# KIRTLAND AIR FORCE BASE
# ALBUQUERQUE, NEW MEXICO

## FINAL STATUS SURVEY REPORT
## FOR REMEDIATION OF SITE RW-06

October 2012

377 MSG/CEANR
2050 Wyoming Blvd. SE
Kirtland AFB, New Mexico 87117-5270

# KIRTLAND AIR FORCE BASE
# ALBUQUERQUE, NEW MEXICO

# Final Status Survey Report
# For The Remediation of Site RW-06

**October 2012**

***Prepared for***

Air Force Center for Engineering and the Environment (AFCEE)

3300 Sidney Brooks

Brooks City- Base, Texas

Contract No. FA8903-04-D8693
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***Prepared by***

Cabrera Services, Inc.
5911 Jefferson Street, NE, Suite A
Albuquerque, NM  87109

****NRC Comments addressed by USAF***

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# NOTICE

This Final Status Survey Report (FSSR) was prepared for the Air Force Center for Engineering and the Environment (AFCEE) by Cabrera Services, Inc. (CABRERA) for the purpose of reporting results of sufficient quality and quantity to support decisions for unrestricted release of surface soil and surfaces of remediated areas at the RW-06 site at Kirtland Air Force Base. Prior site remediation identified, removed and disposed of radioactive contaminants and chemical materials present at RW-06, Radioactive Burial Site 11, also known as Solid Waste Management Unit (SWMU) 6-30 (burial pits and surface contamination from 9 trenches and five surficial hot spots) and restored the site soil to levels below project release criteria in accordance with Worldwide Environmental Restoration and Construction (WERC) Contract FA8903-04-8693-0005 for Kirtland Air Force Base, New Mexico, under the base's Environmental Restoration Program (ERP).

This reports aids in the implementation of a final remedial action plan for the U.S. Air Force Center for Environmental Excellence. As the report relates to actual or possible releases of potentially hazardous substances, its release prior to a final decision on use of remediated areas is in the public's interest. The limitations of this document with its recommendations for disposition plans for some wastes and the ongoing nature of the ERP, along with the evolving knowledge of site conditions and chemical effects on the environment and health, must be considered when evaluating this report, as subsequent facts may become known that may make this report premature or inaccurate.

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# JANUARY 2011

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ROBERT L. MANESS, Colonel, USAF

Commander

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Kirtland Air Force Base

377 ABW Public Affairs

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# NATURAL RESOURCE INJURY

The Natural Resource Injury (NRI) program is a mechanism designed to restore natural resources injured by hazardous substance releases. The NRI program measures the extent of injury to natural resources and determines environmental pathways, necessary restoration measures, costs, and liability. The NRI requires parties responsible for contamination and injuries to pay for losses. In certain cases, restoration may include replacement or acquisition of equivalents for habitats; populations of wildlife; and human services, including hunting, fishing, and recreational activities.

The NRI program is carried out by various federal, state, and tribal trustees for fish, wildlife, other living resources, water, lands, and protected areas. Trusteeship is derived from treaties (federal and tribal), statutes (federal and state), and other regulations. Federal agencies responsible for land management include the National Park Service; United States Fish & Wildlife Service; Bureau of Land Management; United States Department of Agriculture, including the United States Forest Service; Department of Defense; and the Department of Energy.

The NRI program has established a restoration fund to be used to restore resources lost or injured by the release of hazardous materials and oil spills. The NRI program has been traditionally associated with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). CERCLA directed the Department of Interior to prepare rules for NRI at hazardous waste sites and for emergency incidents involving CERCLA substances. The integration of the NRI with the Resource Conservation and Recovery Act (RCRA) is currently being considered by the Department of Defense under the proposed Range Rule.

CERCLA and RCRA provide tools to clean up contaminants from the environment. However, these cleanup programs focus on human health and environmental concerns related to human health. The programs are primarily carried out by the U.S. Environmental Protection Agency (EPA) working with the states. These programs do not concentrate on restoring natural resources, although cleanup may prevent further injuries to natural resources. The CERCLA and RCRA programs often do not deal with downstream and offsite contaminated sediments outside National Priority List and Solid Waste Management Unit boundaries. With regard to injuries to natural resources, CERCLA states the following: 1) responsible parties are liable for compensatory damages for injuries to natural resources owned, managed, or controlled by government agencies or Indian tribes; 2) government agencies and Indian tribes may assess and collect the damages, acting on behalf of the public as trustees for the injured natural resources; and 3) recovered damages must be used to restore, rehabilitate, replace, or acquire the equivalent of the injured natural resources. Therefore, the NRI program was established to ensure restoration and compensation where needed and appropriate.

### *Conclusions and Recommendations:*

The RW-06 SWMU at Kirtland Air Force Base is unlikely to require an NRI program. Previous recommendations from the Resource Conservation and Recovery Act Facility Investigation Report for Solid Waste Management Unit 6-30, Radioactive Burial 11 (RW-06) in October 2007 included excavation of nine disposal trenches, waste segregation, and transport and disposal of chemical and radiological wastes to appropriate off-site disposal facilities.

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# ENVIRONMENTAL JUSTICE CONSIDERATION

Presidential Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* requires identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of federal programs, policies, and activities on minority and low-income populations. For purposes of this report, the population within a 50-mile radius around Kirtland AFB was considered. Demographic and economic census information presented in *Addressing Environmental Justice under the National Environmental Policy Act at Sandia National Laboratories/New Mexico* was used as a primary reference.

The minority populations living within a 50-mile radius of Kirtland AFB, which exceed 49 percent of the total population according to census data, are evaluated with regard to health and environmental effects from activities at Kirtland AFB. Similarly, the low-income population, which exceeds 21 percent of the general population, was analyzed for effects from corrective measures activities at Kirtland AFB.

Minority populations are considered to be all *people of all color* except white people who are not Hispanic. In 1990, 49 percent (51 percent by 1996) of New Mexico's population was minority (Census, 1998). Neighborhoods having minority population percentages exceeding the minority population percentage of 49 percent (slightly more conservative than 51 percent) were identified on a block-by-block basis, with clusters of blocks known as block groups.

The Bureau of the Census characterizes persons in poverty (low-income persons) as those whose incomes are less than a statistical poverty threshold. The threshold is a weighted-average based on family size and age of family members. For instance, the 1990 census threshold for a family of four was based on a 1989 household income of $12,674 (Census, 1990). By 1996, the household income threshold rose to $16,036 (Census, 1997). In 1989, 21 percent of New Mexico's population was listed in poverty or designated as having low income (Census, 1996). By 1996, the estimated percentage stood at 24 percent (Census, 1997). In this analysis, low-income block groups (same as above) occur where the low-income population percentage in the block group exceeds the poverty percentage for the state of New Mexico.

According to 1990 census data, approximately 280,360 minority individuals from an approximate total population of 609,500 reside within the 50-mile radius. This represents 46 percent of the total radius-of-influence (ROI) population (SNL, 1997).

Block groups having less than 21 percent low-income individuals were not considered to contain a large number of low-income neighborhoods because they contain less than or equal to the state average of 21 percent. Approximately 85,330 persons were identified as being low income, representing approximately 14 percent of the ROI population.

This distribution of low-income population has a strong correlation to minority populations of Blacks, Native Americans, and Hispanics. For example, portions of the Pueblo of Isleta, south of the city, have high percentages of low-income individuals. To the southeast of Kirtland AFB, the rural Hispanic villages of Tajique, Torreon, and Escobosa are also low income. To the north of Kirtland AFB, high concentrations of low-income populations are located in the Pueblos of Jemez, Santo Domingo, and Cochiti, as well as in the rural Hispanic villages of La Cienega and Jemez Springs. High concentrations of low-income populations occur west of Kirtland AFB, along the Rio Grande, in the predominantly Hispanic South Valley neighborhoods. In addition, small pockets of low-income populations reflect the locations of Black neighborhoods such as the Kirtland Addition and South Broadway/East San Jose area.

The environmental and human health effects considered include potential impacts to surface and groundwater from contamination, restricted access by Native Americans to traditional cultural sites, biological resources, air quality, and noise.  Based on the geographical location within Kirtland AFB (see map at Figure 1-1), there would be no disproportionally high or adverse impacts to minority and low-income populations.

# PREFACE

This Final Site Survey Report (FSSR) was prepared for AFCEE by CABRERA to present results of the Site RW-06 remedial action construction project for excavation, segregation, packaging, transportation and disposal of all waste material and final status survey performed in accordance with Section F.2 of Module IV of the EPA, Region 6, Hazardous Waste Permit (Identification No, NM9570024423) for Kirtland Air Force Base, New Mexico, under the base's Environmental Restoration Program (ERP). This work is performed under the authority of the AFCEE WERC contract number FA8903-04-8693, Delivery Order 0005. Mr. Joseph Urrutia is the AFCEE Project Manager for this program.

This project was conducted with the cooperation and oversight of Kirtland AFB Environmental Restoration Section Chief and Project Manager, Mr. Ludie W. Bitner. Key CABRERA personnel involved in the project include Mr. Greg Miller, Program/Project Manager; Mr. Paul Schwartz, Certified Industrial Hygienist (CIH), Certified Safety Professional (CSP), Corporate Safety Manager; Mr. Hank Siegrist, PE, CHP, Corporate Radiation Safety Officer. This FSSR was prepared by a team of multidisciplinary engineers, compliance, and quality control professionals.

June 2011

Greg Miller, Esq.

Program/Project Manager

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# CONTENTS

# APPENDICES

# FIGURES



# TABLES

# ACRONYMS AND ABBREVIATIONS

| ACRONYM / ABBREVIATION | DEFINITION |
|---|---|
| α | Alpha |
| β | Beta |
| σ | Sigma; one standard deviation |
| µ | Mu; micro |
| % | percent |
| µCi | microcurie |
| µCi/ml | microCuries per milliliter |
| AFB | Air Force Base |
| ALARA | As Low As Reasonably Achievable |
| $^{241}$Am | americium-241 |
| ANSI | American National Standards Institute |
| $^{98}$Au | gold |
| $^{140}$Ba | Barium-140 |
| bags | below ground surface |
| BEHP | Bis (2-ethylhexyl) phthalate |
| $^{14}$C | carbon-14 |
| cm | centimeters |
| $^{137}$Cs | cesium-137 |
| CABRERA | Cabrera Services, Inc. |
| $^{144}$Ce | Cesium-144 |
| CFR | Code Of Federal Regulations |
| cm | centimeters |
| cm$^2$ | centimeter squared |
| $^{57}$Co | cobalt-57 |
| COPC | contaminants of potential concern |
| $^{57}$Cr | Chromium-57 |
| CV | coefficient of variation |
| CY | cubic yard |
| DCGL$_W$ | Derived Concentration Guideline Level for the statistical test |
| DoD | U.S. Department of Defense |
| DQAR | Data Quality Assessment Report |
| DQO | Data Quality Objective |
| DRO | diesel range organic |
| EDA | Exploratory Data Analysis |
| EMC | elevated measurement comparison |
| EPA | U.S. Environmental Protection Agency |

| ACRONYM / ABBREVIATION | DEFINITION |
|---|---|
| FIDLER | Field Instrument For The Detection Of Low Energy Radiation |
| FSP | Field Sampling Plan |
| FSS | Final Status Survey |
| FSSR | Final Status Survey Report |
| ft | foot/feet |
| GPS | Global Positioning System |
| GRO | gasoline range organic |
| HPGe | High purity germanium |
| H0 | null hypothesis |
| $^3$H | tritium |
| Ha | alternate hypothesis |
| $^{203}$Hg | mercury-203 |
| HPG$_e$ | high purity germanium |
| $^{59}$I | iodine-59 |
| $^{131}$I | iodine-131 |
| ke-V | kilo-electron volt |
| $^{85}$Kr | krypton-85 |
| $^{88}$Kr | krypton-88 |
| 140La | lanthanum-140 |
| L | liter |
| m | meter |
| MARSSIM | Multi Agency Radiation Survey and Site Investigation Manual |
| ml | milliliter |
| MDC | Minimum Detectable Concentration |
| mg/kg | milligrams per kilogram |
| mg/l | milligrams per liter |
| min | minute |
| MQO | measurement quality objectives |
| mrem/yr | millirem per year |
| NaI | sodium iodide |
| $^{95}$Nb | niobium-95 |
| nCi | nanocuries |
| NIST | National Institute Of Standards And Technology |
| NMED | New Mexico Environment Dept. |
| NRC | Nuclear Regulatory Commission |
| pCi | picoCurie |
| pCi/g | picoCuries per gram |
| PCB | polychlorinated biphenyls |

| ACRONYM / ABBREVIATION | DEFINITION |
|---|---|
| $^{144}$Pe | praseodymium-144 |
| PID | Photoionization Detector |
| Ppm | parts per million |
| PSQ | principal study question |
| $^{239}$Pu | plutonium-239 |
| QAPP | Quality Assurance Project Plan |
| QC | Quality Control |
| $^{226}$Ra | radium-226 |
| RCRA | Resource Conservation and Recovery Act |
| RFI | RCRA Facility Investigation |
| ROC | radionuclide of concern |
| RSL | regional screening level |
| $^{103}$Ru | ruthenium-103 |
| $^{106}$Ru | ruthenium-106 |
| SOL | |
| SOR | Sum of the Ratios |
| sqft | square feet |
| $^{85}$Sr | strontium-85 |
| $^{89}$Sr | strontium-89 |
| $^{90}$Sr | strontium-90 |

| ACRONYM / ABBREVIATION | DEFINITION |
|---|---|
| SRM | Site Remediation Manager |
| SSHO | Site Safety And Health Officer |
| SSL | soil screening level |
| SU | survey units |
| SVOC | Semi-volatile Organic Compound |
| SWAPP | Storm Water Pollution Prevention Plan |
| SWMU | Solid Waste Management Unit |
| TCLP | Toxicity Characteristic Leaching Procedure |
| VOC | Volatile Organic Compounds |
| WERC | Worldwide Environmental Restoration and Construction |
| WRS | Wilcoxon Rank Sum |
| XRF | x-ray fluorescence |
| $^{91}$Y | yttrium-91 |
| $^{90}$Y | yttrium-90 |
| $^{65}$Z | zinc-65 |
| $^{95}$Zr | zirconium-95 |

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# Executive Summary

This Final Status Survey Report (FSSR) presents the results of the remediation and radiological Final Status Survey (FSS) performed by Cabrera Services, Inc. (CABRERA) from October 9 through November 20, 2009 to obtain closure for Site RW-06, Radioactive Burial 11, also known as Solid Waste Management Unit (SWMU) 6-30 (hereafter referred to as RW-06 or the Site) at Kirtland Air Force Base (AFB), New Mexico. The purpose of this FSSR is to report project results of sufficient quality and quantity to support decisions for unrestricted release of surface soil and surfaces of remediated areas at the RW-06 site. The project data quality objectives, field activities, survey design, quality assurance and quality control, results and recommendations have been reviewed, analyzed, and presented in this FSSR.

The goal of this remediation project is to identify, remove and dispose of radioactive contaminants present at RW-06 (burial pits and surface contamination) and restore the site soil to levels below project release criteria listed in Section 1.3.3. Based on the historical information, data from the RW-06 planning survey completed by CABRERA in October 2008, and the approved project plans, it is concluded that all wastes and debris have primarily radioactive contamination. Site-attributable organic or inorganic chemical contamination may be present at low levels and data has been collected and compared against New Mexico Environment Department (NMED) screening levels.

The Radiation Effects Laboratory, Biophysics Division, operated from 1960 to 1971 and performed experiments on large and small animals during that time. The waste from these experiments was controlled and disposed in trenches located at the RW-06 Site. The disposal site consists of nine known former burial trenches. The only suspected major remaining compound classes of concern at RW-06 are metals and radioactive isotopes.

The radionuclides of concern (ROCs) are $^{3}H$, $^{14}C$, $^{90}Sr$, $^{137}Cs$, $^{226}Ra$, $^{239}Pu$, and $^{241}Am$. All of the ROCs except $^{239}Pu$ were selected based on the discussion of historical investigations and the planning survey at RW-06 and were approved in the "*Field Sampling Plan for Remedial Action Construction at Site RW-06*", CABRERA 2009. During project work, a small (approximately 30-gallon) drum with material containing $^{239}Pu$ and $^{241}Am$ was located, segregated, and secured with project contaminated waste. Due to this material being located, $^{239}Pu$ was included as a project ROC. The United States Nuclear Regulatory Commission (NRC) screening level for $^{239}Pu$ was added to the list of Derived Concentration Guideline Levels ($DCGL_W$s) in Table 1-1; analysis for isotopic plutonium was performed on all soil and debris samples, and the data included in the statistical analysis and summary for all project ROCs.

Excavation and removal of radioactively contaminated soil and debris was performed prior to the FSS at the RW-06 investigation area. Field excavation was accomplished in a controlled, safe manner following the approved project plans. Safety violations or incidents did not occur. Field changes to the approved plans are summarized within the report.

The FSS was designed and implemented in accordance with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) as described in the approved project plans. All areas were surveyed for radiological contamination using instrumentation and techniques appropriate for the ROCs identified and MARSSIM classification. Quality assurance (QA) measures were implemented throughout the project to ensure data met known and suitable data quality criteria

such as precision, accuracy, representativeness, comparability, and completeness. The quality of analytical data was also controlled through the performance of quality control (QC) measurements and the calibration of field and laboratory equipment. Onsite radiological measurement techniques were used based on radiological characteristics of the potential contaminants and the reasonable implementation of best available technology. The measurement analysis results were reviewed, evaluated using Explanatory Data Analysis (EDA), and compared to the project release criteria using the Wilcoxon Rank Sum Test (WRS).

There were seven Class 1 and one Class 2 final status survey units (SU) created after the RW-06 Site was remediated. All of these remediated area survey units passed the WRS test and the null hypothesis was rejected. The northwest corner of FSS-SU02 (trench four) had three systematic measurement location $^{239}$Pu values (RW6-FSS-SU02-012 [4.16 pCi/g], RW6-FSS-SU02-014 [2.83 pCi/g], RW6-FSS-SU02-015 [4.70 pCi/g]) that exceeded the $DCGL_W$ (2.3 pCi/g). Systematic sample RW6-FSS-SU08-003 (15.2 pCi/g) exceeded the project $^{14}$C $DCGL_W$ (11.6 pCi/g). The estimated area of elevated activity represented by these data points was investigated by elevated measurement comparison (EMC) and the total dose for SU02 and SU08 are less than the release criteria.

Twelve biased samples were also collected based on analysis and review of the gross gamma scan data for each of survey units SU02, SU08, SU10, and SU11. The Sum of the Ratios (SOR) for project ROCs were <1.0 for all biased sample results except Sample RW6-FSS-SU11-016 in SU11, which had $^{137}$Cs reported at 15.7 pCi/g ($DCGL_W$ of 11.0 pCi/g). The area of elevated activity represented by this data point (approximately 20 $m^2$) was investigated by elevated measurement comparison and the total dose for SU11 is less than the release criteria.

Additional excavation was performed in January 2011 on the areas in SU02 and SU11 that contained the measurement results above the DCGL for $^{239}$Pu and $^{137}$Cs, respectively. Approximately 80 additional CY of soil were removed and the excavation area footprint was defined as a Class 1 FSS-SU12. Survey unit 12 passed the WRS test and the null hypothesis was rejected. The results of the Final Status Survey for SU12 are contained as an addendum in Appendix D of this Report.

Potentially non-contaminated soil excavated from trenches was laid out in the staging area as four MARSSIM Class 1 survey units, and appropriate surveys and sampling were performed to support decisions for unrestricted release and reuse as backfill. All of the four soil overburden (SO) survey units passed the WRS test and the null hypothesis was rejected. Although SO-SU01 and SO-SU04 passed the WRS test, one systematic measurement in each survey unit (i.e., samples RW6-SO-SU01-003 [5.3 pCi/g $^{239}$Pu value] and RW6-SO-SU04-0013 [12.4 pCi/g $^{14}$C]) exceeded the $DCGL_W$. The area of elevated activity represented by these data points was investigated by EMC and the total dose is less than the release criteria. Thirteen biased samples were also collected based on analysis and review of the gamma walkover scan data for survey units SO-SU01, SO-SU02, SO-SU03, and SO-SU04. The SOR was <1.0 for all biased measurements.

A total of 36 soil samples were collected from the twelve remediation and soil overburden units (three from each of twelve SUs) and analyzed for stabile chemistry constituents. Constituent concentrations were compared to the NMED residential SSLs as well as the United States Environmental Protection Agency (EPA) residential regional screening levels (RSLs). Results of the FSS samples indicated that there were not any VOCs or SVOCs that exceeded the NMED residential soil screening levels (SSL) or EPA residential RSLs. Sixteen of 37 samples had concentrations (maximum of 5.9 mg/kg) of arsenic in excess of the NMED residential SSL of 3.9 mg/kg and all samples exceeded the EPA residential RSL of 0.39 mg/kg. However, regional studies report a mean abundance of 8.5 mg/kg in source bedrock samples (which none of the project sample results exceeded) and one of three background samples also exceeded the NMED residential SSL. One FSS sample, RW6-FSS-SU05-001, had a result for bis (2-ethylhexyl) phthalate (BEHP) of 71,000µg/kg, exceeding the EPA residential RSL of 35,000µg/kg, but well below the NMED residential soil screening level of 347 mg/kg. BEHP is a plasticizer, which is commonly found as a laboratory contaminant. The FSS samples have met their data quality objectives (DQO) based on comparison to NMED SSLs.

A total of fifty-two “super sacks” of waste (35 with soils, eight soils with debris, and nine with plastic and other investigation derived waste) were collected as a result of project remediation efforts. Each super sack contains approximately 8 cubic yards of material for an estimated total of 416 cubic yards. Thirteen composite samples were collected and analyzed for radiological and chemical contamination to properly direct disposition of the waste. The waste was shipped the week of 23 May 2011 to the Energy Solutions Clive, Utah facility for disposal. The waste disposal certificates are contained in Appendix E of this report.

The excavated trenches were backfilled after completion of the FSS with clean soil obtained from project location which had been surveyed and cleared for use as fill material. In addition, reseeding of native grasses required to restore the site has been performed.

Based on the Conclusions presented above, the following recommendation is proposed:

1. Unconditionally release FSS SUs 2, 5, 6, 7, 8, 9, 10, 11, 12, and SO SUs 1, 2, 3, and 4. Soil from SO-SU01, SO-SU02, SO-SU03, and SO-SU04 may be utilized as backfill for trenches at the RW-06 site.

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# 1.0 Introduction

This Final Status Survey Report (FSSR) presents the results of the remediation and radiological Final Status Survey (FSS) performed by Cabrera Services, Inc. (CABRERA) from October 9 through November 20, 2009 to obtain closure for Site RW-06, Radioactive Burial 11, also known as Solid Waste Management Unit (SWMU) 6-30 (hereafter referred to as RW-06 or the Site) at Kirtland Air Force Base (AFB), New Mexico (Figures 1-1 and 1-2). CABRERA has prepared this FSSR for Kirtland AFB under Worldwide Environmental Restoration and Construction (WERC) Contract No. FA8903-04-D8693, Delivery Order 0005, to the Air Force Center for Environmental Excellence.

The purpose of this FSSR is to report results of sufficient quality and quantity to support decisions for unrestricted release of surface soil and surfaces of remediated areas at the RW-06 **site.**

## 1.1 Project Objectives

The goal of this remediation project is to identify, remove and dispose of radioactive contaminants present at RW-06 (burial pits and surface contamination) and restore the site soil to levels below project release criteria listed in Section 1.3.3. Based on the historical information, data from the RW-06 planning survey completed by CABRERA in October 2008, and the approved project plans, it is assumed that all wastes and debris will have primarily radioactive contamination. The objective of project remediation support and final status survey (FSS) activities is to obtain data of sufficient quality and quantity so that they can be evaluated against approved radiological criteria and support decisions for unrestricted release of the RW-06 site. Site-attributable organic or inorganic chemical contamination may be present at low levels and data has been collected and compared against New Mexico Environment Department (NMED) screening levels.

## 1.2 Site Description and History

### *1.2.1*

Kirtland AFB is located in Albuquerque, New Mexico, on the southeastern side of the city. RW-06 occupies approximately 4.5 acres of flat, desert soil and minimal vegetation and from 1960 to 1971 was part of a 40-acre facility operated by the Radiobiology Laboratory, Biophysics Branch, Air Force Weapons Laboratory (USAF, 1981). The portion of the Radiobiology Laboratory that was used as a radioactive burial site contained 9 trenches that were used for the disposal of animal carcasses, low-level radioactive material, and other laboratory wastes. RW-06 is located within a fenced field area immediately east-southeast of the former Riding Stables complex (Figure 1-2).

### *1.2.2 Site History*

The Radiation Effects Laboratory, Biophysics Division, operated from 1960 to 1971 and performed experiments on large and small animals during that time. The waste from these experiments was controlled and disposed in trenches located at the RW-06 Site. The disposal site consists of 9 known former burial trenches. Of the 9 trenches, four were described as being 50-feet (ft) long by 2-ft wide by 9-ft deep. These trenches were closed by 1965. The two southernmost trenches were covered with asphalt caps that were visible during the 2006 Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) activities. The dimensions of the other five trenches were less well documented, although two of the trenches were described as being 100-ft long by 6-ft wide by 20-ft deep. Additionally, a pre-planning survey completed by CABRERA in October 2008 included a gamma drive over survey and identified five surface locations with elevated activity.

The documents entitled, *Procedures for the Disposal of Radioactive Wastes* (dated 1965) and *Radioactive Wastes Survey* (dated 1 July 1971) provide some details of waste disposal practices, locations, and expected contaminants of concern at RW-06. The 1965 document specifically describes four waste disposal pits, which, at the time of writing in 1965, were closed. These pits are described as being 9-ft deep, 2-ft wide and about 50-ft long. Pits were reported as being covered with a minimum of 4-ft of earth and two of the pits were surfaced with asphalt, while the remaining two had compacted earth covers. These four pits were reportedly enclosed in a fenced area. Material disposed in these pits was reported as animal carcasses, animal excreta, and contaminated solid waste (USAF, 1965). Most contaminated solid waste was reported as having been placed in steel drums prior to burial, although some waste was sealed in double, plastic bags. Animal carcasses were buried both by sealing in steel drums and by direct burial without a container. High-level waste and most liquid wastes are reported to have been disposed of through appropriate USAF channels and therefore, presumably, were not placed in the disposal pits.

In the 1965 USAF document, two other disposal trenches that were in use at the time of writing also were described. These two disposal trenches were described as being 20-ft deep, 6-ft wide, and roughly 100-ft long. As with the other trenches, waste was described as being contained in steel drums or plastic bags prior to disposal. The total amount of waste disposed in each trench was limited by the amount of total radioactivity that would be present based on the radioactivity of the materials disposed. It was reported that at the end of 1965, one of the disposal trenches (pit No. 5) was only one-quarter (25 %) full based on disposed waste activity to that point. The 1971 *Radioactive Wastes Survey* (USAF, 1971) corroborates the same general operation and disposal methods at the Radiobiology Laboratory as those presented in the 1965 document.

Based on the 1965 *Procedures for the Disposal of Radioactive Wastes* document, an estimate was made of the possible maximum remaining isotope activity potentially present in materials disposed of in the SWMU 6-30 (RW-06) trenches to that date. The total maximum possible activity was estimated by comparing the total stock of radioisotopes that had been distributed to the facility in 1959 and comparing those activities to the current stock at the time of writing in 1965. The difference between the original volumes and the 1965 stock, taking into account volumes known to have been used through other applications, was assumed to be the maximum amounts of radioactive materials that could be present in the disposed waste material.

According to the 1965 document, the radionuclides with total potential activities greater than 1 microcurie (μCi) included calcium-45 ($^{45}$Ca), cerium-144 ($^{144}$Ce), praseodymium-144 ($^{144}$Pe), cesium-137 ($^{137}$Cs), Iron-59 ($^{59}$Fe), mercury-203 ($^{203}$Hg), krypton-85 ($^{85}$Kr), ruthenium-106 ($^{106}$Ru), strontium- 90 ($^{90}$Sr), yttrium-91 ($^{91}$Y), zinc-65 ($^{65}$Zn), zirconium-95 ($^{95}$Zr), and niobium-95 ($^{95}$Nb). Other possibly present isotopes — all with total potential activities less than, or equal to, 1 μCi — included gold-198 ($^{198}$Au), barium-140 ($^{140}$Ba), lanthanum-140 ($^{140}$La), cerium- 141 ($^{141}$Ce), cobalt-57 ($^{57}$Co), chromium-51 ($^{51}$Cr), iodine-131 ($^{131}$I), radium-226 ($^{226}$Ra), ruthenium-103 ($^{103}$Ru), strontium-85 ($^{85}$Sr), strontium-89 ($^{89}$Sr), yttrium-90 ($^{90}$Y), mixed fission products (MFP), and possible trace amounts of plutonium-239 ($^{239}$Pu). These calculated volumes were only estimates and this does not necessarily mean that all, or any, of the listed radioisotope volumes were actually present in the waste emplaced in the disposal trenches.

Of the listed radionuclides, only four possess half-lives long enough to theoretically still be present in significant quantities after 40 years of decay — $^{85}$Kr, $^{90}$Sr, $^{137}$Cs,and $^{226}$Ra. Krypton-85 is an inert gas and is not expected to remain at the site. Calculations for potential remaining activity for these and all other listed radionuclides were discussed in the *RCRA Facility Investigation Sampling and Analysis Plan for Solid Waste Management Unit 6-30, Radioactive Burial 11 (RW-06)* (USAF, 2006). That plan concluded that $^{239}$Pu was not likely to be present at the site based on historical process information.

Figure 1-1: Site Location Map

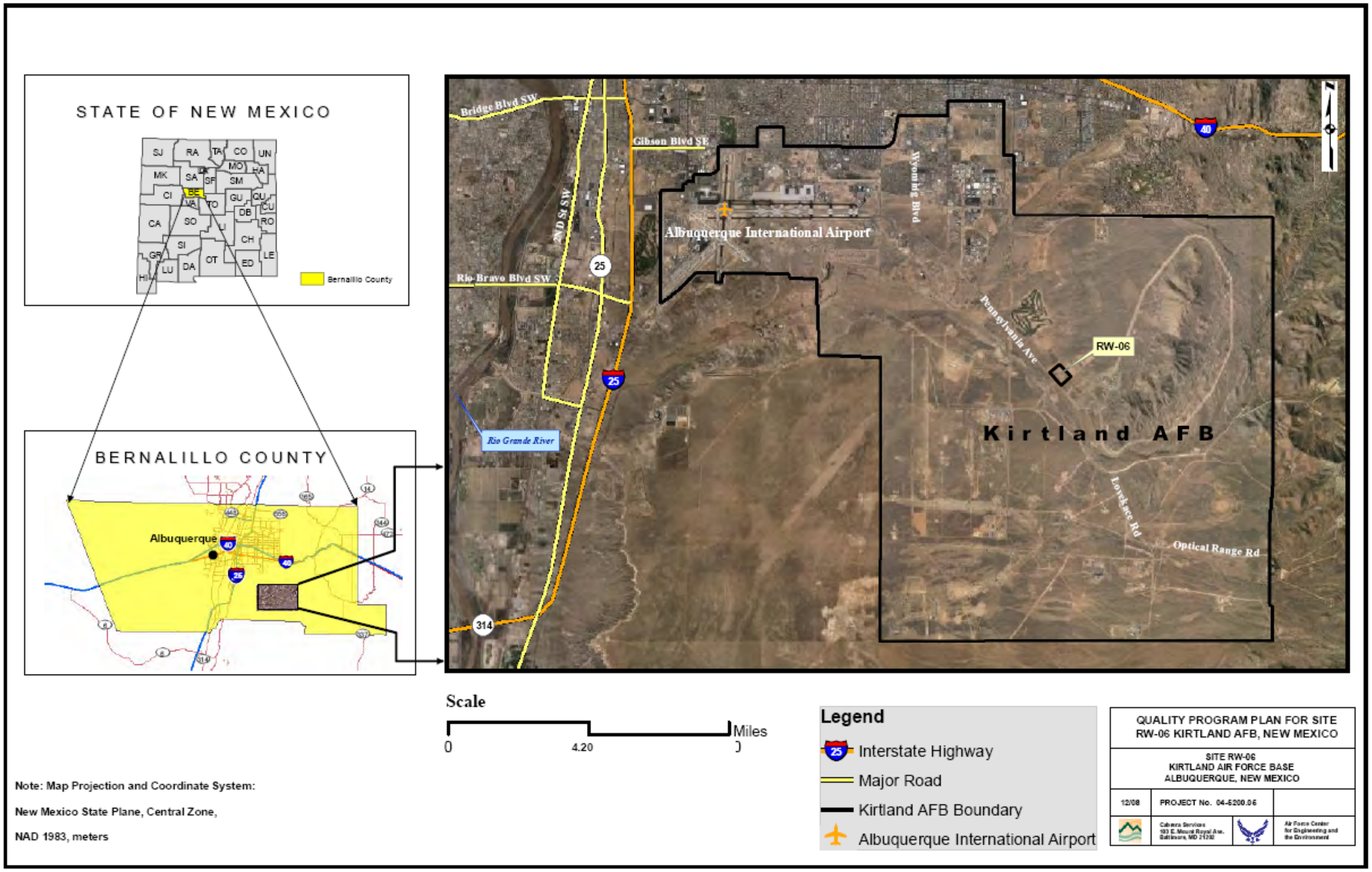
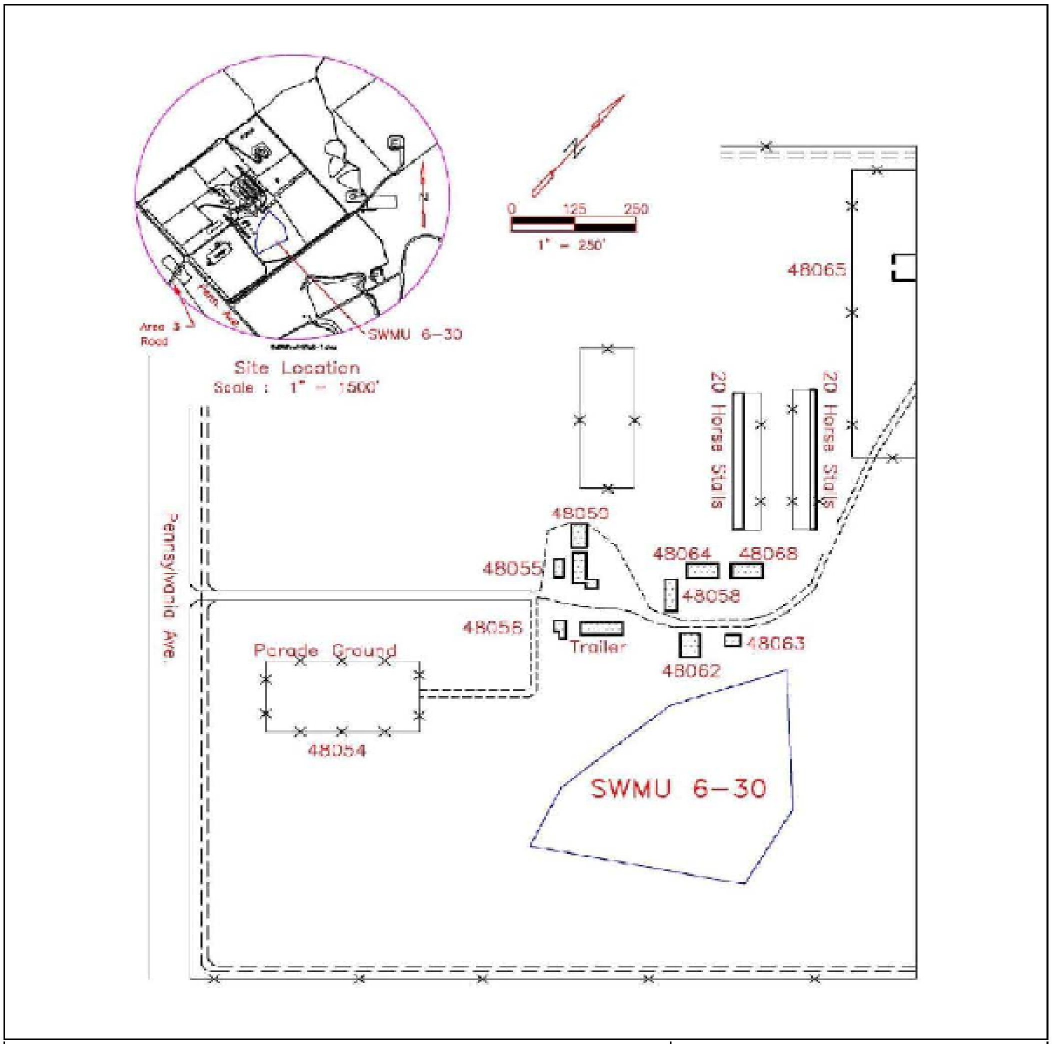


Figure 1-2: SWMU 6-30 (RW-06) Vicinity Map




| | |
|---|---|
| | SWMU 6-30 (RW-06) VICINITY MAP |
| | SITE RW-06<br>KIRTLAND AIR FORCE BASE<br>ALBUQUERQUE, NEW MEXICO |
| | 12/08 PROJECT No. 04-5200.06 |
| Source: RCRA Facility Investigation Report, CH2M Hill, 2004 for SWMU 6-30, RW-06 | Cabrera Services 103 E. Mount Royal Ave. Baltimore, MD 21202 — Air Force Center for Engineering and the Environment |

### 1.2.3 Review of Previous Investigations

A review of radiological data collected during previous surveying and sampling efforts was conducted during preparation of the remediation and FSS design to evaluate the potential for residual contamination at RW-06.

Numerous investigations were conducted at the RW-06 site including radiation surveys, geophysical surveys, extensive site sampling, installation of a groundwater monitoring well, and installation of a horizontal borehole.

Historically, the possible contaminants of concern at RW-06 have been considered to be volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), petroleum hydrocarbon gasoline rang organics (GRO) and diesel rang organics (DRO), metals, cyanide, and potentially a variety of alpha, beta, and gamma emitting radionuclides.

These suites of contaminants have been the focus of several previous investigations on the site. However, sample results to date have not indicated that any of these types of contaminants, except for radionuclides, exceeded the regulatory release levels.

A Phase 2 Stage 1 field investigation in 1985 included the advancement of two 100-ft exploratory holes at the south end of the site. Sampling from these boreholes identified only sodium and iron in soil samples in excess of the screening levels used at that time. Lead, mercury, silver, total organic halogens, oils and greases, and pesticides were not detected. Field-screening for gamma radiation performed on the drill cuttings identified no activities above background (USAF, 1985).

In January 1988, a surface radiological survey, a subsurface magnetic survey, and a mercury vapor survey were performed at the site. All surface radiation levels were found to be consistent with background. A total of 21 magnetic anomalies were identified by the magnetic survey. Of these 21 anomalies, 13 were attributed to surface or shallow subsurface metal objects that could often be seen. The remaining eight anomalies were described as having the magnetic characteristics of significant masses of buried metal, such as buried drums. Many of these anomalies were oriented in linear configurations, often in association with surface depressions, which suggested subsidence of a disposal trench. The largest identified magnetic anomaly was associated with a linear depression and an exposed drum was observed. No mercury vapors were detected in any of the shallow test boreholes installed in the areas of the significant magnetic anomalies (USAF, 1988).

A June 1992 radiation survey to determine possible air and surface soil contamination identified no radiation levels above background conditions (Caputo, 1992).

A SNL/NM technology demonstration project, consisted of installing a horizontal borehole beneath the six southernmost trenches; field monitoring for mercury vapors and volatile organic compounds (VOCs); measuring gamma radiation in soil adjacent to the borehole using a downhole gamma-ray spectrometer; and sampling soil gas for mercury and VOCs. This investigation did not identify radiation levels above background conditions or contaminated soil vapor, though detailed field screening and analytical results for mercury vapor and VOCs were not included within the technology demonstration report (Floran, 1994). In November 2006, SNL/NM plugged and abandoned the horizontal borehole.

The Appendix IV, Stage 2D-1 RFI (USAF, 1994) was conducted to determine the possible nature and extent of disposal trench contamination and included surface and subsurface soil sampling in soil adjacent to the trenches. Thirty-six boreholes were installed with four to five soil samples collected per borehole for a total of approximately 170 individual soil samples. Soil samples were analyzed for petroleum hydrocarbon gasoline range organics (GROs) and diesel range organics (DROs), VOCs, semivolatile organic compounds (SVOCs), target analyte list (TAL) metals, cyanide, gross alpha and gross beta radiation levels, Ra-226, Ra-228, soil pH, and soil moisture.

Analytical result from the Appendix IV, Stage 2D-1 indicated the presence of seven VOCs including, acetone; ethylbenzene; methylene chloride; tetrachloroethene; toluene; 1,1,1-trichloroethane; and xylenes. These VOCs were detected at low concentrations and in limited number of the soil samples. None of the detected VOCs exceed the current NMED residential SSLs. Eight SVOCs including benzo(b)fluoranthene; benzo(k)fluoranthene; chrysene; di-n-butyl phthalate; bis(2-ethylhexyl)phthalate; fluoranthene; phenathrene; and pyrene were detected at low levels and in a limited number of the site soil samples. None of the detected SVOCs exceed the current NMED residential SSLs. Both DROs and GROs were detected at low levels and in a limited number of the site soil samples.

Antimony, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, vanadium, and zinc were detected in some soil samples at concentrations that exceeded the NMED approved background concentrations. Most of the background exceedences occurred in a limited number of soil samples. Copper concentrations exceeded the NMED-approved background concentration of 17 milligrams per kilogram (mg/kg) in almost all soil samples. The maximum copper concentration was1,210 mg/kg detected in sample RB-11-16 at a depth of 28 to 30 ft. Chromium (1,130 mg/kg), iron (45,300 mg/kg), molybdenum (429 mg/kg), and vanadium (100 mg/kg) were detected in one soil sample, RB-11-30 at a depth of 13 to 17 ft, at concentrations that exceed their NMED residential SSLs. This was the only sample that exceeded any NMED residential SSLs. Samples collected from both shallower and deeper sampling depths within the borehole did not show elevated metals concentrations. Activities for gross alpha, gross beta, and radium-226 were slightly greater than background activities for some of the soil samples. All soil activities were within one order of magnitude of the background activities.

A Phase 2 RFI was conducted at SWMU 6-30 in June and July 1997 (USAF, 1998). The field investigation program was designed to determine if contamination was present within the trenches and in the underlying soils. Boreholes were installed within the apparent disposal trenches using a direct-push drill rig. Since previous investigations did not indicate high levels of radiation would be encountered in the trench, this investigation phase included sampling directly in the apparent trenches. The number of boreholes per trench was based on trench length (approximate 30-ft spacing between boreholes). The depth of boreholes within a trench was based on trench depth with the shallow trenches having 20-ft borehole depths and deep trenches having 30-ft borehole depths.

Thirty-two boreholes were advanced at the site with four to six soil samples collected per borehole for a total of approximately 160 individual soil samples. Soil samples were collected from each borehole at 5-ft intervals to the bottom of the trench and from two additional sampling intervals below the bottom of the trench (10 ft below the bottom of the trench).

Samples were field-screened using a photoionization detector (PID), a beta-gamma meter, and a mercury vapor detector. Samples were analyzed for VOCs, SVOCs, TAL metals, mercury, cyanide, gross alpha and beta radiation levels, gamma spectroscopy, soil pH, and soil moisture.

Analytical result from the 1997 Phase 2 RFI indicated the presence of one VOC, acetone, detected in a limited number of samples and at low levels. Three SVOCs including bis(2-ethylhexyl)phthalate, phenol, and styrene were detected at low levels and in a limited number of the site soil samples. None of the detected VOCs or SVOCs exceed the current NMED residential SSLs.

Arsenic, barium, beryllium, chromium, cobalt, copper, lead, nickel, vanadium, and zinc were detected in some soil samples at concentrations that exceeded their NMED-approved background concentrations. Most of the background exceedences occurred in a limited number of soil samples. Copper concentrations exceeded the NMED-approved background concentration of 17 milligrams per kilogram (mg/kg) in almost all soil samples. The maximum copper concentration was 3,020 mg/kg detected in sample RB-11-48 at a depth of 23 to 25 ft. Iron (38,100 mg/kg) and vanadium (81.4 mg/kg) each were detected in one soil sample at concentrations that exceed their NMED residential SSLs. Arsenic was detected in a number of soil samples that exceed the NMED residential SSL of 3.9 mg/kg. It should be noted that the NMED-approved background concentration of arsenic is 4.4 mg/kg which is greater than the NMED residential SSL. The maximum arsenic concentration was 14.7 mg/kg.

Activities for gross alpha, gross beta, radium-226, thorium-234, and uranium-235 were slightly greater than background activities for some of the soil samples. All soil activities were within one order of magnitude of the background activities. Screening level risk assessments conducted using the radionuclide data collected indicated that the potential dose and excess cancer risk posed by any radioactive material at SWMU 6-30 did not exceed U.S. Department of Energy and U.S. Environmental Protection Agency (EPA) guidelines.

The Phase 3 RFI at SWMU 6-30, Radioactive Burial 11 (RW-06), was conducted in August and September 1999. Investigation activities included installing one groundwater monitoring well (KAFB-6301), downhole geophysical logging, and laboratory analyses. To avoid intrusive work within the boundaries of the actual SWMU area, the groundwater monitoring well was installed outside of the actual fenced SWMU, within 50 ft of the west fence line of the southernmost tip of the SWMU area. Following installation of the monitoring well, groundwater samples were collected and analyzed for VOCs, SVOCs, metals, pesticides, polychlorinated biphenyls (PCBs), herbicides, total petroleum hydrocarbons (GROs and DROs), cyanide, nitrate, nitrite, anions, and radionuclides. Nitrate was detected at a concentration of 6.0 mg/L in the groundwater sample and 5.7 mg/L in duplicate groundwater sample. These concentrations exceed the NMED-approved background value for nitrate in groundwater of 4 mg/L but do not exceed the New Mexico Water Quality Control Commission (NMWQCC) groundwater standard of 10 mg/L. The concentrations of VOCs, SVOCs, metals, and radiogenic isotopes were all below the applicable screening levels.

Following installation, monitoring well KAFB-6301 was added to the Kirtland AFB Long-Term Monitoring (LTM) program. Groundwater samples are collected on an annual basis from the well and analyzed for VOCs, organochlorine pesticides, chlorinated herbicides, mercury, dissolved metals, chloride, fluoride, nitrate, sulfate, total organic carbon, total organic halides, phenols, gross alpha, gross beta, radium, radon, uranium, and gamma spectroscopy. Nitrate continues to occur at concentrations that exceed NMED-approved background of 4 mg/L but do not exceed the NMWQCC standard. All detected constituents are below regulatory standards (USAF, 2003).

During the RCRA RFI (October 2007), three exploratory trenches (Trench A, B, and C accordingly) were cut to further delineate conditions at site RW06. Trench A, extended from the northern end to the southern end of RW06 and cut through all nine former disposal trenches. The total length of Trench A was 421 ft. Exploratory Trench B was located to the east of Trench A. Trench B cut through the eastern ends of former disposal trenches 7 and 8 and had a total length of 72 ft. Exploratory Trench C was located to the east of Trench A and south of Trench B. This trench cut through the eastern end of former disposal trench 6 and had a total length of 40 ft. A total of 533 ft was excavated along the length of the three exploratory trenches.

Exploratory trench depths varied from 10 to 18 ft bgs. The depths of the trenches largely depended on the depths at which waste was encountered. In some areas where little or no waste materials were found but disturbed soil was present, the trenches were extended to the maximum depth that could be reached by the excavation equipment, approximately 18 ft, in order to verify that waste was not present in that location. In some areas, the bottoms of the former disposal trenches were visually identified within the exploratory trenches. In other areas, the maximum exploratory excavation depth did not reach below the base of the former disposal trenches. This was not unexpected based on historical site records that indicated some of the former disposal trenches extended to approximately 10 ft bgs and others extended 15 to 20 ft bgs. All trench widths were approximately 3 to 4 ft wide.

For Total Metals, results of the 2006 RFI identified barium, copper, lead, and zinc at concentrations that exceeded the NMED-approved background concentrations in one or more soil samples collected from within the exploratory trenches. Barium was detected in two soil samples above the NMED-approved background concentration of 200 mg/kg for subsurface soil. The maximum concentration of barium was 280 mg/kg. Copper was detected in one soil sample above the NMED-approved background concentration of 17 mg/kg for subsurface soil. The maximum concentration of copper was 32.1 mg/kg. Lead was detected in two soil samples above the NMED-approved background concentration of 11.2 mg/kg for subsurface soil. The maximum concentration of lead was 40.5 mg/kg. Zinc was detected in one soil sample above the NMED-approved background concentration of 76 mg/kg for subsurface soil. The maximum concentration of zinc was 119 mg/kg. None of these constituents exceeded their respective NMED residential SSLs.

Arsenic was detected in two soil samples that exceeded the NMED residential SSL of 3.9 mg/kg. The maximum arsenic concentration was 4.3 mg/kg. These arsenic concentrations did not exceed the NMED-approved background concentration for arsenic of 4.4 mg/kg.

For TCLP Metals, three soil samples collected from the exploratory trenches were submitted to the laboratory for TCLP metals analyses. Barium was the only metal detected in the soils from the TCLP analyses. Barium was detected at a maximum estimated concentration of 1,090 micrograms per liter (µg/L), well below the screening level of 100,000 µg/L. All other metals were not detected in the TCLP analyses

For Radionuclides, laboratory analytical results for gross alpha exceed the background value of 17.4 picocuries per gram (pCi/g) in all analyzed soil samples. The maximum soil gross alpha measurement was 30.8 pCi/g. All measured values were within an order of magnitude of the background value. Laboratory analytical results for gross beta exceed the background value of 35.4 pCi/g in two soil samples. The maximum soil gross beta measurement was 36.4 pCi/g and only slightly greater than the background value.

Radium-228 exceeded the NMED-approved background value of 0.7 pCi/g in 10 of the soil samples collected. The maximum radium-228 value was 0.94 pCi/g and only slightly greater than the background value. Cesium-137 exceeded the NMED-approved background value of

0.908 pCi/g in one of the soil samples collected. The maximum cesium-137 value was 3.52 pCi/g. This concentration is within an order of magnitude of the NMED-approved background value. Thorium-232 exceeded the NMED-approved background value of 1.01 pCi/g in one of the soil samples collected. The maximum thorium-232 value was 1.02 pCi/g and only slightly greater than the background value.

Two grab samples were collected from waste materials identified in the field as having elevated alpha or beta values based on field screening and swipe samples. The laboratory carboy and associated soil are identified as sample BIO 001 in Table 2-4. The associated soil was analyzed off-site and found to contain americium-241 at a concentration of 508 pCi/g. Two other radionuclides were detected at slightly elevated values including cesium-137 at a concentration of 11.7 pCi/g and lead-210 at an estimated concentration of 49.8 pCi/gm. Both gross alpha and gross beta exceeded the background concentrations by more than an order of magnitude.

Based on results of this RFI report, KAFB decided full remediation of the site would be the best course of action.

## 1.3 Radionuclides of Concern and Derived Concentration Guideline Levels

### *1.3.1 Radionuclides of Concern*

The ROCs are $^{3}$H, $^{14}$C, $^{90}$Sr, $^{137}$Cs, $^{226}$Ra, $^{239}$Pu, and $^{241}$Am. All of the ROCs except $^{239}$Pu were selected based on the discussion of historical investigations (e.g., $^{90}$Sr, $^{137}$Cs, $^{226}$Ra, and $^{241}$Am) and the planning survey at RW-06 (e.g., $^{14}$C) or arbitrarily added due to the fact that the waste came from research laboratories (e.g., $^{3}$H). These ROCs were approved in the "*Field Sampling Plan for Remedial Action Construction at Site RW-06*", CABRERA 2009. During project work, a small (approximately 30-gallon) drum with material containing $^{239}$Pu and $^{241}$Am was located, segregated and secured with project contaminated waste (see investigation description in Section 5.5). Due to this material being located, $^{239}$Pu was included as a project ROC. The NRC screening level for $^{239}$Pu was added to the list of Derived Concentration Guideline Levels ($DCGL_W$s) in Table 1-1, analysis for isotopic plutonium was performed on all soil and debris samples, and the data included in the statistical analysis and summary for all project ROCs.

### *1.3.2 Chemicals of concern*

The only suspected compound class of concern remaining at RW-06 is one for metals. However, project sample analysis also tested for VOCs, SVOCs, or petroleum hydrocarbons resulting from bulk disposal of these compounds. Soil found to be below NMED residential soil screening levels (SSL) for all contaminants will be considered non-chemically contaminated for purposes of both disposal and re-use as backfill.

### 1.3.3 Derived Concentration Guideline Levels

Default NRC screening values for the ROCs have been used as soil evaluation criteria for radionuclides for this project (NRC, 1999a). These values are considered the $DCGL_W$s for this project and are listed in Table 1-1.

Table 1-1: RW-06 ROC Soil $DCGL_W$s

| ROC | $DCGL_W$ (pCi/g)[a] |
|---|---|
| $^{3}H$ | 110 |
| $^{14}C$ | 11.6 |
| $^{90}Sr$ | 1.72 |
| $^{137}Cs$ | 11.0 |
| $^{226}Ra$ | 0.7 |
| $^{241}Am$ | 2.1 |
| $^{239}Pu$ | 2.3 |

[a] pCi/g = picocuries per gram.

For average residual radioactivity found within survey units (SU), the unity rule, or Sum of the Ratios (SOR), is used to ensure that the total dose is within the required 25 millirem per year (mrem/year). When multiple contaminants are present within a SU, site radiological conditions are evaluated using the SOR and a Derived Concentration Guideline Level ($DCGL_W$) of SOR = 1.0. The SOR is calculated as follows:

$$SOR = \frac{(C_1)}{(\mathrm{DCGLw}_1)} + \frac{(C_2)}{(DCGLw_2)} + \frac{(C_3)}{(DCGLw_3)} + \ldots$$

Where: $C_{1,2,3..}$ = Concentration of ROC

$DCGL_{W\ 1,2,3..}$ = $DCGL_W$ for that ROC

If all sample SORs are equal to or less than 1.0, the SU meets the release criteria. If not, the Wilcoxon Rank Sum (WRS) test has been applied to the data. The application of the WRS test is described in Section 5.3.

Bias soil samples collected as part of the investigation of small areas of elevated activity located during scan surveys were evaluated with the SOR value of 1.0 as part of the elevated measurement comparison (EMC) investigation.

### 1.3.4 Project Investigation Levels

An investigation level is a derived, radionuclide-specific concentration or activity level that is based on the release criterion, and triggers a response, such as further investigation or cleanup, when exceeded (EPA, 2000). The radionuclide-specific investigation levels for RW-06 are the $DCGL_W$ values in Table 1-1 and the SOR value of 1.0.

Although an elevated measurement comparison ($DCGL_{EMC}$) value was not calculated for this project during the design phase, systematic sample analysis results above the specific radionuclide $DCGL_W$ and sample analysis results above the SOR value of 1.0 were further investigated (e.g., see Section 5.3.3 and area factors for FSS SU02 in Section 5.4.1).

The definition of investigation level was expanded to include gross gamma measurements performed during gross gamma walkover surveys, even though these measurements are not associated with a specific radionuclide.

Statistical analysis and position correlated mapping are used to define areas of elevated gross gamma activity relative to background. The investigation level for gross gamma data is multiple (trended by spatial distribution or proximity) position correlated data points with z-scores (number of standard deviations above the mean) greater than 3.0. See Section 2.8.1 for additional discussion of scan data investigation.

The responses, if these investigation levels were exceeded, included any or all of the following: investigation with hand-held scan instrumentation, smears, exposure rate measurements, portable gamma spectroscopy, data analysis and review, and/or onsite or off-site sample analysis.

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# 2.0 Summary of Field Activities

This section outlines the planned activities and summarizes field implementation conducted during remediation efforts at the RW-06 Site.

## 2.1 Mobilization and Preliminary Site Preparation Activities

Permit acquisition, notifications, site set up, and procurement were completed as required. Work areas were delineated, security fencing was put in place, required training was performed, a temporary road was built, reference samples were collected and preliminary locations of trenches and contamination hotspots were marked prior to excavation. The Initial Site layout is described in Figure 2-1 of the approved RW-06 Work Plan (CABRERA 2009).

## 2.2 Waste Removal, Segregation, and Remedial Support

The waste removal process prioritized the known surficial hotspots at the south end of the site. Excavation of trenches one through 9 was then performed consecutively from south to north. The control of excavation and segregation of waste was maintained through this planned approach and through the layout of the field work areas for separation of potentially uncontaminated (e.g., overburden) lay down and contaminated waste staging and packaging areas. The Initial Site Layout was modified to allow a portion of the area originally designated as Material Handling Waste Staging Area to be utilized as additional non-impacted soil staging area. The Final Site Layout is shown in Figure 2-1.

Dust suppression was utilized throughout excavation activities (Figure 2-2). Remedial support surveys included visual (for obvious debris or soil staining) and radiological monitoring during all excavation and on each excavation bucket to direct waste segregation prior to transfer to the correct staging area. Soil and debris were monitored for segregation with sodium iodide (NaI) gross gamma volumetric detectors (Figure 2-3) and alpha/beta surface measuring equipment. Air monitoring was routinely performed. Soil and other materials were routinely sampled and analyzed in the onsite laboratory to direct the remediation and ensure readiness for a final status survey. PID detectors were used to test for VOCs during project performance. Routine surveys of personnel, equipment, and facilities were performed to maintain controlled boundaries, ensure personnel safety, and to protect the environment. Safety or security issues did not occur during project performance.

## 2.3 Waste Packaging, Reuse Testing, and Disposal

Waste segregated as contaminated was contained in 10 cubic yard (maximum volume) flexible-sided waste containers separated either as soil or soil like material and debris (Figure 2-4). Thirteen composite samples were collected and analyzed for radiological and chemical contamination to properly characterize and direct waste disposition. Potentially non-contaminated soil was laid out in a separate staging area as four Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NRC, 2000) Class 1 survey units, and appropriate surveys and sampling were performed. The survey and sample results have been used to determine final status for reuse of this soil as backfill for trench excavations or disposal as waste. This approach was part of the planned effort to minimize the waste stream volumes requiring off-site disposal and to separate the wastes into disposal categories to minimize/control cost. Disposal was planned based on the most cost effective (including schedule) means for the waste specific profile.

Figure 2-1: Final Site Layout

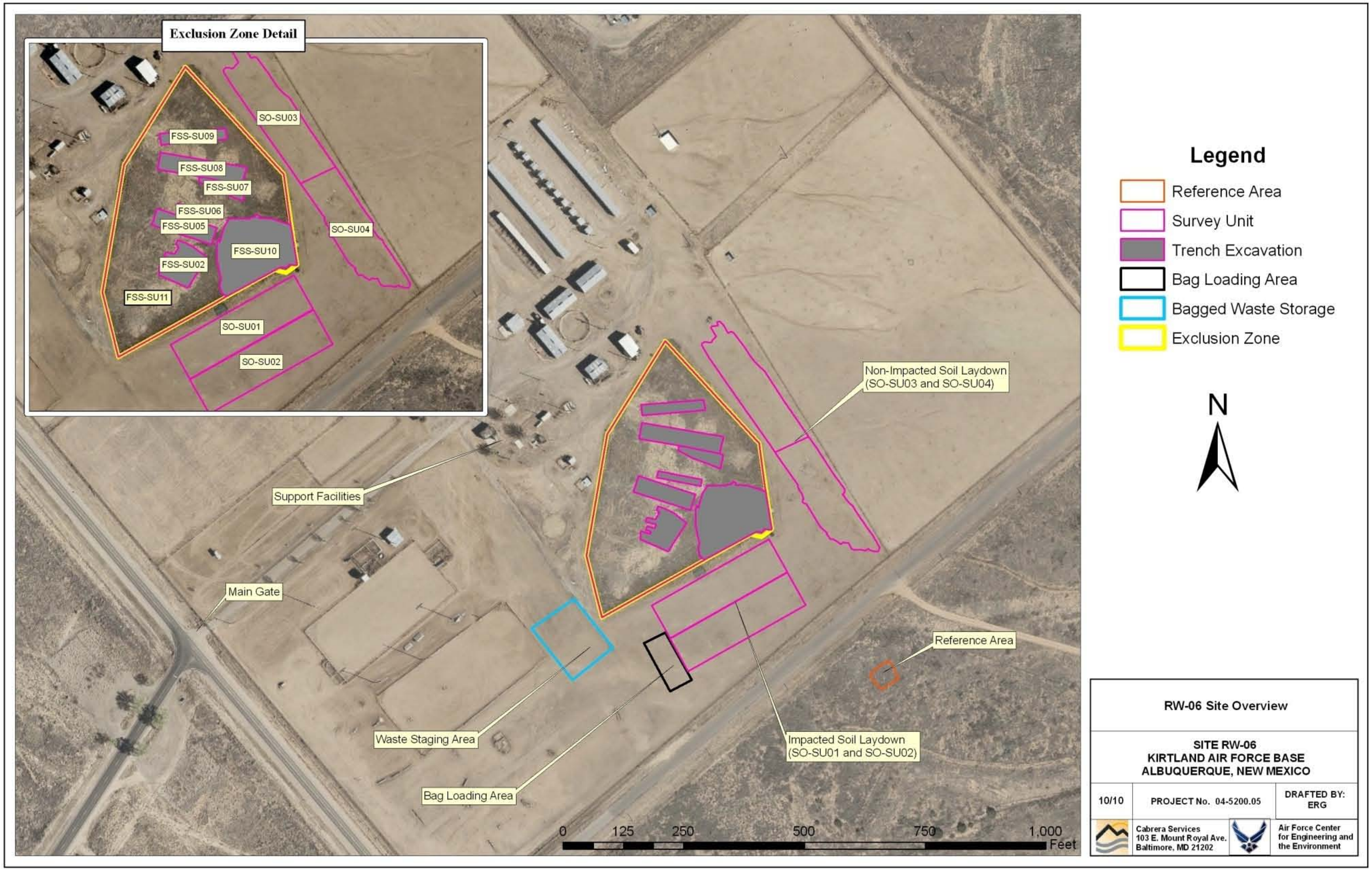


Figure 2-2: Excavation Dust Suppression.

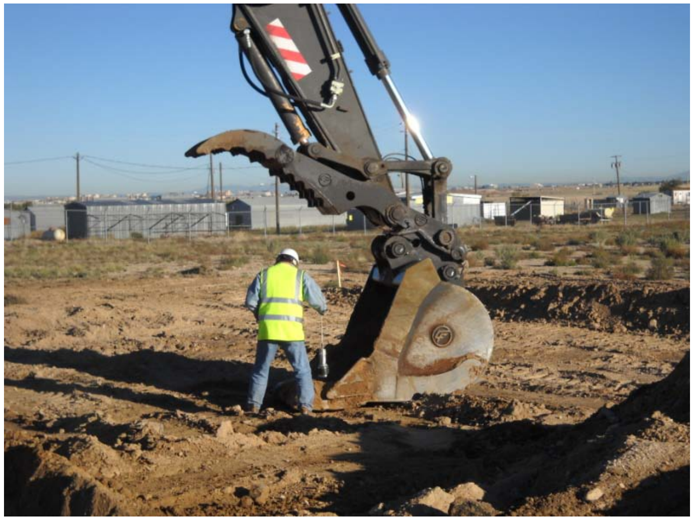

Figure 2-3: Remedial Support Surveys


Figure 2-4: Waste Segregation.

## 2.4 Final Status Survey

This task consisted of implementing an approved final status survey design in accordance with MARSSIM. Average radionuclide concentrations in the survey units were evaluated by collecting surface soil samples on a random-start triangular grid. Small areas of elevated activity between sample locations were evaluated by scanning surface soils in 100% of the (accessible) survey area. Locations identified as potentially exceeding the release criterion were investigated via follow-up measurements and biased soil sampling. All remediated areas were resurveyed.

The impacted area was divided into seven Class 1 survey units (i.e., Trenches 1-4, 5, 6, 7, 8, 9, and 10 (the surface hotspot area)) and one Class 2 survey unit (i.e., the remainder of the fenced surface area). Trenches one through four were designated as one Class 1 survey unit due to the final excavation configuration (excavation left only one contiguous trench). The potentially non-contaminated soil was laid out into four additional Class 1 survey units. A total of 11 Class 1 and one Class 2 (SU11) survey units were surveyed (see attached Figure 2-1 for SU locations).

Fifteen samples were collected in a random start, systematic grid pattern for each survey unit and reference area. The location of the samples was determined using Visual Sampling Plan® (VSP) software (version 5.9). The locations of samples collected in all survey units are shown in Figures 5.5 through 5.12 located in Appendix A. The State plane coordinates for SUs and the reference area where GPS was able to be utilized (FSS-SU02, FSS-SU08, FSS-SU10, FSS-SU11, SO-SU01, SO-SU02, SO-SU03, SO-SU04) are available in Appendix B. A total of 180 systematic surface soil samples were collected for the 12 project survey units. Reference data sets of 15 samples each were collected both from surface (0-15 cm) and subsurface (15-30 cm) soil from outside the impacted area.

One hundred percent of accessible surfaces were scanned for all Class 1 survey units. Approximately 90% of the Class 2 survey unit was scanned. Scan data was reviewed and biased samples were collected to evaluate the elevated measurement comparison and to support the efficacy of the scanning minimum detectable concentration (MDC). A total of twenty five biased samples were collected to investigate areas of elevated gross gamma activity based on review of scan data. All samples were analyzed by gamma spectroscopy in the onsite lab prior to analysis off-site for the project ROCs. MARSSIM statistical testing and sum of fractions were performed for project ROCs to evaluate all survey units against the release criteria in Section 1.3.3. Three chemical samples were also collected from each survey unit during the FSS phase to demonstrate compliance with the NMED residential SSLs. Evaluation of the data for the ROCs and potential site chemicals is presented in the Section 5.0.

## 2.5 Site Backfill and Restoration

The excavated trenches were backfilled after completion of the FSS with clean soil obtained from project location which had been surveyed and cleared for use as fill material. In addition, reseeding of native grasses required to restore the site was performed under this subtask.

## 2.6 Sampling and Analysis Methods

### *2.6.1 Gross Gamma Scan Survey*

Scan data were collected using a Ludlum Model 2221 scaler/ratemeter with attached Ludlum 44-20 NaI detectors. Scan surveys were performed either using converted ‘baby-jogger’ cart platforms with the detector suspended at a height of approximately 10 centimeters (cm) above the ground (for terrain that allowed this standard configuration) and an individually-carried backpack with hand-held NaI detector (for terrain too rough for the ‘baby-jogger’); or suspending the NaI detector via long cable and the meter and technician stationed in an extended boom lift platform over trenches considered unsafe for entry (greater than 3 feet deep). A photograph of the cart platform utilized at RW-06 is shown in Figure 2-5. Surveys were performed in parallel lines approximately 0.5 meter (m) apart at a speed of roughly 0.5 meters per second. Survey data collected with the cart and backpack confirmation were automatically logged and the position correlated with Global Positioning Systems (Trimble XRS). The GPS link tied survey data to spatial locations using state plane coordinates for New Mexico Central, Zone 3002, North American Datum 1983.

During gamma survey activities performed on trench surfaces, including the trench floor and sidewalls, the instruments were not linked with a GPS due to trench depth (up to 20 feet). Instead, the surveyor stood on a platform above the excavation (i.e., a manlift basket, a platform with guardrails), a NaI probe was lowered into the trench (i.e., using a rope or similar method), and the gamma activity survey was performed remotely (see Figure 2-6). A range of values was manually recorded on trench log sheets for the sidewalls and bottom of the trench. Any locations of elevated activity were further investigated, and/or remediated and rescanned during this evolution.

Figure 2-5: Scan Survey Platform in Use at RW-06

Figure 2-6: Gross Gamma Scan With Manlift Platform

### 2.6.2 Surface Soil Sample Collection

Soil was collected over an area of 100 square centimeters ($cm^2$) to a depth of approximately 0.5 ft at each sample location. The soil was transferred into a stainless steel bowl and visually identifiable non-soil components were manually separated, such as stones, twigs, and foreign objects. The sampled soil was mixed to homogenize it and a minimum of 1,000 grams (g) was collected in sealable one gallon (gal) plastic bags. Each sample was labeled with the sample identifier (ID), date and time of collection and double-bagged by the surveyor prior to packaging. Duplicate samples were collected and results evaluated (see Section 4.3.2).

### 2.6.3 Onsite Laboratory Analysis of Soil Samples

An onsite gamma spectroscopy laboratory (Onsite Lab) was set up and operated by CABRERA personnel during the course of the field work to analyze the gamma radiation emitted by surface and subsurface soils and debris samples. The onsite lab was used to provide qualitative data to support remedial excavation or site health and safety during project performance. The only sample preparation for soil was the crude screening of samples to remove large debris prior to analysis. Drying, sieving or screening was not performed.

Analysis was performed using a Canberra Industries high purity germanium (HPGe) detector system. Prior to the performance of project sample analyses, the detector was calibrated using a multi-line gamma marinelli beaker standard, traceable to the National Institute of Standards and Technology (NIST). Quality control (QC) activities included the counting of replicate samples and daily instrument response checks (see Section 4.1 and Appendix C).

The gamma spectroscopy system was operated by a CABRERA technician who was trained in accordance with CABRERA standard operating procedures. The operator performed spectral analysis during each measurement, which encompassed the evaluation of spectra for problems such as peak shift, high dead-time, and other potential inconsistencies in spectral structure. A qualified Radiological Engineer reviewed the integrity of the sample analysis results for each sample. This review included the analysis of sample results for spectral energy shift, agreement

between progeny activities assumed to be in secular equilibrium, the presence of potentially unidentified radionuclides, as well as other potential inconsistencies.

All samples were transferred to one-liter marinelli beaker sample containers and weighed prior to counting. Count times were generally 15 minutes in length, unless sample-specific MDC action levels warranted a longer duration. Situations of this kind were generally the result of low sample volumes due to poor sample recovery.

### 2.6.4 Off-site Laboratory Analysis of Surface Soil Samples

Final Status Survey and waste samples were sent to the Centauri Laboratory, 1000 Monticello Court, Montgomery, Alabama and the ALS Laboratory Group, 225 Commerce Drive, Ft. Collins, Colorado for off-site analysis. All samples were double bagged in one-gal sealable plastic bags, labeled, numbered, logged, and shipped using chain of custody controls. Both laboratories are National Environmental Laboratory Accreditation Program (NELAP) accredited by a state that is authorized to provide certification. A Chain-of-Custody Record was used to transfer custody of the samples to the off-site laboratory (see Appendix C).

The off-site laboratories performed alpha and gamma spectroscopy, liquid scintillation counting, and gas proportional analysis as necessary to detect the emissions for all the ROCs in Table 1-1. Duplicates, laboratory control samples, and blanks were performed as part of the off-site laboratory QC activities.

## 2.7 Summary of Field Changes to Project Plans

Several field level changes to the Project Plans were implemented during the course of the RW-06 field effort. All changes were reviewed and approved by the Project Manager (PM) prior to implementation. A summary of the significant changes are listed below.

### 2.7.1 Construction Work Plan

Contaminated materials were covered daily with plastic sheeting to prevent any runoff or wind dispersion and the waste piles were packaged in containers for storage until removal from the site for disposal. Berms, hay bales or silt fence were not installed around the waste piles, but silt fence was installed around the remainder of the site per the Storm Water Pollution Prevention Plan (SWPPP) to prevent runoff.

Due to the size of the trenches, the use of barricades was not practical. Each area/trench was roped off and caution tape used as a visible barrier. The perimeter chain link fence prevented unauthorized personnel and motor vehicle access. In addition, radiological postings were in place around the perimeter of the Exclusion Zone.

To allow for excavation at anticipated depths, the excavator was used to remove all material in lifts. A dump truck was used to move waste to the staging area. Trenches one through four were excavated as one excavation area due to the closeness of the four trenches. Four discreet trenches were impractical and posed a potential safety issue with minimal support material between the trenches. This decision was based on field discussions with the Site Health and Safety Officer (SSHO), Site Remediation Manager (SRM), and Equipment Operator.

For the Section 4.2, Preliminary Field Screening and Sorting (Series 2), Soil and debris were initially segregated during excavation using the excavator ‘thumb’ attachment. Material was also visually inspected for staining. X-ray fluorescence (XRF) was not used during this stage. Soil was sampled for off-site analysis to determine if materials were compliant with NMED

SSLs and suitable for backfill. Debris was screened for radiological contaminants using a Ludlum 44-9 pancake G-M detector and a Ludlum 44-20 NaI detector.

Elevated preliminary screening data measurements were recorded in the field log book, and any noteworthy/elevated measurements were included in the Daily Quality Control Report (DQCR). Screening results were not incorporated into an excel spreadsheet.

All material not identified as potentially contaminated was staged in an area (~2,000 $m^2$) and graded into 1-ft lifts (~797 cubic yards [CY]). A 100% gamma walkover survey was performed over the area. Fifteen samples were collected from the area and analyzed at the onsite laboratory and then sent off-site for radiological analysis (sample frequency of 1 per 53 CY). Analytical results were evaluated for potential reuse as backfill material. In addition chemical sampling was performed at a frequency of approximately 1/250-CY to ensure material meets NMED SSLs for reuse. Any large items (>3") were segregated by hand (using a shovel or rake). The sample frequency was less than identified in the Field Sampling Plan (FSP) (1 per 25 CY), but more than the proposal (1 per 250 CY). The significant amount of material identified for potential reuse posed a potential space/lay down area issue if material was stockpiled in 25 CY or 100 CY piles. Also, grading material in 1-ft lifts allowed for use of the water truck for dust suppression.

### 2.7.2 Field Sampling Plan

Field screening of soil and waste to detect the presence of metals using a portable XRF detector was not used onsite. The decision to not use an XRF was based on the previous historical data that **"**Inorganic constituents (metals) were detected within or slightly above the NMED-approved background levels (SNL/NM, 1996), but none exceeded NMED SSLs" and the fact that final release of material for reuse will be based on off-site laboratory analytical results.

Field conditions dictated that trenches one through four be excavated as one area. Final Status Survey units were developed and labeled as work progressed and survey unit numbers were identified and documented in the final report.

## 2.8 Real-Time Implementation of Survey Design

Visual inspection, scan survey data, and results of Onsite Lab gamma spectroscopy analysis were all used to provide real-time implementation of the survey design in order to determine if additional data were required. Where potential radioactive contamination was either identified or suspected, additional samples were collected and analyzed to verify its presence (or confirm its absence) and to define its nature and lateral extent. A total of 25 biased soil sample locations were added to investigate areas of elevated activity during the course of the RW-06 FSS.

### 2.8.1 Gross Gamma Walkover Survey Data Evaluation

Scan data were utilized to identify biased surface sample locations for comparison with project $DCGL_W$s. The following description presents the data evaluation and biased sample selection process.

Thousands of gross gamma data points were collected from each survey unit. The data were evaluated with Exploratory Data Analysis (EDA) techniques (i.e., Cumulative Frequency Distributions (CFDs), summary statistics, and z-score calculations) prior to presentation as color-coded spatial distribution plots to assist biased sample selection. Processed scan data were plotted as CFDs to obtain information on the general shape of the data distribution and

to identify outliers. A sample of a CFD used for RW-06 FSS Survey Unit 10 is shown in Figure 2-7. Distinctly elevated gross gamma activity data deviate from the underlying normal distribution as individual outliers or separate populations. Gross gamma count rate data from the underlying normal distribution were used to calculate an average and a standard deviation for each survey unit (except deep trenches where trench sheets were used to manually record scan data. The standard deviation was used to compute z-scores (number of standard deviations from the mean), which were used to create gross gamma spatial distribution plots based on the z-score.

A straight-line data set represents a single normal distribution for a specific survey area. Multiple straight lines on a single plot represent multiple distributions present in the same survey area. For example, different surficial ground surfaces may contain variations in their natural background signatures (e.g., topsoil/grass, gravel, clay, etc) relative to each other. These distributions will be exhibited as lines with either varying means or slopes.

The data of interest are points on the far right of the plots that deviate from the normal distribution. These distinctly elevated populations or individual outliers may represent locations for further investigation (i.e. biased sampling). Areas with z-score greater than 3.0 (99.9% of data in a normal distribution are less than three standard deviations above the mean for that distribution) were used as an indicator for investigating whether radioactivity exceeded project investigation levels for surface soil. Z-scores greater than 3.0 are expected 0.1% of the time. If 10,000 data points are collected from a normal distribution (i.e., a typical number of data points for a gamma survey), 10 points would be expected to be above z-score of 3.0, but still come from the same distribution and do not represent the presence of contamination. These would occur randomly. Data with z-scores above 3.0 coupled with their spatial orientation (i.e. clustered together) represent the potential presence of contamination and are investigated.

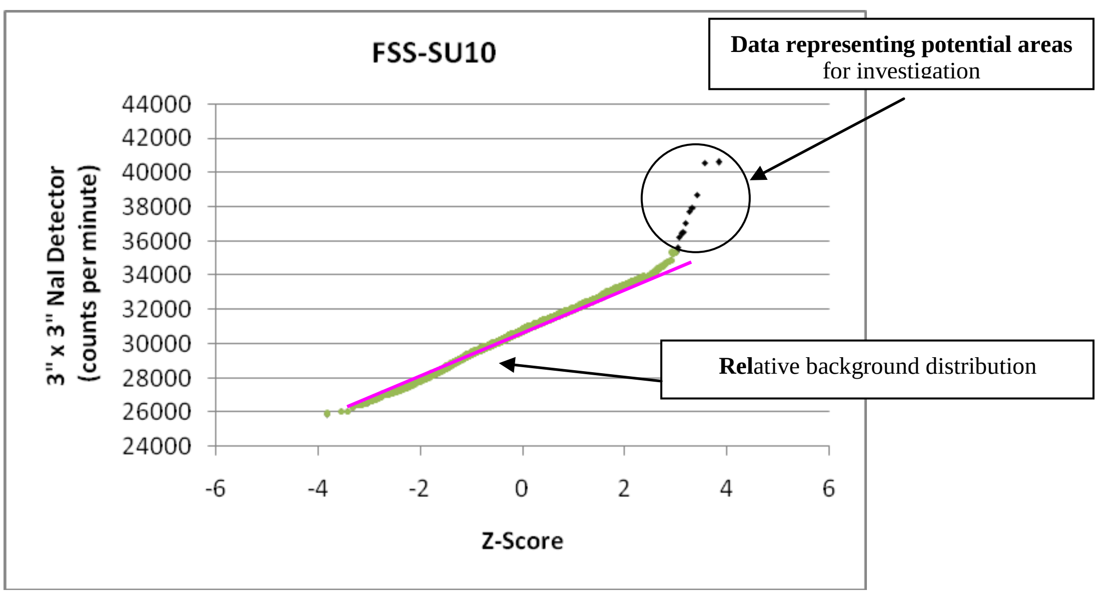


Figure 2-7: Cumulative Frequency Distribution Plot for scan data performed at RW-06 FSS SU10

The responses if these investigation levels were exceeded included any or all of the following: investigation with hand-held scan instrumentation, smears, exposure rate measurements, portable gamma spectroscopy, data analysis and review, further remediation and resurvey, and/or onsite or off-site sample analysis.

# 3.0 Data Quality Assessment

Data Quality Assessment (DQA) is the scientific and statistical evaluation of data to determine if the data are of the right type, quality, and quantity to determine that the planning objectives are achieved. There are five steps in the DQA Process as described in Appendix E of MARSSIM:

- Review the Data Quality Objectives (DQOs) and Survey Design
- Conduct a Preliminary Data Review
- Select the Statistical Test
- Verify the Assumptions of the Statistical Test
- Draw Conclusions from the Data

This section reviews the DQOs and survey design and documents the preliminary data review. Quality assurance (QA) and quality control (QC) is expanded in Section 4.0 to complete the review of data quantity and quality. Section 5.0 completes the data review by presenting survey results in the form of calculated statistical quantities, data graphing, selected statistical test results, and verifying the assumptions of the statistical test.

## 3.1 Data Quality Objective Review

The general DQOs of the radiological survey were to provide sufficient information to

- Confirm whether one or more radionuclides of concern exceed the project action levels in areas with known or suspected radioactive contamination.
- Define the nature and lateral/vertical extent of areas (i.e., areas of surface soil) where radionuclide concentrations exceed the project investigation levels and remediate those areas.
- Verify assumptions used to develop the radiological survey design.
- Delineate areas where no radionuclide concentrations exceed the project release criteria and support recommendation for unrestricted release.

QA measures were implemented throughout the project to ensure data met known and suitable data quality criteria such as precision, accuracy, representativeness, comparability, and completeness. The quality of analytical data was also controlled through the performance of quality control (QC) measurements and the calibration of field and laboratory equipment. Onsite radiological measurement techniques were used based on radiological characteristics of the potential contaminants and the reasonable implementation of best available technology. The measurement analysis results were reviewed, evaluated using EDA, and compared to the project release criteria using the WRS Test.

A review and summary of the DQO seven step process previously described in the approved Quality Assurance Project Plan (QAPP) is performed in the following sections.

### *3.1.1 Step 1 – State the Problem*

The goal of this remediation project is to identify, remove and dispose of radioactive contaminants present at RW-06 (burial pits and surface contamination) and restore the site soil to levels below project release criteria listed in Section 1.3.3. Based on the historical information, data from the RW-06 2008 planning survey (CABRERA 2008), and the approved project plans, it is assumed that all wastes and debris have primarily radioactive contamination. The objective of project remediation support and FSS activities is to obtain data of sufficient quality and quantity that they can be evaluated against approved radiological criteria and support decisions for unrestricted release of the RW-06 site. Site-attributable organic or inorganic chemical contamination data has been collected and compared against NMED screening levels.

The problem is the potential presence of concentrations of ROCs exceeding project release criteria in surface or in remediated areas at the RW-06 site.

### 3.1.2 Step 2 – Identify the Decision

Do the concentrations of the ROCs and other potential contaminants at the RW-06 site exceed applicable levels for unrestricted release?

The following statements assume that ROC concentrations exceed release levels. Decision statements should be evaluated sequentially, as shown below.

A) Determine whether SU ROC concentrations exceed background concentrations by more than the acceptable release criteria.

B) If SU ROC concentrations exceed background concentrations by more than the acceptable release criteria, then affected SUs must be remediated to levels satisfying the release criteria.

The Principal Study Question (PSQ) for the survey was to determine the nature and extent of radioactivity in surface soils at RW-06 (either undisturbed soils or residual surface soils post-excavation), and whether or not concentrations of ROCs in surface soils demonstrate compliance with the release criteria. The following alternative actions resulted from resolution of the PSQ for this investigation:

- If radionuclide activity concentrations were found to be below the investigation levels, then final status survey was performed as part of the survey design and recommendation for unrestricted release.
- If radionuclide activity concentrations were found to be above the investigation levels, then further remediation was performed prior to performance of final status survey and recommendation for unrestricted release was made.

The historical information and previous investigation data were utilized to excavate, segregate waste, and perform final status based on current project inputs for data collection.

### 3.1.3 Step 3 – Identify Inputs to the Decision

The objective of this section is to identify the informational inputs required to resolve the decision statements identified above. This section also describes the sources of those inputs, determines which inputs require environmental measurements, and discusses the means of obtaining the required inputs. The following site characteristics were determined to resolve the applicable decision statements.

#### 3.1.3.1 Concentration of residual ROCs in SUs:

This information was used to determine whether a SU exceeded the applicable release criteria. This data facilitated decision-making regarding whether additional remediation was required in specific SUs.

#### 3.1.3.2 Information Sources:

Concentrations of residual radioactive material in the survey units were determined by means of

- Surface radioactivity scan and direct measurements,
- Transferable radioactivity measurements (using smears),
- Volumetric sampling and analysis of surface soils in RW-06 SUs, and debris and material samples from trenches, and
- Exposure rate surveys.

The following criteria were utilized to support decisions at RW-06:

- Project ROCs (Section 1.3.1)
- Project $DCGL_W$s (Section 1.3.3) and Investigation Levels (Section 1.3.4)
- Measurements and Sample Analysis Inputs (Sections 2.6.8, and 5.1.2)

### *3.1.4 Step- 4 - Define the Study Boundaries*

#### *3.1.4.1 Define the Target Population*

The target population of interest consists of the contents of the burial trenches, contaminated soils in and under those trenches, and five identified surface soil contamination areas. Additional areas of residual radioactivity were not discovered during the performance of project work.

#### *3.1.4.2 Spatial Boundaries of the Decision Statement*

The spatial boundaries are limited to the trenches, the areas of elevated surface activity, and surrounding areas within RW-06 shown in Figure 2-1. The maximum depth for any trench was 20 ft. The target population of interest for decisions of unrestricted release is the radionuclide concentration in surface soils to a post excavation depth of 0.5 ft over the area of interest within the surveyed boundary of the RW-06 site.

#### *3.1.4.3 Constraints on Data Collection*

Radiological data collection and excavation activities were constrained several times during site remediation due to weather conditions (i.e., rain and snow) and a nearby $^{60}Co$ irradiation facility which created fluctuations in background readings that interfered with gross gamma data collection. Both excavation and data collection were adequately managed around these constraints through cooperation with the Air Force. Road base was added to areas to allow safe operation of equipment during wet weather and notifications and scheduling were maintained with the irradiation facility to allow collection of gamma data without background interference and fluctuation from outside sources. The depth and irregular slope of the trench walls for SUs 5, 6, 7, and 9 constrained the accuracy of positional information (GPS could not be used) routinely used to document sample collection locations and record scan data. Physical measurements of surface and depth dimensions of these trenches were used to record scan data (gross gamma counts) as ranges on trench log sheets and to position sample locations.

### *3.1.5 Step 5 - Decision Rules*

The decision rules shown in Table 3-1 were applied. Decisions on whether to perform additional investigations were made for individual sample locations. Each measurement result was compared to the appropriate project decision criteria to determine if additional data were required to support a release decision for areas of the site. Decisions were made on whether to release each SU at RW-06 for unrestricted use.

Table 3-1: Decision Rules for RW-06 FSS

| Parameter of Interest | IF | THEN | Comments |
|---|---|---|---|
| **Gross Gamma Walkover** | | | |
| Presence of Contamination | Area with clustered z-scores greater than 3.0 is identified. | Investigate the area with hand-held instruments and/or sample for onsite or off-site laboratory analysis | Z-score values greater than 3.0 are expected 0.1% of the time and potentially identify areas of elevated activity. |
| **Small Areas of Elevated Activity** | | | |
| Identify Small Areas of Elevated Activity | The sum of fractions based on the $DCGL_W$ exceeds 1.0 for any soil sample. | The location will be considered a small area of elevated activity and further excavation may be performed as an ALARA precaution. | Small areas of elevated activity may result in doses exceeding the release criterion or are not considered ALARA. |
| **Average Radionuclide Activity Concentration** | | | |
| Average survey unit activity | The test statistic exceeds the critical value for the WRS test. | Decide the average activity in the survey unit demonstrates compliance with the release criterion. | Survey units that pass the MARSSIM statistical tests and do not contain small areas of elevated activity that would exceed the release criteria or are considered ALARA demonstrate compliance with the release criteria and are recommended for unrestricted release. |
| | The test statistic is less than or equal to the critical value for the WRS test. | Decide the average activity in the survey unit exceeds the release criterion and notify the AF PM. | Survey units that fail the MARSSIM statistical test require additional investigation to determine radiological status. |

### 3.1.6 Step 6 – Specify Limits on Decision Errors

The survey was designed as a graded approach using a combination of gross gamma scan survey data, onsite gamma spectroscopy analysis, and off-site laboratory analysis of surface soil samples to manage uncertainty. Sampling uncertainty was controlled by collecting additional biased samples from the area of interest. Analytical uncertainty was controlled by use of appropriate instruments, methods, techniques, and QC. Minimum detectable concentrations (MDC) for individual radionuclides using specific analytical methods were established. Uncertainty in the decision to release areas for unrestricted use was controlled by the number of data points in each area and the uncertainty in the estimate of the mean radionuclide concentrations.

### 3.1.7 Step 7 – Optimize the Design for Obtaining Data

Sampling and analysis processes were designed to provide real-time data during implementation of field activities. These data were evaluated (i.e., against the project decision criteria and by EDA) and used to refine the scope of field activities, as needed, to optimize implementation of the survey design and ensure the DQOs were met.

### 3.1.8 FSS Measurement Quality Objectives for Chemical and Radiological Data

Measurement quality objectives (MQOs) for chemical and radiological data include the routine, standard QC measurements specified in the analytical methods — typically made on laboratory-prepared standard materials and samples to monitor MQOs for accuracy and precision. The MQOs for radiological analyses for the ROCs identified for the RW-06 FSS are presented in Table 3-2. Laboratory QC checks included the following:

- Calibration checks
- Laboratory control samples
- Tracer recovery
- Matrix spike samples (where appropriate)
- Duplicate samples
- Method blank samples

Some of the checks listed above are procedure or instrument specific and will not necessarily apply to all analyses. Specific QC checks vary with the analytical methods and instrumentation used.

For laboratory-generated QC measurement data for accuracy or bias, the MQOs are generally accepted industry values. Acceptable values for the analytical methods, parameters, and sample matrices for the project ROCs are included in Table 3-2 below. The approved MQO Table 3-1 from the project QAPP did not originally list MQOs for all project ROCs. Since the criteria for all ROCs were actually set with each contract laboratory, tritium and plutonium were added here for completeness. QC results that are not within the acceptance limits may result in qualification of the data, re-sampling and analysis, or other corrective actions that may be indicated.

The subcontractor analytical laboratory reported the measured result, MDC, and the total propagated uncertainty.

**Table 3-2: Measurement Quality Objectives for ROCs**

| ROC | Analysis[a] | $DCGL_W$s (pCi/g)[b] | Detection Limit (pCi/g) | Accuracy Soil Percent Recovery[c] | | Precision ZRep[d] |
|---|---|---|---|---|---|---|
| Carbon-14 ($^{14}C$) | LSC | 11.6 | 1.0 | 70 | 130 | ±2 |
| Strontium-90 ($^{90}Sr$) | LSC or GP | 1.72 | 0.1 | 70 | 130 | ±2 |
| Cesium-137 ($^{137}Cs$) | Gamma Spectrometry | 11.0 | 1.0 | 70 | 130 | ±2 |
| Radium-226 ($^{226}Ra$) | Gamma Spectrometry | 0.7 | 0.05 | 70 | 130 | ±2 |
| Americium-241 ($^{241}Am$) | Gamma Spectroscopy | 2.1 | 0.20 | 70 | 130 | ±2 |
| Tritium ($^{3}H$) | LSC | 110 | 10 | 70 | 130 | ±2 |
| Plutonium-239 ($^{239}Pu$) | Alpha Spectroscopy | 2.3 | 0.05 | 70 | 130 | ±2 |

(a) Radiochemical separations followed by identified counting technique. LSC = liquid scintillation counting; GP = gas proportional counting
(b) pCi/g = picocuries per gram.
(c) Lower and upper range of acceptable values.
(d) ZRep = replicate Z-score.

## 3.2 Survey Design Review

The FSS was designed using the approach outlined in MARSSIM (NRC, 2000a). Under MARSSIM guidance, a minimum number of measurement locations are required in each SU to obtain sufficient statistical confidence that the conclusions drawn from the measurements represent the entire SU.

### *3.2.1 Identification and Classification of Survey Units*

As discussed in MARSSIM (NRC, 2000a), SUs are classified according to their potential for residual radioactivity. Based on historical information and characterization work, Class 1 SUs are the most likely to contain residual radioactivity exceeding the $DCGL_W$s, while Class 3 SUs are the least likely. In addition, MARSSIM recommends that all remediated areas be considered Class 1 SUs. MARSSIM recommends the limitations on SU size and area scan coverage shown in Table 3-3.

**Table 3-3. MARSSIM-Recommended FSS Survey Unit Sizes**

| Survey Unit Class | Recommended Survey Area Size – Soil Areas |
|---|---|
| 1 | Up to 2,000 $m^2$ |
| 2 | 2,000 to 10,000 $m^2$ |
| 3 | No limit |

The SUs are shown in Figure 2-1. All SUs are considered Class 1 except for SU 11, which is the land area within the RW-06 area, but outside of the known surface contamination. SU11 is considered a Class 2 area. All SUs were within MARSSIM recommendations for size limits.

### *3.2.2 Survey Reference Coordinate System*

A FSS reference coordinate system was developed and installed early in the FSS process. Coordinates were referenced to the State Plane Coordinate System. The boundaries of the SUs were identified and clearly marked. Pin flags were utilized to physically mark SU boundaries to assist the scan of SUs. The global positioning system (GPS) obviates the need for marking small grid intervals.

Final status SUs 2, 8, 10, and 11 consist of the final bottom and sidewall surfaces of the excavated trenches or (in the case of SU11) the remainder of the area around the excavation zones. These survey units were approximately three to eight feet deep and were stepped during excavation for access that allowed GPS scanning. The soil overburden SUs 1, 2, 3, and 4 were also scanned with GPS position correlation. SUs 5, 6, 7, and 9 had steep sides and deep bottoms (up to 20 ft deep, 100 ft long, and 6 ft wide), which were not accessible and only the perimeters could be scanned using GPS positioning. The bottom southwestern corner of each trench was considered as point (0,0).

### 3.2.3 Number of Sample Locations Per Survey Unit

A minimum number of sample locations are required in SUs to obtain sufficient statistical confidence that the conclusions drawn from the measurements are correct. The minimum required number of measurements is based on expected radionuclide concentrations near or at background in site areas that may be suitable for release for unrestricted use.

The project DQOs used $\alpha$=0.05 and $\beta$=0.05, and the relative shift of 3.0, to calculate the required number of systematic samples per SU from MARSSIM Table 5.3 as 10. On this basis, 10 samples per SU are statistically sufficient to support a decision. However, due to potential scan MDC limitations discussed in Section 6.1 of the approved FSP and to provide additional data at the site, a sample density of 15 samples was applied to each SU.

Systematic sample locations were placed within each Class 1 or Class 2 SU depending on the total surface area of the bottom and sidewall surfaces.

### 3.2.4 Scanning Survey Criteria

The purpose of the scan surveys is to identify areas of elevated radioactivity between systematic sample locations. MARSSIM recommends that scan surveys for Class 1 SUs be performed to cover 100% of the accessible areas and Class 2 SU scans be performed over a minimum of 10% of the accessible area.

For the purposes of this FSS design, outdoor scans were performed on 100% of soils within Class 1 SUs, including inside trenches where feasible. Scans within the Class 2 SU were performed over approximately 90% of the area.

## 3.3 Preliminary Data Review

Survey data were verified authentic, appropriately documented, and technically defensible. Specifically, the following conclusions were made:

- The instruments used to collect the data were capable of detecting the radiation types and energies of interest at or below project $DCGL_W$s and/or the target MDCs.
- The calibration of the instruments used to collect the data was current and radioactive sources used for calibration were NIST traceable.
- Instrument response was checked before and, where required, after instrument use each day data were collected.
- The MDCs and the assumptions used to develop them were appropriate for the instruments and the survey methods used to collect the data.
- The survey methods used to collect the data were appropriate for the media and types of radiation being measured.
- The custody of samples collected for off-site laboratory analysis was tracked from the point of collection until final results were obtained.

The survey data consist of qualified measurement results that are representative of the area of interest and collected as prescribed by the survey design.

# 4.0 Quality Assurance/Quality Control

A Quality Assurance Project Plan (QAPP) was developed for this project and is part of the Field Sampling Plan (FSP) (CABRERA, 2009) for Kirtland Air Force Base for the remedial construction activities at RW-06. The QAPP established requirements for both field and laboratory quality control (QC) procedures for collection and analysis of radiological and chemical samples.

A primary goal of the QA program is to ensure that the quality of results for all environmental measurements is appropriate for their intended use. To achieve this end, the QAPP and standardized field procedures were compiled to guide the investigation. Through the process of readiness review, training, equipment calibration, QC implementation, and detailed documentation, the project has successfully accomplished the goals set by the QA Program.

## 4.1 Field Instrument QA / QC

Table 4-1 provides the survey and stationary instruments used during Kirtland remediation and radiological FSS activities. Field instruments were utilized on this project to protect against the potential spread of contamination (through surveys of equipment, material, and personnel); determine areas of elevated activity during remedial support and final status surveys; and to protect worker, public, and environmental safety during all project activities.

Table 4-1: Field Instrumentation

| Instrument Model | Serial Number: | Detector Model | SN: | Principal Detectable Emissions | Primary Application |
|---|---|---|---|---|---|
| Ludlum 2929 | 163827 | Ludlum 43-10-1 | PR171322 | alpha / beta | Smear counting |
| Ludlum 2929 | 129566 | Ludlum 43-10-1 | PR132720 | alpha / beta | Smear counting |
| Ludlum 2360 | 202398 | Ludlum 43-93 | 211706 | alpha / beta | Alpha/beta equipment, material, and personnel surveys |
| Ludlum 2224-1 | 162426 | Ludlum 43-93 | PR193921 | alpha/beta | Alpha/beta equipment, material, and personnel surveys |
| Ludlum 2221 | 97841 | Alpha Spectra FIDLER | 120999F | Low-energy gamma | GWS |
| Ludlum 2221 | 196086 | Alpha Spectra FIDLER | 021700L | Low-energy gamma | GWS |
| Ludlum 2221 | 218559 | Ludlum 44-20 | 215468 | gamma | GWS |
| Ludlum 2221 | 161581 | Ludlum 44-20 | 182742 | gamma | GWS |
| Ludlum 2221 | 196087 | Ludlum 44-20 | 182712 | gamma | GWS |
| Ludlum 2221 | 161580 | Ludlum 44-20 | 254904 | gamma | GWS |
| Ludlum 3 | 89973 | Ludlum 44-9 | PR084781 | beta / gamma | Personnel / equipment frisking |
| Ludlum 3 | 166511 | Ludlum 44-9 | PR073107 | beta / gamma | Personnel / equipment frisking |
| Bicron microrem | 1359 | N/A | N/A | gamma | Exposure Rate |
| Bicron RSO-500 | A448F | N/A | N/A | gamma | Exposure Rate |
| Ludlum 19 | 144026 | N/A | N/A | gamma | Exposure Rate |

### 4.1.1 Instrument Calibration

All instruments used during the course of the survey were in current calibration, using sources traceable to the NIST. Copies of all project field and onsite laboratory instrument calibration certificates are provided in Appendix C.

### 4.1.2 Quality Control Tracking

QC measurements were performed on all deployed field instruments each day, at a minimum frequency of before and after each use. A controlled area was used to perform these checks. The QC investigation levels for count rate instruments used during the FSS were ± 2-sigma (2σ) for check source measurements and ± 3σ for background. Exposure rate instruments were evaluated using a qualitative ± 20% against the indicated check source response on the meter. If any single measurement was found to be outside of its investigation level, the measurement was repeated.

If the second count was also found to be outside of this criterion, the instrument was investigated to assess if any external biases or physical damage were present. If response checks were found to be outside of ± 3σ, the instrument was taken out of service until evaluated and approved by the Radiation Safety Officer (RSO). Control charts for check source response, background count rates (where applicable), and copies of the daily check source logs for all instruments are provided in Appendix C.

### 4.1.3 Field Instrument MDC

Field instruments for smear counting, personnel monitoring, air monitoring, and material and equipment scanning were checked daily (when in use) for the parameters described above. MDCs were calculated to check sensitivities relative to Regulatory Guide 1.86 limits for removable and fixed contamination.

Using NUREG-1507 as guidance, *a priori* scan MDC and soil scanning sensitivity was calculated for $^{137}$Cs, $^{226}$Ra, and $^{241}$Am using Microshield® and presented in Section 6.1.1 in the Approved FSP. The results of these calculations are presented in Table 4-2.

Table 4-2: NaI Scanning Sensitivities for Soil

| Detector | Description | ROC | Scan MDC (pCi/g) |
|---|---|---|---|
| Ludlum 44-20 | NaI 3 x 3 | $^{137}$Cs | 3.7 |
| Alpha Spectra | FIDLER | $^{226}$Ra | 1.7 |
| Alpha Spectra | FIDLER | $^{241}$Am | 1.5 |

The scan instruments were subjected to daily background and source checks as described above to ensure functionality for field use. Scan survey z-scores for selected bias sampled areas were greater than 3.0, but less than 5.0, and the sample analysis results were representative of the background distribution. The soil sample analysis results for both biased and random start systematic samples support the efficacy of the project *a prior* scan MDCs and methodology. Summary of the systematic and biased sample results are presented in Sections 5.1.1 and 5.3.3, respectively.

## 4.2 Off-site Lab Quality Assurance / Quality Control

The United States Environmental Protection Agency (EPA) "definitive" radiological and chemical data have been reported by the off-site contract laboratories, including basic information listed below.

- laboratory case narratives
- sample results
- laboratory method blank results
- laboratory control standard results
- laboratory sample matrix spike recoveries
- laboratory duplicate results
- sample extraction dates
- sample analysis dates

The laboratory data, along with field information, provides the basis for subsequent data evaluation relative to precision, accuracy, representativeness, and completeness. These parameters have been presented in the following sections of this assessment.

Three laboratories analyzed samples for this project. The data from the labs was reviewed as it arrived, and several issues that were resolved from these reviews are described below.

<u>Centauri Labs (GPL Laboratories, Inc.)</u>

GPL Laboratories, Inc. (GPL), 1000 Monticello Court, Montgomery, Alabama 36117 was the original project contract laboratory. The laboratory was bought out and the name was changed to Centauri Labs in January 2010 during the project, but the physical address and laboratory performing the work stayed the same. Samples were analyzed for all initial project ROCs; $^{14}C$ and $^{3}H$ by liquid scintillation; $^{90}Sr$ by gas proportional counting; and the rest of the ROCs by gamma spectroscopy in a canned geometry (for ingrowth of $^{226}Ra$ daughters to reach equilibrium). Between September 2009 and January 2010, Centauri performed definitive radiological analysis on 30 background soil samples, 180 FSS soil samples, 12 soil sample field duplicates, and 25 biased soil samples. Qualitative radiological analysis was performed on five bone (from waste debris) samples and three smears.

The background radiation samples were sent to Centauri and analyzed before any other samples. The first batch of 15 background surface soil sample results did not contain any deficiencies in the report received October, 2009. The second batch of background subsurface (6-12 inches) soil samples contained a deficiency of high carrier recoveries in regard to the $^{14}C$ analysis. One sample (RW-06-SO-BG-D07-006) from background soil analyses was reported as 13 pCi/g $^{14}C$. Because of the $^{14}C$ method problems occurring at the Centauri Lab and the unlikely validity of the 13 pCi/g appearing in background, it was decided that the sample would be reanalyzed by a contract laboratory (Teledyne Brown Engineering, Inc., 2508 Quality Lane, Knoxville, Tennessee 37931-3133) and to have the contract lab analyze all future $^{14}C$ samples. The reanalyzed sample activity for sample RW06-SO-BG-D07-006 was 0.12 pCi/g and that value was used to replace the initial 13 pCi/g value. Summary statistics for all reference data (both surface and subsurface) are presented in Section 5.2. The surface soil reference data for all ROCs are used for statistical testing.

Three of the 205 systematic and biased $^{14}C$ soil analysis results were more than half the $DCGL_W$ and were investigated by reanalysis. One of the values (55.8 pCi/g) was removed from the data, and the reanalyzed value was used for SU statistical analysis. Detail for reanalysis of the four data points is included within Section 5.3, with results specific to each survey unit.

The soil for gamma spectroscopy was canned with a hermetic seal to allow ingrowth of $^{226}Ra$ daughters and to present equilibrium activity concentrations without loss of $^{222}Ra$ gas. The reported values for $^{214}Bi$ were used to represent the $^{226}Ra$ activity in soil for the Centauri data.

Analyses were also performed for VOCs, SVOCs, and metals. Centauri performed three background, and thirty-seven FSS soil sample chemical analyses.

ALS Laboratory Group (Paragon laboratory)

ALS Laboratory Group (ALS (formerly Paragon Laboratory)), 225 Commerce Drive, Fort Collins, Colorado, USA 80524 analyzed 13 samples (from material segregated and containerized as radioactive waste) in November 2009 for $^{14}C$ and $^{3}H$ by liquid scintillation; $^{90}Sr$ by gas proportional counting; gamma spectroscopy in a canned geometry (for ingrowth of $^{226}Ra$ daughters to reach equilibrium); and, additionally isotopic plutonium, uranium, and americium by alpha spectroscopy.

The 13 waste composite samples were also analyzed by ALS for the full suite of chemicals and metals necessary to profile for waste disposal. The list of analyses includes Toxicity Characteristic Leaching Procedure (TCLP) RCRA volatiles; TCLP Tumble extraction; RCRA semi-volatiles; RCRA pesticides; RCRA herbicides; RCRA metals plus copper and zinc; ignitability; iorrosivity; reactivity; paint filter; and, polychlorinated biphenyls (PCBs).

ALS also analyzed the 30 background soil samples, 180 FSS soil samples, 12 soil sample field duplicates, 25 biased soil samples for isotopic plutonium; and one relocated sample for all project ROCs including isotopic plutonium during September and October 2010.

There were not any quality issues reported by ALS that impacted project data.

### 4.2.1 Accuracy

Accuracy provides a gauge or measure of the agreement between an observed result and the true value for an analysis. Analytical accuracy is evaluated by measuring the agreement between an analytical result and its known or true value. This is generally determined through use of laboratory control samples (LCSs) and matrix spike (MS) analysis samples. Accuracy, as measured through the use of LCSs, determines the method's implementation of accuracy independent of sample matrix, as well as documents laboratory analytical process control. Accuracy determined by the MS is a function of both matrix and analytical process. Spike results are reported by the laboratory as percent recovery and are compared to the accuracy objectives stated in the QAPP.

Results that do not satisfy the objectives are assigned a data qualifier flag to indicate uncertainty associated with inaccuracy. The analytical results for soils analyzed by the laboratory showed that more than 90% of the individual chemical and radiological spike recoveries and LCS recoveries were within the (70 to 130) % criteria for the MS/MSD samples. There were some recoveries that were outside of the control limits. Explanation of these cases was made in the narrative and/or this caused a reanalysis of the sample for a particular suite of parameters (e.g., VOCs). With the exception of these minor cases all percent recoveries for LCS and MS samples were within the control limits. None of the data was rejected.

### 4.2.2 Precision (Field Duplicate Sample Analysis)

The approved FSP and the QAPP called for the collection of field duplicates at a rate of one in 20 (five percent). This requirement is not specifically addressed in project documents for stable chemistry testing. The field duplicate requirement was implemented for radiological samples but was not applied to the stable chemistry samples.

The laboratory performed duplicate stable chemistry samples as part of their internal QA/QC process and reported those results in the narrative of each analytical report. For the volatile organic compound (VOC) narrative for file 911016, a duplicate sample was run for sample RW6-SO-SU02-013 because of a low internal standard response. The sample was re-analyzed with similar results and all other internal standard responses were within the QC limits. The initial analysis result was used for reporting and the re-analysis used for QA/QC. Sample RW6-FSS-SU11-014 in file 911046 was also reanalyzed with the initial sample being reported and the reanalysis used as QA/QC. These reanalyzed samples should be considered as duplicate samples.

The field team collected field duplicate samples at a rate of 5% of all SU radiological systematic samples. Field duplicate statistical analyses entailed comparing the results of the sample and field duplicate. The samples were numbered using a unique identifier. For example, RW6-FSS-SU06-005 would be the sample identification number and RW6-FSS-SU06-105, the field duplicate sample number.

Field duplicate analyses were compared to the initial analytical results by calculating $Z_{Rep}$ values for each data set as defined below and in the RW-06 QAPP (CABRERA 2009).

$$Z_{\mathrm{Re}\,p} = \frac{Sample - Duplicate}{\sqrt{\sigma^2_{Sample} + \sigma^2_{Duplicate}}}$$

*where*:

| | | |
|---|---|---|
| Sample | = | first sample value (original) |
| Duplicate | = | second sample value (duplicate) |
| $\sigma_{Sample}$ | = | total propagated uncertainty of the sample |
| $\sigma_{Duplicate}$ | = | total propagated uncertainty of the duplicate |

Results of the off-site lab field duplicate $Z_{Rep}$ analysis are provided in Table 4-3. Three analysis results from field duplicates showed $Z_{Rep}$ values greater than ±2.0. These differences are likely due to the original and duplicate samples not containing like-sample matrix. This leads to errors in relation to heterogeneous distribution caused either by insoluble contaminants, or due to differences in sample aliquots (grams removed from kilogram samples, also subject to heterogeneous distribution) taken from each to perform the required analyses. Sample RW6-SO-SU04-009 was reanalyzed since the $Z_{Rep}$ value for $^{14}C$was 26.8, and not any other project data for $^{14}C$ approached the activity concentration of 55.8 pCi/g. The $Z_{Rep}$ for the reanalysis and field duplicate still failed the 2.0 criteria, but the reanalysis value is more representative of the survey unit and was utilized for the statistical testing. Precision was adequate for project data analysis.

Table 4-3: Results of Off-site Lab Field Duplicate $Z_{Rep}$ Analysis

| Sample ID | Radionuclide | Sample Activity (pCi/g) | TPU | Duplicate Sample Activity (pCi/g) | Duplicate TPU | Replicate Z-Score | Pass/Fail |
|---|---|---|---|---|---|---|---|
| RW6-FSS-SU02-004 | $^{241}$Am | 0.11 | 0.10 | -0.21 | 0.21 | 1.40 | Pass |
| RW6-FSS-SU02-004 | $^{214}$Bi | 0.87 | 0.18 | 0.77 | 0.15 | 0.43 | Pass |
| RW6-FSS-SU02-004 | $^{14}$C | -0.49 | 0.91 | -1.23 | 0.83 | 0.60 | Pass |
| RW6-FSS-SU02-004 | $^{137}$Cs | 0.02 | 0.04 | 0.03 | 0.03 | -0.35 | Pass |
| RW6-FSS-SU02-004 | $^{3}$H | 3.23 | 4.86 | 5.36 | 4.99 | -0.31 | Pass |
| RW6-FSS-SU02-004 | $^{90}$Sr | -0.12 | 0.17 | 0.05 | 0.19 | -0.67 | Pass |
| RW6-FSS-SU05-015 | $^{241}$Am | -0.29 | 0.24 | -0.06 | 0.21 | -0.71 | Pass |
| RW6-FSS-SU05-015 | $^{214}$Bi | 0.84 | 0.17 | 0.85 | 0.17 | -0.03 | Pass |
| RW6-FSS-SU05-015 | $^{14}$C | -6.01 | 0.96 | -5.02 | 0.87 | -0.76 | Pass |
| RW6-FSS-SU05-015 | $^{137}$Cs | -0.04 | 0.03 | 0.00 | 0.03 | -0.77 | Pass |
| RW6-FSS-SU05-015 | $^{3}$H | 1.83 | 4.81 | 2.93 | 4.86 | -0.16 | Pass |
| RW6-FSS-SU05-015 | $^{90}$Sr | 0.01 | 0.40 | -0.08 | 0.35 | 0.17 | Pass |
| RW6-FSS-SU07-004 | $^{241}$Am | 0.02 | 0.15 | -0.05 | 0.07 | 0.39 | Pass |
| RW6-FSS-SU07-004 | $^{214}$Bi | 0.73 | 0.15 | 0.75 | 0.15 | -0.13 | Pass |
| RW6-FSS-SU07-004 | $^{14}$C | -0.74 | 0.75 | 8.21 | 0.95 | -7.41 | Fail |
| RW6-FSS-SU07-004 | $^{137}$Cs | 0.01 | 0.03 | 0.02 | 0.03 | -0.33 | Pass |
| RW6-FSS-SU07-004 | $^{3}$H | 4.27 | 4.88 | 5.85 | 4.98 | -0.23 | Pass |
| RW6-FSS-SU07-004 | $^{90}$Sr | 0.00 | 0.09 | 0.00 | 0.09 | 0.00 | Pass |
| RW6-FSS-SU08-008 | $^{241}$Am | 0.05 | 0.18 | -0.18 | 0.09 | 1.09 | Pass |
| RW6-FSS-SU08-008 | $^{214}$Bi | 0.79 | 0.17 | 0.90 | 0.18 | -0.43 | Pass |
| RW6-FSS-SU08-008 | $^{14}$C | -1.73 | 0.61 | -1.41 | 0.69 | -0.35 | Pass |
| RW6-FSS-SU08-008 | $^{137}$Cs | -0.02 | 0.03 | 0.00 | 0.04 | -0.57 | Pass |
| RW6-FSS-SU08-008 | $^{3}$H | -1.40 | 4.89 | 0.73 | 4.93 | -0.31 | Pass |
| RW6-FSS-SU08-008 | $^{90}$Sr | -0.18 | 0.33 | -0.09 | 0.34 | -0.19 | Pass |
| RW6-FSS-SU09-007 | $^{241}$Am | 0.10 | 0.23 | -0.12 | 0.08 | 0.90 | Pass |
| RW6-FSS-SU09-007 | $^{214}$Bi | 0.82 | 0.16 | 0.78 | 0.16 | 0.18 | Pass |
| RW6-FSS-SU09-007 | $^{14}$C | -0.91 | 0.76 | -0.99 | 0.60 | 0.08 | Pass |
| RW6-FSS-SU09-007 | $^{137}$Cs | -0.02 | 0.03 | 0.01 | 0.03 | -0.63 | Pass |
| RW6-FSS-SU09-007 | $^{3}$H | 2.12 | 5.19 | 3.97 | 5.28 | -0.25 | Pass |
| RW6-FSS-SU09-007 | $^{90}$Sr | -0.71 | 0.45 | 0.18 | 0.68 | -1.08 | Pass |
| RW6-FSS-SU11-013 | $^{241}$Am | 0.01 | 0.18 | -0.07 | 0.16 | 0.32 | Pass |
| RW6-FSS-SU11-013 | $^{214}$Bi | 1.01 | 0.20 | 0.59 | 0.14 | 1.75 | Pass |
| RW6-FSS-SU11-013 | $^{14}$C | -0.93 | 0.65 | -0.96 | 0.65 | 0.03 | Pass |
| RW6-FSS-SU11-013 | $^{137}$Cs | 0.27 | 0.08 | 0.18 | 0.06 | 0.93 | Pass |
| RW6-FSS-SU11-013 | $^{3}$H | 1.70 | 5.12 | 5.20 | 5.29 | -0.48 | Pass |
| RW6-FSS-SU11-013 | $^{90}$Sr | 0.00 | 0.34 | -0.08 | 0.30 | 0.17 | Pass |
| RW6-SO-SU02-006 | $^{241}$Am | -0.09 | 0.17 | -0.31 | 0.24 | 0.73 | Pass |
| RW6-SO-SU02-006 | $^{214}$Bi | 0.97 | 0.20 | 1.06 | 0.21 | -0.31 | Pass |
| RW6-SO-SU02-006 | $^{14}$C | 2.19 | 1.11 | -0.98 | 1.05 | 2.08 | Fail |
| RW6-SO-SU02-006 | $^{137}$Cs | 0.00 | 0.03 | -0.01 | 0.03 | 0.21 | Pass |
| RW6-SO-SU02-006 | $^{3}$H | 4.32 | 5.13 | 0.85 | 4.98 | 0.48 | Pass |
| RW6-SO-SU02-006 | $^{90}$Sr | -0.10 | 0.33 | 0.01 | 0.45 | -0.21 | Pass |
| RW6-SO-SU03-003 | $^{241}$Am | -0.06 | 0.17 | -0.13 | 0.09 | 0.35 | Pass |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| RW6-SO-SU03-003 | $^{214}$Bi | 0.74 | 0.16 | 0.85 | 0.17 | -0.45 | Pass |
| RW6-SO-SU03-003 | $^{14}$C | -0.57 | 0.77 | -1.64 | 0.86 | 0.92 | Pass |
| RW6-SO-SU03-003 | $^{137}$Cs | 0.00 | 0.03 | 0.00 | 0.04 | -0.01 | Pass |
| RW6-SO-SU03-003 | $^{3}$H | 6.95 | 5.27 | 3.35 | 5.05 | 0.49 | Pass |
| RW6-SO-SU03-003 | $^{90}$Sr | -0.23 | 0.27 | -0.06 | 0.20 | -0.52 | Pass |
| RW6-SO-SU04-009 | $^{241}$Am | 0.02 | 0.25 | -0.03 | 0.20 | 0.14 | Pass |
| RW6-SO-SU04-009 | $^{214}$Bi | 1.03 | 0.19 | 0.96 | 0.20 | 0.24 | Pass |
| RW6-SO-SU04-009 | $^{14}$C | 55.80 | 1.90 | -0.50 | 0.90 | 26.76 | Fail |
| RW6-SO-SU04-009 | $^{137}$Cs | 0.01 | 0.04 | 0.00 | 0.04 | 0.17 | Pass |
| RW6-SO-SU04-009 | $^{3}$H | 1.59 | 4.72 | 5.00 | 4.89 | -0.50 | Pass |
| RW6-SO-SU04-009 | $^{90}$Sr | -0.52 | 0.33 | -0.33 | 0.49 | -0.31 | Pass |
| RW6-FSS-SU06-015 | $^{241}$Am | 0.13 | 0.25 | -0.22 | 0.16 | 1.15 | Pass |
| RW6-FSS-SU06-015 | $^{214}$Bi | 0.90 | 0.17 | 0.83 | 0.17 | 0.27 | Pass |
| RW6-FSS-SU06-015 | $^{14}$C | 1.98 | 0.79 | 0.24 | 0.58 | 1.78 | Pass |
| RW6-FSS-SU06-015 | $^{137}$Cs | -0.01 | 0.03 | 0.00 | 0.03 | -0.16 | Pass |
| RW6-FSS-SU06-015 | $^{3}$H | 1.58 | 4.95 | -1.71 | 4.88 | 0.47 | Pass |
| RW6-FSS-SU06-015 | $^{90}$Sr | -1.16 | 0.43 | -1.04 | 0.34 | -0.22 | Pass |

TPU: Total propagated Uncertainty

### *4.2.3 Representativeness and Comparability*

Representativeness expresses the degree to which data accurately reflect the analyte or parameter of interest for an environmental site and is the qualitative term most concerned with the proper design of a sampling program. Factors that affect the representativeness of analytical data include proper preservation, holding times, use of standard sampling and analytical methods, and determination of matrix or analyte interferences. Sample analytical methodologies and soil sampling methodologies were documented to be adequate and consistently applied.

Centauri $^{14}$C samples RW6-FSS-SU08-003 (15.2 pCi/g), RW6-SO-SU04-009 (55.8 pCi/g), RW6-SO-SU04-109 (-0.498 pCi/g, field duplicate for RW6-SO-SU04-009), RW6-SO-SU04-0013 (12.4 pCi/g), were all recounted and reanalyzed to investigate higher than expected activity concentrations that did not appear representative of the survey unit. The field duplicate sample was reanalyzed as a conservative measure to investigate potential interference or homogeneity issues with sample RW6-SO-SU04-009. All reanalyzed values were at or near background, but the only reanalyzed result that was used for statistical testing of survey units was sample RW6-SO-SU04-009. The other original sample values were used for the SU statistical testing and did not impact the decisions for those SUs. The Centauri laboratory QC manager discussed the interference potential for false positives in the scintillation counting method whereby any microscopic light-producing event can produce cascade photons and consequently be detected. High natural levels of carbon were also discussed in the narrative for Centauri's analysis of samples RW6-SO-BG-D01-001 through RW6-SO-BG-D20-015 as a potential matrix interference with percent recovery resulting in high bias for $^{14}$C analysis results.

Comparability, like representativeness, is a qualitative term relative to a project data set. These investigations employed appropriate sampling methodologies, site surveillance, use of standard sampling devices, uniform training, documentation of sampling, standard analytical protocols/procedures, QC checks with standard control limits, and universally accepted data reporting units to ensure comparability to other data sets. Through the proper implementation and documentation of these standard practices, the project has established the confidence that the data will be comparable to other project and programmatic information.

### 4.2.4 Completeness

Usable data are defined as those data that pass individual scrutiny during the verification and validation process and are accepted for unrestricted use. The data quality objective of achieving 90% completeness, as defined in QAPP, was satisfied with the project producing valid results for 100% of the sample analyses performed and successfully collected.

### 4.2.5 Offsite Laboratory MDC

The detection limit measurement quality objectives for project ROCs are listed in the survey design described in Table 3-2. A summary of the achieved MDCs for systematic and biased sample results is shown in Table 4-4. Mean values from MDA summary statistics for $^{241}$Am, $^{226}$Ra ($^{214}$Bi), and $^{14}$C were all slightly above the MQO. Mean value results were slightly better than the MQO for $^{137}$Cs. The $^{90}$Sr mean MDA results were significantly higher than the stated MQO (0.1 pCi/g). The stated MQO was not practical. The actual requested laboratory $^{90}$Sr detection limit was 0.9 pCi/g, which was met by the contract laboratory. SOR values using $^{90}$Sr may have to be evaluated with the achieved MDA taken into consideration. There was not any MQO for $^{3}$H listed in the approved project QAPP. The laboratory stated MDA was 10 pCi/g, and they performed better than that goal. Plutonium was added as an ROC during the project performance with a commitment by the contract lab(s) for an MDA of 0.05, which was achieved.

Off-site laboratory detection limits provided data of adequate sensitivity to meet project DQOs.

Table 4-4: Summary Statistics for Minimum Detectable Activities of Biased and Systematic Samples

| *MDA Summary Statistics* | $^{241}$Am | $^{226}$Ra($^{214}$Bi) | $^{14}$C | $^{137}$Cs | $^{3}$H | $^{239}$Pu | $^{90}$Sr |
|---|---|---|---|---|---|---|---|
| Mean (pCi/g) | 0.297 | 0.102 | 1.320 | 0.056 | 8.174 | 0.017 | 0.672 |
| Median (pCi/g) | 0.305 | 0.094 | 1.300 | 0.056 | 8.220 | 0.018 | 0.722 |
| Standard Deviation (pCi/g) | 0.101 | 0.035 | 0.309 | 0.008 | 0.231 | 0.006 | 0.262 |
| Skewness | -0.108 | 3.496 | -0.028 | 0.671 | 0.183 | 0.308 | -0.775 |
| Minimum (pCi/g) | 0.118 | 0.037 | 0.540 | 0.039 | 7.830 | 0.006 | 0.000 |
| Maximum (pCi/g) | 0.575 | 0.275 | 2.130 | 0.094 | 8.600 | 0.036 | 1.320 |
| Count | 205 | 205 | 205 | 205 | 205 | 205 | 205 |
| $DCGL_W$ | 2.1 | 0.7 | 11.6 | 11 | 110 | 2.3 | 1.72 |

## 4.3 Onsite Laboratory Quality Control Results

### 4.3.1 Daily Quality Control Checks

The Onsite Lab HPGe detector was calibrated with a NIST traceable multi-line gamma standard prior to the performance of project sample analyses. This standard was used for the system efficiency calibration and consisted of an identical marinelli container used for sample analyses that was filled with an epoxy. This epoxy matrix was manufactured to have a density of 1.6 g per cubic centimeter, which approximated the density of most soils.

Daily Onsite Lab Management Checklists were completed by the health physics technician or operator to ensure that all essential laboratory tasks were being accomplished on their regular schedule. Checklist items included checking liquid nitrogen levels, performing daily QC activities, and performing daily backups of system data. Copies of all checklists are provided in Appendix C.

QC criteria consisted of detector resolution calculation using measurement of Full Width at Half Maximum, peak energy measurements, and decay corrected activity concentration measurements. Each criterion was evaluated daily for cadmium-109 ($^{109}$Cd) at 88.0 kilo-electron volt (keV) and cobalt-60 ($^{60}$Co) at 1,332.5 keV. Daily QC results passed comparison criteria for each day that project sample analyses were performed. Results for all daily QC checks as well as weekly plots of HPGe control charts are provided in Appendix C.

### 4.3.2 Onsite Laboratory Replicate Sample Analyses

The field team performed replicate analyses for 10% of the samples analyzed in the Onsite Lab. Replicate analysis, as discussed in Section 4.2, was also performed on the Onsite Lab samples. Results of the $Z_{Rep}$ comparisons for the Onsite Lab are shown in Table 45. All Onsite Lab replicate samples except two passed the requisite $Z_{Rep}$ criterion of ±2.00. Onsite Lab data is considered effective and applicable for project DQOs.

Table 4-5: Results of Onsite Laboratory Replicate Sample Analyses

| Sample ID | $^{214}$Bi Activity (pCi/g) | TPU | Duplicate $^{214}$Bi Activity (pCi/g) | Duplicate TPU | Replicate Z-Score | Pass/Fail |
|---|---|---|---|---|---|---|
| RW6-FSS-SU02-006 | 0.76 | 0.05 | 0.78 | 0.05 | -0.26 | Pass |
| RW6-FSS-SU05-008 | 0.73 | 0.04 | 0.66 | 0.04 | 1.26 | Pass |
| RW6-FSS-SU06-002 | 0.59 | 0.04 | 0.68 | 0.04 | -1.69 | Pass |
| RW6-FSS-SU06-012 | 0.51 | 0.04 | 0.54 | 0.04 | -0.60 | Pass |
| RW6-FSS-SU07-015 | 0.59 | 0.04 | 0.57 | 0.04 | 0.41 | Pass |
| RW6-FSS-SU08-001 | 0.64 | 0.04 | 0.53 | 0.04 | 2.12 | Fail |
| RW6-FSS-SU08-010 | 0.45 | 0.03 | 0.58 | 0.04 | -2.83 | Fail |
| RW6-FSS-SU09-003 | 0.61 | 0.04 | 0.57 | 0.04 | 0.75 | Pass |
| RW6-FSS-SU09-012 | 0.59 | 0.04 | 0.62 | 0.04 | -0.49 | Pass |
| RW6-FSS-SU10-006 | 0.54 | 0.04 | 0.56 | 0.04 | -0.39 | Pass |
| RW6-FSS-SU11-007 | 0.46 | 0.04 | 0.48 | 0.04 | -0.29 | Pass |
| RW6-FSS-SU11-016 | 0.87 | 0.05 | 0.82 | 0.06 | 0.54 | Pass |
| RW6-SO-SU01-005 | 0.62 | 0.05 | 0.59 | 0.04 | 0.45 | Pass |
| RW6-SO-SU01-015 | 0.49 | 0.04 | 0.50 | 0.04 | -0.27 | Pass |
| RW6-SO-SU02-005 | 0.63 | 0.05 | 0.76 | 0.06 | -1.76 | Pass |
| RW6-SO-SU02-014 | 0.67 | 0.05 | 0.65 | 0.05 | 0.32 | Pass |
| RW6-SO-SU03-004 | 0.63 | 0.04 | 0.64 | 0.05 | -0.22 | Pass |
| RW6-SO-SU03-014 | 0.66 | 0.04 | 0.60 | 0.05 | 0.99 | Pass |
| RW6-SO-SU04-009 | 0.60 | 0.04 | 0.61 | 0.04 | -0.17 | Pass |

### 4.3.3 Onsite laboratory MDCs

Onsite lab MDC goals described in Section 6.2 of the QAPP indicated “Count times will be long enough to achieve sufficient MDCs for each radionuclide to meet applicable disposal facility WAC.” The onsite lab was only used to provide qualitative data for remedial support decisions during excavation and not support waste acceptance criteria (WAC). Laboratory MDCs were adequate to support these qualitative excavation decisions.

## 4.4 Data Quality Assessment Summary

Data generated during the course of the RW-06 FSS were reviewed and tested in accordance with the requirements set forth in Section 8 of the project QAPP (CABRERA 2009).

*Field Instrumentation*

Field Instrumentation QA and QC are discussed in Section 4.1 and Appendix C. All calibrations, calibration verification checks, and background checks indicated that field instrumentation operated satisfactorily during counting and reporting of FSS data.

*Off-site Laboratory Data*

Data from the Offsite Laboratories were reviewed promptly upon arrival. Data questions or issues have been defined and are described in this report.

Although formal data verification and validation is not required for this project, the data has been reviewed relative to the established project objectives and has been determined to be acceptable for use.

Data, as presented, have been qualified as usable, but estimated when necessary (primarily with metals analyses). Data that have been estimated have percent recoveries outside of the control limits or are indicative of accuracy, precision, or sensitivity being less than desired but adequate for interpretation.

Data produced for this project demonstrate that they can withstand scientific scrutiny, are appropriate for the intended purpose, are technically defensible, and are of known and acceptable sensitivity, precision, and accuracy. Data integrity has been documented through proper implementation of Quality Assurance and Quality Control measures. The environmental information presented has an established confidence, which allows utilization for the project objectives and provides data for future needs.

*Onsite Laboratory Data*

Onsite laboratory QA/QC data was reviewed daily and weekly for operability and data trending purposes. Results of the Onsite Lab QA/QC activities are presented in Appendix C and discussed in Section 4.3. Review of the daily and weekly trends indicates the gamma spectroscopy system was calibrated and operating properly.

The analytical data from the Onsite Lab gamma spectroscopy system was used for screening purposes during the RW-06 FSS and, therefore, does not require qualifiers to be assigned to the raw data.

Review of Onsite Lab precision tests indicate that all samples were within the control limits established in the QAPP. Therefore, additional validation actions were not required.

# 5.0 Survey Results

Four types of measurements were performed as part of the radiological survey —

- Gross gamma scan data measurements,
- Onsite gamma spectroscopy of surface soil samples,
- Off-site analysis of surface soil samples, and
- Gross alpha and beta surface scans of equipment and materials.

These measurement techniques were selected based on the ROCs and survey design. The scan data and onsite gamma spectroscopy of soil samples were used during remediation to provide feedback for confirming the presence, and defining the nature and lateral extent, of gamma-emitting radioactivity. Decision rule implementation using this real-time feedback is described in Section 3.1.5. The use of an onsite laboratory reduced the time required to analyze samples for gamma emitting ROCs believed to be present at RW-06, which expedited decisions for continuation of excavation or implementation of final status survey design. The off-site laboratory performed radionuclide analyses and various chemical analyses of the soil samples to provide definitive quantitative data.

As designed in the approved plans, radiological criteria are used to make decisions for final status. In addition, a minimum of three soil samples were also collected from each SU for stable chemical analysis and the results compared to NMED criteria.

Waste soil with some laboratory debris was segregated by visual and hand-held instrument survey during excavation. This material was bagged in 10 cubic yard super sacks and samples were collected and analyzed to determine the disposition of the waste. Waste results are discussed in Section 5.5 and the data is contained in Appendix B.

## 5.1 Data Analyses by Radionuclide

EDA was performed on all final status survey soil sample radiological analytical results in order to provide a comprehensive perspective on the entire dataset (not specific to each survey unit) and the RW-06 site as a whole. Individual analysis of the data from each project survey unit is presented in Section 5.4.

### *5.1.1 Off-site Laboratory Results Summary by ROC*

A total of 180 systematic and 25 biased soil samples, excluding QC field duplicates, were collected from 12 SUs and quantitatively analyzed by the off-site laboratory for ROCs at RW-06. Summary statistics for all definitive results, grouped as 1) systematic plus biased, 2) systematic, and 3) biased are provided in Table 5-1. Complete laboratory reports, electronic data tables, and Exploratory Data Analysis (EDA) of all results are also provided in Appendix B.

Generally, the data are normally distributed and below the respective $DCGL_W$. The $^{137}$Cs and $^{239}$Pu distributions are characterized by differences in the mean and median with large skewness values. One biased $^{137}$Cs value (15.7 pCi/g) exceeds the project $DCGL_W$ (11.0 pCi/g) and skews the distribution characteristics for this ROC. $^{239}$Pu has four values that exceed the $DCGL_W$ (2.3 pCi/g) and skew the data distribution.

The $^{137}$Cs sample result represents a small area (approximately 10m$^2$) in SU11 that was biased sampled based on scan data investigation. Three of the $^{239}$Pu samples are within close proximity of each other in FSS SU02. The other $^{239}$Pu data point is a single location in SO SU01.

There were two $^{14}$C data points in the final dataset that were outliers, but the distribution was generally normal.

These data points described above are further investigated, analyzed by elevate measurement comparison, and discussed in the individual survey unit evaluation sections.

Table 5-1: Summary Statistics by ROC and Sample Group

| | ROC Concentrations (all results in pCi/g) | | | | | | |
|---|---|---|---|---|---|---|---|
| ***Statistic*** | $^{241}$**Am** | $^{226}$Ra($^{214}$Bi) | $^{14}$C | $^{137}$Cs | $^{3}$H | $^{239/240}$**Pu** | $^{90}$Sr |
| ***All Systematic plus Biased Surface Soils*** | | | | | | | |
| Mean | -0.01 | 0.90 | -0.47 | 0.15 | 2.31 | 0.12 | -0.17 |
| Median | 0.00 | 0.89 | -0.68 | 0.01 | 2.50 | 0.00 | -0.08 |
| SD[1] | 0.11 | 0.14 | 2.27 | 1.12 | 2.86 | 0.63 | 0.47 |
| Skewness | -0.08 | 0.58 | 2.57 | 13.20 | -0.20 | 6.51 | -1.85 |
| Minimum | -0.29 | 0.56 | -6.01 | -0.04 | -6.25 | -0.01 | -3.13 |
| Maximum | 0.31 | 1.36 | 15.2 | 15.7 | 11.5 | 5.30 | 1.61 |
| Count | 205 | 205 | 205 | 205 | 205 | 205 | 205 |
| ***Systematic Surface Soils*** | | | | | | | |
| Mean | -0.01 | 0.87 | -0.48 | 0.07 | 2.64 | 0.14 | -0.18 |
| Median | -0.01 | 0.86 | -0.80 | 0.01 | 2.84 | 0.00 | -0.09 |
| SD[1] | 0.11 | 0.11 | 2.41 | 0.28 | 2.64 | 0.67 | 0.50 |
| Skewness | -0.03 | 0.04 | 2.48 | 7.28 | -0.02 | 6.10 | -1.76 |
| Minimum | -0.29 | 0.56 | -6.01 | -0.04 | -3.48 | -0.01 | -3.13 |
| Maximum | 0.31 | 1.13 | 15.2 | 2.78 | 11.5 | 5.30 | 1.61 |
| Count | 180 | 180 | 180 | 180 | 180 | 180 | 180 |
| ***Biased Surface Soils*** | | | | | | | |
| Mean | 0.00 | 1.10 | -0.53 | 0.73 | -0.06 | 0.03 | -0.07 |
| Median | 0.01 | 1.07 | -0.56 | 0.07 | 0.25 | 0.01 | -0.04 |
| SD[1] | 0.08 | 0.14 | 0.41 | 3.12 | 3.28 | 0.08 | 0.23 |
| Skewness | -0.74 | 0.03 | -0.04 | 4.98 | 0.04 | 3.80 | 0.02 |
| Minimum | -0.23 | 0.85 | -1.39 | -0.04 | -6.25 | 0.00 | -0.58 |
| Maximum | 0.15 | 1.36 | 0.28 | 15.7 | 6.41 | 0.36 | 0.44 |
| Count | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| *[1]SD - Standard Deviation* | | | | | | | |

### *5.1.2 Onsite Laboratory Results Summary*

The Onsite Lab performed gamma spectroscopy that was extensively used for qualitative analysis of the soil (without matrix preparation—drying, sieving, etc), debris, and material samples to support remediation excavation and site health and safety decisions during field work. There were basic differences in the methods and goals used for sample analysis by the onsite and off-site labs. The onsite gamma spectroscopy data was used to drive qualitative decisions during excavation, and off-site data is quantitative for definitive decision making on site final status. Soil samples for the onsite lab were only processed to remove obvious sticks, stones, and organic material, whereas the off-site lab had meticulous soil sample preparation requirements. Some objects that were analyzed onsite did not meet the density or geometry conditions for the modeled instrument efficiency, but the analyses provided useful qualitative radionuclide identification information. Unlike the off-site lab method, soil analyzed in the onsite lab was counted in a one liter marinelli geometry that was not canned with a hermetic seal for ingrowth of $^{226}$Ra daughters. Thus, the reported qualitative results for $^{226}$Ra ($^{214}$Bi) results are impacted by the lack of known equilibrium status and were used for screening purposes only.

Due to the differences in off-site and onsite sample preparation and goals for use of data, the onsite data is presented here for relative description of site conditions during the field work. The sample listed as the maximum $^{137}$Cs activity (152 pCi/g) was an unusual geometry and matrix of vials that was qualitatively analyzed to identify radionuclide content during field work. Overall, it can be determined by review of this data that the site was not grossly contaminated by gamma emitting radionuclides, that contamination activity concentration levels were low, and that the site was ready for final status survey.

The Onsite Lab was able to assess qualitative concentrations for $^{137}$Cs, $^{226}$Ra, and $^{214}$Bi. Gamma spectra were also routinely reviewed for unidentified peaks. A summary statistics table of results for the 233 soil and debris samples is provided in Table 5-2.

A complete listing of all Onsite Lab results is provided in Appendix B.

Table 5-2: Summary of All Onsite Lab Gamma Spectroscopy Results

| | **Nuclide Results** | |
|---|---|---|
| **Statistic** | **$^{226}$Ra($^{214}$Bi)** | **$^{137}$Cs** |
| *Mean (pCi/g)* | 8.60E-01 | 4.06E+00 |
| *SD[1] (pCi/g)* | 3.69E+00 | 1.91E+01 |
| *Skewness* | 1.53E+01 | 6.98E+00 |
| *Minimum (pCi/g)* | 3.66E-01 | 2.05E-02 |
| *Maximum (pCi/g)* | 5.69E+01 | 1.52E+02 |
| *Count* | 233 | 71 |

*[1]SD - Standard Deviation*

## 5.2 Background Reference Data

A total of 30 background reference samples were collected from the reference location shown in Figure 2-1. The samples were laid out randomly. Sample sets (15 samples each) were collected from the surface (0-15 cm) and subsurface (15-30 cm) soil. Since excavation was performed to remediate contaminated trenches and the FSS was performed on the 0-15 cm soil within the excavated areas, the subsurface soil was collected to provide a reference population if the surface reference data was significantly different than the trench surface soil data. Neither the surface or subsurface reference soil data for the project ROCs varied significantly from each other or were critical relative to the project $DCGL_W$s. The surface soil reference dataset was utilized for WRS statistical testing. Summary statistics for both datasets are presented in Table 5-3.

Table 5-3: Background Summary Statistics

| Statistic | $^{241}$Am | $^{226}$Ra($^{214}$Bi) | $^{14}$C | $^{137}$Cs | $^{3}$H | $^{239}$Pu | $^{90}$Sr |
|---|---|---|---|---|---|---|---|
| Reference Area Surface Soil Samples | | | | | | | |
| Mean (pCi/g) | 0.034 | 0.97 | 0.63 | 0.084 | 0.053 | 0.006 | 0.21 |
| Median (pCi/g) | 0.043 | 0.96 | 0.53 | 0.072 | -0.30 | 0.006 | 0.13 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Standard Deviation (pCi/g) | 0.074 | 0.06 | 0.85 | 0.057 | 2.883 | 0.004 | 0.29 |
| Skewness | -0.24 | -0.13 | 0.28 | 1.4 | 0.85 | 0.43 | 0.9 |
| Minimum (pCi/g) | -0.084 | 0.86 | -0.53 | 0.013 | -4.2 | 0 | -0.19 |
| Maximum (pCi/g) | 0.15 | 1.07 | 2.3 | 0.23 | 6.99 | 0.016 | 0.86 |
| Count | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Reference Area Sub-surface Soil Samples | | | | | | | |
| Mean (pCi/g) | -0.0041 | 0.92 | -1.68 | 6.7E-05 | 1.9 | 0.0020 | 0.143 |
| Median (pCi/g) | -0.035 | 0.91 | -1.5 | -0.007 | 1.7 | 0.001 | 0.14 |
| Standard Deviation (pCi/g) | 0.079 | 0.089 | 0.97 | 0.032 | 1.3 | 0.0040 | 0.20 |
| Skewness | 0.64 | 0.44 | -0.89 | 3.4 | 1.0 | 0.90 | 0.14 |
| Minimum (pCi/g) | -0.12 | 0.81 | -4.2 | -0.023 | 0.31 | -0.0020 | -0.22 |
| Maximum (pCi/g) | 0.13 | 1.1 | 0.12 | 0.11 | 4.5 | 0.010 | 0.46 |
| Count | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Reference Area Surface and Sub-surface Soil Samples | | | | | | | |
| Mean (pCi/g) | 0.015 | 0.94 | -0.53 | 0.042 | 0.95 | 0.0040 | 0.18 |
| Median (pCi/g) | 0.0010 | 0.95 | -0.52 | 0.015 | 1.3 | 0.0040 | 0.13 |
| Standard Deviation (pCi/g) | 0.078 | 0.076 | 1.5 | 0.062 | 2.4 | 0.0050 | 0.25 |
| Skewness | 0.16 | -0.078 | -0.21 | 1.3 | 0.056 | 0.58 | 0.83 |
| Minimum (pCi/g) | -0.12 | 0.81 | -4.2 | -0.023 | -4.2 | -0.0020 | -0.22 |
| Maximum (pCi/g) | 0.15 | 1.1 | 2.3 | 0.23 | 7.0 | 0.016 | 0.86 |
| Count | 30 | 30 | 30 | 30 | 30 | 30 | 30 |

## 5.3 Survey Unit Data Evaluation

Final Status Survey soils data from all twelve SUs were evaluated using the WRS test. In addition, the EMC was performed as described in Section 5.3.3 against each systematic and biased sample result to ensure that it did not exceed the investigation levels of Section 1.3.4.

### *5.3.1 Statistical Test*

The off-site laboratory analysis results for the random-start, systematic surface soil samples were evaluated using the WRS Test recommended by MARSSIM. The WRS test is performed for ROCs that are present in background to evaluate the SU median concentration relative to the null hypothesis ($H_0$). $H_0$ assumes the residual contamination in the SU exceeds the release criterion, and the WRS test either accepts (i.e., the SU "fails") or rejects (i.e., the SU "passes") the $H_0$. If $H_0$ is rejected, the alternate hypothesis ($H_a$) that residual contamination meets the release criterion is accepted.

### *5.3.2 WRS Test*

For the WRS test, Survey Unit and background reference area soil sample results collected from the random-start/systematic locations were converted using the SOR process described in Section 1.3 of the approved FSP. The soil evaluation criterion ($DCGL_W$) in this case becomes 1.0. The reference area SOR values will then be adjusted by addition of the evaluation criterion ($DCGL_W$ of 1.0) to the unity value. The results for both the reference and sample SOR data sets are then ranked as follows:

- Rank all SU and reference area SOR values in order of increasing size from one to N, where N is the total number of pooled measurements.
- If several measurements have the same SOR value, assign them the average ranking of the group of tied measurements.
- Sum the ranks to the adjusted reference area SOR values; this value is the WRS test statistic ($W_R$).
- Compare the value of $W_R$ to the critical value in MARSSIM Table I.4 for the appropriate sample size and decision level.

If $W_R$ is less than or equal to the critical value, the $H_0$ is not rejected, and the SU does not meet the established criteria. If $W_R$ is greater than or equal to the critical value, the $H_0$ is rejected, and the SU meets the established criteria.

For all twelve RW-06 SUs, $W_R$ is greater than the critical value and meets the established criterion for median residual activity remaining in the SUs. The results of the WRS Tests are summarized in Table 6-1 and contained in Appendix B.

### *5.3.3 Elevated Measurement Comparison Criterion*

The statistical test described above evaluates whether or not the median residual radioactivity in an area exceeds the $DCGL_W$ for contamination conditions that are approximately uniform across the survey unit. Survey units can have individual measurement results that are above the $DCGL_W$ for specific ROCs and still have median residual activity that meets the release criteria.

In addition to the tests for median residual activity in a survey unit, there should be a reasonable level of assurance that any small areas of elevated residual radioactivity that could be significant relative to the release criteria are not missed during the final status survey. The EMC has been applied to both the systematic and biased samples collected to investigate scan data in order to provide this additional assurance.

A $DCGL_{EMC}$ was not calculated *a priori* for this project and the calculated scan MDCs exceeded the ROC $DCGL_W$s (as described in Section 6.1 of the approved FSP). Plutonium was added to the list of ROCs and does not have an approved surrogate relationship upon which to base a scan MDC. The scan MDC issue was accounted for in the approved FSP by an increased number of samples and Class 1 survey unit classification (providing higher sample density and smaller potential areas of elevated activity that could exceed the $DCGL_W$s). The project DQOs used $\alpha$=0.05 and $\beta$=0.05, and the relative shift of 3.0, to calculate the required number of systematic samples per SU as 10 from MARSSIM Table 5.3. On this basis, 10 samples per SU are statistically sufficient to support a decision. However, due to potential scan MDC limitations and to provide additional data at the site, a sample density of 15 samples was applied to each SU.

A decision rule was developed to implement the EMC for project sample results: If systematic sample results were higher than a nuclide specific $DCGL_W$, but passed the WRS test or biased sample results collected in response to elevated scan data had an SOR> 1.0, then specific dose area factors (AF) were calculated to assist comparison to the project release criteria with the elevated area activity concentration.

Dose area factors are necessary to calculate the $DCGL_{EMC}$, which is used to compare with the area of elevated activity in a survey unit. MARSSIM recommends *a posteriori* methods to calculate $DCGL_{EMC}$ values specific to elevated activity areas found during the survey process. The *a posteriori* $DCGL_{EMC}$ is calculated from MARSSIM Section 8.5.1, Equation 8-1 as

$$DCGL_{EMC} = AF \times DCGL_{W},$$

where AF is the dose area factor for the elevated activity area of the systematic grid. MARSSIM states that the AF is used to evaluate the magnitude by which the concentration within a small area of elevated activity can exceed the evaluation criteria ($DCGL_W$) while maintaining compliance with the overall release criterion. The areas of elevated activity have been estimated for SUs where necessary, compared to the calculated area specific $DCGL_{EMC}$, and reported in the result section for each SU (i.e., FSS SU02, FSS SU11, SO SU01, and SO SU04 in Section 5.4).

Dose area factors have been calculated for $^{239}$Pu, $^{137}$Cs, and $^{14}$C and are presented in Table 5.4 to assist the EMC for survey units. RESRAD version 6.5 with parameters set to default was used to calculate dose from a uniform contamination of one pCi/g in soil. The default value for area (i.e., 10,000 m$^2$) was substituted over the area range shown in Table 5-4. The resulting dose at each substituted area was ratioed with the dose from the 10,000 m$^2$ default dose value to provide an AF.

By the equation above, the $DCGL_{EMC}$ would be calculated by multiplying the $DCGL_W$ for the respective ROC by the AF that matched the estimated area of elevated activity for that SU. If the estimated area of elevated activity for a specific SU did not match one of the AFs in the table, then the specific estimated area was used to calculate an AF for use with the elevated measurement comparison. The AFs calculated in Table 5-4 demonstrate the range of allowed soil residual activity concentration that provides the same dose to individuals when distributed over a small area (elevated area) versus a large area.

Table 5-4: Dose Area Factors

| Nuclide | Area Factor | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 m$^2$ | 3 m$^2$ | 10 m$^2$ | 30 m$^2$ | 100 m$^2$ | 300 m$^2$ | 1000 m$^2$ | 3000 m$^2$ | 10,000 m$^2$ |
| $^{239/240}$Pu | 41.0 | 34.2 | 25.3 | 16.2 | 7.6 | 3.1 | 1.0 | 1.0 | 1.0 |
| $^{137}$Cs | 11 | 5.0 | 2.4 | 1.7 | 1.4 | 1.3 | 1.1 | 1.1 | 1.0 |
| $^{14}$C | 4E3 | 1.3E3 | 400 | 135 | 40 | 13.2 | 3.6 | 2.1 | 1.0 |

Bias soil samples collected as part of the investigation of small areas of elevated activity located during scan surveys were evaluated with the SOR value of 1.0 as part of the EMC. A summary of all biased sample SOR evaluations is presented in Table 5-5. The SOR values for all biased sample results was <1.0, except sample RW6-FSS-SU11-016 in SU11. The reason this sample failed the SORs criterion was that $^{137}$Cs was reported at 15.7 pCi/g. The area was bias sampled due to a maximum scan survey z-score of 8.0 (i.e., approximately 8 standard deviations above the mean). Further investigation for the elevated activity in the area of RW6-FSS-SU11-016 is evaluated in Section 5.4.8.

Sample RW6-FSS-SU11-006* was mis-positioned in the original sample collection effort. The asterisk denotes the label for this specific sample in order to differentiate the results from the correctly located sample RW6-FSS-SU11-006. This original sample labeled with the asterisk was actually physically located in SU02 and analyzed for all project ROCs except $^{239}$Pu. The cause of this mis-positioned sample location is not known. The analytical results for the incorrectly positioned sample are treated as a biased result and reported here for completeness. The correct sample location for RW6-FSS-SU11-006 was later sampled, analyzed for all ROCs including $^{239}$Pu, and evaluated as a systematic sample for SU11.

Table 5-5: Biased Sample SOR Summary

| Sample ID | ROC DCGL$_W$ Fraction[1] | | | | | | | SOR |
|---|---|---|---|---|---|---|---|---|
| | $^{241}$Am | $^{226}$Ra($^{214}$Bi) | $^{14}$C | $^{137}$Cs | $^{3}$H | $^{239}$Pu | $^{90}$Sr | |
| RW6-FSS-SU02-016 | 0.000 | 0.135 | 0.000 | 0.000 | 0.001 | 0.002 | 0.000 | 0.138 |
| RW6-FSS-SU02-017 | 0.000 | 0.045 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.045 |
| RW6-FSS-SU02-018 | 0.000 | 0.421 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.421 |
| RW6-FSS-SU08-016 | 0.000 | 0.392 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.394 |
| RW6-FSS-SU08-017 | 0.000 | 0.478 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.478 |
| RW6-FSS-SU09-016 | 0.005 | 0.000 | 0.000 | 0.000 | 0.028 | 0.005 | 0.000 | 0.038 |
| RW6-FSS-SU09-017 | 0.000 | 0.063 | 0.000 | 0.000 | 0.027 | 0.000 | 0.023 | 0.113 |
| RW6-FSS-SU10-016 | 0.019 | 0.163 | 0.000 | 0.027 | 0.000 | 0.000 | 0.000 | 0.209 |
| RW6-FSS-SU10-017 | 0.001 | 0.563 | 0.000 | 0.022 | 0.031 | 0.001 | 0.000 | 0.618 |
| RW6-FSS-SU10-018 | 0.017 | 0.378 | 0.000 | 0.014 | 0.008 | 0.000 | 0.000 | 0.417 |
| RW6-FSS-SU10-019 | 0.000 | 0.363 | 0.000 | 0.016 | 0.036 | 0.004 | 0.000 | 0.419 |
| RW6-FSS-SU11-016 | 0.000 | 0.149 | 0.000 | 1.420 | 0.027 | 0.016 | 0.000 | 1.612 |
| RW6-SO-SU01-016 | 0.002 | 0.000 | 0.000 | 0.009 | 0.000 | 0.010 | 0.000 | 0.021 |
| RW6-SO-SU01-017 | 0.015 | 0.038 | 0.000 | 0.000 | 0.009 | 0.001 | 0.000 | 0.062 |
| RW6-SO-SU01-018 | 0.011 | 0.149 | 0.000 | 0.002 | 0.002 | 0.153 | 0.000 | 0.317 |
| RW6-SO-SU01-019 | 0.000 | 0.292 | 0.000 | 0.048 | 0.005 | 0.062 | 0.000 | 0.407 |
| RW6-SO-SU01-020 | 0.057 | 0.378 | 0.000 | 0.004 | 0.044 | 0.004 | 0.000 | 0.486 |
| RW6-SO-SU01-021 | 0.000 | 0.000 | 0.000 | 0.007 | 0.058 | 0.035 | 0.000 | 0.100 |
| RW6-SO-SU02-016 | 0.000 | 0.278 | 0.000 | 0.000 | 0.011 | 0.000 | 0.000 | 0.288 |
| RW6-SO-SU02-017 | 0.035 | 0.106 | 0.000 | 0.008 | 0.007 | 0.000 | 0.000 | 0.156 |
| RW6-SO-SU02-018 | 0.000 | 0.449 | 0.000 | 0.000 | 0.000 | 0.000 | 0.136 | 0.586 |
| RW6-SO-SU03-016 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.006 | 0.006 |
| RW6-SO-SU03-017 | 0.000 | 0.178 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.178 |
| RW6-SO-SU04-016 | 0.021 | 0.092 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.114 |
| RW6-SO-SU04-017 | 0.000 | 0.042 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.042 |
| RW6-FSS-SU11-006* | 0.042 | 0.000 | 0.000 | 0.000 | 0.022 | -- | 0.000 | 0.064 |

[1] If individual RCOPC results were negative, these values were truncated to zero prior to calculation of SOR to avoid negative biasing.

*Original Sample was mis-located within SU02. Results treated as Biased Sample. This sample was not analyzed for $^{239}$Pu.

## 5.4 Survey Unit FSS Results

Systematic and biased sample analytical results and statistical testing along with scan data results are summarized for each SU in the text, figures, and tables below. Since there are seven ROCs analyzed for each sample location, summary statistics for the systematic measurement results for each ROC and individual results of interest are presented in each SU section. Complete laboratory reports and electronic data tables for all analytical data for each sample location, and EDA (i.e., cumulative frequency distributions, and histograms) performed on the results are provided in Appendix B. Individual figures that contain scan data results and show the systematic and biased sample locations for each SU are contained in Appendix A. A summary of the systematic sample WRS test and biased sample SOR evaluation results by SU is presented in Table ***6-1.***

### *5.4.1 Final Status Survey Unit 2*

Scan data results and the locations for the 15 systematic and three biased soil sample locations within FSS SU02 are shown on Figure 5-1 in Appendix A. Figure 5-1 shows the scan data before and after additional excavation and soil removal in the Southeast corner of the survey unit (part of original trench 1). This survey unit combines trenches one through four that were so close together that they became one shallow trench when excavated.

Summary statistics for the systematic sample results (uncorrected for reference area background) are presented in Table 5-6. The WRS test for all ROCs passed the release criterion. Sample analysis results for the three biased samples selected for investigation based on elevated gamma scan activity (RW06-FSS-SU02-016, RW06-FSS-SU02-017, RW06-FSS-SU02-018) passed the criterion of SOR <1.0, and additional investigation of these locations was not performed.

Although SU02 passed the WRS test, three systematic $^{239}$Pu values (RW6-FSS-SU02-012 [4.16 pCi/g], RW6-FSS-SU02-014 [2.83 pCi/g], RW6-FSS-SU02-015 [4.70 pCi/g]) exceeded the $DCGL_W$ (2.3 pCi/g) and skewed the data distribution for this ROC. The area of elevated activity represented by these data points was investigated by elevated measurement comparison as described in Section 5.3.3.

The three data point locations are within close proximity of each other as can be seen in Figure 5-1 in Appendix A. The survey unit area is approximately 443 m$^2$ and the samples are approximately 5.1 meters apart. The grid area bounded by a single sample location is approximately 23 m$^2$ estimated using MARSSIM Section 5.5.2.4, $A = 0.866 \times L^2$, for a triangular grid. The total elevated activity area is very conservatively estimated as 207 m$^2$ when using the proximity of the three sample points and including the nearest neighbor grids (for a total of 9 grids). The SU02 specific AF for an elevated area of 207m$^2$ is 4.3 when calculated with RESRAD version 6.5 for $^{239}$Pu. Area factors listed in Table 5-4 also corroborate this value. The $DCGL_{EMC}$ for this elevated area is 9.9 pCi/g ($DCGL_{EMC}$= AF x $DCGL_W$). The Survey unit passes the elevated measurement comparison even considering the highest reported $^{239}$Pu activity as uniform throughout the elevated area.

As an additional measure to investigate these elevated systematic sample results, Section 8.5.2 and Equation 8-2 of MARSSIM were applied to review the potential combined residual activity in the entire survey unit and the area of elevated activity to ensure the total dose is less than the release criteria. The unity rule (Equation 8-2) for combining the total dose from the survey unit and elevated area described above is:

$\delta/DCGL_W$ +[(*average concentration in elevated area* - δ)/(*area factor for elevated area*)($DCGL_W$)]< 1,

where δ is the average residual activity in the survey unit. Using the average SOR value for the survey unit to include all ROCs, the $DCGL_W$ for the entire survey unit as the SOR of 1.0, the average activity for the three elevated $^{239}$Pu sample results as the average concentration in the elevated area, and using the $DCGL_{EMC}$ calculated above, the result is found by the following calculation:

$$0.142/1.0 + [(3.9\ \text{pCi/g})/(9.9\ \text{pCi/g})]= 0.54 < 1.0.$$

The second δ term in equation 8-2 (average residual activity in the entire survey unit) is not subtracted from the average $^{239}$Pu concentration in the elevated area. The reason for this is that the survey unit average SORs calculation includes all residual activity for all ROCs in the entire survey unit, except the three $^{239}$Pu values. The second term in the equation adds the potential dose from the average $^{239}$Pu activity in the area of elevated activity to the potential dose from the entire survey unit (i.e., the first term in the equation) by calculating the ratio of the $^{239}$Pu residual activity from the biased sample to the $DCGL_{EMC}$. Implementation of the unity rule shows that the total potential dose for the SU02, including the residual activity in the elevated area, meets the project release criteria.

Table 5-6: SU02 FSS Systematic Sample Summary Statistics by ROC

| **RW06-FSS-SU02** | **Radionuclide of Concern** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Statistic** | **$^{241}$Am** | **$^{226}$Ra($^{214}$Bi)** | **$^{14}$C** | **$^{137}$Cs** | **$^{3}$H** | **$^{239}$Pu** | **$^{90}$Sr** |
| ***Mean (pCi/g)*** | 0.07 | 0.84 | 0.19 | 0.00 | 3.87 | 0.79 | -0.04 |
| ***Median (pCi/g)*** | 0.09 | 0.84 | -0.59 | 0.00 | 3.78 | 0.01 | -0.02 |
| ***Standard Deviation (pCi/g)*** | 0.10 | 0.07 | 1.79 | 0.02 | 2.39 | 1.65 | 0.10 |
| ***Skewness*** | 0.33 | 0.09 | 1.41 | 0.67 | 0.01 | 1.86 | -0.41 |
| ***Minimum (pCi/g)*** | -0.09 | 0.72 | -1.61 | -0.02 | 0.30 | 0.00 | -0.27 |
| ***Maximum (pCi/g)*** | 0.31 | 0.95 | 4.55 | 0.04 | 8.22 | 4.70 | 0.12 |

Three soil samples were collected and analyzed for VOCs, SVOCs, and metals contamination. Results indicated that there were not any VOCs or SVOCs that exceeded the NMED residential SSLs or EPA residential regional screening levels (RSL). Two of the three samples (RW6-FSS-SU02-002 [4.8 mg/kg] and RW6-FSS-SU02-002 [4.7 mg/kg]) had arsenic concentrations in excess of the NMED residential SSL of 3.9 mg/kg, and all samples exceeded the EPA residential RSL of 0.39 mg/kg.

### *5.4.2 Final Status Survey Unit 5*

Scan data results and the locations for the 15 systematic soil sample locations within FSS SU05 are shown on Figure 5-2 in Appendix A. Summary statistics for the systematic sample results (uncorrected for reference area background) are presented in Table 5-7. All systematic sample analytical results for the ROCs showed residual activity below the project $DCGL_W$s. The WRS test for all ROCs passed the release criterion.

The depth and irregular slope of the trench walls for SU05 required physical measurements of surface and depth dimensions to be used to manually record the range of FSS scan data (gross gamma counts) in 10 ft square grids onto trench log sheets and to position sample locations.

Table 5-7: SU05 FSS Systematic Sample Summary Statistics by ROC

| RW06-FSS-SU05 | Radionuclide of Concern | | | | | | |
|---|---|---|---|---|---|---|---|
| **Statistic** | **$^{241}$Am** | **$^{226}$Ra($^{214}$Bi)** | **$^{14}$C** | **$^{137}$Cs** | **$^{3}$H** | **$^{239}$Pu** | **$^{90}$Sr** |
| ***Mean (pCi/g)*** | -0.05 | 0.82 | -4.53 | -0.01 | 4.06 | 0.01 | -0.51 |
| ***Median (pCi/g)*** | -0.06 | 0.81 | -4.45 | -0.01 | 4.33 | 0.00 | -0.38 |
| ***Standard Deviation (pCi/g)*** | 0.12 | 0.13 | 0.93 | 0.03 | 1.72 | 0.02 | 0.62 |
| ***Skewness*** | -0.38 | 1.19 | 0.26 | 0.97 | -0.07 | 3.81 | -0.94 |
| ***Minimum (pCi/g)*** | -0.29 | 0.66 | -6.01 | -0.04 | 1.28 | 0.00 | -1.73 |
| ***Maximum (pCi/g)*** | 0.13 | 1.13 | -2.96 | 0.06 | 6.89 | 0.09 | 0.23 |

Three soil samples were collected and analyzed for VOCs, SVOCs, and metals contamination. Results indicated that there were not any VOCs or SVOCs that exceeded the NMED residential SSLs or EPA residential RSLs. One sample (RW6-FSS-SU05-007 [4.8 mg/kg]) had an arsenic concentration in excess of the NMED residential SSL of 3.9 mg/kg and all samples exceeded the EPA residential RSL of 0.39 mg/kg. One FSS sample, RW6-FSS-SU05-001, had a result for bis (2-ethylhexyl) phthalate (BEHP) of 71,000µg/kg, exceeding the EPA residential RSL of 35,000µg/kg, but well below the NMED residential soil screening level of 347 mg/kg. BEHP is a plasticizer that is commonly found as a laboratory contaminant.

### 5.4.3 Final Status Survey Unit 6

Scan data results and the locations for the 15 systematic soil sample locations within FSS SU06 are shown on Figure 5-3 in Appendix A. Summary statistics for the systematic sample results (uncorrected for reference area background) are presented in Table 5-8. All systematic sample analytical results for the ROCs showed residual activity below the project $DCGL_W$s. The WRS test for all ROCs passed the release criterion.

The depth and irregular slope of the trench walls for SU06 required physical measurements of surface and depth dimensions to be used to manually record the range of FSS scan data (gross gamma counts) in 10 ft square grids onto trench log sheets and to position sample locations.

Table 5-8: SU06 FSS Systematic Sample Summary Statistics by ROC

| RW06-FSS-SU06 | Radionuclide of Concern | | | | | | |
|---|---|---|---|---|---|---|---|
| **Statistic** | **$^{241}$Am** | **$^{226}$Ra($^{214}$Bi)** | **$^{14}$C** | **$^{137}$Cs** | **$^{3}$H** | **$^{239}$Pu** | **$^{90}$Sr** |
| ***Mean (pCi/g)*** | -0.01 | 0.86 | 0.78 | 0.00 | 0.45 | 0.00 | -0.72 |
| ***Median (pCi/g)*** | 0.01 | 0.86 | 0.18 | -0.01 | 0.55 | 0.00 | -0.48 |
| ***Standard Deviation (pCi/g)*** | 0.12 | 0.08 | 1.53 | 0.02 | 1.98 | 0.01 | 0.81 |
| ***Skewness*** | 0.19 | -0.04 | 2.51 | 0.31 | 0.84 | 3.42 | -2.03 |
| ***Minimum (pCi/g)*** | -0.17 | 0.70 | -0.44 | -0.04 | -2.19 | 0.00 | -3.13 |
| ***Maximum (pCi/g)*** | 0.18 | 1.00 | 5.56 | 0.03 | 4.63 | 0.02 | 0.06 |

Three soil samples were collected and analyzed for VOCs, SVOCs, and metals contamination. Results indicated that there were not any VOCs or SVOCs that exceeded the NMED residential SSLs or EPA residential RSLs. One sample (RW6-FSS-SU06-014 [5.5 mg/kg]) had arsenic concentration in excess of the NMED residential SSL of 3.9 mg/kg, and all samples exceeded the EPA residential RSL.

### 5.4.4 Final Status Survey Unit 7

Scan data results and the locations for the 15 systematic soil sample locations within FSS SU06 are shown on Figure 5-4 in Appendix A. Summary statistics for the systematic sample results (uncorrected for reference area background) are presented in Table 5-9. All analytical results for the ROCs showed residual activity below the project $DCGL_W$s. The WRS test for all ROCs passed the release criterion.

The depth and irregular slope of the trench walls for SU07 required physical measurements of surface and depth dimensions to be used to manually record the range of FSS scan data (gross gamma counts) in 10 ft square grids onto trench log sheets and to position sample locations.

Table 5-9: SU07 FSS Systematic Sample Summary Statistics by ROC

| RW06-FSS-SU07 | Radionuclide of Concern | | | | | | |
|---|---|---|---|---|---|---|---|
| **Statistic** | **$^{241}$Am** | **$^{226}$Ra($^{214}$Bi)** | **$^{14}$C** | **$^{137}$Cs** | **$^{3}$H** | **$^{239}$Pu** | **$^{90}$Sr** |
| ***Mean (pCi/g)*** | -0.01 | 0.85 | -0.43 | 0.01 | 4.45 | 0.00 | 0.03 |
| ***Median (pCi/g)*** | 0.02 | 0.91 | -0.79 | 0.01 | 4.27 | 0.00 | 0.00 |
| ***Standard Deviation (pCi/g)*** | 0.10 | 0.15 | 1.06 | 0.02 | 1.96 | 0.00 | 0.08 |
| ***Skewness*** | -0.84 | -0.56 | 1.69 | 0.17 | 0.60 | 1.14 | 2.53 |
| ***Minimum (pCi/g)*** | -0.20 | 0.56 | -1.35 | -0.03 | 1.28 | 0.00 | 0.00 |
| ***Maximum (pCi/g)*** | 0.13 | 1.08 | 2.23 | 0.05 | 8.97 | 0.01 | 0.26 |

Three soil samples were collected and analyzed for VOCs, SVOCs, and metals contamination. Results indicated that there were not any VOCs or SVOCs that exceeded the NMED residential SSLs or EPA residential RSLs. All samples were below the NMED arsenic residential SSL of 3.9 mg/kg and exceeded the EPA residential RSL of 0.39 mg/kg.

### 5.4.5 Final Status Survey Unit 8

Scan data results and the locations for the 15 systematic and two biased soil sample locations within FSS SU08 are shown on Figure 5-5 in Appendix A. Summary statistics for the systematic sample results (uncorrected for reference area background) are presented in Table 5-10. The WRS test for all ROCs passed the release criterion. Sample analysis results for the two biased samples selected for investigation based on elevated gamma scan activity (RW06-FSS-SU08-016, RW06-FSS-SU08-017) passed the criterion of SOR <1.0, and additional investigations were not performed.

Although SU08 passed the WRS test, systematic sample RW6-FSS-SU08-003 (15.2 pCi/g) exceeded the project $^{14}$C $DCGL_W$ (11.6 pCi/g) and was reanalyzed to investigate the higher than expected activity concentration that did not appear representative of the survey unit. The reanalyzed value was at or near background, but the original value was used for statistical testing of the survey unit. The area of elevated activity represented by this data point was investigated by elevated measurement comparison as described in Section 5.3.3.

The survey unit area is approximately 1300 $m^2$ and the samples are approximately 10 meters apart. The grid area bounded by a single sample location is approximately 87 $m^2$, estimated using MARSSIM Section 5.5.2.4, $A = 0.866 \times L^2$ for a triangular grid. The total elevated activity area is conservatively estimated as an entire triangular grid area bounding this sample

(87 $m^2$). The SU08 specific AF for an elevated area of 87$m^2$ calculated with RESRAD version 6.5 for $^{14}C$ is 46.3. Area factors listed in Table 5-4 also corroborate this value. The $DCGL_{EMC}$ for this elevated area is 537 pCi/g ($DCGL_{EMC}$= AF x $DCGL_W$). The Survey unit passes the elevated measurement comparison, even considering the highest reported $^{14}C$ activity as uniform throughout the elevated area. Further investigation is not necessary for this survey unit.

Table 5-10: SU08 FSS Systematic Sample Summary Statistics by ROC

| **RW06-FSS-SU08** | **Radionuclide of Concern** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Statistic** | **$^{241}$Am** | **$^{226}$Ra($^{214}$Bi)** | **$^{14}$C** | **$^{137}$Cs** | **$^{3}$H** | **$^{239}$Pu** | **$^{90}$Sr** |
| ***Mean (pCi/g)*** | -0.02 | 0.87 | -0.56 | -0.01 | -0.36 | 0.00 | -0.04 |
| ***Median (pCi/g)*** | -0.01 | 0.87 | -1.80 | -0.01 | -1.22 | 0.00 | -0.09 |
| ***Standard Deviation (pCi/g)*** | 0.09 | 0.13 | 4.39 | 0.01 | 1.92 | 0.01 | 0.34 |
| ***Skewness*** | 0.04 | -0.21 | 3.80 | -0.31 | 0.22 | 1.23 | 1.11 |
| ***Minimum (pCi/g)*** | -0.16 | 0.65 | -2.36 | -0.03 | -3.48 | -0.01 | -0.48 |
| ***Maximum (pCi/g)*** | 0.13 | 1.1 | 15.2 | 0.048 | 2.69 | 0.0 | 0.26 |

Three soil samples were collected and analyzed for VOCs, SVOCs, and metals contamination. Results indicated that there were not any VOCs or SVOCs that exceeded the NMED residential SSLs or EPA residential RSLs. All three samples (RW6-FSS-SU08-002 [5.0 mg/kg], RW6-FSS-SU08-005 [4.0 mg/kg], and RW6-FSS-SU08-010 [5.4 mg/kg]) had arsenic concentrations in excess of the NMED residential SSL of 3.9 mg/kg; all samples exceeded the EPA residential RSL of 0.39 mg/kg.

### *5.4.6 Final Status Survey Unit 9*

Scan data results and the locations for the 15 systematic and two biased locations/soil sample locations within FSS SU09 are shown on Figures 5-6 and 5-6(2) in Appendix A. Summary statistics for the systematic sample results (uncorrected for reference area background) are presented in Table 5-11. All systematic sample analytical results for the ROCs showed residual activity below the project $DCGL_W$s. The WRS test for all ROCs passed the release criterion. Two samples were collected in a side excavation of the main trench 9 that was made to investigate visual indications of discolored soil during excavation. No debris was found in the side trench. The two samples were treated as biased samples. Sample analysis results for the two biased samples (RW06-FSS-SU09-016, RW06-FSS-SU09-017) passed the criterion of SOR <1.0; additional investigation of these locations was not performed. The scan and sample location information for this side trench is shown in Figure 5-6 (2) in Appendix A.

The depth and irregular slope of the trench walls for SU09 required that physical measurements of surface and depth dimensions needed to be used to manually record the range of FSS scan data (gross gamma counts) in 10 ft square grids onto trench log sheets and to position sample locations.

Table 5-11: SU09 FSS Systematic Sample Summary Statistics by ROC

| RW06-FSS-SU09 | Radionuclide of Concern | | | | | | |
|---|---|---|---|---|---|---|---|
| **Statistic** | $^{241}$Am | $^{226}$Ra($^{214}$Bi) | $^{14}$C | $^{137}$Cs | $^{3}$H | $^{239}$Pu | $^{90}$Sr |
| ***Mean (pCi/g)*** | -0.01 | 0.83 | -0.23 | -0.01 | 3.74 | 0.00 | 0.07 |
| ***Median (pCi/g)*** | -0.04 | 0.85 | -0.88 | -0.01 | 3.64 | 0.00 | 0.03 |
| ***Standard Deviation (pCi/g)*** | 0.10 | 0.11 | 1.55 | 0.03 | 2.40 | 0.00 | 0.53 |
| ***Skewness*** | 0.31 | -0.38 | 2.18 | 2.08 | -0.79 | 1.20 | 1.65 |
| ***Minimum (pCi/g)*** | -0.16 | 0.62 | -1.22 | -0.04 | -2.23 | 0.00 | -0.71 |
| ***Maximum (pCi/g)*** | 0.18 | 0.96 | 3.91 | 0.07 | 7.29 | 0.01 | 1.61 |

Three soil samples were collected and analyzed for VOCs, SVOCs, and metals contamination. Results indicated that there were not any VOCs or SVOCs that exceeded the NMED residential SSLs or EPA residential RSLs. One sample (RW6-FSS-SU09-007 [4.4 mg/kg]) had an arsenic concentration in excess of the NMED residential SSL of 3.9 mg/kg; all samples exceeded the EPA residential RSL of 0.39 mg/kg.

### 5.4.7 Final Status Survey Unit 10

Scan data results and the locations for the 15 systematic and four biased soil sample locations within FSS SU10 are shown on Figure 5-7 in Appendix A. Summary statistics for the systematic sample results (uncorrected for reference area background) are presented in Table 5-12. All systematic and biased sample analytical results for the ROCs showed residual activity below the project $DCGL_W$s. The WRS test for all ROCs passed the release criterion. Sample analysis results for the four biased samples selected for investigation based on elevated gamma scan activity (RW06-FSS-SU10-016, RW06-FSS-SU10-017, RW06-FSS-SU10-018, RW06-FSS-SU10-019) passed the criterion of SOR <1.0; additional investigation of these locations was not performed.

Table 5-12: SU10 FSS Systematic Sample Summary Statistics by ROC

| RW06-FSS-SU10 | Radionuclide of Concern | | | | | | |
|---|---|---|---|---|---|---|---|
| **Statistic** | $^{241}$Am | $^{226}$Ra($^{214}$Bi) | $^{14}$C | $^{137}$Cs | $^{3}$H | $^{239}$Pu | $^{90}$Sr |
| ***Mean (pCi/g)*** | -0.02 | 0.94 | 0.17 | 0.62 | 4.28 | 0.02 | -0.02 |
| ***Median (pCi/g)*** | -0.02 | 0.96 | 0.04 | 0.41 | 4.21 | 0.01 | -0.03 |
| ***Standard Deviation (pCi/g)*** | 0.14 | 0.11 | 0.33 | 0.77 | 2.92 | 0.03 | 0.27 |
| ***Skewness*** | 0.32 | -0.01 | 0.49 | 2.16 | 0.63 | 3.08 | 0.72 |
| ***Minimum (pCi/g)*** | -0.26 | 0.77 | -0.25 | -0.01 | -0.37 | 0.00 | -0.35 |
| ***Maximum (pCi/g)*** | 0.24 | 1.09 | 0.85 | 2.78 | 11.50 | 0.13 | 0.60 |

Three soil samples were collected and analyzed for VOCs, SVOCs, and metals contamination. Results indicated that there were not any VOCs or SVOCs that exceeded the NMED residential SSLs or EPA residential RSLs. All samples were below the NMED arsenic residential SSL of 3.9 mg/kg and exceeded the EPA residential RSL of 0.39 mg/kg.

### 5.4.8 Final Status Survey Unit 11

Scan data results and the locations for the 15 systematic and one biased soil sample locations within FSS SU11 are shown on Figure 5-8 in Appendix A. Summary statistics for the systematic sample results (uncorrected for reference area background) are presented in Table 5-13. All systematic sample analytical results for the ROCs showed residual activity below the project $DCGL_W$s. The WRS test for all ROCs passed the release criterion. One systematic sample (RW6-FSS-SU11-006 [2.14 pCi/g]) was near, but did not exceed, the $^{239}$Pu $DCGL_W$ of 2.3 pCi/g. This sample was located near the boundary of FSS SU11 and FSS-SU02 (near where the small container characterized with $^{241}$Am and $^{239}$Pu was found and segregated).

The SOR result for the biased sample (RW6-FSS-SU11-016), selected for investigation based on elevated gamma scan activity, was >1.0 and was further investigated. The area was bias sampled due to a cluster of elevated z-scores with a maximum scan survey z-score of 8.0 (i.e., approximately 8 standard deviations above the mean). The reason this sample failed the SORs criterion was that $^{137}$Cs was reported at 15.7 pCi/g ($DCGL_W$ of 11.0 pCi/g). The area of elevated activity represented by this data point was investigated by elevated measurement comparison as described in Section 5.3.3.

The survey unit area is approximately 8445 m$^2$ and the samples are approximately 25 meters apart. The grid area bounded by a single sample location is approximately 550 m$^2$ estimated using MARSSIM Section 5.5.2.4, $A = 0.866 \times L^2$ for a triangular grid. The total elevated activity area bounding this sample (RW6-FSS-SU11-016) is conservatively estimated by review of the gross gamma z-scores as approximately 20 m$^2$. The SU11 specific AF for an elevated area of 20m$^2$ calculated with RESRAD version 6.5 for $^{137}$Cs is 1.9. Area factors listed in Table 5-4 also corroborate this value. The $DCGL_{EMC}$ for this elevated area is 20.8 pCi/g ($DCGL_{EMC}$= AF x $DCGL_W$). The Survey unit passes the elevated measurement comparison, even considering the highest reported $^{137}$Cs activity (15.7 pCi/g) as uniform throughout the elevated area.

As an additional measure to investigate this elevated biased sample result for $^{137}$Cs, Section 8.5.2 and Equation 8-2 of MARSSIM were applied to review the potential combined residual activity in the entire survey unit and the area of elevated activity to ensure the total dose is less than the release criteria. The unity rule (MARSSIM Equation 8-2) for combining the total dose from the survey unit and elevated area described above is

$\delta/DCGL_W + [(\textit{average concentration in elevated area} - \delta)/(\textit{area factor for elevated area})(DCGL_W)] < 1$,

where δ is the average residual activity in the survey unit. Using the average SOR value for the entire survey unit to include all ROCs, using the $DCGL_W$ for the entire survey unit as the SOR of 1.0, using the activity for the $^{137}$Cs biased sample result as the average concentration in the elevated area, and using the $DCGL_{EMC}$ calculated above, the result is found in the following equation:

$$0.153/1.0 + [(15.7\ \text{pCi/g})/(20.8\ \text{pCi/g})] = 0.91 < 1.0.$$

The second δ term in equation 8-2 (average residual activity in the survey unit) is not subtracted from the $^{137}$Cs concentration in the elevated area. The reason for this is the survey unit average SORs calculation includes all residual activity for all ROCs in the entire survey unit based on systematic sample results. The second term in the equation only adds the potential dose from the area of elevated activity to the potential dose from the entire survey unit by calculating the ratio of the $^{137}$Cs residual activity from the biased sample to the $DCGL_{EMC}$. Implementation of the unity rule shows the total potential dose for the SU11, including the residual activity in the elevated area, meets the project release criteria.

Table 5-13: SU11 FSS Systematic Sample Summary Statistics by ROC

| RW06-FSS-SU11 | Radionuclide of Concern | | | | | | |
|---|---|---|---|---|---|---|---|
| **Statistic** | $^{241}$Am | $^{226}$Ra($^{214}$Bi) | $^{14}$C | $^{137}$Cs | $^{3}$H | $^{239}$Pu | $^{90}$Sr |
| ***Mean (pCi/g)*** | -0.03 | 0.88 | -0.57 | 0.14 | 2.05 | 0.19 | -0.05 |
| ***Median (pCi/g)*** | 0.01 | 0.89 | -0.88 | 0.13 | 2.39 | 0.01 | 0.06 |
| ***Standard Deviation (pCi/g)*** | 0.10 | 0.11 | 1.24 | 0.12 | 1.92 | 0.55 | 0.28 |
| ***Skewness*** | -0.78 | 0.44 | 2.78 | 0.86 | -0.61 | 3.58 | -1.26 |
| ***Minimum (pCi/g)*** | -0.26 | 0.75 | -1.54 | 0.00 | -2.60 | 0.00 | -0.66 |
| ***Maximum (pCi/g)*** | 0.14 | 1.09 | 3.50 | 0.39 | 5.52 | 2.14 | 0.34 |

Three soil samples were collected and analyzed for VOCs, SVOCs, and metals contamination. Results indicated that there were not any VOCs or SVOCs that exceeded the NMED residential SSLs or EPA residential RSLs. All samples were below the NMED arsenic residential SSL of 3.9 mg/kg and exceeded the EPA arsenic residential RSL of 0.39 mg/kg.

### 5.4.9 Soil Overburden Survey Unit 1

Scan data results and the locations for the 15 systematic and six biased soil sample locations within SO SU01 are shown on Figure 5-9 in Appendix A. Summary statistics for the systematic sample results (uncorrected for reference area background) are presented in Table 5-14. The WRS test for all ROCs passed the release criterion. Sample analysis results for the six biased samples selected for investigation based on elevated gamma scan activity (RW06-SO-SU01-016, RW06-SO-SU01-017, RW06-SO-SU01-018, RW06-SO-SU01-019, RW06-SO-SU01-020, RW06-SO-SU01-021) passed the criterion of SOR <1.0; additional investigation of these locations was not performed.

Although SO SU01 passed the WRS test for all ROCs, one systematic $^{239}$Pu value (RW6-SO-SU01-003 [5.3 pCi/g]) exceeded the $DCGL_W$ (2.3 pCi/g) for this ROC. The soil in this survey unit was segregated from trenches one through four (FSS SU02), which contained the debris associated with the small container with $^{239}$Pu activity described in Section 1.3.1. The area of elevated activity represented by these data points was investigated by elevated measurement comparison as described in Section 5.3.3.

The survey unit area is approximately 2000 m$^2$ and the samples are approximately 13 meters apart. The grid area bounded by a single sample location is approximately 146 m$^2$, estimated using MARSSIM Section 5.5.2.4, $A = 0.866 \times L^2$ for a triangular grid. The total elevated activity area is conservatively estimated as an entire triangular grid area bounding this sample (146 m$^2$). The SU01 specific AF for an elevated area of 146 m$^2$, calculated with RESRAD version 6.5 for $^{239}$Pu, is 5.71. Area factors listed in Table 5-4 also corroborate this value. The $DCGL_{EMC}$ for this elevated area is 13.1 pCi/g ($DCGL_{EMC}$= AF x $DCGL_W$). The Survey unit passes the elevated measurement comparison even considering the highest reported $^{239}$Pu activity (5.3 pCi/g) as uniform throughout the elevated area.

As an additional measure to investigate this one elevated systematic sample result, Section 8.5.2 and Equation 8-2 of MARSSIM were applied to review the potential combined residual activity in the entire survey unit and the area of elevated activity to ensure the total dose is less than the release criteria. The unity rule (Equation 8-2) for combining the total dose from the survey unit and elevated area is

$$\delta/DCGL_W + [(\textit{average concentration in elevated area} - \delta)/(\textit{area factor for elevated area})(DCGL_W)] < 1$$

where δ is the average residual activity in the survey unit. Using the average SOR value for the survey unit to include all ROCs, the $DCGL_W$ for the entire survey unit as the SOR of 1.0, the activity for the $^{239}$Pu sample result as the average concentration in the elevated area, and the $DCGL_{EMC}$ calculated above, the result is found by the following equation:

$$0.164/1.0 + [(5.3 \text{ pCi/g})/(13.1 \text{ pCi/g})]= 0.57< 1.0.$$

The second δ term in equation 8-2 (average residual activity in the entire survey unit) is not subtracted from the average $^{239}$Pu concentration in the elevated area. The reason for this is that the survey unit average SORs calculation includes all residual activity for all ROCs in the entire survey unit except the $^{239}$Pu activity in the elevated area. The second term in the equation adds the potential dose from the average $^{239}$Pu activity in the area of elevated activity to the potential dose from the entire survey unit (i.e., the first term in the equation) by calculating the ratio of the $^{239}$Pu residual activity from the biased sample to the $DCGL_{EMC}$. Implementation of the unity rule shows the total potential dose for the SO SU01, including the residual activity in the elevated area, meets the project release criteria.

Table 5-14: SO SU01 Systematic Sample Summary Statistics by ROC

| **RW06-SO-SU01** | **Radionuclide of Concern** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Statistic** | **$^{241}$Am** | **$^{226}$Ra($^{214}$Bi)** | **$^{14}$C** | **$^{137}$Cs** | **$^{3}$H** | **$^{239}$Pu** | **$^{90}$Sr** |
| ***Mean (pCi/g)*** | -0.01 | 0.81 | -0.41 | 0.10 | 3.63 | 0.59 | -0.51 |
| ***Median (pCi/g)*** | -0.04 | 0.80 | -0.45 | 0.07 | 3.89 | 0.04 | -0.39 |
| ***Standard Deviation (pCi/g)*** | 0.11 | 0.08 | 0.36 | 0.12 | 1.35 | 1.39 | 0.58 |
| ***Skewness*** | 0.14 | 0.40 | 1.16 | 2.64 | -0.33 | 3.20 | -0.03 |
| ***Minimum (pCi/g)*** | -0.23 | 0.64 | -0.85 | 0.02 | 0.79 | 0.01 | -1.38 |
| ***Maximum (pCi/g)*** | 0.16 | 1.00 | 0.48 | 0.47 | 6.20 | 5.30 | 0.49 |

Three soil samples were collected and analyzed for VOCs, SVOCs, and metals contamination. Results indicated that there were not any VOCs or SVOCs that exceeded the NMED residential SSLs or EPA residential RSLs. Two of the three samples (RW6-SO-SU01-003 [4.9 mg/kg], and RW6-SO-SU01-003 [4.4 mg/kg]) had an arsenic concentration in excess of the NMED residential SSL of 3.9 mg/kg; all samples exceeded the EPA residential RSL of 0.39 mg/kg.

### *5.4.10 Soil Overburden Survey Unit 2*

Scan data results and the locations for the 15 systematic and three biased soil sample locations within SO SU02 are shown on Figure 5-9 in Appendix A. Summary statistics for the systematic sample results (uncorrected for reference area background) are presented in Table 5-15. All systematic and biased sample analytical results for the ROCs showed residual activity below the project $DCGL_W$s. The WRS test of the residual activity using the SORs for all ROCs passed the release criterion. Sample analysis results for the three biased samples (RW06-SO-SU02-016, RW06-SO-SU02-017, RW06-SO-SU02-018), selected for investigation based on elevated gamma scan activity, passed the criterion of SOR <1.0; additional investigation of these locations was not performed.

Table 5-15: SO SU02 Systematic Sample Summary Statistics by ROC

| **RW06-SO-SU02** | **Radionuclide of Concern** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Statistic** | **$^{241}$Am** | **$^{226}$Ra($^{214}$Bi)** | **$^{14}$C** | **$^{137}$Cs** | **$^{3}$H** | **$^{239}$Pu** | **$^{90}$Sr** |
| ***Mean (pCi/g)*** | -0.02 | 0.96 | -0.13 | 0.02 | 0.48 | 0.01 | -0.19 |
| ***Median (pCi/g)*** | -0.03 | 0.97 | -0.98 | 0.01 | 0.67 | 0.00 | -0.15 |
| ***Standard Deviation (pCi/g)*** | 0.12 | 0.10 | 1.60 | 0.02 | 2.21 | 0.01 | 0.55 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***Skewness*** | 0.22 | 0.00 | 0.81 | 0.85 | -0.32 | 2.80 | -1.44 |
| ***Minimum (pCi/g)*** | -0.20 | 0.80 | -1.66 | -0.01 | -3.35 | 0.00 | -1.74 |
| ***Maximum (pCi/g)*** | 0.18 | 1.13 | 2.59 | 0.05 | 4.32 | 0.04 | 0.59 |

Three soil samples were collected and analyzed for VOCs, SVOCs, and metals contamination. Results indicated that there were not any VOCs or SVOCs that exceeded the NMED residential SSLs or EPA residential RSLs. All three samples (RW6-SO-SU02-005 [4.2 mg/kg], RW6-SO-SU02-008 [5.9 mg/kg], and RW6-SO-SU02-013 [4.3 mg/kg]) had arsenic concentrations in excess of the NMED residential SSL of 3.9 mg/kg, and all samples exceeded the EPA residential RSL of 0.39 mg/kg.

### 5.4.11 Soil Overburden Survey Unit 3

Scan data results and the locations for the 15 systematic and two biased soil sample locations within SO SU03 are shown on Figure 5-10 in Appendix A. Summary statistics for the systematic sample results (uncorrected for reference area background) are presented in Table 5-16. All systematic and biased sample analytical results for the ROCs showed residual activity below the project $DCGL_W$s. The WRS test for all ROCs passed the release criterion. Sample analysis results for the two biased samples (RW06-SO-SU03-0016, RW06-SO-SU03-017), selected for investigation based on elevated gamma scan activity, passed the criterion of SOR <1.0; additional investigation of these locations was not performed.

Table 5-16: SO SU03 Systematic Sample Summary Statistics by ROC

| **RW06-SO-SU03** | **Radionuclide of Concern** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Statistic** | **$^{241}$Am** | **$^{226}$Ra($^{214}$Bi)** | **$^{14}$C** | **$^{137}$Cs** | **$^{3}$H** | **$^{239}$Pu** | **$^{90}$Sr** |
| ***Mean (pCi/g)*** | 0.00 | 0.86 | -0.49 | 0.01 | 1.43 | 0.00 | -0.06 |
| ***Median (pCi/g)*** | -0.01 | 0.87 | -1.01 | 0.00 | 1.40 | 0.00 | -0.11 |
| ***Standard Deviation (pCi/g)*** | 0.07 | 0.09 | 1.73 | 0.03 | 2.31 | 0.00 | 0.21 |
| ***Skewness*** | 0.13 | -0.20 | 2.10 | 1.31 | 0.64 | -0.23 | 2.30 |
| ***Minimum (pCi/g)*** | -0.11 | 0.71 | -1.95 | -0.02 | -2.01 | -0.01 | -0.32 |
| ***Maximum (pCi/g)*** | 0.11 | 1.01 | 4.44 | 0.08 | 6.95 | 0.01 | 0.60 |

Three soil samples were collected and analyzed for VOCs, SVOCs, and metals contamination. Results indicated that there were not any VOCs or SVOCs that exceeded the NMED residential SSLs or EPA residential regional screening levels (RSL). Two of the three samples (RW6-SO-SU03-008 [4.0 mg/kg], and RW6-SO-SU03-015 [4.1 mg/kg]) had an arsenic concentration in excess of the NMED residential SSL of 3.9 mg/kg, and all samples exceeded the EPA residential RSL of 0.39 mg/kg.

### 5.4.12 Soil Overburden Survey Unit 4

Scan data results and the locations for the 15 systematic and two biased soil sample locations within SO SU04 are shown on Figure 5-11 in Appendix A. Summary statistics for the systematic sample results (uncorrected for reference area background) are presented in Table 5-17. The WRS test for all ROCs passed the release criterion. Sample analysis results for the two biased samples (RW06-SO-SU04-016, RW06-SO-SU04-017), selected based on elevated gamma scan activity, passed the criterion of SOR <1.0, and additional investigation of these locations was not performed.

Although the SU passed the WRS test for residual activity concentration, systematic sample RW6-SO-SU04-0013 (12.4 pCi/g) exceeded the project $^{14}$C $DCGL_W$ (11.6 pCi/g) and was reanalyzed toinvestigate the higher than expected activity concentration that did not appear representative of the survey unit. The reanalyzed value was at or near background, but the original value was used for statistical testing of the survey unit. The area of elevated activity represented by these data points was investigated by elevated measurement comparison as described in Section 5.3.3.

The survey unit area is approximately 2000 $m^2$ and the samples are approximately 13 meters apart. The grid area bounded by a single sample location is approximately 146 $m^2$, estimated using MARSSIM Section 5.5.2.4, $A = 0.866 \times L^2$ for a triangular grid. The total elevated activity area is conservatively estimated as an entire triangular grid area bounding this sample (146 $m^2$). The SO SU04 specific AF for an elevated area of 146 $m^2$ calculated with RESRAD version 6.5 for $^{14}C$ is 27.5. Area factors listed in Table 5-4 also corroborate this value. The $DCGL_{EMC}$ for this elevated area is 319 pCi/g ($DCGL_{EMC}$= AF x $DCGL_W$). The Survey Unit passes the elevated measurement comparison, even considering the highest reported $^{14}C$ activity (12.4 pCi/g) as uniform throughout the elevated area. Further investigation of this area of elevated activity is not necessary.

Table 5-17: SO SU04 Systematic Sample Summary Statistics by ROC

| RW06-SO-SU04 | Radionuclide of Concern | | | | | | |
|---|---|---|---|---|---|---|---|
| **Statistic** | **$^{241}Am$** | **$^{226}Ra(^{214}Bi)$** | **$^{14}C$** | **$^{137}Cs$** | **$^{3}H$** | **$^{239}Pu$** | **$^{90}Sr$** |
| ***Mean (pCi/g)*** | -0.01 | 0.94 | 0.74 | 0.01 | 3.48 | 0.00 | -0.15 |
| ***Median (pCi/g)*** | 0.01 | 0.94 | -1.01 | 0.01 | 4.51 | 0.00 | -0.15 |
| ***Standard Deviation (pCi/g)*** | 0.12 | 0.09 | 4.07 | 0.01 | 2.11 | 0.00 | 0.27 |
| ***Skewness*** | -0.26 | 0.29 | 2.12 | 0.01 | -0.17 | 0.57 | 0.14 |
| ***Minimum (pCi/g)*** | -0.25 | 0.81 | -1.96 | -0.02 | 0.18 | 0.00 | -0.52 |
| ***Maximum (pCi/g)*** | 0.18 | 1.11 | 12.40 | 0.03 | 6.47 | 0.01 | 0.28 |

Three soil samples were collected and analyzed for VOCs, SVOCs, and metals contamination. Results indicated that there were not any VOCs or SVOCs that exceeded the NMED residential SSLs or EPA residential RSLs. One sample (RW6-SO-SU04-013 [4.0 mg/kg]) had an arsenic concentration in excess of the NMED residential SSL of 3.9 mg/kg, and all samples exceeded the EPA residential RSL of 0.39 mg/kg.

## 5.5 Packaged Waste Results

Waste segregated as contaminated during excavation was contained in 10 cubic yard flexible-sided waste containers separated either as soil or soil like material, and debris. Thirty-seven bags of waste (29 soil and 8 soil plus debris or about 333 cubic yards) were excavated in the initial October 2009 work evolution. An additional 15 bags of soil and plastic debris was collected in an additional waste soil excavation effort in January 2011 for a total of 52 bags with approximately 416 cubic yards of waste. The waste containers were additionally covered in heavy duty plastic that was sandbagged into position to further maintain container integrity. Thirteen composite samples were collected and analyzed for radiological and chemical contamination to properly direct disposition of the waste. Waste sample data results and the waste profile are located in Appendix B.

Analytical results for radiological activity concentrations included the project ROCs with additional alpha spectroscopy analyses for isotopic plutonium, americium, and uranium as required in the project plans. Reported $^{137}Cs$ activity values in the packaged waste exceeded the Table 3.1 values of the NRC 20.2002 Exemption requested by the Air Force in January 2008. The $^{137}Cs$ value in Table 3.1 is 0.42 pCi/g, and the mean value from the 13 waste samples analyzed is 1.0 pCi/g. The analytical method MDCs for $^{90}Sr$, $^{230}Th$, and $^{234}Th$ also exceed the listed Table 3.1 values for those radionuclides

A small container with a dose rate of approximately 50 µrem/h at 1 ft was pulled out of the trench four excavation on 22 October 2010 and packaged in plastic. The container was further investigated on 27 October 2010 with an Inspector 1000® gamma spectroscopy instrument. The only contaminant identified by gamma spectroscopy was $^{241}$Am with an approximate activity of 100 µCi. A smear was performed on the drum and sent to an off-site laboratory for qualitative analysis. The radionuclides and activity reported were $^{241}$Am (170 pCi/smear) by gamma spectroscopy, and $^{238}$Pu (11.7 pCi/smear) and $^{239/240}$Pu (642 pCi/smear) by alpha spectroscopy. The waste has been further characterized by quantitative non-destructive radioassay and determined to meet the definition of transuranic radioactive waste stated in Title 40 of the Code of Federal Regulations, Part 191.02. The small drum is currently wrapped in plastic and sealed inside a 55-gallon drum and secured in a bunker under control of 377 AMDS/ SGPB.

Due to the fact that $^{239}$Pu was not listed as a ROC for RW-06, the $^{238}$Pu and $^{239}$Pu activity concentrations reported for the 13 waste samples were further reviewed and additional isotopic plutonium analyses were performed on all project systematic, biased and reference soil samples (235 samples). The packaged waste analyses reported a mean value of 0.025 +/-0.02 pCi/g with a range of 0.001 to 0.05 pCi/g for $^{239}$Pu. The maximum value reported for the waste was below the mean +2 Standard Deviations (SD).

A total of 14 soil samples were collected and analyzed for waste characterization of stabile chemical constituents during the RW-06 field activities. One sample was collected as a waste pile composite prior to packaging, and 13 were collected as composite samples of the packaged waste. Results from the waste characterization samples indicated that there were not any constituents exceeding the RCRA hazardous criteria and, therefore, the waste was not considered to be hazardous.

# 6.0 Summary And Conclusions

Excavation and removal of radioactively contaminated soil and debris was performed prior to FSS at the RW-06 investigation area. The FSS was designed and implemented in accordance with the MARSSIM manual as described in the approved project plans. All areas were surveyed for radiological contamination using instrumentation and techniques appropriate for the ROCs identified and MARSSIM classification. The data are of a quantity and quality to support decision making for final status of the RW-06 site. This section is a summary of the FSS performed for excavated trenches, the area surrounding the trenches, the overburden soil, the segregated waste, and the current site conditions. Certain unconditional release and additional ALARA recommendations have been made in Section 7.0.

## 6.1 RW-06 Excavation Final Status Survey (FSS) Units

There are seven Class 1 and one Class 2 final status SUs for the remediated areas at the RW-06 Site. Fifteen soil samples and one field duplicate were collected for each SU as designed. The results of the MARSSIM statistical test (WRS) for each of the survey units are located in Table 6-1. All of the eight survey units passed the WRS test and the null hypothesis was rejected.

Although FSS-SU02 passed the WRS test, three systematic $^{239}$Pu values (RW6-FSS-SU02-012 [4.16 pCi/g], RW6-FSS-SU02-014 [2.83 pCi/g], RW6-FSS-SU02-015 [4.70 pCi/g]) exceeded the $DCGL_W$ (2.3 pCi/g) and skewed the data distribution for this ROC. The three data point locations are within close proximity of each other within the northwest corner of this survey unit (trench four). As an additional measure to investigate these elevated systematic sample results, Section 8.5.2 and Equation 8-2 of MARSSIM were applied to ensure that total dose from the combined residual activity in the entire survey unit and the area of elevated activity is less than the release criteria.

Although FSS-SU08 passed the WRS test, systematic sample RW6-FSS-SU08-003 (15.2 pCi/g) exceeded the project $^{14}$C $DCGL_W$ (11.6 pCi/g) and was reanalyzed to investigate the higher than expected activity concentration that did not appear representative of the survey unit. The reanalyzed value was at or near background, but the original value was used for statistical testing of the survey unit. The Survey unit passes the elevated measurement comparison even considering the highest reported $^{14}$C activity as uniform throughout the elevated area. Further investigation is not necessary for this survey unit.

Twelve biased samples were also collected based on analysis and review of the scan data for each of survey units SU02, SU08, SU09, SU10, and SU11. Sample RW6-FSS-SU11-016 in SU11 was collected due to a cluster of elevated z-scores with a maximum scan survey z-score of 8.0 (i.e., approximately 8 standard deviations above the mean) and the analysis results showed 15.7 pCi/g of $^{137}$Cs. All other scan survey z-scores for selected bias sampled areas were greater than 3.0, but less than 5.0, and the sample analysis results were representative of the background distribution. The soil sample analysis results for both biased and random start systematic samples support the efficacy of the project a prior scan MDCs and methodology for gamma emitters.

Survey units SU05, SU06, SU07, and SU09 were deep trenches (10 to 20 feet) that were scanned from a boom lift. Two additional samples were collected in a side excavation of the main trench 9 (SU09) that was made to investigate visual indications of discolored soil during excavation. The two samples were treated as biased samples. Elevated activity (if found during scanning in any of these trenches) was removed and the area rescanned. The final scan data was recorded on Trench Data Sheets as described in Section 6.1.1 of the approved FSP; additional biased samples were not necessary.

The SORs for project ROCs were <1.0 for all biased sample results, except Sample RW6-FSS-SU11-016 in SU11. The area was bias sampled due to a cluster of elevated z-scores with a maximum scan survey z-score of 8.0 (i.e., approximately 8 standard deviations above the mean). The reason this sample failed the SORs criterion was that $^{137}Cs$ was reported at 15.7 pCi/g ($DCGL_W$ of 11.0 pCi/g). The area of elevated activity represented by this data point was investigated by elevated measurement comparison and the total dose is less than the release criteria.

A total of 24 soil samples were collected from the FSS SUs (three from each of eight SUs) and analyzed for stabile chemistry constituents. Constituent concentrations were compared to the NMED residential SSLs as well as the United States Environmental Protection Agency (EPA) residential regional screening levels. Results of the FSS samples indicated that there were not any VOCs or SVOCs that exceeded the NMED residential SSLs or EPA residential RSLs. Eight of twenty-five samples had concentrations of arsenic in excess of the NMED residential SSL of 3.9 mg/kg, and all samples exceeded the EPA residential RSL of 0.39 mg/kg. However, regional studies report a mean abundance of 8.5 mg/kg in source bedrock samples (which none of the project sample results exceeded) and one of three background samples also exceeded the NMED residential SSL. One FSS sample, RW6-FSS-SU05-001, had a result for bis (2-ethylhexyl) phthalate (BEHP) of 71,000µg/kg, exceeding the EPA residential RSL of 35,000µg/kg, but it was well below the NMED residential soil screening level of 347 mg/kg. BEHP is a plasticizer that is commonly found as a laboratory contaminant. The FSS samples have met their DQOs based on comparison to NMED SSLs.

Table 6-1: FSS and SO Survey Unit Summary

| **Survey Unit** | **Systematic Samples** | **Biased Samples** | **WRS** | **EMC** |
|---|---|---|---|---|
| FSS-SU02 | 15 | 3 | Pass | Pass |
| FSS-SU05 | 15 | - | Pass | Pass |
| FSS-SU06 | 15 | - | Pass | Pass |
| FSS-SU07 | 15 | - | Pass | Pass |
| FSS-SU08 | 15 | 2 | Pass | Pass |
| FSS-SU09 | 15 | 2 | Pass | Pass |
| FSS-SU10 | 15 | 4 | Pass | Pass |
| FSS-SU11 | 15 | 1 | Pass | Pass* |
| SO-SU01 | 15 | 6 | Pass | Pass |
| SO-SU02 | 15 | 3 | Pass | Pass |
| SO-SU03 | 15 | 2 | Pass | Pass |
| SO-SU04 | 15 | 2 | Pass | Pass |
| Total | 180 | 25 | 12 | 12 |

*Biased sample RW6-FSS-SU11-016 exceeds SOR for the radionuclides of concern.

## 6.2 Soil Overburden (SO) Survey Units

Potentially non-contaminated soil excavated from trenches was laid out in the staging area as four MARSSIM Class 1 survey units and appropriate surveys and sampling were performed to support decisions for unrestricted release and reuse as backfill. Fifteen soil samples and one field duplicate were collected for each SU as designed. The result of the MARSSIM statistical test (WRS) for each survey unit is located in Table 6-1. All of the four soil overburden survey units passed the WRS test; the null hypothesis was rejected. Thirteen biased samples were also collected based on analysis and review of the gamma walkover scan data for each of survey units SO-SU01, SO-SU02, SO-SU03, and SO-SU04. The SOR was <1.0 for all biased measurements.

Although SO SU01 passed the WRS test for all ROCs, one systematic $^{239}$Pu value (RW6-SO-SU01-003) [5.3 pCi/g]) exceeded the DCGL$_W$ (2.3 pCi/g) for this ROC. The soil in this survey unit was segregated from trenches one through four (FSS SU02. The area of elevated activity represented by this data point was investigated by elevated measurement comparison, and the total dose is less than the release criteria.

Although SO-SU04 passed the WRS test, systematic sample RW6-SO-SU04-0013 (12.4 pCi/g) exceeded the project $^{14}$C DCGL$_W$ (11.6 pCi/g) and was reanalyzed to investigate the higher than expected activity concentration that did not appear representative of the survey unit. The reanalyzed value was at or near background, but the original value was used for statistical testing of the survey unit. The area of elevated activity represented by this data point was investigated by elevated measurement comparison, and the total dose is less than the release criteria.

A total of 12 soil samples were collected from the four SO SUs and analyzed for stabile chemistry constituents. Constituent concentrations were compared to the NMED residential SSLs as well as the EPA residential RSLs. Results of the SO samples indicated that there were not any VOCs or SVOCs that exceeded the NMED residential SSLs or USEPA residential RSLs. Eight of twelve samples had concentrations of arsenic in excess of the NMED residential SSL of 3.9 mg/kg, and all samples exceeded the EPA residential RSL of 0.039 mg/kg. However, regional studies report a mean abundance of 8.5 mg/kg in source bedrock samples (which none of the project sample results exceeded) and one of three background samples also exceeded the NMED residential SSL. Based on the sample results the overburden soil is suitable for use as backfill material.

## 6.3 Packaged Waste

A total of fifty-two soft sided “super sacks” of waste (35 with soils, eight soils with debris, and nine with plastic and other investigation derived waste) were collected from remediation activities. Each super sack contained approximately 8 cubic yards of material for an estimated total volume of 416 cubic yards. Thirteen composite samples were collected and analyzed for radiological and chemical contamination to properly direct disposition of the waste. Waste analysis data results and the waste profile are located in Appendix B.

Analytical results for radiological activity concentrations included the project ROCs with additional alpha spectroscopy analyses for isotopic plutonium, americium, and uranium as required in the project plans. Reported $^{137}$Cs activity values in the packaged waste exceeded the Table 3.1 values of the NRC 20.2002 Exemption requested by the Air Force January 2008. The

$^{137}Cs$ value in Table 3.1 is 0.42 pCi/g and the mean value from the 13 waste samples analyzed is 1.0 pCi/g. The analytical method MDCs for $^{90}Sr$, $^{230}Th$, and $^{234}Th$ also exceeded the listed Table 3.1 values for those radionuclides.

A container (small drum) segregated from trench debris was determined to contain $^{241}Am$ and isotopes of plutonium through qualitative smear and in situ gamma spectroscopy analysis. The waste has been further characterized by non-destructive radioassay and determined to meet the definition of transuranic radioactive waste stated in Title 40 of the Code of Federal Regulations, Part 191.02. The small drum is currently wrapped in plastic and sealed inside a 55- gallon drum in the Kirtland AFB secured and posted waste storage area and is awaiting disposition as a separate waste stream.

A total of 14 soil samples were collected and analyzed for waste characterization of stabile chemical constituents during the RW-06 field activities. One sample was collected as a waste pile composite prior to packaging, and 13 were collected as composite samples of the packaged waste. Results from the waste characterization samples indicated that there were not any constituents exceeding the RCRA hazardous criteria and, therefore, the waste is not considered to be hazardous.

The approximately 416 cubic yards of packaged waste were shipped and disposed by Energy Solutions at their Clive, Utah facility. The waste disposal certificates are contained in Appendix E in this final.

# 7.0 Recommendations

Based on the Conclusions presented above, the following recommendation is proposed:

a. Unconditionally release FSS SUs 2, 5, 6, 7, 8, 9, 10, 11, 12, and SO SUs 1, 2, 3, and 4. Soil from SO-SU01, SO-SU02, SO-SU03, and SO-SU04 may be utilized as backfill for trenches at the RW-06 site.

# 8.0 References

CABRERA 2009. *Field Sampling Plan for Remedial Action Construction at Site RW-06*

CABRERA 2009. *Quality Assurance Project Plan for Remedial Action Construction at Site RW-06*

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USAF, 2006. *RCRA Facility Investigation Sampling and Analysis Plan for Solid Waste Management Unit 6-30, Radioactive Burial 11 (RW-06).* Kirtland Air Force Base, New Mexico.

U.S. Code of Federal Regulations 10 CFR 20.1402. U.S. Nuclear Regulatory Commission. “Radiological Criteria for Unrestricted Use.”

# APPENDIX A

## SURVEY UNIT SCAN DATA PLOTS AND SAMPLE LOCATIONS

### Figures 5-1 through 5-11

# APPENDIX B

## RAW DATA TABLES AND OFFSITE LABORATORY DATA FILES

### Data on DVD

# APPENDIX C

## INSTRUMENT QA/QC, SAMPLE COCs, and PROJECT PHOTOS

## Data on DVD

# Appendix D

## SURVEY UNIT 12 ADDENDUM- FINAL STATUS SURVEY RESULTS

# Kirtland Air Force Base, New Mexico

# Addendum to the revised Final Status Survey Report for Remediation of Site RW-06: Survey Unit 12 Final Status Survey Results

## Executive Summary

Additional excavation was performed in portions of SU02 and SU11 on the RW-06 site in January 2011 (after the original October 2009 excavation and final status survey documented in "Kirtland Air Force Base, Albuquerque, New Mexico, revised Final Status Survey Report For Remediation of Site Rw-06", November 2011 [hereafter, Final Report]). SUs 02 and 11 passed the Wilcoxon Rank Sum (WRS) test, but contained measurement results above the DCGL for $^{239}$Pu and $^{137}$Cs, respectively. The excavation removed approximately 80 additional CY of soil in and around the area these measurements were located. The excavation area footprint and a conservative buffer area surrounding these operations (approximately 781 m$^2$total) were defined as a Class 1 FSS-SU12. The same sampling and analysis protocol for final status survey designed in the approved project plans and reviewed in the Final Report was applied to SU12. Fifteen soil samples were collected from a random start systematic grid. The entire area was scanned for gross gamma radiation and one location was selected for collection of a biased soil sample. Survey unit 12 passed the WRS test and the null hypothesis was rejected. The recommendations in the Final Report are supported by the sampling and data analysis performed for SU12 and documented in this Addendum.

## Introduction

This Addendum presents the results of the additional remediation and radiological Final Status Survey (FSS) performed by Cabrera Services, Inc. (CABRERA) in portions of SU02 and SU11 on the RW-06 site in January 2011.As described in the Final Report, SUs 02 and 11 passed the Wilcoxon Rank Sum (WRS) test, but contained measurement results above the DCGL for $^{239}$Pu and $^{137}$Cs, respectively. The goal of the excavation was to further remove minor amounts of measurable radioactive material contamination in order to apply the As Low As Reasonably Achievable (ALARA) concept. Soil in and around the area of the elevated measurements was removed to a depth of approximately six inches within a radiologically controlled and bounded foot print. The excavation area footprint and a conservative buffer area surrounding these operations (approximately 781 m$^2$ total) were defined as a Class 1 FSS-SU12. An overview of SU12 as it fits into the RW-06 Site layout is shown in Figure 1.

The purpose of this Addendum is to document a summary of the final status survey for SU12 to support the recommendations for unrestricted release of surface soil and surfaces of remediated areas at the RW-06 site made in the Final Report. The project data quality objectives, field activities, survey design, quality assurance and quality control, results and recommendations have been reviewed, analyzed, and presented in the Final Report.

## Summary of Field Activities

The processes described and reviewed in the Final Report Section 2.0 were followed for this minor excavation activity. Field excavation was accomplished in a controlled, safe manner following the approved project plans. Safety violations or incidents did not occur.

The boundaries of the excavation area (the area surrounding the locations of samples in SU02 where $^{239}$Pu values (RW6-FSS-SU02-012 [4.16 pCi/g], RW6-FSS-SU02-014 [2.83 pCi/g], RW6-FSS-SU02-015 [4.70 pCi/g]) exceeded the $DCGL_W$ (2.3 pCi/g)and in SU11 where RW6-FSS-SU11-016$^{137}$Cs activity was reported at 15.7 pCi/g ($DCGL_W$ of 11.0 pCi/g))were marked using a global positioning system prior to performance of work. Figure 2 shows the pre-marked excavation areas within the buffer area of the work footprint. The soil was excavated with heavy equipment and placed in soft-sided “super sacks” within the SU12 boundary. The excavated material and area were monitored with radiation detection instrumentation (3”x3” NaI and FIDLER detectors) during performance of work. The waste sacks were moved to the previously designated waste storage area.

The random start systematic grid of the fifteen sample locations was laid out by Visual Sample Plan within the described SU12 boundary. One hundred percent of the soil surface was scanned with the 3”x3” NaI detector and 2360 meter connected to a GPS system and one biased sample was collected at the area of highest gross gamma activity. Figure 2 shows the boundary, sample locations, and scan data results. All samples were sent offsite for sample analyses with the same requirements as per the Final Report. No stabile chemistry constituents were analyzed since the areas had already met their data quality objectives based on comparison to NMED SSLs as previously documented in the Final Report.

## Data Quality Assessment Summary

Survey data were verified authentic, appropriately documented, and technically defensible. The survey data consist of qualified measurement results that are representative of the area of interest and collected as prescribed by the survey design.

All instruments used during the course of the survey were in current calibration, using sources traceable to the NIST. Copies of all project field and onsite laboratory instrument calibration certificates are provided in Appendix C. All calibrations, calibration verification checks, and background checks indicated that field instrumentation operated satisfactorily during counting and reporting of FSS data.

Although formal data verification and validation is not required for this project, the data has been reviewed relative to the established project objectives and has been determined to be acceptable for use.

Table 1 summarizes the offsite analytical laboratory Minimum Detectable Activities (MDAs) for the methods applied for the sixteen samples collected in SU12. The $^{14}C$ MDA is significantly higher than seen in analyses performed for the Final Report. The samples were counted for an extended period of 180 minutes as noted in the offsite laboratory narrative, but the requested MDC of 2.0 pCi/g was not met and the results were qualified to note the higher than requested MDA. No other issues were noted with this data and no sample activities are at or near the project Derived Concentration Guideline Levels (DCGLs) (see Table 2) and the results are accepted as reported.

**Table 1: Summary Statistics for Minimum Detectable Activities of Biased and Systematic Samples in Survey Unit 12.**

| ***MDA Summary Statistics*** | **$^{241}Am$** | **$^{226}Ra(^{214}Bi)$** | **$^{14}C$** | **$^{137}Cs$** | **$^{3}H$** | **$^{239}Pu$** | **$^{90}Sr$** |
|---|---|---|---|---|---|---|---|
| Mean (pCi/g) | 0.014 | 0.33 | 10.4 | 0.095 | 0.064 | 0.008 | 0.303 |
| Median (pCi/g) | 0.014 | 0.30 | 10.4 | 0.092 | 0.063 | 0.008 | 0.300 |
| Standard Deviation (pCi/g) | 0.007 | 0.14 | 0.141 | 0.030 | 0.004 | 0.003 | 0.008 |
| Skewness | 0.38 | 2.5 | -0.485 | 2.91 | 0.996 | -1.030 | -0.492 |
| Minimum (pCi/g) | 0.007 | 0.23 | 10.1 | 0.056 | 0.058 | 0.000 | 0.290 |
| Maximum (pCi/g) | 0.027 | 0.77 | 10.6 | 0.200 | 0.074 | 0.013 | 0.310 |
| Count | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| DCGL | 2.1 | 0.7 | 11.6 | 11 | 110 | 2.3 | 1.72 |

## Final Status Survey Results for SU12

Scan data results and the locations for the 15 systematic and one biased soil sample locations within FSS SU12 are shown on Figure 2.

Summary statistics for the systematic sample results and the sum of ratios results for the one biased sample collected are presented in Table 2 and Table 3, respectively. The raw data, exploratory data analysis, and statistical testing for all SU12 samples and scan data are located in Appendix B of the Final Report. The WRS test for all ROCs passed the release criterion. Sample analysis results for the one biased sample (RW6-FSS-SU12-016) passed the criterion of SOR <1.0, and additional investigation of this sample location was not performed.

Although SU12 passed the WRS test, one systematic $^{239}$Pu result (RW6-FSS-SU12-011 [5.03 pCi/g]) exceeded the $DCGL_W$ (2.3 pCi/g) and skewed the data distribution for this ROC. The area of elevated activity represented by these data points was investigated by elevated measurement comparison as described in Section 5.3.3 of the Final Report.

The one data point location can be seen in Figure 2. The survey unit area is approximately 781 $m^2$ and the samples are approximately 5.1 meters apart. The grid area bounded by a single sample location is approximately 23 $m^2$ estimated using MARSSIM Section 5.5.2.4, $A = 0.866 \times L^2$, for a triangular grid, which is conservatively used as the total area of elevated activity. The SU12 specific Area Factor (AF) for an elevated area of 23$m^2$ is 19.6 when calculated with RESRAD version 6.5 for $^{239}$Pu. Area factors listed in Table 5-4 of the Final Report also corroborate this value. The $DCGL_{EMC}$ for this elevated area is 45pCi/g ($DCGL_{EMC}$= AF x $DCGL_W$). The Survey unit passes the elevated measurement comparison even considering the highest reported $^{239}$Pu activity as uniform throughout the elevated area.

As an additional measure to investigate these elevated systematic sample results, Section 8.5.2 and Equation 8-2 of MARSSIM were applied to review the potential combined residual activity in the entire survey unit and the area of elevated activity to ensure the total dose is less than the release criteria. The unity rule (Equation 8-2) for combining the total dose from the survey unit and elevated area described above is:

**į**/*$DCGL_W$* +[(*average concentration in elevated area* - **į**)/(*area factor for elevated area*)(*$DCGL_W$*)]< 1,

where **į** is the average residual activity in the survey unit. Using the average SOR value for the survey unit to include all ROCs, the $DCGL_W$ for the entire survey unit as the SOR of 1.0, the average activity for the elevated $^{239}$Pu sample results as the average concentration in the elevated area, and using the $DCGL_{EMC}$ calculated above, the result is found by the following calculation:

0.47/1.0 + [(5.0pCi/g)/(45pCi/g)]= 0.58< 1.0

The second **į** term in equation 8-2 (average residual activity in the entire survey unit) is not subtracted from the average $^{239}$Pu concentration in the elevated area. The reason for this is that the survey unit average SORs calculation includes all residual activity for all ROCs in the entire survey unit, except the one elevated $^{239}$Pu value. The second term in the equation adds the potential dose from the average $^{239}$Pu activity in the area of elevated activity to the potential dose from the entire survey unit (i.e., the first term in the equation) by calculating the ratio of the $^{239}$Pu residual activity to the $DCGL_{EMC}$. Implementation of the unity rule shows that the total potential dose for the SU12, including the residual activity in the elevated area, meets the project release criteria.

**Table 2: SU12 FSS Systematic Sample Summary Statistics by ROC**

| RW06-FSS-SU10 | Radionuclide of Concern | | | | | | |
|---|---|---|---|---|---|---|---|
| **Statistic** | **$^{241}$Am** | **$^{226}$Ra($^{214}$Bi)** | **$^{14}$C** | **$^{137}$Cs** | **$^{3}$H** | **$^{239}$Pu** | **$^{90}$Sr** |
| ***Mean (pCi/g)*** | 0.03 | 1.01 | 2.00 | 0.07 | 0.01 | 0.69 | 0.05 |
| ***Median (pCi/g)*** | 0.02 | 1.03 | 1.20 | 0.04 | 0.01 | 0.34 | 0.03 |
| ***Standard Deviation (pCi/g)*** | 0.03 | 0.23 | 2.71 | 0.13 | 0.01 | 1.26 | 0.08 |
| ***Skewness*** | 0.90 | -0.81 | 0.57 | 2.64 | -0.87 | 3.28 | 0.16 |
| ***Minimum (pCi/g)*** | 0.00 | 0.48 | -2.50 | -0.04 | -0.02 | 0.00 | -0.07 |
| ***Maximum (pCi/g)*** | 0.09 | 1.38 | 7.80 | 0.50 | 0.02 | 5.03 | 0.19 |

**Table 3: Biased Sample SOR Summary**

| Sample ID | ROC DCGL Fraction[1] | | | | | | | SOR |
|---|---|---|---|---|---|---|---|---|
| | **$^{241}$Am** | **$^{226}$Ra($^{214}$Bi)** | **$^{14}$C** | **$^{137}$Cs** | **$^{3}$H** | **$^{239}$Pu** | **$^{90}$Sr** | |
| RW6-FSS-SU12-016 | 0.000 | 0.492 | 0.000 | 0.015 | 0.000 | 0.013 | 0.000 | 0.520 |

[1]If individual radiological contaminant of potential concern (RCOPC) results were negative, these values were truncated to zero prior to calculation of SOF to avoid negative biasing.

**SU 12 Packaged Waste Summary**

The excavation removed approximately 80 additional CY of soil from an area in and around the measurement locations previously described. The soil was packaged in ten,10-cubic yard super sacks and placed within the storage area designated in the Final Report. The waste profile applied for disposal purposes was revised to reflect the increase in total project waste volume and the highest activity listed for $^{137}$Cs and $^{239}$Pu have been stated to reflect the highest measured values for these radionuclides. The waste profile is contained in Appendix E of the Final Report along with Waste Disposal records for all project waste.

## Recommendation

The recommendation is made to unconditionally release FSS SU12 based on the information and data presented above.

# FIGURES

/ Figure 1:  RW06 Survey Unit Layout including SU12

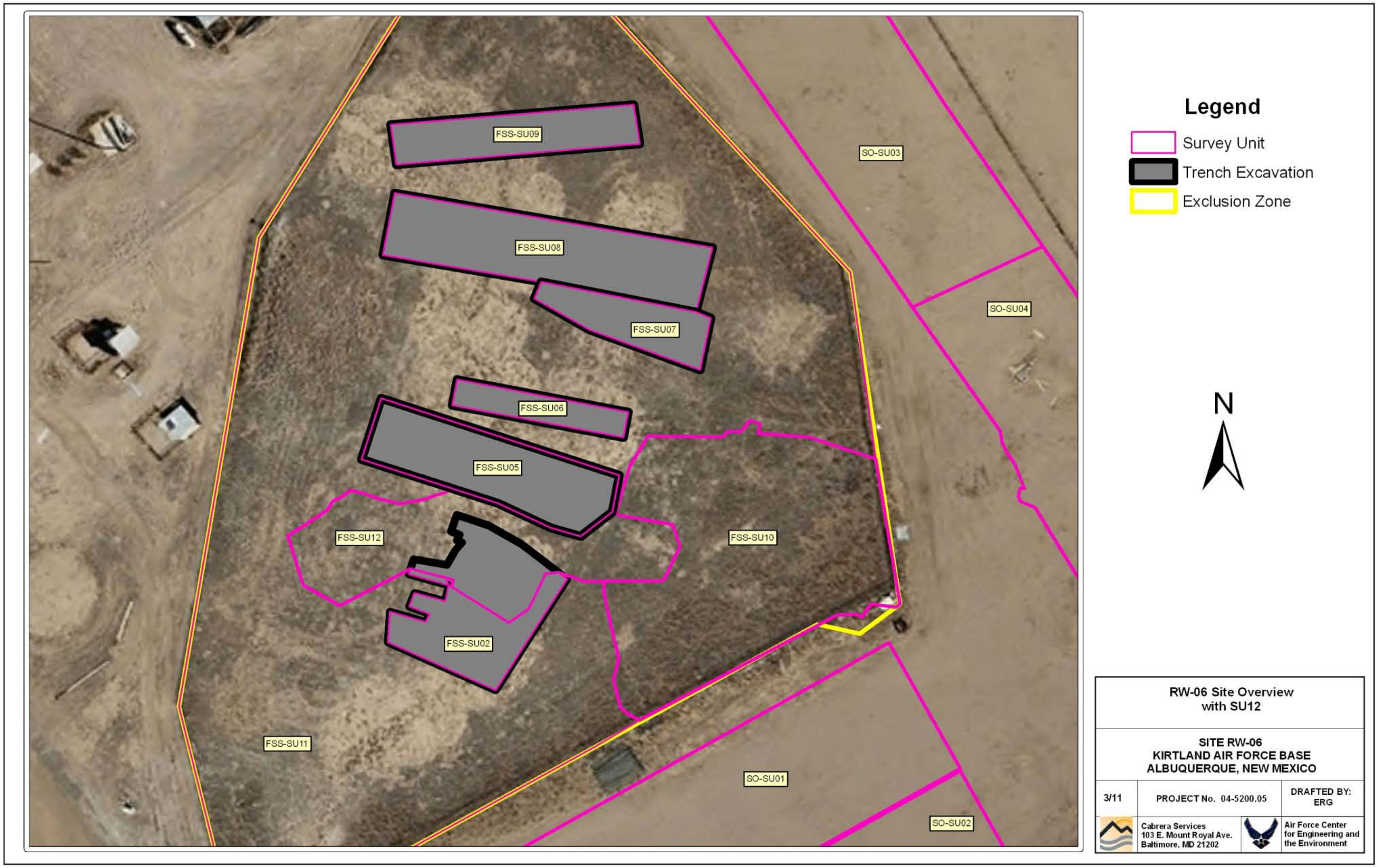
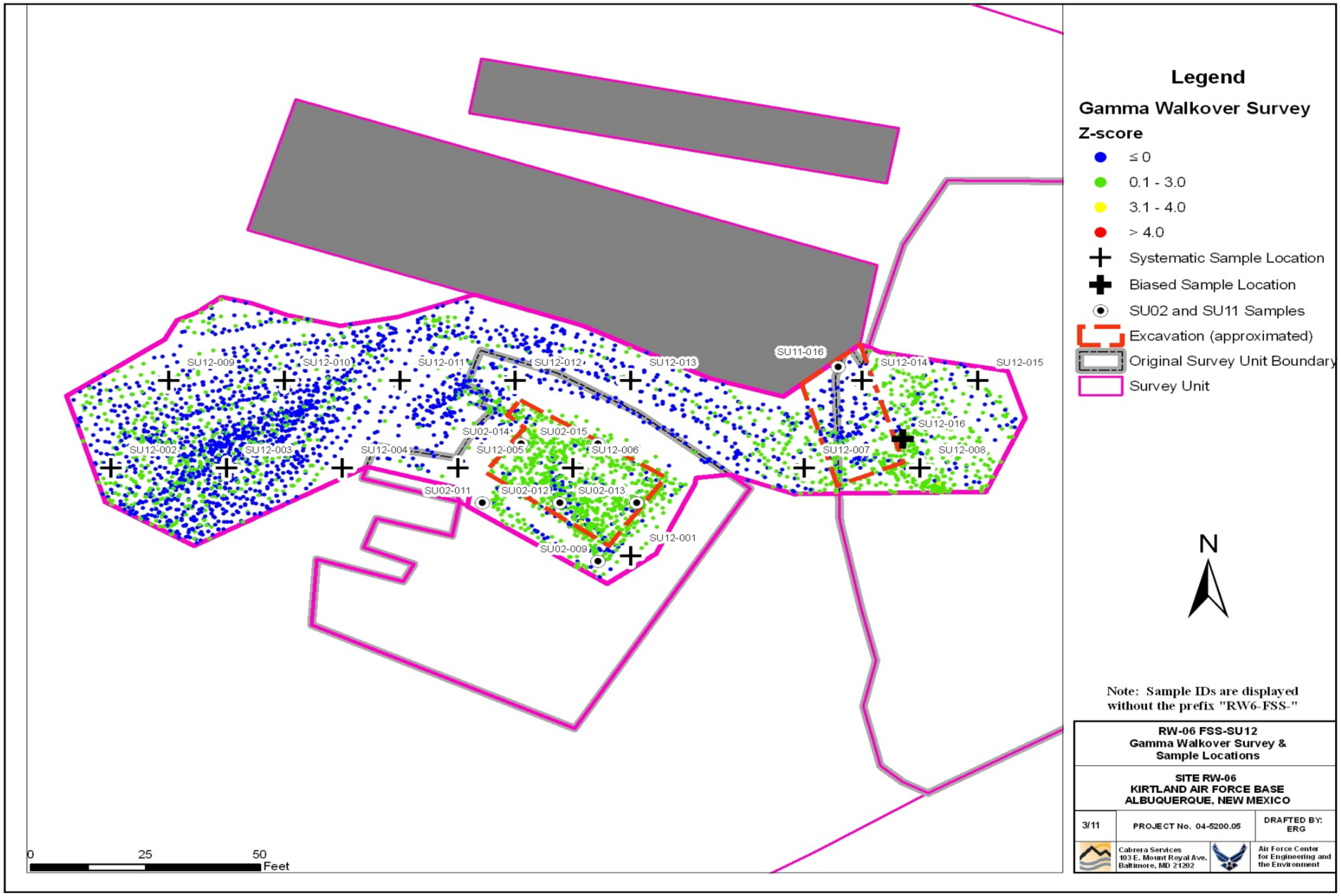


Figure 2: SU12 Sample Locations and Scan results



# Appendix E

# Waste Disposal Records