	0.96-1.53	GB-084	0.02-0.08	1.40	1.40	0.22	No	1.66E+00	Yes	1.53	-	1.24	5	0.29	
Area in Vicinity of Trenches 1-9 Subsurface (Depths +6")																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	112	112	-	-	0.03-0.38	0.07	-	-	-	-	-	0.00	28	0.00	0	0.00	
Plutonium 239	pCi/g	108	107	0.12-0.12	GB-043	0.03-0.28	0.04	0.12	0.02	No	460E-02	No	0.05	33	0.00	1	0.05	
Plutonium 241	pCi/g	112	109	13.9-27.4	GB-052	7.08-15.3	5.83	20.57	2.74	No	6.01E+00	No	6.01	890	0.00	3	6.01	
Radium 228	pCi/g	116	0	0.68-2.19	GB-019	0.04-0.24	1.38	1.38	0.35	Yes	1.44E+00	No	1.44	1.7	1.66	28	0.00	
Thorium 232	pCi/g	116	0	0.34-2.2	GB-036	0.01-0.26	1.31	1.31	0.39	Yes	1.37E+00	No	1.37	1.4	1.77	15	0.00	
Uranium 234	pCi/g	116	0	0.49-508.0	GB-043	0.04-038	9.43	9.43	51.91	No	3.06E+00	No	3.60	96	1.28	52	2.32	
Uranium 235 (alpha)	pCi/g	116	81	0.06-46.9	GB-043	0.03-0.29	0.82	2.57	4.74	No	2.86E-01	No	0.29	35	0.27	17	0.02	
Uranium 238	pCi/g	116	1	0.37-36.9	GB-043	0.01-0.25	1.84	1.86	3.79	No	1.77E+00	No	1.77	120	1.41	39	0.36	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Area in Vicinity of Trenches 1-9 Subsurface (Depths +6")																		
Soil																		
Secondary ROPC																		
Cesium 137	pCi/g	111	108	0.07-0.26	GB-023	0.01-0.1	0.02	0.18	0.03	No	2.26E-02	No	0.02	-	0.00	3	0.02	
Cobalt 60	pCi/g	116	116	-	-	0.01-0.07	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 238	pCi/g	12	12	-	-	0.04-0.29	0.07	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 242	pCi/g	10	9	0.15-0.15	GB-050	0.04-0.16	0.06	0.15	0.04	No	8.79E-02	No	0.09	-	0.00	1	0.09	
Radium 226	pCi/g	116	0	0.54-2.26	GB-092	0.02-0.12	1.02	1.02	0.27	No	1.06E+00	No	1.06	-	1.32	13	0.00	
Thorium 230	pCi/g	12	0	0.47-2.4	GB-081	0.02-0.1	1.22	1.22	0.48	Yes	1.47E+00	No	1.47	-	1.16	7	0.31	
EU 1 Future Use [Area in Vicinity of Trenches 1-9 Composite (all depths)]																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	170	170	-	-	0.03-0.41	0.07	-	-	-	-	-	0.00	28	0.00	0	0.00	
Plutonium 239	pCi/g	165	164	0.12-0.12	GB-043	0.03-0.28	0.04	0.12	0.02	No	4.32E-02	No	0.04	33	0.00	1	0.04	
Plutonium 241	pCi/g	170	166	13.9-27.4	GB-052	5.87-15.3	5.7	21.78	2.75	No	5.83E+00	No	5.83	890	0.00	4	5.83	
Radium 228	pCi/g	178	0	0.68-2.23	GB-051	0.04-0.25	1.34	1.34	0.32	Yes	1.38E+00	No	1.38	1.7	1.61	36	0.00	
Thorium 232	pCi/g	178	0	0.34-2.2	GB-036	0.01-0.26	1.28	1.28	0.35	Yes	1.32E+00	No	1.32	1.4	1.68	25	0.00	
Uranium 234	pCi/g	178	0	0.49-508.0	GB-043	0.04-0.38	8.49	8.49	42.28	No	5.02E+00	No	5.02	96	1.29	102	3.73	
Uranium 235 (alpha)	pCi/g	178	100	0.06-46.9	GB-043	0.03-0.29	0.70	1.52	3.84	No	4.01E-01	No	0.40	35	0.25	50	0.15	
Uranium 238	pCi/g	178	1	0.37-36.9	GB-043	0.01-0.31	1.82	1.83	3.32	No	1.75E+00	No	1.75	120	1.38	63	0.37	
Secondary ROPC																		
Cesium 137	pCi/g	172	132	0.03-1.16	GB-025	0.01-0.1	0.07	0.25	0.15	No	6.55E-02	No	0.07	-	0.16	21	0.00	
Cobalt 60	pCi/g	176	176	-	-	0.01-0.07	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 238	pCi/g	18	18	-	-	0.04-0.29	0.07	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 242	pCi/g	15	14	0.15-0.15	GB-050	0.03-0.19	0.05	0.15	0.04	No	7.28E-02	No	0.07	-	0.00	1	0.07	
Radium 226	pCi/g	178	0	0.54-2.26	GB-092	0.02-0.12	1.02	1.02	0.23	No	1.04E+00	No	1.04	-	1.32	14	0.00	
Thorium 230	pCi/g	18	0	0.47-2.4	GB-081	0.02-0.1	1.28	1.28	0.42	Yes	1.45E+00	No	1.45	-	1.18	10	0.27	

Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
EU 2 Current Use [Area in Vicinity Trench 10 Surface (Depths 0-6")]																		
Soil																		
Primary ROPC																		
Americium 241	PCi/g	29	13	0.46-319.5	GB-101	0.04-0.3	17.27	31.24	63.30	No	1.17E+02	No	116.84	28	0.00	16	116.84	
Plutonium 239	pCi/g	29	10	0.15-325.0	GB-102	0.03-0.27	15.83	24.14	60.60	No	2.52E+02	No	251.57	33	0.00	19	251.57	
Plutonium 241	pCi/g	25	21	24.4-628.0	GB-102	9.27-15.4	37.43	204.13	125.52	No	3.36E+01	No	33.57	890	0.00	4	33.57	
Radium 228	PCi/g	29	0	0.95-1.41	GB-094	0.07-0.3	1.19	1.19	0.14	Yes	1.23E+00	No	1.23	1.7	1.42	0	0.00	
Thorium 232	pCi/g	29	0	0.79-1.76	GB-012	0.02-0.46	1.20	1.20	0.23	Yes	1.27E+00	No	1.27	1.4	1.31	9	0.00	
Uranium 234	pCi/g	29	0	0.86-8.86	GB-017	0.04-0.31	1.66	1.66	1.50	No	1.88E+00	No	1.88	96	1.32	11	0.56	
Uranium 235 (alpha)	pCi/g	29	20	0.16-0.54	GB-017	0.05-0.26	0.12	0.26	0.12	No	1.65E-01	No	0.17	35	0.19	6	0.00	
Uranium 238	pCi/g	29	0	0.79-4.86	GB-017	0.04-0.26	1.25	1.25	0.73	No	1.38E+00	No	1.38	120	1.25	8	0.13	
Secondary ROPC																		
Cesium 137	pCi/g	29	5	0.04-0.4	GB-100	0.02-0.08	0.13	0.15	0.10	No	2.20E-01	No	0.22	-	0.79	0	0.00	
Cobalt 60	pCi/g	29	28	0.09-0.09	GB-101	0.02-0.09	0.02	0.09	0.01	No	2.41E-02	No	0.02	-	0.00	1	0.02	
Plutonium 238	pCi/g	3	3	-	-	0.05-0.1	0.04	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 242	pCi/g	3	3	-	-	0.04-0.1	0.03	-	-	-	-	-	0.00	-	0.00	0	0.00	
Radium 226	pCi/g	29	0	0.72-1.39	GB-102	0.04-0.15	0.93	0.93	0.15	No	9.76E-01	No	0.97	-	1.32	1	0.00	
Thorium 230	pCi/g	3	0	0.97-1.53	GB-003	0.05-0.1	1.23	1.23	0.28	Yes	1.71E+00	Yes	1.53	-	1.24	1	0.29	
Area in Vicinity of Trench 10 Subsurface (Depths 6"+)																		
Soil																		
Primary ROPC																		
Americium 241	PCi/g	59	54	0.58-12.76	GB-101	0.03-0.33	0.51	5.27	1.98	No	2.78E-01	No	0.28	28	0.00	5	0.28	
Plutonium 239	pCi/g	55	48	0.2-5.55	GB-008	0.03-0.27	0.30	2.03	0.91	No	2.43E-01	No	0.23	33	0.00	7	0.23	
Plutonium 241	pCi/g	47	46	24.0-24.0	GB-008	6.31-15.4	6.07	24.00	2.82	No	6.45E+00	No	6.45	890	0.00	1	6.45	
Radium 228	pCi/g	59	0	1.07-1.87	GB-001	0.05-0.33	1.47	1.47	0.16	Yes	1.50E+00	No	1.50	1.7	1.66	6	0.00	
Thorium 232	pCi/g	59	2	0.97-2.15	GB-012	0.02-0.82	1.41	1.45	0.30	No	1.53E+00	No	1.53	1.4	1.77	4	0.00	
Uranium 234	pCi/g	59	0	0.63-1.49	GB-010	0.03-0.26	1.06	1.06	0.17	Yes	1.09E+00	No	1.09	96	1.28	5	0.00	
Uranium 235 (alpha)	pCi/g	59	48	0.11-0.38	GB-009	0.04-0.26	0.09	0.21	0.07	No	1.01E-01	No	0.10	35	0.27	1	0.00	
Uranium 238	pCi/g	59	0	0.7-1.37	GB-015	0.03-0.28	1.04	1.04	0.15	Yes	1.07E+00	No	1.07	120	1.41	0	0.00	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Area in Vicinity of Trench 10 Subsurface (Depths 6"+)																		
Soil																		
Secondary ROPC																		
Cesium 137	pCi/g	55	55	-	-	0.01-0.09	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Cobalt 60	pCi/g	58	58	-	-	0.02-0.1	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 238	pCi/g	6	6	-	-	0.03-0.25	0.04	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 242	pCi/g	4	4	-	-	0.06-0.12	0.05	-	-	-	-	-	0.00	-	0.00	0	0.00	
Radium 226	pCi/g	59	0	0.73-1.21	GB-002	0.03-0.16	0.99	0.99	0.09	Yes	1.01E+00	No	1.01	-	1.01	0	0.00	
Thorium 230	pCi/g	7	0	1.02-1.38	GB-003	0.02-0.11	1.17	1.17	0.12	Yes	1.26E+00	No	1.26	-	1.16	4	0.10	
EU 2 Future Use [Area in Vicinity of Trench 10 Composite (all depths)]																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	88	67	0.46-319.5	GB-101	0.03-0.33	6.03	25.06	36.81	No	2.11E+00	No	2.11	28	0.00	21	2.11	
Plutonium 239	pCi/g	84	58	0.15-325.0	GB-102	0.03-0.27	5.66	18.19	35.98	No	3.18E+00	No	3.18	33	0.00	26	3.18	
Plutonium 241	pCi/g	72	67	24.0-628.0	GB-102	6.31-15.4	16.96	168.10	74.55	No	1.06E+01	No	10.56	890	0.00	5	10.56	
Radium 228	pCi/g	88	0	0.95-1.87	GB-001	0.05-0.33	1.38	1.38	0.20	Yes	1.41E+00	No	1.41	1.7	1.61	9	0.00	
Thorium 232	pCi/g	88	2	0.79-2.15	GB-012	0.02-0.82	1.34	1.36	0.29	No	1.42E+00	No	1.42	1.4	1.68	8	0.00	
Uranium 234	pCi/g	88	0	0.63-8.86	GB-017	0.03-0.31	1.25	1.25	0.91	No	1.30E+00	No	1.30	96	1.29	16	0.01	
Uranium 235 (alpha)	pCi/g	88	68	0.11-0.54	GB-017	0.04-0.26	0.10	0.23	0.09	No	1.11E-01	No	0.11	35	0.25	4	0.00	
Uranium 238	pCi/g	88	0	0.7-4.86	GB-017	0.03-0.28	1.11	1.11	0.44	No	1.15E+00	No	1.15	120	1.38	5	0.00	
Secondary ROPC																		
Cesium 137	pCi/g	84	60	0.04-0.4	GB-100	0.01-0.09	0.06	0.15	0.08	No	6.52E-02	No	0.07	-	0.16	8	0.00	
Cobalt 60	pCi/g	87	86	0.09-0.09	GB-101	0.02-0.1	0.02	0.09	0.01	No	2.10E-02	No	0.02	-	0.00	1	0.02	
Plutonium 238	pCi/g	9	9	-	-	0.03-0.25	0.04	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 242	pCi/g	7	7	-	-	0.04-0.12	0.04	-	-	-	-	-	0.00	-	0.00	0	0.00	
Radium 226	pCi/g	88	0	0.72-1.39	GB-102	0.03-0.16	0.97	0.97	0.12	No	9.89E-01	No	0.99	-	1.32	1	0.00	
Thorium 230	pCi/g	10	0	0.97-1.53	GB-003	0.02-0.11	1.18	1.18	0.17	Yes	1.28E+00	No	1.28	-	1.18	5	0.10	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
EU 3 Current Use [New Area Surface (Depths 0-6")]																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	11	11	-	-	0.05-0.2	0.07	-	-	-	-	-	0.00	28	0.00	0	0.00	
Plutonium 239	pCi/g	11	11	-	-	0.05-0.15	0.05	-	-	-	-	-	0.00	33	0.00	0	0.00	
Plutonium 241	pCi/g	7	7	-	-	7.12-13.2	5.47	-	-	-	-	-	0.00	890	0.00	0	0.00	
Radium 228	pCi/g	11	0	1.03-1.38	GB-064	0.08-0.21	1.20	1.20	0.11	Yes	1.26E+00	No	1.26	1.7	1.42	0	0.00	
Thorium 232	pCi/g	11	0	0.96-1.31	GB-056	0.02-0.08	1.16	1.16	0.13	Yes	1.23E+00	No	1.23	1.4	1.31	0	0.00	
Uranium 234	pCi/g	11	0	1.14-8.09	GB-062	0.07-0.21	4.18	4.18	2.88	No	8.43E+00	Yes	8.09	96	1.32	9	6.77	
Uranium 235 (alpha)	pCi/g	11	4	0.24-1.32	GB-062	0.06-0.19	0.34	0.50	0.37	No	1.42E+00	Yes	1.32	35	0.19	7	1.13	
Uranium 238	pCi/g	11	0	0.81-1.37	GB-063	0.07-0.19	1.12	1.12	0.17	Yes	1.22E-00	No	1.22	120	1.25	4	0.00	
Secondary ROPC																		
Cesium 137	pCi/g	11	1	0.09-0.5	GB-065	0.03-0.06	0.26	0.29	0.14	Yes	3.42E-01	No	0.34	-	0.79	0	0.00	
Cobalt 60	pCi/g	11	11	-	-	0.02-0.07	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 242	pCi/g	1	1	-	-	0.11-0.11	0.05	-	-	-	-	-	0.00	-	0.00	0	0.00	One value
Radium 226	pCi/g	11	0	0.93-1.08	GB-096	0.05-0.12	1.01	1.01	0.05	Yes	1.04E+00	No	1.04	-	1.32	0	0.00	
Thorium 230	pCi/g	1	0	1.53-1.53	GB-058	0.05-0.05	1.53	1.53	0.00	-	-	-	1.53	-	1.24	0	0.29	One value
New Area Subsurface (Depths 6"+)																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	32	32	-	-	0.03-0.24	0.06	-	-	-	-	-	0.00	28	0.00	0	0.00	
Plutonium 239	pCi/g	27	27	-	-	0.03-0.13	0.04	-	-	-	-	-	0.00	33	0.00	0	0.00	
Plutonium 241	pCi/g	26	26	-	-	7.0-13.3	5.49	-	-	-	-	-	0.00	890	0.00	0	0.00	
Radium 228	pCi/g	32	0	0.37-1.48	GB-062	0.04-0.19	0.94	0.94	0.29	Yes	1.03E+00	No	1.03	1.7	1.66	0	0.00	
Thorium 232	pCi/g	32	0	0.28-1.46	GB-058	0.02-0.08	0.91	0.91	0.33	Yes	1.01E+00	No	1.01	1.4	1.77	0	0.00	
Uranium 234	pCi/g	32	0	0.37-2.56	GB-096	0.07-0.33	0.80	0.80	0.42	No	9.20E-01	No	0.92	96	1.28	2	0.00	
Uranium 235 (alpha)	pCi/g	31	30	0.15-0.15	GB-096	0.03-0.26	0.06	0.15	0.03	No	7.61E-02	No	0.08	35	0.27	0	0.00	
Uranium 238	pCi/g	32	0	0.23-2.41	GB-096	0.04-0.22	0.75	0.75	0.4	No	9.05E-01	No	0.90	120	1.41	1	0.00	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
New Area Subsurface (Depths 6"+)																		
Soil																		
Secondary ROPC																		
Cesium 137	pCi/g	30	28	0.14-0.15	GB-064	0.01-0.09	0.02	0.15	0.03	No	2.59E-02	No	0.03	-	0.00	2	0.03	
Cobalt 60	pCi/g	31	31	-	-	0.01-0.06	0.01	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 238	pCi/g	3	3	-	-	0.03-0.08	0.03	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 242	pCi/g	3	3	-	-	0.09-0.16	0.06	-	-	-	-	-	0.00	-	0.00	0	0.00	
Radium 226	pCi/g	32	0	0.3-1.24	GB-096	0.02-0.11	0.68	0.68	0.21	Yes	7.43E-01	No	0.74	-	1.32	0	0.00	
Thorium 230	pCi/g	3	0	0.52-1.48	GB-058	0.04-0.06	0.97	0.97	0.48	Yes	1.79E+00	Yes	1.48	-	1.16	1	0.32	
EU 3 Future Use [New Area Composite (all depths)]																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	43	43	-	-	0.03-0.24	0.06	-	-	-	-	-	0.00	28	0.00	0	0.00	
Plutonium 239	pCi/g	38	38	-	-	0.03-0.15	0.04	-	-	-	-	-	0.00	33	0.00	0	0.00	
Plutonium 241	pCi/g	33	33	-	-	7.0-13.3	5.49	-	-	-	-	-	0.00	890	0.00	0	0.00	
Radium 228	pCi/g	43	0	0.37-1.48	GB-062	0.04-0.21	1.00	1.00	0.28	Yes	1.08E+00	No	1.08	1.7	1.61	0	0.00	
Thorium 232	pCi/g	43	0	0.28-1.46	GB-058	0.02-0.08	0.98	0.98	0.31	No	1.11E+00	No	1.11	1.4	1.68	0	0.00	
Uranium 234	pCi/g	43	0	0.37-8.09	GB-062	0.07-0.33	1.66	1.66	2.08	No	2.03E+00	No	2.03	96	1.29	11	0.74	
Uranium 235 (alpha)	pCi/g	42	34	0.15-1.32	GB-062	0.03-0.26	0.13	0.45	0.22	No	1.64E-01	No	0.16	35	0.25	5	0.00	
Uranium 238	pCi/g	43	0	0.23-2.41	GB-096	0.04-0.22	0.85	0.85	0.39	No	9.94E-01	No	0.99	120	1.38	1	0.00	
Secondary ROPC																		
Cesium 137	pCi/g	41	29	0.09-0.5	GB-065	0.01-0.09	0.09	0.27	0.13	No	1.51E-01	No	0.15	-	0.16	8	0.00	
Cobalt 60	pCi/g	42	42	-	-	0.01-0.07	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 238	pCi/g	3	3	-	-	0.03-0.08	0.03	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 242	pCi/g	4	4	-	-	0.09-0.16	0.06	-	-	-	-	-	0.00	-	0.00	0	0.00	
Radium 226	pCi/g	43	0	0.3-1.24	GB-096	0.02-0.12	0.76	0.76	0.23	Yes	8.24E-01	No	0.82	-	1.32	0	0.00	
Thorium 230	pCi/g	4	0	0.52-1.53	GB-058	0.04-0.06	1.11	1.11	0.48	Yes	1.92E+00	Yes	1.53	-	1.18	2	0.35	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Site-Wide Surface Soil																		
Sediment and Soil																		
Primary ROPC																		
Americium 241	pCi/g	104	88	0.46-319.5	GB-101	0.03-0.41	4.87	31.24	33.90	No	8.10E-01	No	0.81	28	0.00	16	0.81	
Plutonium 239	pCi/g	103	84	0.15-325.0	GB-102	0.02-0.27	4.48	24.14	32.54	No	9.89E-01	No	0.99	33	0.00	19	0.99	
Plutonium 241	pCi/g	96	91	24.4-628.0	GB-102	5.87-15.4	13.75	168.38	64.69	No	8.51E+00	No	8.51	890	0.00	5	8.51	
Radium 228	pCi/g	108	0	0.8-2.23	GB-051	0.05-0.3	1.23	1.23	0.22	No	1.26E+00	No	1.26	1.7	1.42	14	0.00	
Thorium 232	pCi/g	108	0	0.45-1.76	GB-012	0.02-0.46	1.20	1.20	0.24	Yes	1.24E+00	No	1.24	1.4	1.31	32	0.00	
Uranium 234	pCi/g	108	0	0.57-71.3	GB-084	0.04-0.38	5.26	5.26	8.28	No	6.00E+00	No	6.00	96	1.32	75	4.68	
Uranium 235 (alpha)	pCi/g	108	46	0.07-3.97	GB-084	0.04-0.29	0.40	0.64	0.61	No	5.21E-01	No	0.52	35	0.19	54	0.33	
Uranium 238	pCi/g	108	0	0.44-17.0	GB-084	0.03-0.31	1.54	1.54	1.73	No	1.58E+00	No	1.58	120	1.25	46	0.33	
Secondary ROPC																		
Cesium 137	pCi/g	107	30	0.03-1.16	GB-025	0.01-0.08	0.16	0.22	0.19	No	2.36E-01	No	0.24	-	0.79	2	0.00	
Cobalt 60	pCi/g	106	105	0.09-0.09	GB-101	0.02-0.09	0.02	0.09	0.01	No	2.06E-02	No	0.02	-	0.00	1	0.02	
Plutonium 238	pCi/g	10	10	-	-	0.04-0.27	0.06	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 242	pCi/g	10	10	-	-	0.02-0.19	0.04	-	-	-	-	-	0.00	-	0.00	0	0.00	
Radium 226	pCi/g	108	0	0.53-1.59	GB-051	0.03-0.15	0.97	0.97	0.15	No	9.93E-01	No	0.99	-	1.32	2	0.00	
Thorium 230	pCi/g	11	0	0.96-1.53	GB-003	0.02-0.1	1.34	1.34	0.24	No	1.50E+00	No	1.50	-	1.24	7	0.26	
Site-Wide Subsurface Soil																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	203	198	0.58-12.76	GB-101	0.03-0.38	0.20	5.27	1.08	No	1.07E-01	No	0.11	28	0.00	5	0.11	
Plutonium 239	pCi/g	190	182	0.12-5.55	GB-008	0.03-0.28	0.12	1.79	0.50	No	7.21E-02	No	0.07	33	0.00	8	0.07	
Plutonium 241	pCi/g	185	181	13.9-27.4	GB-052	6.31-15.4	5.85	21.43	2.58	No	5.97E+00	No	5.97	890	0.00	4	5.97	
Radium 228	pCi/g	207	0	0.37-2.19	GB-019	0.04-0.33	1.34	1.34	0.34	Yes	1.38E+00	No	1.38	1.7	1.66	34	0.00	
Thorium 232	pCi/g	207	2	0.28-2.2	GB-036	0.01-0.82	1.28	1.29	0.39	Yes	1.32E+00	No	1.32	1.4	1.77	19	0.00	
Uranium 234	pCi/g	207	0	0.37-508.0	GB-043	0.03-0.38	5.71	5.71	39.02	No	2.10E+00	No	2.10	96	1.28	59	0.82	
Uranium 235 (alpha)	pCi/g	206	159	0.06-46.9	GB-043	0.03-0.29	0.5	1.96	3.57	No	1.66E-01	No	0.17	35	0.27	18	0.00	
Uranium 238	pCi/g	207	1	0.23-36.9	GB-043	0.01-0.28	1.44	1.45	2.88	No	1.38E+00	No	1.38	120	1.41	40	0.00	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Site-Wide Subsurface Soil																		
Soil																		
Secondary ROPC																		
Cesium 137	pCi/g	196	191	0.07-0.26	GB-023	0.01-0.1	0.02	0.16	0.03	No	2.11E-02	No	0.02	-	0.00	5	0.02	
Cobalt 60	pCi/g	205	205	-	-	0.01-0.1	0.02	-	-	-	-	-	0.0	-	0.00	0	0.00	
Plutonium 238	pCi/g	21	21	-	-	0.03-0.29	0.06	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 242	pCi/g	17	16	0.15-0.15	GB-050	0.04-0.16	0.05	0.15	0.03	No	6.81E-02	No	0.07	-	0.00	1	0.07	
Radium 226	pCi/g	207	0	0.3-2.26	GB-092	0.02-0.16	0.96	0.96	0.25	No	9.96E-01	No	1.00	-	1.32	13	0.00	
Thorium 230	pCi/g	22	0	0.47-2.4	GB-081	0.02-0.11	1.17	1.17	0.39	No	1.36E+00	No	1.36	-	1.16	12	0.20	
Site-Wide Composite (all depths)																		
Sediment and Soil																		
Primary ROPC																		
Americium 241	pCi/g	307	286	0.46-319.5	GB-101	0.03-0.41	1.78	25.06	19.81	No	2.00E-01	No	0.20	28	0.00	21	0.20	
Plutonium 239	pCi/g	293	266	0.12-325.0	GB-102	0.02-0.28	1.65	17.52	19.35	No	1.66E-01	No	0.17	33	0.00	27	0.17	
Plutonium 241	pCi/g	281	272	13.9-628.0	GB-102	5.87-15.4	8.55	103.07	37.92	No	6.60E+00	No	6.60	890	0.00	9	6.60	
Radium 228	pCi/g	315	0	0.37-2.23	GB-051	0.04-0.33	1.30	1.30	0.31	No	1.34E+00	No	1.34	1.7	1.61	45	0.00	
Thorium 232	pCi/g	315	2	0.28-2.2	GB-036	0.01-0.82	1.25	1.25	0.35	No	1.30E+00	No	1.30	1.4	1.68	33	0.00	
Uranium 234	pCi/g	315	0	0.37-508.0	GB-043	0.03-0.38	5.55	5.55	31.97	No	3.14E+00	No	3.14	96	1.29	133	1.85	
Uranium 235 (alpha)	pCi/g	314	205	0.06-46.9	GB-043	0.03-0.29	0.46	1.21	2.91	No	2.50E-01	No	0.25	35	0.25	62	0.00	
Uranium 238	pCi/g	315	1	0.23-36.9	GB-043	0.01-0.31	1.48	1.48	2.54	No	1.42E+00	No	1.42	120	1.38	72	0.04	
Secondary ROPC																		
Cesium 137	pCi/g	303	221	0.03-1.16	GB-025	0.01-0.1	0.07	0.22	0.13	No	6.72E-02	No	0.07	-	0.16	37	0.00	
Cobalt 60	pCi/g	311	310	0.09-0.09	GB-101	0.01-0.1	0.02	0.09	0.01	No	1.91E-02	No	0.02	-	0.00	1	0.02	
Plutonium 238	pCi/g	31	31	-	-	0.03-0.29	0.06	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 242	pCi/g	27	26	0.15-0.15	GB-050	0.02-0.19	0.05	0.15	0.03	No	6.15E-02	No	0.06	-	0.00	1	0.06	
Radium 226	pCi/g	315	0	0.3-2.26	GB-092	0.02-0.16	0.96	0.96	0.22	No	9.88E-01	No	0.99	-	1.32	15	0.00	
Thorium 230	pCi/g	33	0	0.47-2.4	GB-081	0.02-0.11	1.22	1.22	0.35	No	1.36E+00	No	1.36	-	1.18	17	0.18	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Carnahan Run																		
Sediment																		
Primary ROPC																		
Americium 241	pCi/g	6	6	-	-	0.07-0.22	0.07	-	-	-	-	-	0.00	28	0.00	0	0.00	
Plutonium 239	pCi/g	6	6	-	-	0.02-0.05	0.02	-	-	-	-	-	0.00	33	0.00	0	0.00	
Plutonium 241	pCi/g	6	6	-	-	10.7-12.6	5.84	-	-	-	-	-	0.00	890	0.00	0	0.00	
Radium 228	pCi/g	6	0	1.06-1.29	WS/SE-CR-02	0.06-0.12	1.16	1.16	0.08	Yes	1.22E+00	No	1.22	1.7	1.42	0	0.00	
Thorium 232	pCi/g	6	0	0.93-1.3	WS/SE-CR-05	0.04-0.07	1.10	1.10	0.14	Yes	1.22E+00	No	1.22	1.4	1.31	0	0.00	
Uranium 234	pCi/g	6	0	0.87-1.49	WS/SE-CR-01	0.13-0.26	1.16	1.16	0.21	Yes	1.34E+00	No	1.34	96	1.32	1	0.02	
Uranium 235 (alpha)	pCi/g	6	6	-	-	0.13-0.23	0.09	-	-	-	-	-	0.00	35	0.19	0	0.00	
Uranium 238	pCi/g	6	0	0.77-1.2	WS/SE-CR-01	0.07-0.21	0.99	0.99	0.16	Yes	1.13E+00	No	1.13	120	1.25	0	0.00	
Secondary ROPC																		
Cesium 137	pCi/g	6	4	0.04-0.05	WS/SE-CR-01	0.02-0.04	0.02	0.05	0.02	Yes	3.85E-02	No	0.04	-	0.79	0	0.00	
Cobalt 60	pCi/g	6	6	-	-	0.02-0.04	0.02		-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 238	pCi/g	1	1	-	-	0.05-0.05	0.03	-	-	-	-	-	0.00	-	0.00	-	0.00	One value
Plutonium 242	pCi/g	1	1	-	-	0.05-0.05	0.03	-	-	-	-	-	0.00	-	0.00	0	0.00	One value
Radium 226	pCi/g	6	0	0.81-1.35	WS/SE-CR-01	0.03-0.06	0.98	0.98	0.20	Yes	1.14E+00	No	1.14	-	1.32	1	0.00	
Thorium 230	pCi/g	1	0	1.08-1.08	WS/SE-CR-03	0.04-0.04	1.08	1.08	0.00	-	-	-	1.08	-	1.24	0	0.00	One value
Surface Water																		
Primary ROPC																		
Americium 241 (alpha)	PCI/L	6	6	-	-	0.53-0.79	0.33	-	-	-	-	-	0.00	-	-	-	-	
Plutonium 239	PCI/L	6	6	-	-	0.05-0.13	0.05	-	-	-	-	-	0.00	-	-	-	-	
Plutonium 241	PCI/L	4	4	-	-	10.6-13.5	5.99	-	-	-	-	-	0.00	-	-	-	-	
Radium 228 (beta)	PCI/L	6	5	1.64-1.64	WS/SE-CR-06	1.26-1.71	0.90	1.64	0.37	No	1.28E+00	No	1.28	-	-	-	-	
Thorium 232	PCI/L	6	6	-	-	0.13-0.3	0.12	-	-	-	-	-	0.00	-	-	-	-	
Uranium 234	PCI/L	6	6	-	-	0.18-0.27	0.11	-	-	-	-	-	0.00	-	-	-	-	
Uranium 235 (alpha)	PCI/L	6	6	-	-	0.15-0.22	0.09	-	-	-	-	-	0.00	-	-	-	-	
Uranium 238	PCI/L	6	6	-	-	0.07-0.24	0.08	-	-	-	-	-	0.00	-	-	-	-	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Dry Run																		
Sediment																		
Primary ROPC																		
Americium 241	pCi/g	6	6	-	-	0.05-0.23	0.07	-	-	-	-	-	0.00	28	0.00	0	0.00	
Plutonium 239	pCi/g	6	6	-	-	0.02-0.05	0.02	-	-	-	-	-	0.00	33	0.00	0	0.00	
Plutonium 241	pCi/g	6	6	-	-	9.18-10.75	5.05	-	-	-	-	-	0.00	890	0.00	0	0.00	
Radium 228	pCi/g	6	0	0.83-1.4	WS/SE-DR-02	0.1-0.14	1.03	1.03	0.26	No	1.30E+00	No	1.30	1.7	1.42	0	0.00	
Thorium 232	pCi/g	6	0	0.67-1.49	WS/SE-DR-01	0.02-0.07	1.06	1.06	0.31	Yes	1.31E+00	No	1.31	1.4	1.31	2	0.00	
Uranium 234	pCi/g	6	0	0.91-20.0	WS/SE-DR-03	0.15-0.26	9.56	9.56	9.03	Yes	1.70E+01	No	16.99	96	1.32	4	15.67	
Uranium 235 (alpha)	pCi/g	6	3	0.8-3.24	WS/SE-DR-03	0.17-0.27	0.99	1.88	1.25	Yes	2.02E+00	No	2.02	35	0.19	3	1.83	
Uranium 238	pCi/g	6	0	0.73-1.78	WS/SE-DR-02	0.09-0.25	1.29	1.29	0.43	Yes	1.64E+00	No	1.64	120	1.25	3	0.39	
Secondary ROPC																		
Cesium 137	pCi/g	6	0	0.07-0.16	WS/SE-DR-06	0.03-0.04	0.13	0.13	0.03	No	1.79E-01	Yes	0.16	-	0.79	0	0.00	
Cobalt 60	pCi/g	6	6	-	-	0.03-0.04	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 238	pCi/g	1	1	-	-	0.06-0.06	0.03	-	-	-	-	-	0.00	-	0.00	0	0.00	One value
Plutonium 242	pCi/g	1	1	-	-	0.02-0.02	0.01	-	-	-	-	-	0.00	-	0.00	0	0.00	One value
Radium 226	pCi/g	6	0	0.53-0.93	WS/SE-DR-01	0.05-0.07	0.75	0.75	0.15	Yes	8.69E-01	No	0.87	-	1.32	0	0.00	
Thorium 230	pCi/g	1	0	1.1-1.1	WS/SE-DR-05	0.02-0.02	1.10	1.10	0.00	-	-	-	1.10	-	1.24	0	0.00	One value
Surface Water																		
Primary ROPC																		
Americium 241 (alpha)	PCI/L	6	6	-	-	0.2-0.6	0.19	-	-	-	-	-	0.00	-	-	-	-	
Americium 241 (gamma)	PCI/L	1	1	-	-	20.0-20.0	10.00	-	-	-	-	-	0.00	-	-	-	-	One value
Plutonium 239	PCI/L	6	6	-	-	0.05-0.79	0.11	-	-	-	-	-	0.00	-	-	-	-	
Plutonium 241	PCI/L	6	6	-	-	9.46-13.75	6.04	-	-	-	-	-	0.00	-	-	-	-	
Radium 228 (beta)	PCI/L	6	5	1.12-1.12	WS/SE-DR-04	1.22-2.11	0.86	1.12	0.22	Yes	1.04E+00	No	1.04	-	-	-	-	
Radium 228 (gamma)	PCI/L	1	1	-	-	14.2-14.2	7.10	-	-	-	-	-	0.00	-	-	-	-	One value
Thorium 232	PCI/L	6	6	-	-	0.13-0.4	0.14	-	-	-	-	-	0.00	-	-	-	-	
Uranium 234	PCI/L	6	3	0.53-6.63	WS/SE-DR-01	0.09-0.47	1.41	2.69	2.58	No	5.05E+02	Yes	6.63	-	-	-	-	
Uranium 235 (alpha)	PCI/L	6	6	-	-	0.17-0.25	0.11	-	-	-	-	-	0.00	-	-	-	-	
Uranium 238	PCI/L	6	6	-	-	0.13-0.3	0.10	-	-	-	-	-	0.00	-	-	-	-	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Dry Run																		
Surface Water																		
Secondary ROPC																		
Cesium 137	PCI/L	1	1	-	-	3.7-3.7	1.85	-	-	-	-	-	0.00	-	-	-	-	One value
Cobalt 60	PCI/L	1	1	-	-	3.65-3.65	1.83	-	-	-	-	-	0.00	-	-	-	-	One value
Plutonium 238	PCI/L	1	1	-	-	0.13-0.13	0.07	-	-	-	-	-	0.00	-	-	-	-	One value
Plutonium 242	PCI/L	1	1	-	-	0.13-0.13	0.07	-	-	-	-	-	0.00	-	-	-	-	One value
Radium 226 (alpha)	PCI/L	1	1	-	-	0.33-0.33	0.16	-	-	-	-	-	0.00	-	-	-	-	One value
Thorium 230	PCI/L	1	0	0.99-0.99	WS/SE-DR-05	0.47-0.47	0.99	0.99	0.00	-	-	-	0.99	-	-	-	-	One value

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Trench 1 (Depths > 4')																		
Soil																		
Primary ROPC																		
Americium 241	PCi/g	7	7	-	-	0.16-0.27	0.10	-	-	-	-	-	0.00	28	0.00	0	0.00	
Plutonium 239	pCi/g	7	7	-	-	0.04-0.08	0.03	-	-	-	-	-	0.00	33	0.00	0	0.00	
Plutonium 241	pCi/g	7	7	-	-	7.64-12.8	5.12	-	-	-	-	-	0.00	890	0.00	0	0.00	
Radium 228	pCi/g	7	0	1.07-2.02	TR-01-017	0.13-0.16	1.46	1.46	0.40	Yes	1.75E+00	No	1.75	1.7	1.66	2	0.09	
Thorium 232	pCi/g	7	0	1.02-1.78	TR-01-017	0.03-0.06	1.35	1.35	0.24	Yes	1.52E+00	No	1.52	1.4	1.77	1	0.00	
Uranium 234	pCi/g	7	0	1.16-3.79	TR-01-018	0.09-0.17	1.94	1.94	1.14	No	3.29E+00	No	3.29	96	1.28	4	2.01	
Uranium 235 (alpha)	pCi/g	7	5	0.24-0.32	TR-01-017	0.05-0.14	0.12	0.28	0.12	No	4.63E-01	Yes	0.32	35	0.27	1	0.05	
Uranium 238	pCi/g	7	0	0.89-1.43	TR-01-017	0.05-0.12	1.20	1.20	0.21	Yes	1.36E+00	No	1.36	120	1.41	1	0.00	
Secondary ROPC																		
Cesium 137	pCi/g	7	7	-	-	0.03-0.05	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Cobalt 60	pCi/g	7	7	-	-	0.03-0.05	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Radium 226	pCi/g	7	0	0.96-1.18	TR-01-019	0.06-0.09	1.06	1.06	0.09	Yes	1.13E+00	No	1.13	-	1.32	0	0	
Trench 2 (Depths 0'- 4')																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	1	1	-	-	0.17-0.17	0.09	-	-	-	-	-	0.00	28	0.00	1	0.00	One value
Plutonium 239	pCi/g	1	1	-	-	0.04-0.04	0.02	-	-	-	-	-	0.00	33	0.00	1	0.00	One value
Plutonium 241	pCi/g	1	1	-	-	9.6-9.6	4.8	-	-	-	-	-	0.00	890	0.00	1	0.00	One value
Radium 228	pCi/g	1	0	1.14-1.14	TR-02-022	0.15-0.15	1.14	1.14	0.00	-	-	-	1.14	1.7	1.66	1	0.00	One value
Thorium 232	pCi/g	1	0	1.47-1.47	TR-02-022	0.02-0.02	1.47	1.47	0.00	-	-	-	1.47	1.4	1.77	1	0.00	One value
Uranium 234	pCi/g	1	0	4.52-4.52	TR-02-022	0.09-0.09	4.52	4.52	0.00	-	-	-	4.52	96	1.28	1	3.24	One value
Uranium 235 (alpha)	pCi/g	1	0	0.23-0.23	TR-02-022	0.09-0.09	0.23	0.23	0.00	-	-	-	0.23	35	0.27	1	0.00	One value
Uranium 238	pCi/g	1	0	1.49-1.49	TR-02-022	0.06-0.06	1.49	1.49	0.00	-	-	-	1.49	120	1.41	1	0.08	One value
Secondary ROPC																		
Cesium 137	pCi/g	1	1	-	-	0.04-0.04	0.02	-	-	-	-	-	0.00	-	0.00	1	0.00	One value
Cobalt 60	pCi/g	1	1	-	-	0.05-0.05	0.02	-	-	-	-	-	0.00	-	0.00	1	0.00	One value
Radium 226	pCi/g	1	0	1.09-1.09	TR-02-022	0.07-0.07	1.09	1.09	0.00	-	-	-	1.09	-	1.32	1	0.00	One value

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Trench 2 (Depths > 4')																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	2	2	-	-	0.15-0.17	0.08	-	-	-	-	-	0.00	28	0.00	1	0.00	Two values
Plutonium 239	pCi/g	2	2	-	-	0.08-0.08	0.04	-	-	-	-	-	0.00	33	0.00	1	0.00	Two values
Plutonium 241	pCi/g	2	2	-	-	7.95-9.56	4.38	-	-	-	-	-	0.00	890	0.00	1	0.00	Two values
Radium 228	pCi/g	2	0	1.23-1.66	TR-02-022	0.07-0.1	1.45	1.45	0.3	-	-	-	1.66	1.7	1.66	1	0.00	Two values
Thorium 232	pCi/g	2	0	1.4-1.64	TR-02-022	0.02-0.06	1.52	1.52	0.17	-	-	-	1.64	1.4	1.77	1	0.00	Two values
Uranium 234	pCi/g	2	0	52.5-72.0	TR-02-022	0.09-0.18	62.25	62.25	13.79	-	-	-	72.00	96	1.28	1	70.72	Two values
Uranium 235 (alpha)	pCi/g	2	0	6.09-6.65	TR-02-022	0.07-0.14	6.37	6.37	0.40	-	-	-	6.65	35	0.27	1	6.38	Two values
Uranium 238	pCi/g	2	0	4.62-14.1	TR-02-022	0.07-0.12	9.36	9.36	6.70	-	-	-	14.10	120	1.41	1	12.69	Two values
Secondary ROPC																		
Cesium 137	pCi/g	2	1	0.05-0.05	TR-02-022	0.02-0.03	0.03	0.05	0.03	-	-	-	0.05	-	0.00	1	0.05	Two values
Cobalt 60	pCi/g	2	2	-	-	0.02-0.03	0.01	-	-	-	-	-	0.00	-	0.00	1	0.00	Two values
Radium 226	pCi/g	2	0	0.75-1.03	TR-02-022	0.04-0.04	0.89	0.89	0.20	-	-	-	1.03	-	1.32	1	0.00	Two values
Solid Waste																		
Primary ROPC																		
Americium 241	pCi/g	4	4	-	-	0.16-1.22	0.28	-	-	-	-	-	0.00	28	0.00	0	0.00	
Plutonium 239	pCi/g	3	3	-	-	0.03-0.28	0.07	-	-	-	-	-	0.00	33	0.00	0	0.00	
Plutonium 241	pCi/g	4	4	-	-	9.4-11.9	5.30	-	-	-	-	-	0.00	890	0.00	0	0.00	
Radium 228	pCi/g	4	0	0.97-4.33	TR-02-023	0.11-0.27	1.99	1.99	1.57	No	2.12E+01	Yes	4.33	1.7	1.66	1	2.67	
Thorium 232	pCi/g	4	1	0.97-2.6	TR-02-023	0.05-0.63	1.38	1.73	0.97	Yes	3.01E+00	Yes	2.60	1.4	1.77	1	0.83	
Uranium 234	pCi/g	4	0	22.4-1,160.0	TR-02-023	0.1-0.6	547.35	547.35	469.37	Yes	1.33E+03	Yes	1,160.00	96	1.28	4	1,158.72	
Uranium 235 (alpha)	pCi/g	4	0	1.59-44.4	TR-02-023	0.09-0.62	25.77	25.77	17.80	Yes	5.56E+01	Yes	44.40	35	0.27	4	44.13	
Uranium 238	pCi/g	4	0	2.7-41.9	TR-02-021	0.08-0.41	17.85	17.85	16.81	Yes	4.60E+01	Yes	41.90	120	1.41	4	40.49	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Trench 2 (Depths > 4')																		
Solid Waste																		
Secondary ROPC																		
Cesium 137	pCi/g	4	1	0.27-0.5	TR-02-024	0.04-0.08	0.27	0.35	0.20	Yes	5.96E-01	Yes	0.50	-	0.00	3	0.50	
Cobalt 60	pCi/g	4	4	-	-	0.04-0.1	0.03	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 238	pCi/g	1	1	-	-	0.26-0.26	0.13	-	-	-	-	-	0.00	-	0.00	-	0.00	One value
Plutonium 242	pCi/g	1	1	-	-	0.28-0.28	0.14	-	-	-	-	-	0.00	-	0.00	0	0.00	One value
Radium 226	pCi/g	4	0	0.84-1.39	TR-02-023	0.06-0.16	1.11	1.11	0.23	Yes	1.50E+00	Yes	1.39	-	1.32	1	0.07	
Thorium 230	pCi/g	1	0	1.32-1.32	TR-02-024	0.61-0.61	1.32	1.32	0.00	-	-	-	1.32	-	1.16	1	0.16	One value
Trench 3 (Depths >4')																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	1	1	-	-	0.16-0.16	0.08	-	-	-	-	-	0.00	28	0.00	4	0.00	One value
Plutonium 239	pCi/g	1	1	-	-	0.05-0.05	0.02	-	-	-	-	-	0.00	33	0.00	4	0.00	One value
Plutonium 241	pCi/g	1	1	-	-	10.8-10.8	5.40	-	-	-	-	-	0.00	890	0.00	4	0.00	One value
Radium 228	pCi/g	1	0	1.33-1.33	TR-03-029	0.14-0.14	1.33	1.33	0.00	-	-	-	1.33	1.7	1.66	4	0.00	One value
Thorium 232	pCi/g	1	0	1.29-1.29	TR-03-029	0.04-0.04	1.29	1.29	0.00	-	-	-	1.29	1.4	1.77	4	0.00	One value
Uranium 234	pCi/g	1	0	16.9-16.9	TR-03-029	0.15-0.15	16.90	16.90	0.00	-	-	-	16.90	96	1.28	4	15.62	One value
Uranium 235 (alpha)	pCi/g	1	0	1.93-1.93	TR-03-029	0.11-0.11	1.93	1.93	0.00	-	-	-	1.93	35	0.27	4	1.66	One value
Uranium 238	pCi/g	1	0	2.73-2.73	TR-03-029	0.12-0.12	2.73	2.73	0.00	-	-	-	2.73	120	1.41	4	1.32	One value
Secondary ROPC																		
Cesium 137	pCi/g	1	1	-	-	0.04-0.04	0.02	-	-	-	-	-	0.00	-	0.00	4	0.00	One value
Cobalt 60	pCi/g	1	1	-	-	0.05-0.05	0.02	-	-	-	-	-	0.00	-	0.00	4	0.00	One value
Radium 226	pCi/g	1	0	1.0-1.0	TR-03-029	0.07-0.07	1.00	1.00	0.00	-	-	-	1.00	-	1.32	4	0.00	One value

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Trench 4 (Depths >4')																		
Solid Waste																		
Primary ROPC																		
Americium 241	pCi/g	2	2	-	-	0.14-0.26	0.01	-	-	-	-	-	0.00	28	0.00	4	0.00	Two values
Plutonium 239	pCi/g	2	2	-	-	0.06-0.06	0.03	-	-	-	-	-	0.00	33	0.00	4	0.00	Two values
Plutonium 241	pCi/g	2	2	-	-	10.4-10.8	5.30	-	-	-	-	-	0.00	890	0.00	4	0.00	Two values
Radium 228	pCi/g	2	0	1.43-1.51	TR-04-039	0.13-0.19	1.47	1.47	0.06	-	-	-	1.51	1.7	1.66	4	0.00	Two values
Thorium 232	pCi/g	2	0	1.49-1.56	TR-04-039	0.03-0.06	1.53	1.53	0.05	-	-	-	1.56	1.4	1.77	4	0.00	Two values
Uranium 234	pCi/g	2	0	11.8-2,180.0	TR-04-040	0.14-0.23	1,095.90	1,095.90	1,533.15	-	-	-	2,180.00	96	1.28	4	2,178.72	Two values
Uranium 235 (alpha)	pCi/g	2	0	1.15-217.0	TR-04-040	0.1-0.16	109.08	109.08	152.63	-	-	-	217.00	35	0.27	4	216.73	Two values
Uranium 238	pCi/g	2	0	1.55-61.8	TR-04-040	0.11-0.18	31.68	31.68	42.60	-	-	-	61.80	120	1.41	4	60.39	Two values
Secondary ROPC																		
Cesium 137	pCi/g	2	1	0.28-0.28	TR-04-040	0.04-0.05	0.15	0.28	0.18	-	-	-	0.28	-	0.00	4	0.28	Two values
Cobalt 60	pCi/g	2	2	-	-	0.04-0.05	0.02	-	-	-	-	-	0.00	-	0.00	4	0.00	Two values
Radium 226	pCi/g	2	0	1.11-1.31	TR-04-039	0.06-0.09	1.21	1.21	0.14	-	-	-	1.31	-	1.32	4	0.00	Two values
Trench 5 (Depths >4')																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	2	2	-	-	0.06-0.07	0.03	-	-	-	-	-	0.00	28	0.00	4	0.00	Two values
Plutonium 239	pCi/g	2	2	-	-	0.04-0.06	0.03	-	-	-	-	-	0.00	33	0.00	4	0.00	Two values
Plutonium 241	pCi/g	2	2	-	-	9.69-14.9	6.15	-	-	-	-	-	0.00	890	0.00	4	0.00	Two values
Radium 228	pCi/g	2	0	1.26-1.46	TR-05-041	0.15-0.18	1.36	1.36	0.14	-	-	-	1.46	1.7	1.66	4	0.00	Two values
Thorium 232	pCi/g	2	0	1.39-1.4	TR-05-042	0.04-0.06	1.40	1.40	0.01	-	-	-	1.40	1.4	1.77	4	0.00	Two values
Uranium 234	pCi/g	2	0	18.0-26.6	TR-05-041	0.14-0.17	22.3	22.3	6.08	-	-	-	26.60	96	1.28	4	25.32	Two values
Uranium 235 (alpha)	pCi/g	2	0	0.85-1.81	TR-05-041	0.1-0.15	1.33	1.33	0.68	-	-	-	1.81	35	0.27	4	1.54	Two values
Uranium 238	pCi/g	2	0	1.83-2.0	TR-05-041	0.09-0.1	1.92	1.92	0.12	-	-	-	2.00	120	1.41	4	0.59	Two values
Secondary ROPC																		
Cesium 137	pCi/g	2	1	0.06-0.06	TR-05-042	0.04-0.05	0.04	0.06	0.03	-	-	-	0.06	-	0.00	4	0.06	Two values
Cobalt 60	pCi/g	2	2	-	-	0.04-0.06	0.02	-	-	-	-	-	0.00	-	0.00	4	0.00	Two values
Radium 226	pCi/g	2	0	1.1-1.32	TR-05-041	0.07-0.09	1.21	1.21	0.16	-	-	-	1.32	-	1.32	4	0.00	Two values

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Trench 6 (Depths >4')																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	1	1	-	-	0.29-0.29	0.14	-	-	-	-	-	0.00	28	0.00	4	0.00	One value
Plutonium 239	pCi/g	1	1	-	-	0.12-0.12	0.06	-	-	-	-	-	0.00	33	0.00	4	0.00	One value
Plutonium 241	pCi/g	1	1	-	-	13.2-13.2	6.60	-	-	-	-	-	0.00	890	0.00	4	0.00	One value
Radium 228	pCi/g	1	0	1.51-1.51	TR-06-035	0.14-0.14	1.51	1.51	0.00	-	-	-	1.51	1.7	1.66	4	0.00	One value
Thorium 232	pCi/g	1	0	2.25-2.25	TR-06-035	0.05-0.05	2.25	2.25	0.00	-	-	-	2.25	1.4	1.77	4	0.48	One value
Uranium 234	pCi/g	1	0	5.38-5.38	TR-06-035	0.19-0.19	5.38	5.38	0.00	-	-	-	5.38	96	1.28	4	4.10	One value
Uranium 235 (alpha)	pCi/g	1	0	0.79-0.79	TR-06-035	0.16-0.16	0.79	0.79	0.00	-	-	-	0.79	35	0.27	4	0.52	One value
Uranium 238	pCi/g	1	0	1.76-1.76	TR-06-035	0.15-0.15	1.76	1.76	0.00	-	-	-	1.76	120	1.41	4	0.35	One value
Secondary ROPC																		
Cesium 137	pCi/g	1	1	-	-	0.04-0.04	0.02	-	-	-	-	-	0.00	-	0.00	4	0.00	One value
Cobalt 60	pCi/g	1	1	-	-	0.05-0.05	0.02	-	-	-	-	-	0.00	-	0.00	4	0.00	One value
Radium 226	pCi/g	1	0	1.02-1.02	TR-06-035	0.07-0.07	1.02	1.02	0.00	-	-	-	1.02	-	1.32	4	0.00	One value
Trench 6 (Depths >4')																		
Solid Waste																		
Primary ROPC																		
Americium 241	pCi/g	2	2	-	-	0.32-0.58	0.23	-	-	-	-	-	0.00	28	0.00	4	0.00	Two values
Plutonium 239	pCi/g	2	2	-	-	0.08-0.2	0.07	-	-	-	-	-	0.00	33	0.00	4	0.00	Two values
Plutonium 241	pCi/g	2	2	-	-	11.0-11.8	5.70	-	-	-	-	-	0.00	890	0.00	4	0.00	Two values
Radium 228	pCi/g	2	0	1.26-1.74	TR-06-037	0.14-0.26	1.50	1.50	0.34	-	-	-	1.74	1.7	1.66	4	0.08	Two values
Thorium 232	pCi/g	2	0	0.67-1.43	TR-06-038	0.07-0.19	1.05	1.05	0.54	-	-	-	1.43	1.4	1.77	4	0.00	Two values
Uranium 234	pCi/g	2	0	57.3-159.0	TR-06-037	0.19-1.38	108.15	108.15	71.91	-	-	-	159.00	96	1.28	4	157.72	Two values
Uranium 235 (alpha)	pCi/g	2	0	5.51-26.5	TR-06-037	0.31-0.51	16.01	16.01	14.84	-	-	-	26.50	35	0.27	4	26.23	Two values
Uranium 238	pCi/g	2	0	66.5-478.0	TR-06-037	0.24-0.51	272.25	272.25	290.97	-	-	-	478.00	120	1.41	4	476.59	Two values

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Trench 6 (Depths >4')																		
Solid Waste																		
Secondary ROPC																		
Cesium 137	pCi/g	1	0	0.66-0.66	TR-06-037	0.08-0.08	0.66	0.66	0.00	-	-	-	0.66	-	0.00	4	0.66	One value
Cobalt 60	pCi/g	2	2	-	-	0.04-0.09	0.03	-	-	-	-	-	0.00	-	0.00	4	0.00	Two values
Plutonium 238	pCi/g	1	1	-	-	0.23-0.23	0.12	-	-	-	-	-	0.00	-	0.00	4	0.00	One value
Radium 226	pCi/g	2	0	1.31-1.56	TR-06-037	0.08-0.13	1.44	1.44	0.18	-	-	-	1.56	-	1.32	4	0.24	Two values
Thorium 230	pCi/g	1	0	1.32-1.32	TR-06-037	0.23-0.23	1.32	1.32	0.00	-	-	-	1.32	-	1.16	4	0.16	One value
Trench 7 (Depths >4')																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	3	3	-	-	0.06-0.39	0.10	-	-	-	-	-	0.00	28	0.00	0	0.00	
Plutonium 239	pCi/g	3	3	-	-	0.04-0.33	0.07	-	-	-	-	-	0.00	33	0.00	0	0.00	
Plutonium 241	pCi/g	3	3	-	-	7.39-16.4	5.46	-	-	-	-	-	0.00	890	0.00	0	0.00	
Radium 228	pCi/g	3	0	1.18-1.65	TR-07-032	0.12-0.18	1.45	1.45	0.24	Yes	1.87E+00	Yes	1.65	1.7	1.66	0	0.00	
Thorium 232	pCi/g	3	0	1.22-1.43	TR-07-034	0.04-0.05	1.31	1.31	0.11	Yes	1.49E+00	Yes	1.43	1.4	1.77	0	0.00	
Uranium 234	pCi/g	3	0	17.2-30.3	TR-07-032	0.11-0.14	21.97	21.97	7.24	Yes	3.42E+01	Yes	30.30	96	1.28	3	29.02	
Uranium 235 (alpha)	pCi/g	3	0	0.89-3.45	TR-07-032	0.09-0.18	1.96	1.96	1.33	Yes	4.20E+00	Yes	3.45	35	0.27	3	3.18	
Uranium 238	pCi/g	3	0	1.87-2.68	TR-07-032	0.09-0.14	2.33	2.33	0.41	Yes	3.03E+00	Yes	2.68	120	1.41	3	1.27	
Secondary ROPC																		
Cesium 137	pCi/g	3	3	-	-	0.04-0.05	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Cobalt 60	pCi/g	3	3	-	-	0.04-0.06	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Radium 226	pCi/g	3	0	1.06-1.56	TR-07-032	0.06-0.09	1.30	1.30	0.25	Yes	1.73E+00	Yes	1.56	-	1.32	1	0.24	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Trench 7 (Depths >4')																		
Solid Waste																		
Primary ROPC																		
Americium 241	pCi/g	1	1	-	-	0.88-0.88	0.44	-	-	-	-	-	0.00	28	0.00	3	0.00	One value
Plutonium 239	pCi/g	1	1	-	-	0.38-0.38	0.19	-	-	-	-	-	0.00	33	0.00	3	0.00	One value
Plutonium 241	pCi/g	1	1	-	-	10.2-10.2	5.10	-	-	-	-	-	0.00	890	0.00	3	0.00	One value
Radium 228	pCi/g	1	0	1.14-1.14	TR-07-033	0.21-0.21	1.14	1.14	0.00	-	-	-	1.14	1.7	1.66	3	0.00	One value
Thorium 232	pCi/g	1	0	1.08-1.08	TR-07-033	0.28-0.28	1.08	1.08	0.00	-	-	-	1.08	1.4	1.77	3	0.00	One value
Uranium 234	pCi/g	1	0	1,450.0-1,450	TR-07-033	1.39-1.39	1,450.00	1,450.00	0.00	-	-	-	1,450.00	96	1.28	3	1,448.72	One value
Uranium 235 (alpha)	pCi/g	1	0	143.0-143.0	TR-07-033	1.9-1.9	143.00	143.00	0.00	-	-	-	143.00	35	0.27	3	142.73	One value
Uranium 238	pCi/g	1	0	582.0-582.0	TR-07-033	1.39-1.39	582.00	582.00	0.00	-	-	-	582.00	120	1.41	3	580.59	One value
Secondary ROPC																		
Cesium 137	pCi/g	1	1	-	-	0.08-0.08	0.04	-	-	-	-	-	0.00	-	0.00	3	0.00	One value
Cobalt 60	pCi/g	1	1	-	-	0.05-0.05	0.03	-	-	-	-	-	0.00	-	0.00	3	0.00	One value
Radium 226	pCi/g	1	0	1.01-1.01	TR-07-033	0.13-0.13	1.01	1.01	0.00	-	-	-	1.01	-	1.32	3	0.00	One value
Trench 9 (Depths >4')																		
Solid Waste																		
Primary ROPC																		
Americium 241	PCi/g	3	3			0.12-0.25	0.09						0.00	28	0.00	0	0.00	
Plutonium 239	pCi/g	3	3	-	-	0.06-0.07	0.03	-	-	-	-	-	0.00	33	0.00	0	0.00	
Plutonium 241	pCi/g	3	3	-	-	10.9-11.2	5.53	-	-	-	-	-	0.00	890	0.00	0	0.00	
Radium 228	pCi/g	3	0	1.63-1.7	TR-09-027	0.06-0.12	1.67	1.67	0.04	Yes	1.74E+00	Yes	1.70	1.7	1.66	2	0.04	
Thorium 232	pCi/g	3	0	1.72-2.1	TR-09-027	0.06-0.08	1.90	1.90	0.19	Yes	2.22E+00	Yes	2.10	1.4	1.77	2	0.33	
Uranium 234	pCi/g	3	0	170.0-392.0	TR-09-027	0.1-0.13	278.00	278.00	111.12	Yes	4.65E+02	Yes	392.00	96	1.28	3	390.72	
Uranium 235 (alpha)	pCi/g	3	0	17.7-54.2	TR-09-027	0.11-0.14	33.27	33.27	18.83	Yes	6.50E+01	Yes	54.20	35	0.27	3	53.93	
Uranium 238	pCi/g	3	0	13.2-27.9	TR-09-027	0.1-0.11	20.4	20.4	7.35	Yes	3.28E+01	Yes	27.9	120	1.41	3	26.49	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Trench 9 (Depths >4')																		
Solid Waste																		
Secondary ROPC																		
Cesium 137	pCi/g	3	0	0.14-0.16	TR-09-026	0.02-0.03	0.15	0.15	0.01	Yes	1.60E-01	Yes	0.16	-	0.00	3	0.16	
Cobalt 60	pCi/g	3	3	-	-	0.02-0.03	0.01	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 238	pCi/g	1	1	-	-	0.04-0.04	0.02	-	-	-	-	-	0.00	-	0.00	-	0.00	One value
Plutonium 242	pCi/g	1	1	-	-	0.07-0.07	0.04	-	-	-	-	-	0.00	-	0.00	0	0.00	One value
Radium 226	pCi/g	3	0	0.95-1.02	TR-09-027	0.03-0.06	1.00	1.00	0.04	No	1.08E+00	Yes	1.02	-	1.32	0	0.00	
Thorium 230	pCi/g	1	0	2.24-2.24	TR-09-026	0.06-0.06	2.24	2.24	0.00	-	-	-	2.24	-	1.16	2	1.08	One value
Trench 10 (Depths 0'-4')																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	3	0	3.39-11.3	TR-10-002	0.16-0.19	7.23	7.23	3.96	Yes	1.39E+01	Yes	11.30	28	0.00	3	11.30	
Plutonium 239	pCi/g	3	0	3.1-24.8	TR-10-002	0.03-0.08	13.13	13.13	10.94	Yes	3.16E+01	Yes	24.80	33	0.00	3	24.80	
Plutonium 241	pCi/g	3	1	24.4-37.1	TR-10-002	9.27-15.4	22.05	30.75	16.36	Yes	4.96E+01	Yes	37.10	890	0.00	2	37.10	
Radium 228	pCi/g	3	0	0.95-1.17	TR-10-005	0.1-0.2	1.06	1.06	0.11	Yes	1.24E+00	Yes	1.17	1.7	1.66	0	0.00	
Thorium 232	pCi/g	3	0	1.04-1.27	TR-10-005	0.03-0.06	1.19	1.19	0.13	Yes	1.40E+00	Yes	1.27	1.4	1.77	0	0.00	
Uranium 234	pCi/g	3	0	1.62-1.87	TR-10-002	0.07-0.1	1.78	1.78	0.14	Yes	2.01E+00	Yes	1.87	96	1.28	3	0.59	
Uranium 235 (alpha)	pCi/g	3	3	-	-	0.09-0.12	0.05	-	-	-	-	-	0.00	35	0.27	0	0.00	
Uranium 238	pCi/g	3	0	1.18-1.69	TR-10-001	0.06-0.1	1.43	1.43	0.26	Yes	1.86E+00	Yes	1.69	120	1.41	2	0.28	
Secondary ROPC																		
Cesium 137	pCi/g	3	0	0.07-0.14	TR-10-005	0.02-0.06	0.11	0.11	0.03	Yes	1.71E-01	Yes	0.14	-	0.00	3	0.14	
Cobalt 60	pCi/g	3	3	-	-	0.03-0.06	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Radium 226	pCi/g	3	0	0.81-1.02	TR-10-005	0.05-0.1	0.90	0.90	0.11	Yes	1.08E+00	Yes	1.02	-	1.32	0	0.00	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Trench 10 (Depths >4')																		
Soil																		
Primary ROPC																		
Americium 241	pCi/g	13	10	0.12-6.66	TR-10-002	0.05-0.25	0.67	2.67	1.83	No	1.91E+00	No	1.91	28	0.00	3	1.91	
Plutonium 239	pCi/g	13	10	0.58-6.4	TR-10-002	0.04-0.13	0.64	2.59	1.75	No	2.43E+00	No	2.43	33	0.00	3	2.43	
Plutonium 241	pCi/g	13	13	-	-	8.08-14.0	5.56	-	-	-	-	-	0.00	890	0.00	0	0.00	
Radium 228	pCi/g	13	0	1.18-1.71	TR-10-005	0.11-0.23	1.50	1.50	0.17	Yes	1.58E+00	No	1.58	1.7	1.66	3	0.00	
Thorium 232	pCi/g	13	0	0.56-1.81	TR-10-004	0.02-0.08	1.27	1.27	0.32	Yes	1.43E+00	No	1.43	1.4	1.77	1	0.00	
Uranium 234	pCi/g	13	0	0.86-10.5	TR-10-002	0.04-0.24	2.40	2.40	2.58	No	3.68E+00	No	3.68	96	1.28	7	2.40	
Uranium 235 (alpha)	pCi/g	13	9	0.23-0.41	TR-10-002	0.04-0.2	0.14	0.31	0.13	No	2.63E+01	No	0.26	35	0.27	2	0.00	
Uranium 238	pCi/g	13	0	0.87-5.53	TR-10-003	0.06-0.17	1.67	1.67	1.26	No	2.24E+00	No	2.24	120	1.41	5	0.83	
Secondary ROPC																		
Cesium 137	pCi/g	13	11	0.13-0.14	TR-10-002	0.03-0.06	0.04	0.14	0.04	No	6.21E-02	No	0.06	-	0.00	2	0.06	
Cobalt 60	pCi/g	13	13	-	-	0.04-0.07	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 238	pCi/g	1	1	-	-	0.25-0.25	0.12	-	-	-	-	-	0.00	-	0.00	-	0.00	One value
Plutonium 242	pCi/g	1	1	-	-	0.1-0.1	0.05	-	-	-	-	-	0.00	-	0.00	0	0.00	One value
Radium 226	pCi/g	13	0	0.85-1.14	TR-10-005	0.06-0.12	0.98	0.98	0.08	Yes	1.02E+00	No	1.02	-	1.32	0	0.00	
Thorium 230	pCi/g	1	0	1.15-1.15	TR-10-007R	0.06-0.06	1.15	1.15	0.00	-	-	-	1.15	-	1.16	3	0.00	One value

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
All Trench Solid Waste Samples																		
Solid Waste																		
Primary ROPC																		
Americium 241	pCi/g	13	13	-	-	0.12-1.22	0.20	-	-	-	-	-	0.00	28	0.00	0	0.00	
Plutonium 239	pCi/g	12	12	-	-	0.03-0.38	0.06	-	-	-	-	-	0.00	33	0.00	0	0.00	
Plutonium 241	pCi/g	13	13	-	-	9.4-11.9	5.40	-	-	-	-	-	0.00	890	0.00	0	0.00	
Radium 228	pCi/g	13	0	0.97-4.33	TR-02-023	0.06-0.27	1.64	1.64	0.84	No	1.99E+00	No	1.99	1.7	1.66	4	0.33	
Thorium 232	pCi/g	13	1	0.67-2.6	TR-02-023	0.02-0.63	1.47	1.56	0.60	Yes	1.77E+00	No	1.77	1.4	1.77	3	0.00	
Uranium 234	pCi/g	13	0	11.8-2,180.0	TR-04-040	0.1-1.39	530.56	530.56	667.10	No	7.34E+03	Yes	2,180.00	96	1.28	13	2,178.72	
Uranium 235 (alpha)	pCi/g	13	0	1.15-217.0	TR-04-040	0.09-1.9	45.96	45.96	63.54	No	5.73E+02	Yes	217.00	35	0.27	13	216.73	
Uranium 238	pCi/g	13	0	1.55-582.0	TR-07-033	0.05-1.39	101.89	101.89	192.35	No	1.37E+03	Yes	582.00	120	1.41	13	580.59	
Secondary ROPC																		
Cesium 137	pCi/g	12	4	0.14-0.66	TR-06-037	0.02-0.08	0.21	0.30	0.20	No	9.80E-01	Yes	0.66	-	0.00	8	0.66	
Cobalt 60	pCi/g	13	13	-	-	0.02-0.1	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 238	pCi/g	3	3	-	-	0.04-0.26	0.09	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 242	pCi/g	2	2	-	-	0.07-0.28	0.09	-	-	-	-	-	0.00	-	0.00	0	0.00	Two values
Radium 226	pCi/g	13	0	0.84-1.56	TR-06-037	0.03-0.16	1.17	1.17	0.22	Yes	1.28E+00	No	1.28	-	1.32	3	0.00	
Thorium 230	pCi/g	3	0	1.32-2.24	TR-09-026	0.06-0.61	1.63	1.63	0.53	No	4.06E+00	Yes	2.24	-	1.16	3	1.08	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
All Trench Samples																		
Soil and Solid Waste																		
Primary ROPC																		
Americium 241	pCi/g	46	40	0.12-11.3	TR-10-002	0.05-1.22	0.75	4.95	2.16	No	6.84E-01	No	0.68	28	0.00	6	0.68	
Plutonium 239	pCi/g	45	39	0.58-24.8	TR-10-002	0.03-0.38	1.09	7.86	4.12	No	7.38E-01	No	0.74	33	0.00	6	0.74	
Plutonium 241	pCi/g	46	44	24.4-37.1	TR-10-002	7.39-16.4	6.49	30.75	5.48	No	6.91E+00	No	6.91	890	0.00	2	6.91	
Radium 228	pCi/g	46	0	0.95-4.33	TR-02-023	0.06-0.27	1.48	1.48	0.50	No	1.57E+00	No	1.57	1.7	1.66	9	0.00	
Thorium 232	pCi/g	46	1	0.56-2.6	TR-02-023	0.02-0.63	1.38	1.40	0.40	Yes	1.48E+00	No	1.48	1.4	1.77	6	0.00	
Uranium 234	pCi/g	46	0	0.86-2,180.0	TR-04-040	0.04-1.39	156.72	156.72	418.49	No	6.30E+02	No	630.03	96	1.28	37	628.75	
Uranium 235 (alpha)	pCi/g	46	17	0.23-217.0	TR-04-040	0.04-1.9	13.57	21.50	38.74	No	1.16E+02	No	116.24	35	0.27	25	115.97	
Uranium 238	pCi/g	46	0	0.87-582.0	TR-07-033	0.05-1.39	30.31	30.31	109.24	No	2.66E+01	No	26.65	120	1.41	31	25.24	
Secondary ROPC																		
Cesium 137	pCi/g	45	30	0.05-0.66	TR-06-037	0.02-0.08	0.08	0.21	0.13	No	1.10E-01	No	0.11	-	0.00	15	0.11	
Cobalt 60	pCi/g	46	46	-	-	0.02-0.1	0.02	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 238	pCi/g	4	4	-	-	0.04-0.26	0.10	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 242	pCi/g	3	3	-	-	0.07-0.28	0.08	-	-	-	-	-	0.00	-	0.00	0	0.00	
Radium 226	pCi/g	46	0	0.75-1.56	TR-06-037	0.03-0.16	1.07	1.07	0.18	No	1.12E+00	No	1.12	-	1.32	4	0.00	
Thorium 230	pCi/g	4	0	1.15-2.24	TR-09-026	0.06-0.61	1.51	1.51	0.49	Yes	2.34E+00	Yes	2.24	-	1.16	3	1.08	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

Table 6-4
EXPOSURE POINT CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL AT SLDA

Parameter*	Units	# observ	# ND	Range of Det	LOCID of Max Det	Range of MDL	Mean	Mean (Det)	STDev	Normal?	UCL95	UCL>Max?	EPC	PRG	Background UTL	# Exceed Background	NET EPC	Comments
Ecological Site Wide Soils																		
Soil and Solid Waste																		
Primary ROPC																		
Americium 241	pCi/g	307	285	0.46-319.5	GB-101	0.03-0.41	1.8	24.22	19.81	No	2.11E-01	No	0.21	28	0.00	22	0.21	
Plutonium 239	pCi/g	293	265	0.12-325.0	GB-102	0.03-0.28	1.67	17.12	19.35	No	1.77E-01	No	0.18	33	0.00	28	0.18	
Plutonium 241	pCi/g	281	272	13.9-628.0	GB-102	5.87-15.4	8.54	103.07	37.93	No	6.60E+00	No	6.60	890	0.00	9	6.60	
Radium 228	pCi/g	315	0	0.37-2.23	GB-051	0.04-0.33	1.31	1.31	0.31	No	1.34E+00	No	1.34	1.7	1.61	47	0.00	
Thorium 232	pCi/g	315	2	0.28-2.2	GB-036	0.01-0.82	1.25	1.26	0.35	No	1.30E+00	No	1.30	1.4	1.68	33	0.00	
Uranium 234	pCi/g	315	0	0.37-508.0	GB-043	0.03-0.38	5.82	5.82	32.19	No	3.31E+00	No	3.31	96	1.29	134	2.02	
Uranium 235 (alpha)	pCi/g	314	203	0.06-46.9	GB-043	0.03-0.29	0.48	1.24	2.93	No	2.62E-01	No	0.26	35	0.25	64	0.01	
Uranium 238	pCi/g	315	1	0.23-36.9	GB-043	0.01-0.31	1.53	1.54	2.64	No	1.46E+00	No	1.46	120	1.38	72	0.08	
Secondary ROPC																		
Cesium 137	pCi/g	303	225	0.03-1.16	GB-025	0.01-0.1	0.07	0.22	0.13	No	6.43E-02	No	0.06	-	0.16	37	0.00	
Cobalt 60	pCi/g	311	310	0.09-0.09	GB-101	0.01-0.1	0.02	0.09	0.01	No	1.92E-02	No	0.02	-	0.00	1	0.02	
Plutonium 238	pCi/g	30	30	-	-	0.03-0.29	0.06	-	-	-	-	-	0.00	-	0.00	0	0.00	
Plutonium 242	pCi/g	26	25	0.15-0.15	GB-050	0.03-0.19	0.05	0.15	0.03	No	6.01E-02	No	0.06	-	0.00	1	0.06	
Radium 226	pCi/g	315	0	0.3-2.26	GB-092	0.02-0.16	0.97	0.97	0.23	No	9.95E-01	No	0.99	-	1.32	17	0.00	
Thorium 230	pCi/g	32	0	0.47-2.4	GB-081	0.02-0.11	1.23	1.23	0.36	No	1.37E+00	No	1.37	-	1.18	17	0.19	

*** Plutonium 239 / 240 reported from the lab is assumed to be Plutonium 239.**

TABLE 6-5
EXPOSURE SCENARIO ASSUMPTIONS AND INTAKE PARAMETERS[a]

Parameter	Variable	Unit	*Current-Use Scenarios*		*Future-Use Scenarios*	
			Maintenance Worker	Adolescent Trespasser	Construction Worker	Subsistence Farmer
Inhalation rate	IR_a	m^3/hr	2.5	2.0	2.5	0.98
Incidental ingestion of soil and sediment	IR_s	mg/d or mg/event	100	50	330	50
Incidental ingestion of surface water or groundwater	IR_w	mL/d or mL/event	-	200	200	-
Exposure time	ET	h/d	8	4	8	18.6
Exposure frequency	EF	d/yr or events/yr	20	10	250	365
Exposure duration	ED	yr	10	5	1	30
Ingestion of drinking water	IR_{dw}	L/d	-	-	-	1.3
Ingestion of produce	IR_p	kg/yr	-	-	-	133.4
Ingestion of beef and poultry	IR_{bp}	kg/yr	-	-	-	65.1
Ingestion of dairy products	IR_{dp}	L/yr	-	-	-	233
Ingestion of fish	IR_f	kg/yr	-	-	-	20.6

[a] This table addresses the exposure parameters identified for the four hypothetical scenarios as discussed in Sections 6.3.2 through 6.3.4. A hyphen means that entry is not applicable for that scenario. The rationale and sources for the values provided in this table are given in the text. There are many more input parameters used in the RESRAD calculations for the Subsistence Farmer scenario than presented in this table. All of the input parameters for this scenario are given in Appendix A of the SAP (USACE 2003a).

TABLE 6-6
RADIOLOGICAL RISK COEFFICIENTS AND DOSE CONVERSION FACTORS

Table 6.6 Radiological Risk Coefficients and Dose Conversion Factors									
Radionuclide	Coefficient for Lifetime Cancer Risk Morbidity			Dose Conversion Factor			Decay Factor		
	Inhalation Slope Factor (1/pCi)	Ingestion Slope Factor (1/pCi)	External Gamma (1/yr per pCi/g)	Inhalation (mrem/pCi)	Ingestion (mrem/pCi)	External (mrem per pCi/g per yr)	Half-Life $T_{1/2}$ yr	Near Term (yr) 1	Long Term (yr) 100
Primary ROPCs									
Americium-241	2.8E-08	1.3E-10	2.8E-08	4.4E-01	3.6E-03	4.4E-02	4.3E+02	1	8.5E-01
Plutonium-239	3.3E-08	1.7E-10	2.0E-10	4.3E-01	3.5E-03	3.0E-04	2.4E+04	1	1.0E+00
Plutonium-241	3.3E-10	2.3E-12	1.3E-11	8.3E-03	6.9E-05	1.9E-05	1.4E+01	1	7.1E-03
Radium-228	9.7E-08	1.9E-09	1.2E-05	3.5E-01	2.3E-03	1.6E+01	5.8E+00	1	6.5E-06
Thorium-232	2.4E-08	1.3E-10	3.4E-10	1.6E+00	2.7E-03	5.2E-04	1.4E+10	1	1.0E+00
Uranium-234	2.8E-08	9.6E-11	2.5E-10	1.3E-01	2.8E-04	4.0E-04	2.4E+05	1	1.0E+00
Uranium-235	2.5E-08	9.8E-11	5.4E-07	1.2E-01	2.7E-04	7.6E-01	7.0E+08	1	1.0E+00
Uranium-238	2.4E-08	1.2E-10	8.5E-08	1.2E-01	2.7E-04	1.4E-01	4.5E+09	1	1.0E+00
Secondary ROPCs									
Cesium-137	1.2E-11	3.7E-11	2.6E-06	3.2E-05	5.0E-05	3.4E+00	3.0E+01	1	9.9E-02
Cobalt-60	1.0E-10	2.2E-11	1.2E-05	2.2E-04	2.7E-05	1.6E+01	5.3E+00	1	2.1E-06
Plutonium-238	3.4E-08	1.7E-10	7.2E-11	3.9E-01	3.2E-03	1.5E-04	8.8E+01	1	4.5E-01
Plutonium-240	3.3E-08	1.7E-10	7.0E-11	4.3E-01	3.5E-03	1.5E-04	6.5E+03	1	9.9E-01
Plutonium-242	3.1E-08	1.7E-10	6.3E-11	4.1E-01	3.4E-03	1.3E-04	3.8E+05	1	1.0E+00
Radium-226	2.6E-08	4.0E-09	8.5E-06	3.2E-02	8.6E-03	1.1E+01	1.6E+03	1	9.6E-01
Thorium-230	2.4E-08	1.2E-10	8.2E-10	3.3E-01	5.5E-04	1.2E-03	7.7E+04	1	1.0E+00
Values for Future-Use Scenarios (See note below)									
Actinium-227	1.0E-07	6.5E-10	1.50E-06	6.7E+00	1.5E+00	2.0E+00			
Protactinium-231	4.1E-08	2.3E-10	1.40E-07	1.3E+00	1.1E-02	1.9E-01			
Plutonium-241	1.5E-08	7.3E-11	1.5E-08	2.4E-01	2.0E-03	2.3E-02			
Thorium-232	1.2E-07	2.0E-09	1.2E-05	2.0E+00	4.9E-03	1.6E+01			
Uranium-234	2.8E-08	9.6E-11	9.3E-09	1.3E-01	2.8E-04	1.5E-02			
Uranium-235	2.7E-08	1.1E-10	5.6E-07	2.2E-01	5.6E-04	7.8E-01			
Uranium -238	2.4E-08	1.2E-10	9.2E-08	1.2E-01	2.7E-04	1.5E-01			

TABLE 6-6 (Continued)
RADIOLOGICAL RISK COEFFICIENTS AND DOSE CONVERSION FACTORS

Chemical Toxicity for Noncarcinogenic Effects Oral Exposure					
Chemical	**RfD, Chronic (mg/kg-d)**	**Confidence Level**	**Uncertainty Factor**	**Modifying Factor**	**Critical Effect**
Metals					
Uranium, sol.salt	3.00E-03	Medium	1000 H,A,L	1	Kidney damage

Note:

This table provides cancer risk coefficients and DCFs for inhalation, ingestion, and external gamma irradiation for the primary and secondary ROPCs at the SLDA. For ingestion and inhalation, units are risk of cancer induction or dose (in mrem) per picoCurie (pCi) taken into the body. Units for external gamma exposure are risk or dose (in mrem) per pCi/g soil for one year of continuous exposure. Values presented here include the contributions from short-lived decay products. All values are given to two significant figures.

The DCFs for inhalation and ingestion represent the 50-year CEDE using the methodology developed by the ICRP. The DCFs for external gamma irradiation represent the EDE for that exposure. These internal and external DCFs are based on a metabolic and anatomical model for an adult male. The internal (inhalation and ingestion) factors were obtained from FGR 11 (EPA 1988), and the factors for external gamma irradiation were obtained from FGR 12 (EPA 1993). A number of radionuclides contain multiple (up to three) inhalation DCFs based on the rate of clearance from the lung. The three lung clearance classes are D, W, and Y corresponding to retention half-times of less than 10 days, 10 to 100 days, and greater than 100 days, respectively. Where multiple values are given for inhalation DCFs, the most conservative (highest) values have been tabulated here for used in this assessment. In addition, multiple ingestion DCFs corresponding to various fractional uptakes from the intestines (f_1) are provided for some radionuclides. Where multiple values are given for ingestion, the most conservative (highest) values were used.

The cancer risk coefficients given in this table represent the lifetime risk of incurring all cancers (including those that are cured) and were obtained from FGR 13 (EPA 1999b). These coefficients represent values that are averaged over all ages and both genders. For inhalation of radionuclides, risk coefficients are provided for three types of particulates corresponding to fast (F), medium (M), and slow (S) absorption to blood. The risk coefficients corresponding closest to the DCF were used. (For example, if the most conservative DCF corresponded to an inhalation class of W, the risk coefficient for M would be used.) Two sets of ingestion risk coefficients are given in FGR 13, i.e., corresponding to “dietary” and “tap water” intakes. The dietary values are given here, as these are the highest for ingestion exposures; values for tap water ingestion are typically 70 to 80% of those for diet. The fractional uptake from the intestines (f_1) varies from 0.0001 to 1.0 for the various radionuclides; only one ingestion risk value (corresponding to a specific value of f_1) is given for each radionuclide.

Additional cancer risk coefficients and DCFs were calculated for five of the primary ROPCs for the two future-use scenarios to account for the effect of radionuclide ingrowth. The future-use scenarios were evaluated in a manner consistent with the approach used to develop the PRGs for the Subsistence Farmer scenario. The PRGs were developed from the mean dose-to-source ratios of the peak doses over 1,000-year time period using the probabilistic version of RESRAD. The peak doses for these five ROPCs occur many years in the future, and at different times. See Appendix R for a description of the approach used to develop these values and the time periods at which the peak doses are estimated to occur. Values are also given in this table for actinium-227 (Ac-227) and protactinium-231 (Pa-231), as these are longer-lived decay products of U-235.

TABLE 6-7

ESTIMATED CARCINOGENIC RISKS FOR HYPOTHETICAL EXPOSURES AT THE SLDA[a]

Scenario	Inhalation	Ingestion	External Gamma	Total
Exposure Unit 1				
Maintenance Worker	2E-08	2E-08	7E-08	1E-07
Adolescent Trespasser	2E-09	2E-09	9E-09	1E-08
Construction Worker	1E-08	3E-08	4E-08	8E-08
Subsistence Farmer	4E-06	9E-06	1E-06	1E-05
Exposure Unit 2				
Maintenance Worker	1E-06	1E-06	6E-07	3E-06
Adolescent Trespasser	1E-07	1E-07	7E-08	3E-07
Construction Worker	2E-08	6E-08	2E-08	9E-08
Subsistence Farmer	5E-08	6E-06	6E-07	7E-06
Exposure Unit 3				
Maintenance Worker	2E-08	2E-08	1E-07	1E-07
Adolescent Trespasser	2E-09	2E-09	1E-08	2E-08
Construction Worker	2E-09	5E-09	2E-09	9E-09
Subsistence Farmer	7E-07	1E-06	6E-08	2E-06
Site-Wide				
Maintenance Worker	2E-08	2E-08	4E-08	8E-08
Adolescent Trespasser	2E-09	2E-09	5E-09	9E-09
Construction Worker	7E-09	2E-08	7E-09	3E-08
Subsistence Farmer	2E-06	4E-06	3E-07	6E-06

[a] The radiological carcinogenic risks represent the probability that an individual will develop cancer during their lifetime as a result of exposures at the SLDA. The scenarios evaluated in this assessment are described in Section 6.3. Additional information on these estimates including the contribution of the various radionuclides to these risks is given in Appendix R. All values are given to one significant figure.

TABLE 6-8

ESTIMATED RADIATION DOSES FOR HYPOTHETICAL EXPOSURES AT THE SLDA[a]

Scenario	Inhalation	Ingestion	External Gamma	Total	Annual Dose
Exposure Unit 1					
Maintenance Worker	1.E-01	6.E-02	1.E-01	3.E-01	3.E-02
Adolescent Trespasser	1.E-02	7.E-03	1.E-02	3.E-02	6.E-03
Construction Worker	7.E-02	1.E-01	5.E-02	3.E-01	3.E-01
Subsistence Farmer	1.E+01	3.E+01	2.E+00	4.E+01	1.E+00
Exposure Unit 2					
Maintenance Worker	2.E+01	3.E+01	9.E-01	4.E+01	4.E+00
Adolescent Trespasser	2.E+00	3.E+00	1.E-01	5.E+00	1.E+00
Construction Worker	2.E-01	1.E+00	3.E-02	2.E+00	2.E+00
Subsistence Farmer	6.E-01	1.E+02	1.E+00	1.E+02	5.E+00
Exposure Unit 3					
Maintenance Worker	1.E-01	4.E-02	2.E-01	3.E-01	3.E-02
Adolescent Trespasser	1.E-02	6.E-03	2.E-02	3.E-02	7.E-03
Construction Worker	1.E-02	1.E-02	3.E-03	3.E-02	3.E-02
Subsistence Farmer	2.E+00	4.E+00	1.E-01	6.E+00	2.E-01
Site-Wide					
Maintenance Worker	1.E-01	2.E-01	6.E-02	4.E-01	4.E-02
Adolescent Trespasser	1.E-02	2.E-02	8.E-03	4.E-02	9.E-03
Construction Worker	5.E-02	2.E-01	1.E-02	2.E-01	2.E-01
Subsistence Farmer	5.E+00	3.E+01	5.E-01	3.E+01	1.E+00

[a] The radiation doses given in this table are the 50-year TEDE as described in Section 6.4.1. The scenarios evaluated in this assessment are described in Section 6.3. Additional information on these estimates including the contribution of the various radionuclides to these doses is given in Appendix R. All values are given to one significant figure.

TABLE 6-9

ESTIMATED HAZARD INDEXES FOR HYPOTHETICAL EXPOSURES AT THE SLDA[a]

Scenario	Oral Intake (mg)[b]	Body Weight (kg)	Averaging Time (days)	Reference Dose (mg/kg-day)	Hazard Index[c] (mg/kg-day)
Exposure Unit 1					
Maintenance Worker	4.42E-02	70	3,650	3E-03	6E-05
Adolescent Trespasser	5.53E-03	50	1,825	3E-03	2E-05
Construction Worker	8.20E-02	70	365	3E-03	1E-03
Subsistence Farmer	2.22E+01	70	10,950	3E-03	1E-02
Exposure Unit 2					
Maintenance Worker	7.75E-03	70	3,650	3E-03	1E-05
Adolescent Trespasser	9.69E-04	50	1,825	3E-03	4E-06
Construction Worker	1.14E-07	70	365	3E-03	1E-09
Subsistence Farmer	3.16E-05	70	10,950	3E-03	1E-08
Exposure Unit 3					
Maintenance Worker	1.05E-02	70	3,650	3E-03	1E-05
Adolescent Trespasser	1.31E-03	50	1,825	3E-03	5E-06
Construction Worker	8.43E-06	70	365	3E-03	1E-07
Subsistence Farmer	2.34E-03	70	10,950	3E-03	1E-06
Site-Wide					
Maintenance Worker	2.27E-02	70	3,650	3E-03	3E-05
Adolescent Trespasser	2.84E-03	50	1,825	3E-03	1E-05
Construction Worker	8.36E-03	70	365	3E-03	1E-04
Subsistence Farmer	2.20E+00	70	10,950	3E-03	1E-03

[a] The hazard index (HI) is a measure of the potential for noncarcinogenic health concerns as a result of exposures at the SLDA site, with an HI greater than 1 being the level of potential concern. The scenarios evaluated in this assessment are described in Section 6.3. The HI calculation is limited to oral intakes of uranium, consistent with the scope of this assessment.

[b] The oral intake of uranium was determined using the ingestion intakes given in Tables R.1 through R.16 of Appendix R for the three uranium isotopes, and multiplying these activities (in pCi) by the following factors to obtain the mass (in mg) – U-234: 1.60×10^{-7}, U-235: 4.62×10^{-4}, and U-238: 2.98×10^{-3}. These factors are simply the reciprocals of the standard specific activities for these three uranium isotopes (Ci/g), divided by 1 billion to get the conversion factors into the correct units of mg/pCi. The intakes (in mg) for the three uranium isotopes are then summed to obtain the total oral intake of uranium. The intakes are given to two significant figures. See Table R.34 in Appendix R for the details of this calculation.

[c] The HI is calculated as the oral intake divided by the product of the body weight, averaging time, and reference dose. The HI is given to one significant figure.

TABLE 6-10

ESTIMATED CARCINOGENIC RISKS, RADIATION DOSES, AND HAZARD INDEXES AT THE SLDA[a]

Scenario	Radiological Risk	Radiation Dose (mrem)	Annual Dose (mrem/year)	Hazard Index
Exposure Unit 1				
Maintenance Worker	1.E-07	3.E-01	3.E-02	6.E-05
Adolescent Trespasser	1.E-08	3.E-02	6.E-03	2.E-05
Construction Worker	8.E-08	3.E-01	3.E-01	1.E-03
Subsistence Farmer	1.E-05	4.E+01	1.E+00	1.E-02
Exposure Unit 2				
Maintenance Worker	3.E-06	4.E+01	4.E+00	1.E-05
Adolescent Trespasser	3.E-07	5.E+00	1.E+00	4.E-06
Construction Worker	9.E-08	2.E+00	2.E+00	1.E-09
Subsistence Farmer	7.E-06	1.E+02	5.E+00	1.E-08
Exposure Unit 3				
Maintenance Worker	1.E-07	3.E-01	3.E-02	1.E-05
Adolescent Trespasser	2.E-08	3.E-02	7.E-03	5.E-06
Construction Worker	9.E-09	3.E-02	3.E-02	1.E-07
Subsistence Farmer	2.E-06	6.E+00	2.E-01	1.E-06
Site-Wide				
Maintenance Worker	8.E-08	4.E-01	4.E-02	3.E-05
Adolescent Trespasser	9.E-09	4.E-02	9.E-03	1.E-05
Construction Worker	3.E-08	2.E-01	2.E-01	1.E-04
Subsistence Farmer	6.E-06	3.E+01	1.E+00	1.E-03

[a] The radiological carcinogenic risk estimates represent the probability that an individual will develop cancer during their lifetime as a result of exposures to the radioactive contaminants at the SLDA site. The radiation doses are the 50-year TEDE and represent the total dose over the duration of the exposure period. The hazard indexes represent the potential for adverse health effects other than cancer and were calculated from the oral intakes of uranium. A hazard index less than 1 indicates little potential for the occurrence of adverse health effects. All values are given to one significant figure.

Table 7-1
C0NCENTRATIONS OF PRIMARY ROPCs IN SURFACE SOIL TERRESTRIAL EXPOSURE UNIT
0-4 feet bgs

Radionuclide	Units	Observation	Num ND	Range of Det	LOCID Max Hit	Range of MDL	Mean	Mean (Det)	STDev	Normal	UCL95	UCL>Max?	Final UCL95	PRG	Background	Net EPC	COPC	Comments	Depth
Americium 241	pCi/g	307	285	0.46-319.5	GB-101	0.03-0.41	1.81	24.22	19.81	No	2.11E-01	No	0.211	28	0.00	0.21	Yes		B
Plutonium 239	pCi/g	293	265	0.12-325.0	GB-102	0.03-0.28	1.67	17.12	19.35	No	1.77E-01	No	0.177	33	0.00	0.18	Yes		B
Plutonium 241	pCi/g	281	272	13.9-628.0	GB-102	5.87-15.4	8.54	103.07	37.93	No	6.60E+00	No	6.6	890	0.00	6.6	Yes		B
Radium 228	pCi/g	315	0	0.37-2.23	GB-051	0.04-0.33	1.31	1.31	0.31	No	1.34E+00	No	1.34	1.7	1.66	0	Yes		B
Thorium 232	pCi/g	315	2	0.28-2.2	GB-036	0.01-0.82	1.25	1.26	0.35	No	1.30E+00	No	1.3	1.4	1.77	0	Yes		B
Uranium 234	pCi/g	315	0	0.37-508.0	GB-043	0.03-0.38	5.82	5.73	32.19	No	3.31E+0	No	3.31	96	1.28	2.02	Yes		B
Uranium 235 (alpha)	pCi/g	314	203	0.06-46.9	GB-043	0.03-0.29	0.48	1.24	2.93	No	2.62E-01	No	0.262	35	0.27	0.01	Yes		B
Uranium 238	pCi/g	315	1	0.23-36.9	GB-043	0.01-0.31	1.53	1.54	2.64	No	1.46E+00	No	1.46	120	1.41	0.08	Yes		B

Table 7-2
CONCENTRATIONS OF PRIMARY ROPCs IN DRY RUN

MatrixD	Radionuclide	Units	Observation (n)	Num ND	Range of Det	LOCID Max Hit	Range of MDL	Mean	Mean (Det)	STDev	Normal	UCL95	UCL>Max?	Final UCL95	PRG	Background	Net EPC	COPC	Comments	Depth
Sediment	Americium 241	pCi/g	6	6	-	-	0.05-0.23	0.07	-	-	-	-	-	0	28	0.00	0.00	No		S
Sediment	Plutonium 239	pCi/g	6	6	-	-	0.02-0.05	0.02	-	-	-	-	-	0	33	0.00	0.00	No		S
Sediment	Plutonium 241	pCi/g	6	6	-	-	9.18-10.75	5.05	-	-	-	-	-	0	890	0.00	0.00	No		S
Sediment	Radium 228	pCi/g	6	0	0.83-1.4	WS/SE-DR-02	0.1-0.14	1.03	1.03	0.26	No	1.3	No	1.3	1.7	1.42	0.00	No		S
Sediment	Thorium 232	pCi/g	6	0	0.67-1.49	WS/SE-DR-01	0.02-0.07	1.06	1.06	0.31	Yes	1.31	No	1.31	1.4	1.31	0.18	Yes		S
Sediment	Uranium 234	pCi/g	6	0	0.91-20.0	WS/SE-DR-03	0.15-0.26	9.56	9.56	9.03	Yes	17.1	No	16.99	96	1.32	15.67	Yes		S
Sediment	Uranium 235 (alpha)	pCi/g	6	3	0.8-3.24	WS/SE-DR-03	0.17-0.27	0.99	1.88	1.25	Yes	2.02	No	2.02	35	0.19	1.83	Yes		S
Sediment	Uranium 238	pCi/g	6	0	0.73-1.78	WS/SE-DR-02	0.09-0.25	1.29	1.29	0.43	Yes	1.64	No	1.64	120	1.25	0.53	Yes		S
Surface Water	Americium 241 (alpha)	pCi/L	6	6	-	-	0.2-0.6	0.19	-	-	-	-	-	0	-	-	N/A	No		S
Surface Water	Americium 241 (gamma)	pCi/L	1	1	-	-	20.0-20.0	10.00	-	-	-	-	-	0	-	-	N/A	No	One value	S
Surface Water	Plutonium 239	pCi/L	6	6	-	-	0.05-0.79	0.11	-	-	-	-	-	0	-	-	N/A	No		S
Surface Water	Plutonium 241	pCi/L	6	6	-	-	9.46-13.75	6.04	-	-	-	-	-	0	-	-	N/A	No		S
Surface Water	Radium 228 (beta)	pCi/L	6	5	1.12-1.12	WS/SE-DR-04	1.22-2.11	0.86	1.12	0.22	Yes	1.04	No	1.04	-	-	N/A	??		S
Surface Water	Radium 228 (gamma)	pCi/L	1	1	-	-	14.2-14.2	7.10	-	-	-	-	-	0	-	-	N/A	No	One value	S
Surface Water	Thorium 232	pCi/L	6	6	-	-	0.13-0.4	0.14	-	-	-	-	-	0	-	-	N/A	No		S
Surface Water	Uranium 234	pCi/L	6	3	0.53-6.63	WS/SE-DR-01	0.09-0.47	1.41	2.69	2.58	No	505	Yes	6.63	-	-	N/A	??		S
Surface Water	Uranium 235 (alpha)	pCi/L	6	6	-	-	0.17-0.25	0.11	-	-	-	-	-	0	-	-	N/A	No		S
Surface Water	Uranium 238	pCi/L	6	6	-	-	0.13-0.3	0.10	-	-	-	-	-	0	-	-	N/A	No		S

Table 7-3
CONCENTRATIONS OF PRIMARY ROPCs IN CARNAHAN RUN

MatrixD	Radionuclide	Units	Observation (n)	Num ND	Range of Det	LOCID Max Hit	Range of MDL	Mean	Mean (Det)	STDev	Normal	UCL95	UCL>Max?	Final UCL95	PRG	Background	Net EPC	COPC	Comments	Depth
Sediment	Americium 241	pCi/g	6	6	-	-	0.07-0.22	0.07	-	-	-	-	-	0	28	0.00	0.00	No		S
Sediment	Plutonium 239	pCi/g	6	6	-	-	0.02-0.05	0.02	-	-	-	-	-	0	33	0.00	0.00	No		S
Sediment	Plutonium 241	pCi/g	6	6	-	-	10.7-12.6	5.84	-	-	-	-	-	0	890	0.00	0.00	No		S
Sediment	Radium 228	pCi/g	6	0	1.06-1.29	WS/SE-CR-02	0.06-0.12	1.16	1.16	0.08	Yes	1.22	No	1.22	1.7	1.42	0.00	No		S
Sediment	Thorium 232	pCi/g	6	0	0.93-1.3	WS/SE-CR-05	0.04-0.07	1.10	1.10	0.14	Yes	1.22	No	1.22	1.4	1.31	0.00	No		S
Sediment	Uranium 234	pCi/g	6	0	0.87-1.49	WS/SE-CR-01	0.13-0.26	1.16	1.16	0.21	Yes	1.34	No	1.34	96	1.32	0.02	Yes		S
Sediment	Uranium 235 (alpha)	pCi/g	6	6	-	-	0.13-0.23	0.09	-	-	-	-	-	0	35	0.19	0.00	No		S
Sediment	Uranium 238	pCi/g	6	0	0.77-1.2	WS/SE-CR-01	0.07-0.21	0.99	0.99	0.16	Yes	1.13	No	1.13	120	1.25	0.00	No		S
Surface Water	Americium 241 (alpha)	pCi/L	6	6	-	-	0.53-0.79	0.33	-	-	-	-	-	0	-	-	N/A	No		S
Surface Water	Plutonium 239	pCi/L	6	6	-	-	0.05-0.13	0.05	-	-	-	-	-	0	-	-	N/A	No		S
Surface Water	Plutonium 241	pCi/L	4	4	-	-	10.6-13.5	5.99	-	-	-	-	-	0	-	-	N/A	No		S
Surface Water	Radium 228 (beta)	pCi/L	6	5	1.64-1.64	WS/SE-CR-06	1.26-1.71	0.90	1.64	0.37	Yes	1.28	No	1.14	-	-	N/A	??		S
Surface Water	Thorium 232	pCi/L	6	6	-	-	0.13-0.3	0.12	-	-	-	-	-	0	-	-	N/A	No		S
Surface Water	Uranium 234	pCi/L	6	6	-	-	0.18-0.27	0.11	-	-	-	-	-	0	-	-	N/A	No		S
Surface Water	Uranium 235 (alpha)	pCi/L	6	6	-	-	0.15-0.22	0.09	-	-	-	-	-	0	-	-	N/A	No		S
Surface Water	Uranium 238	pCi/L	6	6	-	-	0.07-0.24	0.08	-	-	-	-	-	0	-	-	N/A	No		S

Table 7-4
CONVERSION OF URANIUM RADIOACTIVITY IN SITE-WIDE ECOLOGICAL TERRESTRIAL UNIT TO MASS CONCENTRATIONS

Isotope	Specific Activity pCi/mg
Uranium-234	6.25E+06
Uranium-235	2.16E+03
Uranium-238	3.36E+02

	Maximum Concentrations		Site-Wide EPC		Dry Run Sediments	
	pCi/g-soil	mg-U/kg-soil	pCi/g	mg/kg	pCi/g	mg/g
Uranium-234	5.1E+02	8.1E-02	3.31	5.3E-04	15.67	2.5E-03
Uranium-235	4.7E+01	2.2E+01	0.26	1.2E-01	1.83	8.5E-01
Uranium-238	3.7E+01	1.1E+02	1.46	4.3E+00	0.39	1.2E+00
Total Uranium		**1.3E+02**		**4.5E+00**		**2.0E+00**

Table 7-5

SLDA: SITE WIDE SOIL, 0 - 4 FEET BGS

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

	Water, Terrestrial Systems			Soil			Water &
	Water Limit	Site Data	Partial	Limit	Site	Partial	Soil Sum
Nuclide	pCi/L	Data	Fraction	pCi/g	Data	Fraction	of Fractions
Am-241	**2.E+05**	0.00E 00		**4.E+03**	3.20E 02	8.2E-02	8.24E-02
Pu-239	**2.E+05**	0.00E 00		**6.E+03**	3.25E 02	5.3E-02	5.31E-02
Pu-241	***No screening level developed***	0.00E 00			6.28E 02		
Ra-228	**7.E+03**	1.12E 00	**1.7E-04**	**4.E+01**	2.23E 00	5.1E-02	5.12E-02
Th-232	**5.E+04**	0.00E 00		**2.E+03**	2.20E 00	1.5E-03	1.46E-03
U-234	**4.E+05**	6.63E 00	**1.6E-05**	**5.E+03**	5.08E 02	9.9E-02	9.91E-02
U-235	**4.E+05**	0.00E 00		**3.E+03**	4.69E 01	1.7E-02	1.65E-02
U-238	**4.E+05**	0.00E 00		**2.E+03**	3.69E 01	2.3E-02	2.34E-02
	Sum of fractions for radionuclides in water		1.82E-04	**Sum of fractions for radionuclides in soil**		3.3E-01	3.27E-01

Table 7-6

DRY RUN

Aquatic System Data Entry / BCG Worksheet

Limits for Water and Sediments in Std Units

Nuclide	Nuclide data from single media or co-located samples?	Water Limit pCi/L	Site Data	Partial Fraction	Sediment Limit pCi/g	Site Data	Partial Fraction	Water & Sediment Sum of Fractions
Am-241	**co-located**	**4.E+02**	0.E+00		**5.E+03**	0.E+00		
Pu-239	**co-located**	**2.E+02**	0.E+00		**6.E+03**	0.E+00		
Pu-241	***No screening level developed***		0.E+00			0.E+00		
Ra-228	**co-located**	**3.E+00**	1.E+00	3.3E-01	**9.E+01**	1.E+00	1.60E-02	3.47E-01
Th-232	**co-located**	**3.E+02**	0.E+00		**1.E+03**	1.E+00	1.15E-03	1.15E-03
U-234	**co-located**	**2.E+02**	7.E+00	3.3E-02	**5.E+03**	2.E+01	3.80E-03	3.67E-02
U-235	**co-located**	**2.E+02**	0.E+00		**4.E+03**	3.E+00	8.70E-04	8.70E-04
U-238	**co-located**	**2.E+02**	0.E+00		**2.E+03**	2.E+00	7.15E-04	7.15E-04
	Sum of fractions for radionuclides in water			3.64E-01	Sum of fractions sediment		2.25E-02	TOTAL **3.86E-01**

Table 7-7
CARNAHAN RUN

Aquatic System Data Entry/BCG Worksheet

Limits for Water and Sediments in Std Units

Nuclide	Nuclide data from single media or co-located samples?	Water Limit pCi/L	Site Data	Partial Fraction	Sediment Limit pCi/g	Site Data	Partial Fraction	Water & Sediment Sum of Fractions
Am-241	**co-located**	**4.E+02**	0.E+00		**5.E+03**	0.E+00		
Pu-239	**co-located**	**2.E+02**	0.E+00		**6.E+03**	0.E+00		
Pu-241	***No screening level developed***		0.E+00			0.E+00		
Ra-228	**co-located**	**3.E+00**	2.E+00	4.8E-01	**9.E+01**	1.E+00	1.47E-02	4.99E-01
Th-232	**co-located**	**3.E+02**	0.E+00		**1.E+03**	1.E+00	1.00E-03	1.00E-03
U-234	**co-located**	**2.E+02**	0.E+00		**5.E+03**	1.E+00	2.83E-04	2.83E-04
U-235	**co-located**	**2.E+02**	0.E+00		**4.E+03**	0.E+00		
U-238	**co-located**	**2.E+02**	0.E+00		**2.E+03**	1.E+00	4.82E-04	4.82E-04

Sum of fractions for radionuclides in water 4.85E-01 Sum of fractions sediment 1.65E-02 **TOTAL** **5.01E-01**

Table 7-8
ECOLOGICAL RISK CHARACTERIZATION FOR CHEMICAL TOXICITY OF TOTAL URANIUM IN SITE-WIDE TERRESTRIAL EXPOSURE UNIT

	Concentration mg/kg	Soil Screening Level mg/kg	Ecological Effects Quotient
Maximum	1.3E+02	5	3.E+01
EPC	4.5E+00	5	9.E-01