# RECORD OF TECHNICAL CHANGE

Technical Change No. DOE/NV--1524 ROTC 1 Page 1 of 3

Activity Name CAU 541, Small Boy Date 07/21/2015

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The following technical changes (including justification) are requested by:

| Steve Mergenmeier | Corrective Action Unit Lead |
|---|---|
| (Name) | (Title) |

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Description of Change:

The CAIP Appendix C providing pre-calculated exposure scenario-specific RRMGs were revised. The following table changes address the revised RRMGs.

Replace pages C-1 of C-2 and C-2 of C-2, Appendix C, Entire Tables C.1-1 and C.1-2 with the attached tables.

Justification:

It was discovered that the RRMGs in the CAIP were derived from the RESRAD output that presented RRMGs at the time of the maximum dose for each individual radionuclide. This results in RRMGs that are based on different points in time. While this makes very little difference to the resulting calculated doses, it is inconsistent with the Soils RBCA instructions for calculating dose which specifies the use of RRMGs at the time of when the total dose is the highest.

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The task time will be (Increased) (Decreased) (Unchanged) by approximately 0 days.

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Applicable Activity-Specific Document(s):

Corrective Action Investigation Plan for Corrective Action Unit 541: Small Boy, Nevada National Security Site and Nevada Test and Training Range, Nevada. Revision No.: 0. DOE/NV--1524

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Approved By: /s/ Tiffany A. Lantow Date 8/11/2015
Activity Lead

/s/ Robert F. Boehlecke Date 8/11/15
EM Operations Manager

/s/ Mark McLane Date 8/13/2015
NDEP

## Table C.1-1
## Total Effective Dose RRMGs (pCi/g)
## for the Ground Troops Exposure Scenario

| Radionuclide | Ground Troops Exposure Scenario |
|---|---|
| Ag-108m | 4.797E+01 |
| Al-26 | 3.099E+01 |
| Am-241 | 2.867E+03 |
| Am-243 | 3.471E+02 |
| Cm-243 | 5.661E+02 |
| Cm-244 | 9.841E+03 |
| Co-60 | 3.246E+01 |
| Cs-137 | 1.291E+02 |
| Eu-152 | 6.777E+01 |
| Eu-154 | 6.326E+01 |
| Eu-155 | 1.703E+03 |
| Nb-94 | 4.982E+01 |
| Np-237 | 3.283E+02 |
| Pu-238 | 5.061E+03 |
| Pu-239/240 | 4.629E+03 |
| Pu-241 | 2.288E+05 |
| Sr-90 | 1.201E+04 |
| Tc-99 | 1.252E+06 |
| Th-232 | 9.140E+02 |
| U-233 | 2.448E+04 |
| U-234 | 2.737E+04 |
| U-235 | 4.491E+02 |
| U-238 | 2.463E+03 |

A soil sample at this RRMG value would present a TED potential of 25 mrem per calendar year.

mrem = Millirem
pCi/g = Picocuries per gram

## Table C.1-2
## Internal Dose RRMGs (pCi/g)
## for the Ground Troops Exposure Scenario

| Radionuclide | Ground Troops Exposure Scenario |
|---|---|
| Ag-108m | 7.452E+05 |
| Al-26 | 4.905E+05 |
| Am-241 | 5.818E+03 |
| Am-243 | 5.797E+03 |
| Cm-243 | 7.936E+03 |
| Cm-244 | 9.896E+03 |
| Co-60 | 5.008E+05 |
| Cs-137 | 1.250E+05 |
| Eu-152 | 1.152E+06 |
| Eu-154 | 8.196E+05 |
| Eu-155 | 5.316E+06 |
| Nb-94 | 9.955E+05 |
| Np-237 | 1.066E+04 |
| Pu-238 | 5.077E+03 |
| Pu-239/240 | 4.648E+03 |
| Pu-241 | 2.396E+05 |
| Sr-90 | 5.267E+04 |
| Tc-99 | 2.660E+06 |
| Th-232 | 4.470E+03 |
| U-233 | 2.737E+04 |
| U-234 | 2.851E+04 |
| U-235 | 2.970E+04 |
| U-238 | 2.929E+04 |

A soil sample at this RRMG value would present an internal dose potential of 25 mrem per calendar year.

mrem = Millirem
pCi/g = Picocuries per gram

Nevada
Environmental
Management
Operations Activity

DOE/NV--1524

National Nuclear Security Administration

# Corrective Action Investigation Plan for Corrective Action Unit 541: Small Boy Nevada National Security Site and Nevada Test and Training Range, Nevada

Controlled Copy No.: ___
Revision No.: 0

September 2014

UNCLASSIFIED

/s/ Joseph P. Johnston 09/10/2014
Joseph P. Johnston, N-I CO Date

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U.S. Department of Energy
National Nuclear Security Administration
Nevada Field Office

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DOE/NV--1524

# CORRECTIVE ACTION INVESTIGATION PLAN FOR CORRECTIVE ACTION UNIT 541: SMALL BOY NEVADA NATIONAL SECURITY SITE AND NEVADA TEST AND TRAINING RANGE, NEVADA

U.S. Department of Energy, National Nuclear Security Administration
Nevada Field Office
Las Vegas, Nevada

Controlled Copy No.: ___

Revision No.: 0

September 2014

**CORRECTIVE ACTION INVESTIGATION PLAN FOR CORRECTIVE ACTION UNIT 541: SMALL BOY NEVADA NATIONAL SECURITY SITE AND NEVADA TEST AND TRAINING RANGE, NEVADA**

Approved by: /s/ Tiffany A. Lantow Date: 09/10/2014

Tiffany A. Lantow
Soils Activity Lead

Approved by: /s/ Robert F. Boehlecke Date: 09/10/2014

Robert F. Boehlecke
Environmental Management Operations Manager

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## *Table of Contents (Continued)*

## Table of Contents *(Continued)*

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***Number*** ***Title*** ***Page***

## *List of Tables (Continued)*

**Number** **Title** **Page**

## List of Acronyms and Abbreviations

| | |
|---|---|
| 4JA | Jackass Flats |
| A12 | Rainier Mesa |
| A18 | Area 18 |
| A27 | Area 27 |
| Ac | Actinium |
| Ag | Silver |
| agl | Above ground level |
| Al | Aluminum |
| Am | Americium |
| ASTM | ASTM International |
| bgs | Below ground surface |
| BJY | Buster Jangle Y |
| CAA | Corrective action alternative |
| CAI | Corrective action investigation |
| CAIP | Corrective action investigation plan |
| CAS | Corrective action site |
| CAU | Corrective action unit |
| CERCLA | *Comprehensive Environmental Response, Compensation, and Liability Act* |
| CFR | *Code of Federal Regulations* |
| cm | Centimeter |
| Cm | Curium |
| Co | Cobalt |
| COC | Contaminant of concern |
| COPC | Contaminant of potential concern |
| cpm | Counts per minute |
| cps | Counts per second |
| Cs | Cesium |

## List of Acronyms and Abbreviations *(Continued)*

| | |
|---|---|
| CS | Cane Springs |
| CSM | Conceptual site model |
| DCF | Dose conversion factor |
| DOE | U.S. Department of Energy |
| DQI | Data quality indicator |
| DQO | Data quality objective |
| DRA | Desert Rock |
| DRI | Desert Research Institute |
| EPA | U.S. Environmental Protection Agency |
| Eu | Europium |
| FAL | Final action level |
| FFACO | *Federal Facility Agreement and Consent Order* |
| FIDLER | Field instrument for the detection of low-energy radiation |
| FSL | Field-screening level |
| FSR | Field-screening result |
| ft | Foot |
| $g/cm^3$ | Grams per cubic centimeter |
| g/m | Grams per meter |
| $g/m^3$ | Grams per cubic meter |
| g/yr | Grams per year |
| GPS | Global Positioning System |
| GZ | Ground zero |
| HASL | Health and Safety Laboratory |
| hr/day | Hours per day |
| HWAA | Hazardous waste accumulation area |
| IDW | Investigation-derived waste |
| in. | Inch |

## List of Acronyms and Abbreviations (Continued)

| | |
|---|---|
| K | Potassium |
| kt | Kiloton |
| LCL | Lower confidence limit |
| LTH | Lathrop Gate |
| m | Meter |
| m/sec | Meters per second |
| m/yr | Meters per year |
| $m^2$ | Square meter |
| $m^3$/day | Cubic meters per day |
| $m^3$/hr | Cubic meters per hour |
| $m^3$/yr | Cubic meters per year |
| MCY | Mercury |
| MDC | Minimum detectable concentration |
| mg/day | Milligrams per day |
| mi | Mile |
| mm | Millimeter |
| mm/yr | Millimeters per year |
| mph | Miles per hour |
| mrem | Millirem |
| mrem/GT-yr | Millirem per Ground Troops year |
| mrem/IA-yr | Millirem per Industrial Area year |
| mrem/OA-yr | Millirem per Occasional Use Area year |
| mrem/RW-yr | Millirem per Remote Work Area year |
| mrem/yr | Millirem per year |
| MTE | Military Effects Test |
| MV | Mid Valley |
| MVY | Mid Valley |

## *List of Acronyms and Abbreviations (Continued)*

| | |
|---|---|
| NAC | Nevada Administrative Code |
| NAD | North American Datum |
| NAEG | Nevada Applied Ecology Group |
| Nb | Niobium |
| NDD | Normalized dose difference |
| NDEP | Nevada Division of Environmental Protection |
| NEPA | National Environmental Policy Act |
| NNSA/NFO | U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office |
| NNSS | Nevada National Security Site |
| Np | Neptunium |
| NTTR | Nevada Test and Training Range |
| Pa | Protactinium |
| PAL | Preliminary action level |
| Pb | Lead |
| PCB | Polychlorinated biphenyl |
| pCi/g | Picocuries per gram |
| PET | Potential evapotranspiration |
| PHS | PHS Farm |
| PM1 | Pahute Mesa 1 |
| PPE | Personal protective equipment |
| PSM | Potential source material |
| Pu | Plutonium |
| QA | Quality assurance |
| QAP | Quality Assurance Plan |
| QC | Quality control |
| $r^2$ | Coefficient of determination |

## *List of Acronyms and Abbreviations* (Continued)

| | |
|---|---|
| RBCA | Risk-based corrective action |
| RCRA | Resource Conservation and Recovery Act |
| REOP | Real Estate/Operations Permit |
| RIDP | Radionuclide Inventory and Distribution Program |
| RMA | Radioactive material area |
| RRMG | Residual radioactive material guideline |
| RV | Rock Valley |
| RWMS | Radioactive waste management site |
| Sr | Strontium |
| SVOC | Semivolatile organic compound |
| Tc | Technetium |
| TED | Total effective dose |
| Th | Thorium |
| Tl | Thallium |
| TLD | Thermoluminescent dosimeter |
| TRS | Terrestrial radiological survey |
| TSCA | *Toxic Substances Control Act* |
| TS2 | Tippipah Springs 2 |
| TTR | Tonopah Test Range |
| U | Uranium |
| UCC | Yucca Dry Lake |
| UCL | Upper confidence limit |
| USAF | U.S. Air Force |
| UTM | Universal Transverse Mercator |
| VOC | Volatile organic compound |
| W5B | Well 5B |
| YMR | Yucca Mountain Ridge |

# Executive Summary

Corrective Action Unit (CAU) 541 is co-located on the boundary of Area 5 of the Nevada National Security Site and Range 65C of the Nevada Test and Training Range, approximately 65 miles northwest of Las Vegas, Nevada. CAU 541 is a grouping of sites where there has been a suspected release of contamination associated with nuclear testing. This document describes the planned investigation of CAU 541, which comprises the following corrective action sites (CASs):

- 05-23-04, Atmospheric Tests (6) - BFa Site
- 05-45-03, Atmospheric Test Site - Small Boy

These sites are being investigated because existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend corrective action alternatives (CAAs). Additional information will be obtained by conducting a corrective action investigation before evaluating CAAs and selecting the appropriate corrective action for each CAS. The results of the field investigation will support a defensible evaluation of viable CAAs that will be presented in the investigation report.

The sites will be investigated based on the data quality objectives (DQOs) developed on April 1, 2014, by representatives of the Nevada Division of Environmental Protection; U.S. Air Force; and the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Field Office. The DQO process was used to identify and define the type, amount, and quality of data needed to develop and evaluate appropriate corrective actions for CAU 541. The site investigation process also will be conducted in accordance with the *Soils Activity Quality Assurance Plan*, which establishes requirements, technical planning, and general quality practices to be applied to this activity.

The potential contamination sources associated with CASs 05-23-04 and 05-45-03 are from nuclear testing activities conducted at the Atmospheric Tests (6) - BFa Site and Atmospheric Test Site - Small Boy sites. The presence and nature of contamination at CAU 541 will be evaluated based on information collected from field investigations. Radiological contamination will be evaluated based on a comparison of the total effective dose at sample locations to the dose-based final action level. The total effective dose will be calculated as the total of separate estimates of internal and external dose. Results from the analysis of soil samples will be used to calculate internal radiological dose.

Thermoluminescent dosimeters placed at the center of each sample location will be used to measure external radiological dose.

Appendix A provides a detailed discussion of the DQO methodology and the DQOs specific to each CAS.

This Corrective Action Investigation Plan has been developed in accordance with the *Federal Facility Agreement and Consent Order* that was agreed to by the State of Nevada; DOE, Environmental Management; U.S. Department of Defense; and DOE, Legacy Management. Under the *Federal Facility Agreement and Consent Order*, this Corrective Action Investigation Plan will be submitted to the Nevada Division of Environmental Protection for approval. Fieldwork will be conducted after the plan is approved.

# 1.0 Introduction

This Corrective Action Investigation Plan (CAIP) contains activity-specific information, including facility descriptions, environmental sample collection objectives, and criteria for conducting site investigation activities at Corrective Action Unit (CAU) 541: Small Boy, Nevada National Security Site (NNSS), Nevada (Figure 1-1).

This CAIP has been developed in accordance with the *Federal Facility Agreement and Consent Order* (FFACO) (1996, as amended) that was agreed to by the State of Nevada; U.S. Department of Energy (DOE), Environmental Management; U.S. Department of Defense; and DOE, Legacy Management.

CAU 541 is co-located on the boundary of Area 5 of the NNSS and Range 65C of the Nevada Test and Training Range (NTTR), approximately 65 miles (mi) northwest of Las Vegas, Nevada. CAU 541 is located on the Frenchman Flat playa and comprises the two corrective action sites (CASs) shown on Figure 1-2 and listed in Table 1-1.

The corrective action investigation (CAI) will include field investigations, radiological surveys, sampling of environmental media, analysis of samples, and assessment of investigation results. Data will be obtained to support evaluations of corrective action alternatives (CAAs) and waste management decisions.

## 1.1 Purpose

The CASs in CAU 541 are being investigated because hazardous and/or radioactive contaminants may be present in concentrations that exceed risk-based corrective action (RBCA) levels. Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs. Additional information will be generated by conducting a CAI before evaluating and selecting CAAs.

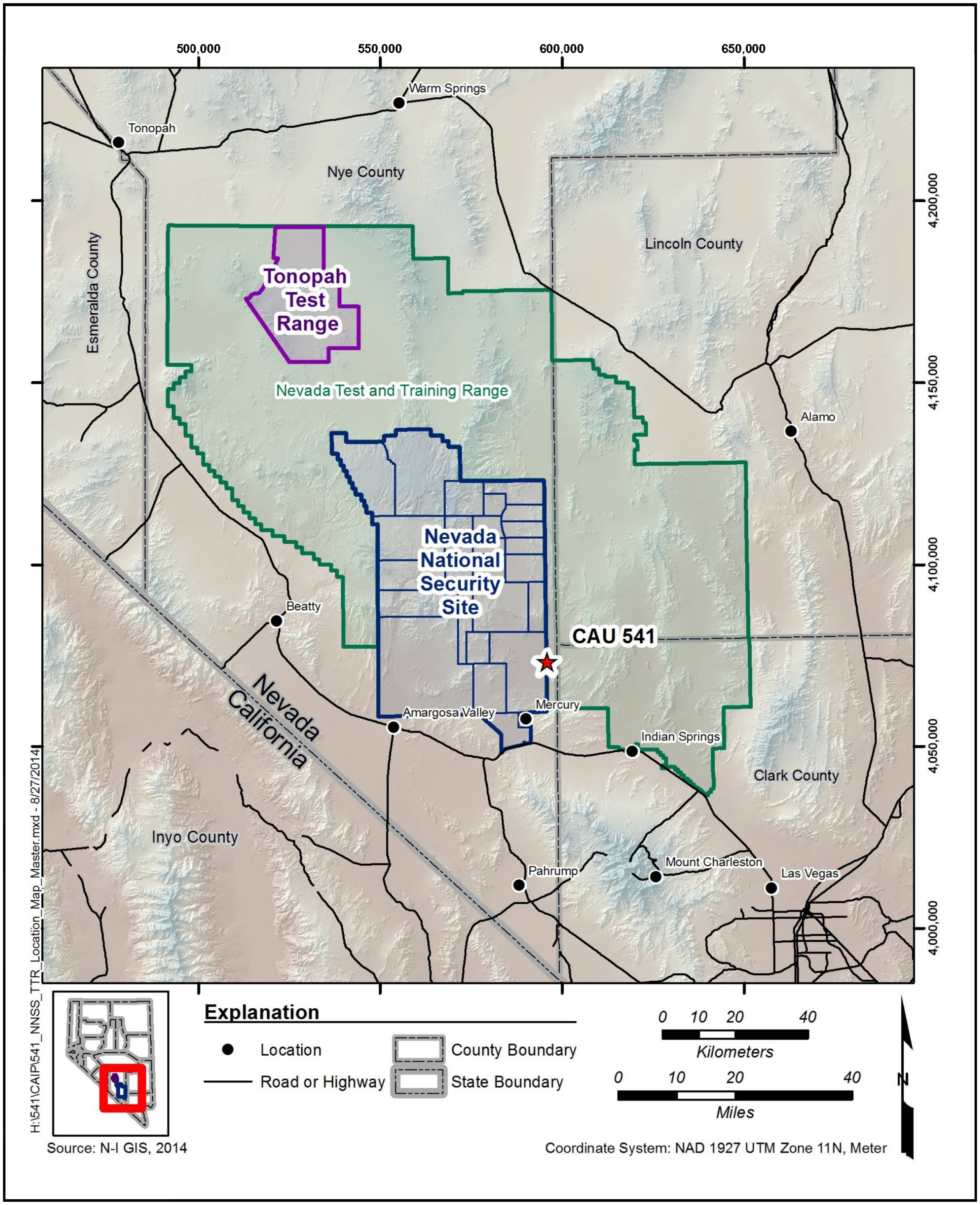


**Figure 1-1**
**Nevada National Security Site**

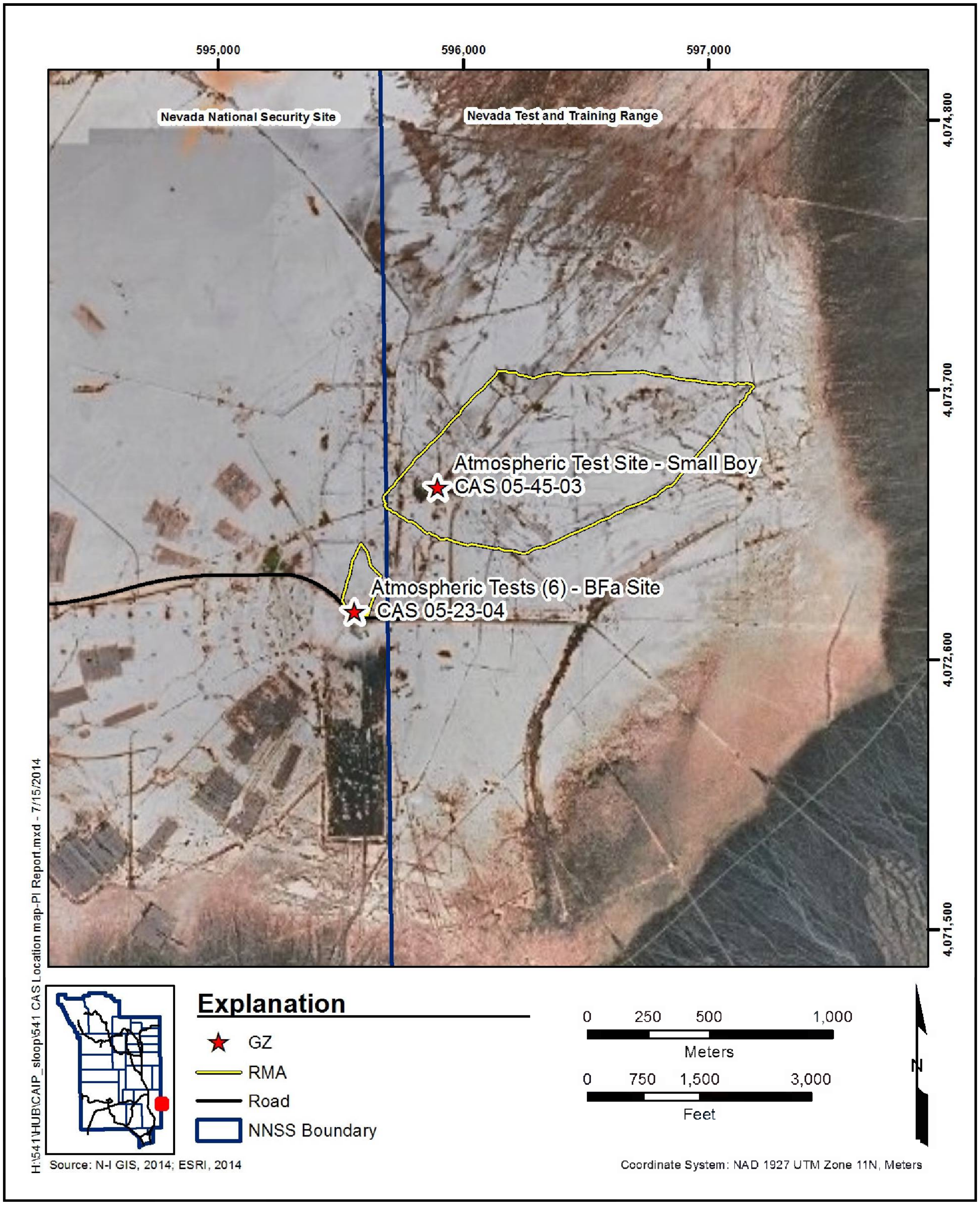


**Figure 1-2**
**CAU 541 CAS Location Map**

**Table 1-1**
**CAU 541 Study Groups**

| Number | Description | FFACO CASs |
|---|---|---|
| Group 1 | BFa Site | 05-23-04 |
| Group 2 | Small Boy Site | 05-45-03 |
| Group 3 | Spills and Debris | 05-23-04, 05-45-03 |

### *1.1.1 CAU 541 History and Description*

CAU 541, Small Boy, consists of two inactive sites co-located in the eastern portion of Area 5 of the NNSS and the western edge of the NTTR (formerly the Nellis Air Force Range). The CAU 541 sites consist of releases of radionuclides to the soil surface as a result of nuclear testing in the 1950s and 1960s. Operational histories for each CAU 541 site are detailed in Section 2.2.

### *1.1.2 Data Quality Objective Summary*

The sites will be investigated based on data quality objectives (DQOs) developed by representatives of the Nevada Division of Environmental Protection (NDEP), U.S. Air Force (USAF), and the DOE, National Nuclear Security Administration, Nevada Field Office (NNSA/NFO). DQOs are used to identify and define the type, quantity, and quality of data needed to develop and evaluate appropriate corrective actions for CAU 541. This CAIP describes the investigative approach developed to collect the necessary data identified in the DQO process. Discussions of the DQO methodology and the DQOs specific to CAU 541 are presented in Appendix A. A summary of the DQO process is provided below.

The DQO problem statement for CAU 541 is as follows: "Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs in CAU 541." To address this problem, resolution of the following decision statements is required:

- **Decision I.** "Is any contaminant of concern (COC) associated with the CAS present in environmental media?" For judgmental sampling decisions, any contaminant associated with a CAS that is present at concentrations exceeding its corresponding final action level (FAL) will be defined as a COC. For probabilistic sampling decisions, any contaminant for which the 95 percent upper confidence limit (UCL) of the mean exceeds its corresponding FAL will be defined as a COC. A COC may also be defined as a contaminant that, in combination with other like contaminants, is determined to jointly pose an unacceptable risk based on a multiple constituent analysis (NNSA/NFO, 2014).

- **Decision II.** "Is sufficient information available to evaluate potential CAAs?" Sufficient information is defined to include to following:

  - The lateral and vertical extent of COC contamination
  - The information needed to predict potential remediation waste types and volumes
  - Any other information needed to evaluate the feasibility of remediation alternatives

A corrective action will be determined for any site containing a COC. The evaluation of the need for corrective action will include the potential for wastes that are present at the site to cause the future contamination of site environmental media if the wastes were to be released (see Section 3.4).

The informational inputs and data required to resolve the problem and decision statements were generated as part of the DQO process for this CAU and are documented in Appendix A. The information necessary to resolve the DQO decisions will be generated for each CAU 541 CAS by collecting and analyzing samples generated during field investigations. The presence of a COC will be determined by collecting and analyzing samples following these two criteria:

- To make a judgmental sampling decision, samples must be collected in areas most likely to contain a COC.

- To make a probabilistic sampling decision, samples must be collected from unbiased locations that represent contamination within the sampling unit (see Section A.5.4).

To facilitate site investigation and the evaluation of DQO decisions for different releases, the reporting of investigation results and the evaluation of DQO decisions for different releases were organized into study groups. The study groups and the CASs associated with each study group are described in Table 1-1. Although the need for corrective action is evaluated separately for each study group, CAAs are evaluated for each FFACO CAS.

**Study Group 1, BFa Site**: This release category is specific to the atmospheric deposition of radionuclide contamination at the BFa site from nuclear weapons testing (comprised mainly of fission and activation products) onto the soil surface.

Radionuclide contaminants that were initially deposited onto the soil surface at this site may have been subsequently displaced through erosion or mechanical disturbance of the soil near ground zero (GZ). Six tests were performed at this site, and disturbances to the soil in this area would be expected between tests. It is reported in historical documentation that clean soil was placed at GZ after the Wrangell test as part of decontamination activities in preparation for the Sanford test (Holmes & Narver, 1959). This study group is located on the Frenchman Flat playa (dry) lake bed on the NNSS. A slight depression is observed at the immediate GZ area at the BFa site that has been observed to collect water during wetter periods and is a potential area for site disturbance.

**Study Group 2, Small Boy Site**: This release category is specific to the atmospheric deposition of fissioned and unfissioned radionuclide contamination on surface soil at the Small Boy site. The highest concentration of contamination associated with this type of release that has not been displaced through excavation or migration (i.e., area outside GZ) is expected to be in the top 5 centimeters (cm) of soil. Atmospheric releases of radionuclides that have been distributed at the NNSS from nuclear testing have been found to be concentrated in the upper 5 cm of undisturbed soil (McArthur and Kordas, 1983 and 1985; Gilbert et al., 1977; Tamura, 1977). The GZ area may be subject to prompt injection from the nuclear test.

Aerial radiological surveys of the area south of the Small Boy site detected an anomalous area of elevated radiological readings spatially separate from the larger radiological contamination plume associated with the BFa and Small Boy sites. Research of archived documents did not reveal a source of this material. Discussions with former workers at the time of the testing also have not revealed a credible source for the elevated radiological material. Although no credible source is identified, the anomalous area is assumed to be related to the Small Boy release and therefore is included in the conceptual site model (CSM).

Radionuclide contaminants that were initially deposited onto the soil surface may have been subsequently displaced through erosion or mechanical disturbance of the soil. Visual observations and an evaluation of historical documentation do not suggest mechanical disturbance to the Small Boy area after the one test conducted at this site. This study group is also located on the Frenchman Flat playa (dry) lake bed on the NTTR. A slight depression is observed at the immediate GZ area at the Small Boy site that has been observed to collect water during wetter periods.

**Study Group 3, Spills and Debris**: This study group investigates chemical or radiological contamination associated with debris and/or spills. Spills will be evaluated based on the presence of biasing factors such as discoloration or elevated instrument readings. Debris and/or spills will be evaluated for waste with the potential to result in the introduction of a COC to the surrounding environmental media.

Investigation of Study Groups 1 and 2 surface soil releases will be accomplished through measurements of surface soil radioactivity using a combination of judgmental and probabilistic sampling schemes. The investigation of subsurface soil will be accomplished using a judgmental sampling scheme at depths dependent upon the nature of the release. Investigation of Study Group 3 releases will consist of a judgmental sampling design based upon biasing factors to establish sample locations and evaluate sample results.

Subsidence craters resulting from underground nuclear tests that affect the closure of Soils Activity sites are not observed in the CAU 541 area.

## 1.2 Scope

To generate information needed to resolve the decision statements identified in the DQO process, the scope of the CAI for CAU 541 includes the following activities:

- Conduct radiological surveys.
- Perform field screening.
- Measure *in situ* external dose rates using thermoluminescent dosimeters (TLDs) or other dose-measurement devices.
- Collect and submit environmental samples for laboratory analysis to determine whether any COC is present.
- Collect and submit environmental samples for laboratory analysis to determine the nature and extent of any COCs that are present.
- Collect samples of waste material, if present, to determine the potential for a release to result in contamination exceeding FALs.

- Collect samples of potential remediation wastes, if present.
- Collect quality control (QC) samples.

Contamination of environmental media originating from activities not identified in the CSM of any CAS will not be considered as part of this CAU unless the CSM and the DQOs are modified to include the release. If not included in the CSM, contamination originating from these sources will not be considered for sample location selection and/or will not be considered COCs. If such contamination is present, the contamination will be identified as part of another CAS (either new or existing).

### *1.3 CAIP Contents*

Section 1.0 presents the purpose and scope of this CAIP, whereas Section 2.0 provides background information about CAU 541. Objectives of the investigation, including the CSM, are presented in Section 3.0. Field investigation and sampling activities are discussed in Section 4.0, and waste management issues are discussed in Section 5.0. General field and laboratory quality assurance (QA) (including collection of QC samples) is presented in Section 6.0 and in the *Soils Activity Quality Assurance Plan* (QAP) (NNSA/NSO, 2012). The activity schedule and records availability are discussed in Section 7.0. Section 8.0 provides a list of references.

Appendix A provides a detailed discussion of the DQO methodology and the DQOs specific to each CAS, while Appendix B contains information on the activity organization. Appendix C contains the pre-calculated exposure scenario-specific residual radioactive material guidelines (RRMGs). Appendix D provides a review of RESRAD Input Parameters for the site-specific exposure scenario used at the CAU. Appendix E contains NDEP comments on the draft version of this document.

# 2.0 Facility Description

CAU 541 comprises two CASs, co-located at the NNSS and NTTR, that consist of atmospheric nuclear test sites. CAS 05-23-04, Atmospheric Tests (6) - BFa Site, is located in Area 5 of the NNSS. CAS 05-45-03, Atmospheric Test Site - Small Boy, is located on the NTTR (Range 65C).

## 2.1 Physical Setting

The following subsections describe the general physical settings of Area 5 of the NNSS and Range 65C of the NTTR. General background information pertaining to topography, geology, hydrogeology, and climatology is provided for these specific areas of the NNSS region in the *Geologic Map of the Nevada Test Site, Southern Nevada* (Frizzell and Shulters, 1990); *CERCLA Preliminary Assessment of DOE's Nevada Operations Office Nuclear Weapons Testing Areas* (DRI, 1988); *Final Environmental Impact Statement, Nevada Test Site, Nye County, Nevada* (ERDA, 1977); and the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE/NV, 1996). General background information for the NTTR is provided in the *Renewal of the Nellis Air Force Range Land Withdrawal, Legislative Environmental Impact Statement* (USAF, 1999). Geological and hydrological setting descriptions for the two sites are detailed in the following subsections based on the Frenchman Flat hydrogeographic area in which they are located.

### 2.1.1 Frenchman Flat

CASs 05-23-04 and 05-45-03 lie within the eastern portion of the Frenchman Flat Hydrographic Area. This hydrographic area consists of a closed basin surrounded by low-lying mountains that separate this area from the Mercury Valley Hydrographic Area to the south and from the Yucca Flat Hydrographic Area to the north (Laczniak et al., 1996). Erosion of the surrounding mountains has resulted in the accumulation of more than 1,000 feet (ft) of alluvial deposits in some areas of the Frenchman Flat playa (DOE/NV, 1996).

Regional groundwater flow beneath the Frenchman Flat playa area occurs primarily within the carbonate-rock aquifer and is generally from the northeast to southwest. Within the overlying alluvial and volcanic aquifers, lateral groundwater flow occurs from the margins to the center of the basin, and downward into the carbonate-rock aquifer. The hydraulic gradient in most areas of the alluvial aquifer in Frenchman Flat is relatively flat (less than 1 ft per mile) except near active water wells and/or test wells (Hevesi et al., 2003). The average annual precipitation measured at Well 5B (W5B), which is located just north of the Frenchman Flat playa, is 4.88 inches (in.) (12.4 cm) based on a 41-year period of record (ARL/SORD, 2014). The Frenchman Flat unsaturated zone extends to approximately 790 ft below ground surface (bgs) (BN, 2001) at the Area 5 Radioactive Waste Management Site (RWMS). Average annual potential evapotranspiration (PET) has been estimated for Area 5 as 161 cm (64 in.) (BN, 2001). Rainfall and PET information is summarized in Table 2-1.

**Table 2-1**
**Rainfall and PET Information for Frenchman Flat**

| | PET (cm) | W5B Precipitation (cm) |
|---|---|---|
| Mean | 161 | 12.4 |

Source: ARL/SORD, 2014; BN, 2001

The nearest groundwater well to CASs 05-23-04 and 05-45-03 is Water Well WW-5a, an active well located approximately 2.2 mi west of CAS 05-23-04. The most recent recorded depth to groundwater at this well is approximately 708 ft bgs (USGS, 2014).

## 2.2 Operational History

The following subsections provide a description of the use and history of each site in CAU 541 that may have resulted in releases of contaminants to the environment. The site-specific summaries are designed to describe the releases associated with each CAS and document all significant, known activities.

The atmospheric testing of nuclear weapons at CAU 541 was performed between 1953 and 1962. Areas of contaminated soils exist from the testing performed at this CAU, and test-related debris remains. As these were atmospheric tests in topographically flat areas, no craters are observed at any of the two sites. However, slight depressions exist at both GZs. Posted, but not fenced, radioactive material areas (RMAs) are designated around both GZs.

Other investigations were performed in the vicinity of CAU 541 at surrounding CASs, as summarized in Table 2-2.

**Table 2-2**
**Surrounding CASs to CAU 541**

| CAS Description | CAS # | CAU # | Closure Strategy | Functional Category |
|---|---|---|---|---|
| Atmospheric Test Site - Able | 05-23-05 | 106 | No Further Action | Rad Contamination Area |
| Atmospheric Test Site - Hamilton | 05-45-01 | 573 | Close In Place | Rad Contamination Area |
| Fallout Shelters | 05-99-01 | 214 | Clean Closure | Other |

### *2.2.1 BFa Site*

This site is defined as the release of contaminants associated with atmospheric testing of nuclear weapons at the BFa site. CAS 05-23-04, Atmospheric Tests (6) - BFa Site, consisted of six tests conducted between 1953 and 1958 from various operations. The following discusses the specifics of each test (DOE/NV, 2000):

- Encore was a weapons-effects test as part of Operation Upshot-Knothole with a yield of 27 kilotons (kt). The test was an airdrop test performed on May 8, 1953. Encore was the first of six tests performed at this site.
- Grable was a weapons-related test as part of Operation Upshot-Knothole with a yield of 15 kt. The airburst test fired from a 280 millimeter (mm) artillery gun was performed on May 25, 1953.
- The Military Effects Test (MET) was a weapons-effect test as part of Operation Teapot. The test was performed on April 15, 1955, from a 400-ft tower with a yield of 22 kt.
- Priscilla was a weapons-related airburst balloon test as part of Operation Plumbbob. The test was performed on June 24, 1957, and conducted at 700 ft with a yield of 37 kt. The yield for Priscilla was the largest observed for CAU 541.
- Wrangell was a weapons-related test as part of Operation Hardtack II with a yield of 115 tons. The airburst balloon test was performed on October 22, 1958, from a height of 1,500 ft.
- Sanford was a weapons-related test performed as part of Operation Hardtack II. The 4.9-kt airburst balloon test was conducted on October 26, 1958, also from a height of 1,500 ft. Sanford was the last of six tests performed at this site.

Extensive testing facilities and debris remain from these activities, and some limited areas of contaminated soils exist. Numerous concrete and steel structures, military fortifications (foxholes and bunkers), bridge/railroad infrastructure, domes, shelters, and diagnostic instrumentation locations remain at this site that could provide the source for a release of contamination.

### 2.2.2 Small Boy Site

This site is defined as the release of contaminants associated with an atmospheric nuclear test at the Small Boy Site. CAS 05-45-03, Atmospheric Test Site - Small Boy, consisted of one test conducted on July 14, 1962. This weapons-effects test, as part of Operation Sunbeam, was a low-yield test conducted from a 10-ft tower.

Testing structures and debris remaining from these activities include instrument stations for diagnostics and test support, and general debris that could provide the source for a release of contamination. Limited areas of contaminated soils exist at this site. Aerial radiological surveys identified two distinct areas of radiological contamination. A larger area encompasses the Small Boy test location, and a smaller area is located to the south of the Small Boy site as shown on Figure 2-1.

## 2.3 Waste Inventory

Available documentation, interviews with former site employees, process knowledge, and general historical NNSS practices were used to identify wastes that may be present. The potential wastes specific to each site are listed in the following subsections.

Solid waste items identified at CAU 541 include substantive instrument stations for test support and diagnostics, military fortifications (foxholes and bunkers), a bridge/railroad infrastructure, domes, shelters, building materials, and general debris. Identified solid waste items include miscellaneous building material debris at both sites. Potential source material (PSM) (i.e., hazardous wastes or materials) identified at the sites include a few scattered lead bricks at both sites and one disintegrated lead-acid battery at the BFa site. Additional wastes may include investigation-derived waste (IDW), decontamination liquids, and soils. Potential waste types include sanitary waste, hydrocarbon waste, *Resource Conservation and Recovery Act* (RCRA) hazardous waste, radioactive waste, and mixed waste.

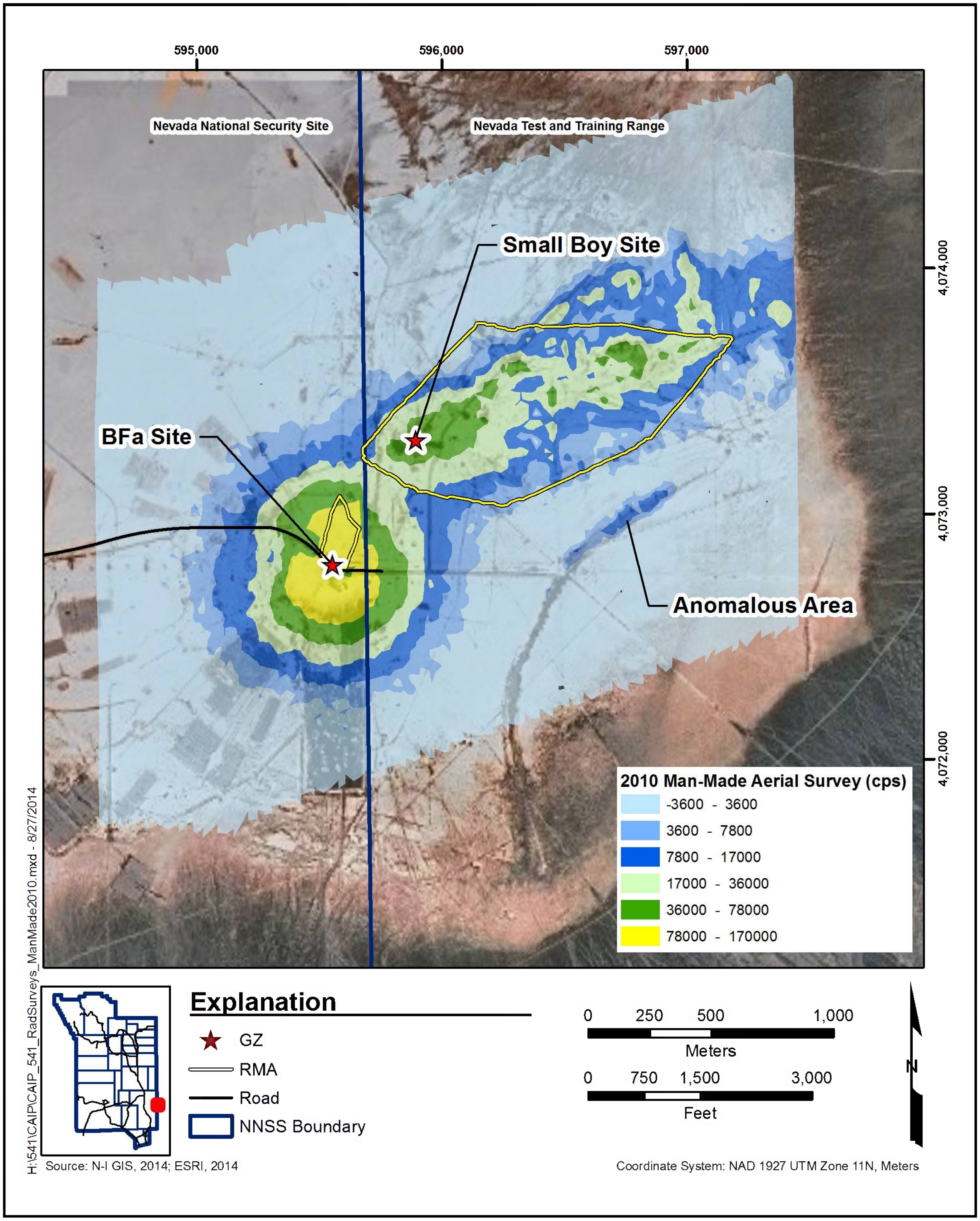


**Figure 2-1**
**CAU 541 Man-Made Gamma-Emitting Radionuclide Aerial Data**

### 2.4 Release Information

The releases of contamination to CAU 541 are directly or indirectly associated with seven atmospheric nuclear tests conducted in the area. The investigation of specific releases at CAU 541 will depend upon the nature of these releases. Therefore, the releases at CAU 541 have been categorized into one of the three study groups defined in Section 1.1.2.

Exposure routes to receptors include ingestion and inhalation of radionuclides in surface soil (internal exposure). Site workers may also be exposed to direct radiation by performing activities in proximity to radiologically contaminated materials (i.e., external dose). Therefore, the CSM will include the potential for receptors to receive an internal dose from contaminated soil and an external dose from contaminated soil and debris.

The following subsections contain study group-specific descriptions of known or suspected releases associated with CAU 541.

#### 2.4.1 Study Group 1, BFa Site

The Study Group 1 investigation will address fission products deposited onto surface soils from fallout during six tests conducted at the BFa site to include activated soil products. This study group will also examine radionuclide contaminants that were initially deposited onto the soil surface that may have subsequently been displaced through wind and water erosion or mechanical disturbance of the soil near GZ. A slight depression at the BFa GZ has been observed to collect water and associated sedimentation during rain events.

The release of radionuclides from the six tests at the BFa site was distributed in a roughly concentric pattern on the ground surface, exhibiting a pattern of surface contamination that is generally decreasing in concentration with increasing distance from the release location. This is illustrated in the 2010 aerial radiological survey showing the man-made signature of the BFa releases (Figure 2-1) (Stampahar, 2012).

### 2.4.2 Study Group 2, Small Boy Site

The Study Group 2 investigation will address fission products deposited onto surface soils from fallout from one atmospheric test, including activated soil products and unfissioned nuclear materials deposited onto the surrounding soil. Radionuclide contaminants that were initially deposited onto the soil surface may have subsequently been displaced through wind or water erosion of the soil. A depression at the immediate GZ has been observed to collect water and associated sedimentation in wetter periods.

The release of radionuclides from the tests was distributed in a defined, but irregular, pattern of surface contamination on the ground surface. This pattern extends from GZ in a northeast pattern that generally decreases in concentration with increased distance from the release location. Although generally decreasing in concentration, the pattern is irregular and not concentric. An anomalous radiologically elevated area of unknown source is also observed to the south of the Small Boy site. The anomalous area is believed to be part of the original deposition plume from the Small Boy test. Preliminary analytical information provided in Section 2.5.5 indicates that there is no significant difference between the plutonium (Pu)-239/240 to americium (Am)-241 ratios at each site. The physically separate anomalous area is more heavily vegetated than the surrounding area, and is believed to have resisted erosion of the original plume and may have trapped some of the contamination eroded from the interstitial area. This is illustrated in the 2010 aerial radiological survey showing the man-made (Figure 2-1) and Am-241 signatures (Figure 2-2) of the CAU 541 releases (Stampahar, 2012). It is noted that the concentric elevated Am-241 signature directly west of the Small Boy site resulted from the Hamilton test and is included in the CAU 573, Alpha Contaminated Sites, investigation.

### 2.4.3 Study Group 3, Spills and Debris

The Study Group 3 investigation will address the contamination associated with the debris present at both CAU 541 sites, including potential releases from lead bricks and lead-acid batteries. The identified lead items may contain exposed lead that is assumed to have the potential to release contamination to the surrounding surface and subsurface soil.

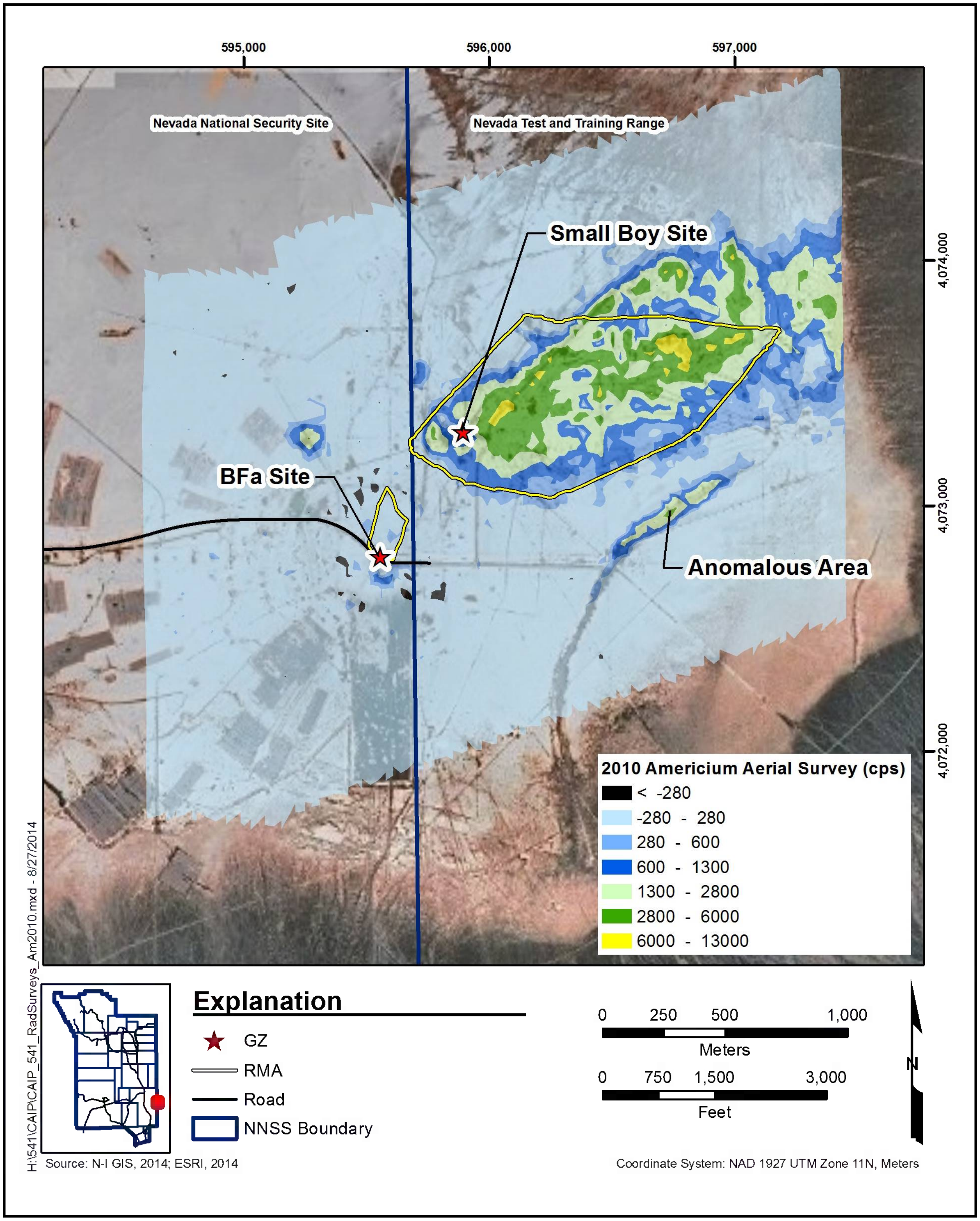


**Figure 2-2**
**CAU 541 Am-241 Aerial Data**

### 2.5 Investigative Background

All previous investigation data are assessed in the planning phase to identify bias used in the selection of appropriate sampling locations. A variety of radiation surveys were conducted in the CAU 541 area. These include aerial and terrestrial radiation surveys. Table 2-3 lists the method descriptions, advantages, limitations, spatial and spectral resolutions, measurement dates, and applied use for the different radiation surveys. The radiation surveys generated discrete measurement points (point data) with the spatial resolutions described in Table 2-3. See Figures 2-4, 2-5, and A.8-2 for the terrestrial radiological survey (TRS) point data results. For all aerial radiation surveys and for the field instrument for the detection of low-energy radiation (FIDLER) survey data (presented in Figure A.8-3), continuous spatial distributions (i.e., interpolated surfaces) are presented. These were estimated from the point data using an inverse distance weighted interpolation technique. Details of the surveys are also discussed in Sections 2.5.1 and 2.5.5.

**Table 2-3**
**Comparison of Radiation Survey Methods**
(Page 1 of 2)

| | FIDLER | PRM-470 | Aerial Radiological Survey |
|---|---|---|---|
| **Method Description Summary** | Ground-based instrument that detects low-energy gamma emissions | Ground-based organic plastic scintillator instrument that detects gamma emissions | Helicopter-mounted thallium-activated sodium iodide, gamma-ray scintillation detectors |
| **Advantages and Limitations** | Advantages: Lightweight hand-held instrument designed to see low-energy gamma emissions.<br>Limitations: Does not discriminate between low energy gamma emissions from different isotopes. | Advantages: Lightweight hand-held instrument that detects gamma emissions.<br>Limitations: Does not distinguish between the radionuclides emitting the gamma emissions. | Advantages: Gives a wide area of view (as opposed to ground-based surveys); can survey large areas quickly.<br>Limitations: Because it is elevated and moving at a fast rate, does not distinguish small localized areas of contamination or materials that are contaminated. |
| **Spatial Resolution** | Held at ~6 in. above ground surface, has a small field of view | Held at ~1 m above ground surface, has a small field of view | Altitude: 15 m above ground surface<br>Line Spacing: 23 m<br>30-m diameter window |
| **Spectral Resolution** | 10 to 100 keV | All gamma emitters | 38 to 3,026 keV |
| **Measurement Date** | July 2012 | July 2012 | 2010 |

**Table 2-3**
**Comparison of Radiation Survey Methods**
(Page 2 of 2)

| | FIDLER | PRM-470 | Aerial Radiological Survey |
|---|---|---|---|
| **Applied Use** | Energies in the 59-keV range, which are indicative of Am-241 or other higher-energy emitters; used to identify Am-241 contamination as an indicator of plutonium contamination | Nondiscriminatory gamma count used to identify contamination from nuclear testing | For Am-241: Processed for energies in the 57- to 70-keV range (Am-241) relative to the 38- to 50-keV and 70- to 82-keV background windows. Used to identify Am-241 contamination as an indicator of plutonium contamination.<br>For man-made: Processed for energies in the 38- to 1,294-keV window relative to the 1,394- to 3,026-keV background window. Used to identify contamination from nuclear testing. |

Source: N-I GIS, 2014; BN, 1999b; Riedhauser, 1999; Buchheit and Marianno, 2005; TSA Systems, 2005

keV = Kiloelectron volt
m = Meter

In accordance with the graded approach described in the Soils QAP (NNSA/NSO, 2012), the quality required of a dataset will be determined by its intended use in decision making. Terrestrial and aerial radiological survey data are classified as decision supporting and are not used, by themselves, to make corrective action decisions. However, the radiation surveys are used to identify bias used in the selection of sample locations and will be evaluated for use in defining corrective action boundaries in the investigation report. For defining corrective action boundaries, the radiation surveys will be used only in terms of defining a relative spatial distribution of contamination.

The aerial radiation surveys provide spectral information that was used to differentiate specific isotopic signatures. This allows the separate mapping of Am-241 and man-made gamma activity within the surveyed areas. The presence of Am-241 is used as an indicator of the potential presence of plutonium contamination.

The radionuclide activity in this area is due to a combination of fission products (primarily high-energy gamma radiation) and unfissioned nuclear material (primarily low-energy gamma, beta, and alpha radiation). The sources of these radiation types are not necessarily co-located (see Section A.2.2.3).

The following subsections summarize additional investigations previously conducted at or near CAU 541.

### 2.5.1 Aerial Radiological Surveys

Aerial radiological surveys were conducted at the NNSS to characterize the radiation exposure. Aerial radiological surveys were initially conducted within Area 5 of the NNSS in 1994 (BN, 1999) and at the NTTR, Range 65C in 1997 (BN, 1997). A subsequent survey was performed in 2010 that covered both the NNSS and NTTR areas within this CAU (Stampahar, 2012). These flyover data provide coverage of the entire CAU and were processed to produce man-made contamination and americium concentration data layers. Details of each survey are provided below.

These aerial surveys were designed to characterize the radiation exposure (BN, 1997 and 1999; Stampahar, 2012) observed on the NNSS and NTTR. A review of the data reveals that the overall pattern of the radiological distribution has not changed significantly from the initial 1994 and 1997 surveys to the 2010 survey. The 2010 data provide the best resolution of the aerial surveys conducted, as this survey was performed at the lowest altitude with the tightest line spacings. For this reason, the data from the 2010 aerial survey are referenced throughout the document. The data from the aerial radiological signatures may be used in the biasing of sample locations or for defining the releases for all study groups.

The aerial radiological surveys conducted in the CAU 541 test areas include the following details:

- An aerial radiological survey was conducted in 1994 for Area 5 of the NNSS by flying along a set of parallel flight lines spaced 150 m apart at 60 m above ground level (agl). The purpose of the survey was to provide a detailed measurement of the natural background gamma radiation levels and areas of man-made activity at the site (BN, 1999).
- An aerial radiological survey was conducted in 1997 for the NTTR (Range 65C) by flying along a set of parallel flight lines spaced 260 m apart at 150 m agl. The purpose of the survey was to measure and document the gamma radiation levels of the area (BN, 1997).
- An aerial radiological survey was conducted in 2010 by flying along a set of parallel flight lines spaced 23 m apart at 15 m agl. The purpose of the survey was to measure, map, and define the areas of man-made gamma and Am-241 activity. Americium levels were measured as an analog to determine the areas of plutonium contamination. It should be noted that no Am-241 was detected at the BFa site (Stampahar, 2012).

This 2010 aerial survey shows that the highest level of gamma radiation are detected at GZ at the BFa test location. Figure 2-1 shows the results of the 2010 aerial survey depicting the man-made count data, and shows the concentric area of concentration around the BFa GZ. This survey also shows the more scattered and less concentric radiation detected northeast of the Small Boy GZ.

Figure 2-2 displays the results of the 2010 aerial survey depicting the Am-241 data. The areas of increased Am-241 activity shown in the survey are located northeast of the Small Boy GZ (CAS 05-45-03) in a defined but non-concentric pattern. The values in the lowest contour range (represented by the darkest areas in the figure near the BFa site) are not indicative of actual Am-241 presence or absence (note the negative counts per second for this level in the legend). These negative values result from an algorithm that corrects the Am-241 response for the presence of europium and are indicative of the limitations of this method to detect Am-241 at these locations.

### *2.5.2 Radionuclide Inventory and Distribution Program*

The Radionuclide Inventory and Distribution Program (RIDP) (McArthur and Mead, 1989) and Nevada Applied Ecology Group (NAEG) (Friesen, 1992) conducted an investigation from 1981 through 1986 that estimated the inventory of man-made radionuclides at the NNSS through *in situ* gamma spectroscopy (McArthur and Mead, 1989). These RIDP data (corrected to August 6, 1990) were extrapolated to estimate levels of plutonium only on the NNSS portion of Frenchman Flat playa as shown on Figure 2-3. The data from the Frenchman Flat playa area include the NNSS section of CAU 541 and other tests (Hamilton and Able) performed in the area. Similar data are not available for the NTTR.

Data collected for the RIDP and by the NAEG in the 1980s allowed for estimates of surface soil inventories throughout the NNSS. The RIDP estimated the inventory through *in situ* soil measurements by gamma spectroscopy and limited confirmatory soil sampling (McArthur and Mead, 1987; Gray et al., 2007). Estimates of the primary radiological soil contaminants detected at Frenchman Lake are provided from the investigation. At locations where soil samples were collected, four increments to a total sampling depth of 15 cm were collected. (McArthur and Mead, 1989; Gray et al., 2007). Results for the subsurface sampling generally showed a trend of radiological activity decreases with depth with the highest activity commonly found within the top 0 to 5 cm.

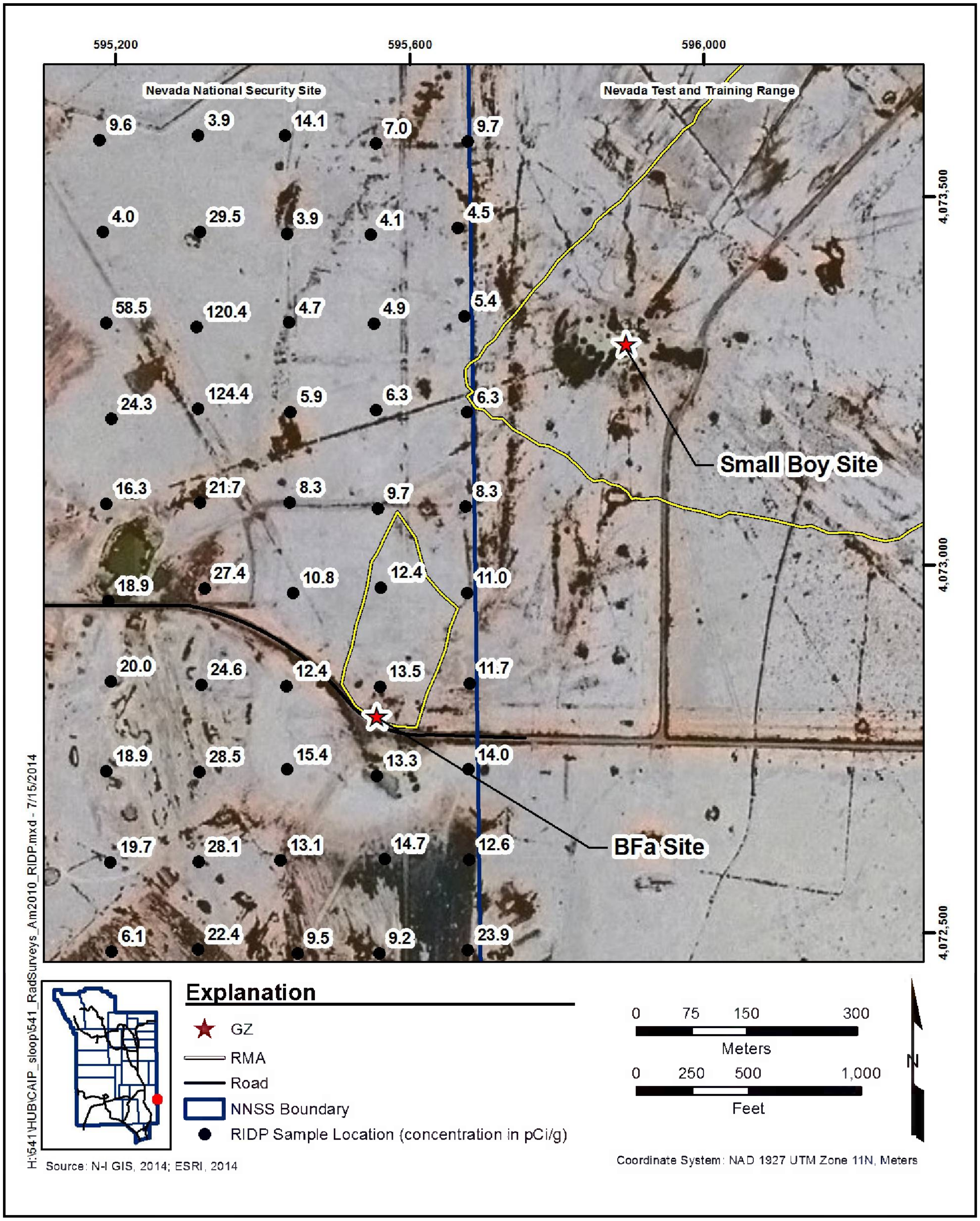


**Figure 2-3**
**CAU 541 RIDP Results**

Although the RIDP data present a general distribution of contamination, there is not sufficient resolution to provide bias in selecting CAU 541 sample locations. In accordance with the graded approach described in the Soils QAP (NNSA/NSO, 2012), RIDP data are classified as informational, and do not directly affect DQOs but provide information to support conceptual models and guide investigations. The RIDP data are used as general background information for the two sites.

### *2.5.3 Desert Research Institute Geochemistry Study*

The Desert Research Institute (DRI) performed a geochemistry study for isotopic analysis of standing water on the Frenchman Flat playa (Hershey et al., 2013). This study examined residual radionuclides during periods of lakebed inundation that may occur during the winter precipitation period (October through March). The study also examined changes in inundation extent between Landsat satellite flyover (imagery) data correlated to monthly precipitation totals; analyzed isotopic and major ion data from collected water samples; characterized suspended and precipitated materials; and modeled water-soil geochemical reactions, as well as mobility of select radionuclides under aqueous conditions. The study concluded the following: (1) residual radionuclides on the dry playa surface may become submerged, allowing water-soil interaction that could provide a mechanism for both horizontal and vertical transport of radionuclides away from known areas of contamination; (2) based on the isotopic data, a significant portion of standing water (approximately 40 percent) on the playa did not evaporate during periods of inundation but rather infiltrated into the subsurface; and (3) infiltration of water from the playa during inundation into the subsurface does not necessarily imply that groundwater recharge is occurring, but it does provide a mechanism for moving residual radionuclide downward into the subsurface of Frenchman Flat playa.

### *2.5.4 CAU 106 Investigation*

In 2011, a study was conducted by the NNSA, Nevada Environmental Restoration Project at CAU 106, Areas 5, 11 Frenchman Flat Atmospheric Sites, for the Able test (NNSA/NSO, 2011). This test was similar to the BFa site in that it was an atmospheric test and is located approximately 1,955 ft west of the BFa site. The Able test was an airdrop conducted on April 1, 1952, and consisted of the atmospheric deposition of radionuclides to the surface soil from the detonation of a weapons-effect test with a 1-kt yield at 800 ft above ground surface (DOE/NV, 2000). The investigation was of the radionuclide release and other non-test releases at this site to determine whether COCs were present.

Investigation activities included TRSs, geophysical surveys, field screening (to include an evaluation of buried contamination), visual inspections, and soil sampling. It was concluded through field screening that none of the subsurface aliquots exceeded field-screening levels (FSLs), indicating buried contamination is not a concern at Able. The CAU 106 study also concluded that the surface radiological contamination at the site does not exceed the FAL of 25 millirem per Industrial Area year (mrem/IA-yr) (see Section 3.1.1), and no corrective actions were required.

### *2.5.5 CAU 541 Preliminary Investigation*

A preliminary field investigation was completed in the CAU 541 test area in 2012. This effort included TRSs, visual surveys, and a limited sampling event. During the visual surveys, which included both the BFa and Small Boy sites, photographs were taken and site conditions were noted. Radiological surveys were performed around the two test areas and the anomalous area to the south of Small Boy.

The TRS were performed around the GZ areas, around the RMAs located at both site GZs, and through the plumes detected by aerial radiological surveys. To the south of the Small Boy site, TRSs were completed through and around the anomalous radiological area. The appropriate radiological instruments were used to detect the suspected contaminants at a particular location. Specifically, the PRM-470 and FIDLER were used within the area where tests were conducted. The PRM-470 was used more extensively around the BFa GZ where the man-made gamma signature was most pronounced. The FIDLER was used more extensively at the Small Boy site and anomalous area where the Am-241 signature was more strongly detected. Figures 2-4 and 2-5 show the results of the TRSs from the PRM-470 and FIDLER radiological instruments, respectively.

In accordance with the graded approach described in the Soils QAP (NNSA/NSO, 2012), TRS data are classified as decision supporting, and will be used for sample location planning and preliminary corrective action boundary identification.

Each of the two study groups associated with atmospheric testing has unique characteristics that result in certain survey data being optimal for use in biasing information. Study Group 1 at the BFa site is related to high-yield tests that resulted in the deposition of fission products (primarily cesium and strontium) and activation products (primarily cobalt and europium). Study Group 2 at the Small

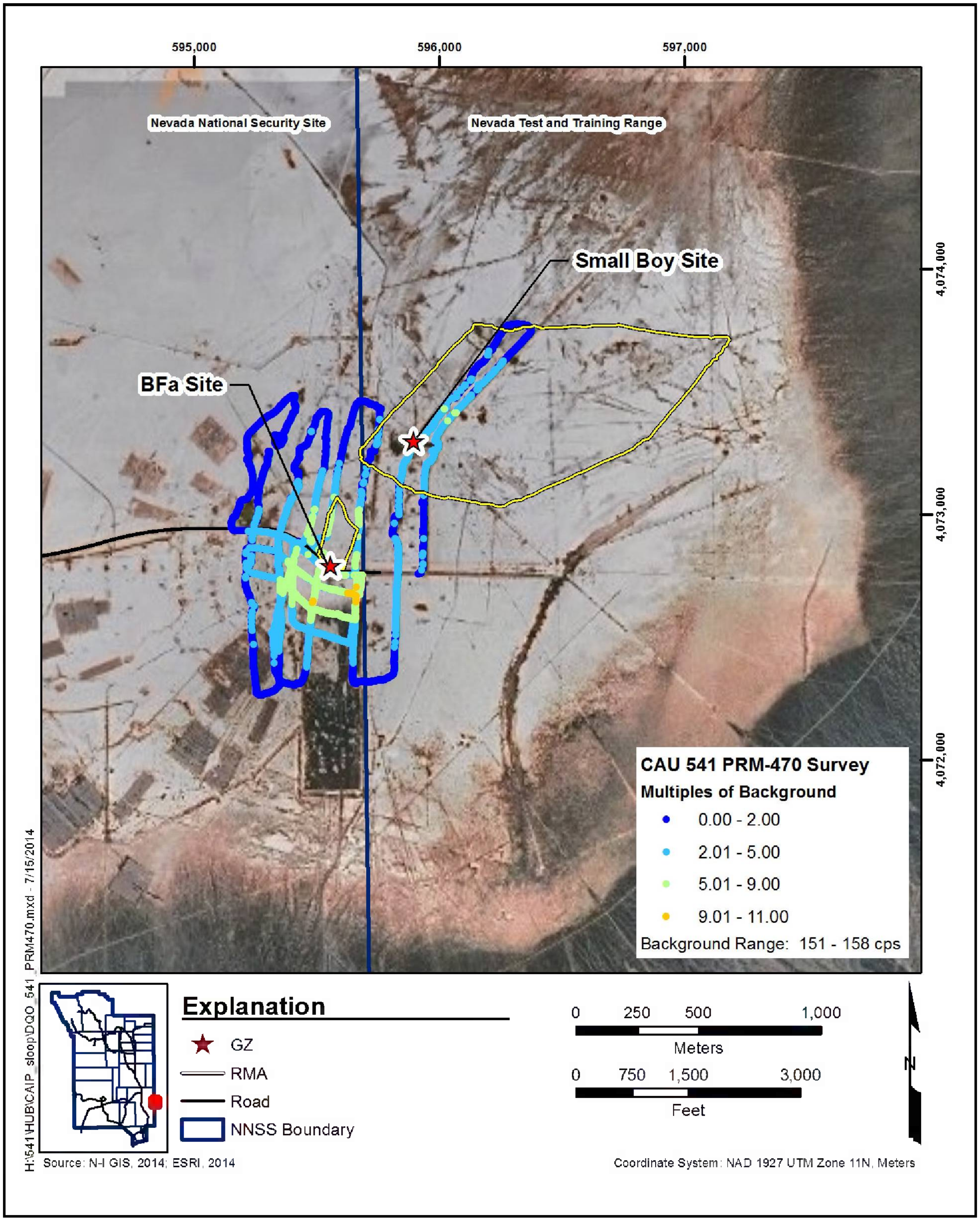


**Figure 2-4**
**CAU 541 PRM-470 Survey Results**

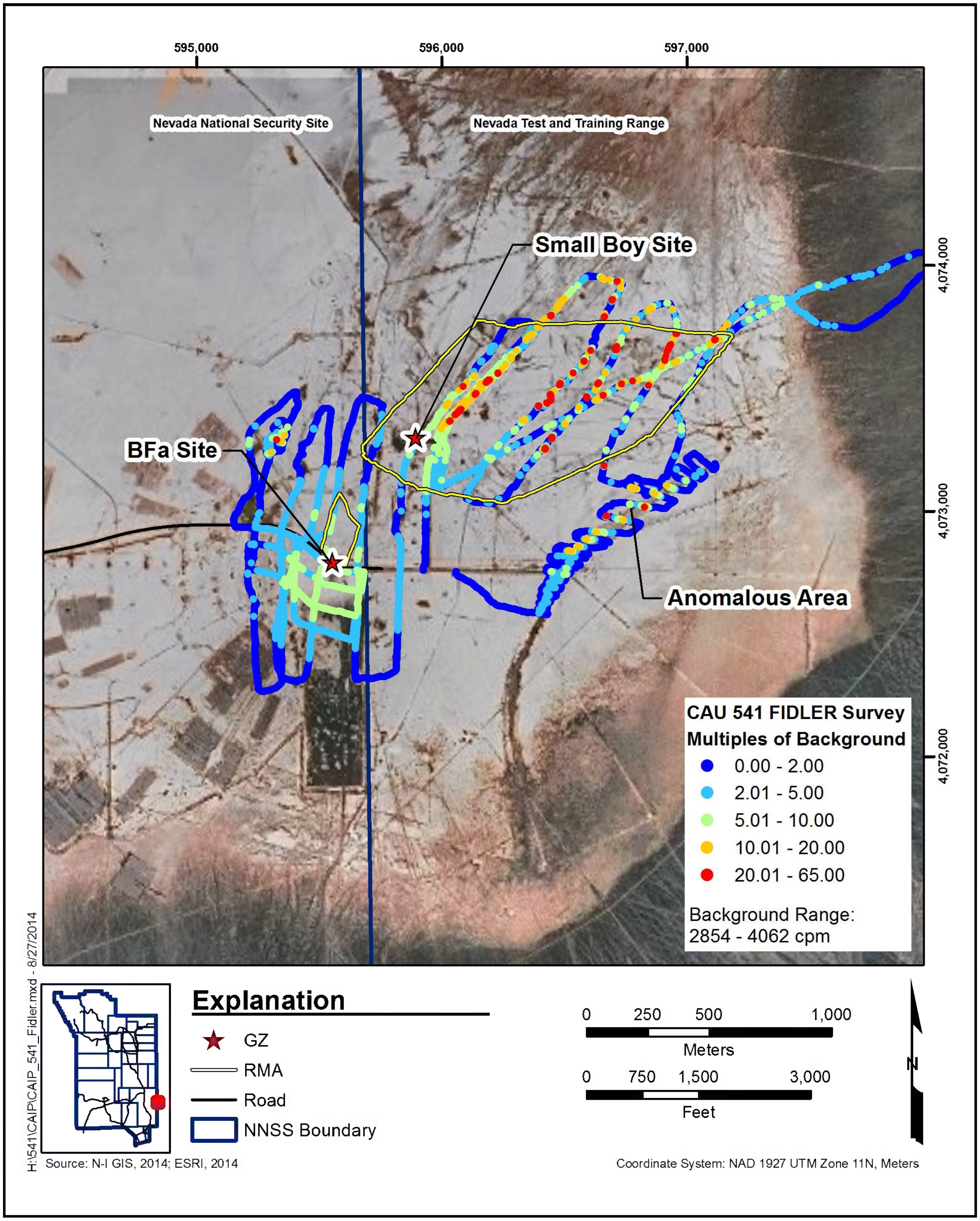


**Figure 2-5**
**CAU 541 FIDLER Survey Results**

Boy site is related to a low-yield test that resulted in the deposition of fissioned and unfissioned products (primarily Am-241). For Study Group 1 and the fissioned material from Study Group 2, the man-made spectra are of the greatest use in delineating the spatial distribution of fissioned material contaminants. Therefore, the aerial survey or the PRM-470 TRS have provided bias in determining sample locations for the investigation of fissioned products. For the unfissioned products at Study Group 2 (to include the anomalous area), the americium spectra is of greatest use in delineating the spatial distribution of unfissioned product contaminants. Therefore, the aerial survey or the FIDLER TRS has provided bias in determining sample locations for the investigation of unfissioned products.

Two grab samples of soil were collected on September 2012 at the Small Boy site. One sample was collected from each the defined plume from the test and the anomalous radiological area to the south. Samples were analyzed for isotopic uranium, americium, and plutonium along with gamma-emitting radionuclides. The samples were collected to gather preliminary information regarding the variability between radionuclides located at each of the areas. Results for the gamma spectroscopy and isotopic analysis indicate similar radionuclide contamination at each site with decreasing levels observed at the anomalous area to the south when compared to the Small Boy GZ area. For example, isotopic results for Pu-239/240 at Small Boy were 8,900 picocuries per gram (pCi/g) as compared to 2,500 pCi/g at the anomalous area to the south. Cesium levels at the Small Boy site were reported at 493 pCi/g while measuring 153 pCi/g at the area to the south. Isotopic uranium (U)-234, -235, and -238 were not detected at either site. A calculation of the ratio of isotopic Pu-239/240 to Am-241 at each site revealed similar ratio results that were within the analytical reporting errors. Additional sampling will be performed during the CAI to fully characterize the site.

During the visual survey, photographs were taken and site conditions noted at both CASs. Scattered metal, concrete, structures, testing-related debris, asphalt, and lead items were identified during the visual survey. A Global Positioning System (GPS) was used to obtain coordinates of debris and structures. Although numerous items and debris were documented, this effort was not a comprehensive inventory of the debris within the CAU 541 area.

### 2.5.6 National Environmental Policy Act

The *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE/NV, 1996) includes site investigation activities such as those proposed for CAU 541.

The *Renewal of the Nellis Air Force Range Land Withdrawal, Legislative Environmental Impact Statement* (USAF, 1999) designates four contaminated areas of the NTTR, to include Small Boy, that are subject to the terms of the FFACO (FFACO, 1996). This document states that USAF, DOE, and NDEP have agreed that military future land-use scenarios will be used for the soil sites on the NTTR and that a dose criteria of 25 mrem/equivalent man/yr and the RESRAD computer program will be used to calculate a corrective action level, where appropriate.

In accordance with the NNSA/NFO *National Environmental Policy Act* (NEPA) Compliance Program, a NEPA checklist will be completed before beginning site investigation activities at CAU 541. This checklist requires NNSA/NFO activity personnel to evaluate their proposed activities against a list of potential impacts that include, but are not limited to, air quality, chemical use, waste generation, noise level, and land use. Completion of the checklist results in a determination of the appropriate level of NEPA documentation by the NNSA/NFO NEPA Compliance Officer. This will be accomplished before mobilization for the field investigation.

# 3.0 Objectives

This section presents an overview of the DQOs for CAU 541 and formulation of the CSM. Also presented is a summary listing of the contaminants of potential concern (COPCs), the preliminary action levels (PALs), and the process used to establish FALs. Additional details and figures depicting the CSM are located in Appendix A.

## 3.1 Conceptual Site Model

The CSM describes the most probable scenario for current conditions at each site and defines the assumptions that are the basis for identifying the future land use, contaminant sources, release mechanisms, migration pathways, exposure points, and exposure routes. The CSM was used to develop appropriate sampling strategies and data collection methods. The CSM was developed for CAU 541 using information from the physical setting, potential contaminant sources, release information, historical background information, knowledge from similar sites, and physical and chemical properties of the potentially affected media and COPCs. (See Figure A.2-1 for a representation of the conceptual pathways to receptors from CAU 541 sources and Figure A.2-2 for a graphical representation of the CSM.) If evidence of contamination that is not consistent with the presented CSM is identified during investigation activities the situation will be reviewed, CSM revised, DQOs reassessed, and a recommendation made as to how best to proceed. In such cases, decision makers listed in Section A.2.1 will be notified and given the opportunity to comment on and/or concur with the recommendation.

The following subsections discuss future land use and the identification of exposure pathways (i.e., combination of source, release, migration, exposure point, and receptor exposure route) for CAU 541.

### 3.1.1 Land-Use and Exposure Scenarios

Land-use zones where the CAU 541 sites are located dictate future land use, which restrict current and future land use to nonresidential (i.e., military or industrial) activities.

The portion of CAU 541 within NNSS boundaries is located in the land-use zone described as the "Research, Test, and Experiment Zone." This area is designated for small-scale research and development projects and demonstrations; pilot projects; outdoor tests; and experiments for the development, QA, or reliability of material and equipment under controlled conditions. This zone includes compatible research, development, and testing activities (DOE/NV, 1998).

The NTTR is divided into two functional areas: North and South Range. The portion of CAU 541 within NTTR boundaries is located within the South Range. Lands in the South Range were withdrawn for military use. Sections of the South Range overlap a portion of the Desert National Wildlife Range established for the protection and preservation of desert bighorn sheep. The western boundary of the Desert National Wildlife Range lies approximately 1.9 mi east of the NNSS boundary. This portion of the range is used for military purposes and is not open to the public. This area includes land and facilities that provide general flexible support for USAF troop movement, testing, training, and experimentation (USAF, 1999).

Exposure scenarios for the CAU 541 sites have been categorized into the following four types based on current and projected future land uses. The exposure scenarios include a site-specific scenario (Ground Troops Scenario) based upon specialized usage of NTTR land:

- **Industrial Area.** This scenario addresses exposure to industrial workers exposed daily to contaminants in soil during an average workday. This scenario assumes that this is the regular assigned work area for the worker who will be on the site for an entire career (250 days per year, 8 hours per day, for 25 years). The total effective dose (TED) calculated using this exposure scenario is the TED an industrial worker receives during 2,000 hours of annual exposure to site radioactivity and contaminants and is expressed in terms of millirem per Industrial Area year (mrem/IA-yr).

- **Remote Work Area.** This exposure scenario assumes noncontinuous work activities at a site. This scenario addresses exposure to industrial workers exposed to contaminants in soil during a portion of an average workday. This scenario assumes that this is an area where the worker regularly visits but is not an assigned work area where the worker spends an entire workday. A site worker under this scenario is assumed to be on the site for an equivalent of 336 hours (or 42 days) per year for an entire career (25 years). The TED calculated using this exposure scenario is the TED a remote area worker receives during 336 hours of annual exposure to site radioactivity and is expressed in terms of millirem per Remote Work Area Year (mrem/RW-yr).

- **Occasional Use Area.** This exposure scenario assumes occasional work activities at a site. This scenario addresses exposure to industrial workers who are not assigned to the area as a regular worksite but may occasionally use the site. This scenario assumes that this is an area where the worker does not regularly visit but may occasionally use for short-term activities. A site worker under this scenario is assumed to be on the site for an equivalent of 80 hours (or 10 days) per year for 5 years. The TED calculated using this exposure scenario is the TED an occasional use area worker receives during 80 hours of annual exposure to site radioactivity and is expressed in terms of millirem per Occasional Use Area year (mrem/OU-yr).

- **Ground Troops Scenario:** This site-specific exposure scenario assumes noncontinuous work activities at a site. This scenario addresses exposure to military ground troops who are not assigned to the area as a regular worksite, but would regularly visit for an entire workday. A site worker under this scenario is assumed to be on the site for an equivalent of 1,008 hours (24 hours per day, 14 days per deployment, for 3 deployments per year). The TED calculated using this scenario is the TED a military ground troop receives during 1,008 hours of annual exposure to site radioactivity and is expressed in terms of millirem per Ground Troops year (mrem/GT-yr).

The CAU 541 land-use zone and exposure scenarios are based on current and future land use at the NNSS and NTTR. CAU 541 is a remote location without any site improvements and where site-specific work will be potentially performed. Operational activity at the NTTR will result in the USAF need to safely conduct outdoor troop operations. Troops could occupy these locations as a regular worksite on a temporary basis such as for the performance of military exercises. Troop movement may include being dropped off within the site, or deployment elsewhere and then movement through or in the vicinity of the site. It is also assumed that ground troop activity will include digging shallow depressions or berms and/or bivouacking on the site. Therefore, this site is classified using the site-specific use of Ground Troops Scenario.

### *3.1.2 Contaminant Sources*

Contaminant sources for CAU 541 CASs are the releases identified in Section 2.4 of radiological contamination to the atmosphere and soil as a result of weapons-effects and weapons-related nuclear tests.

### *3.1.3 Release Mechanisms*

The release mechanisms for the test releases consist of the atmospheric detonation of nuclear materials that deposited contamination onto the soil surfaces. In addition, the Small Boy site may include prompt injection of radionuclides into near subsurface soils from the nuclear test. At the BFa site, the six detonations (Encore, Grable, MET, Priscilla, Wrangell, and Sanford) were co-located and resulted in contamination to the surface soil. Because these tests were conducted at a minimum height of 400 ft, prompt injection is anticipated to be less pronounced. As a result of the tests being performed in close proximity to one another, the surface deposition of contaminants from these tests resulted in plumes of overlapping contamination. The release is expected to be radially distributed outward from the shared GZ at the BFa site. At the Small Boy site, the single detonation resulted in contamination to the surface soil. The release is expected to be in a defined, but more scattered, area distributed outward from the GZ with a significant bias toward the northeast.

Surface wind speeds at the time of the seven tests were generally recorded as calm to 6 miles per hour (mph) in varying directions. The one exception was the MET test with a surface wind speed of 16 mph. Post-test radiological contours for all tests show the prevailing onsite fallout pattern as concentric to GZ or trending to the northeast. Onsite fallout patterns for tests Encore, Grable, Wrangell, and Sanford show concentric patterns to GZ with no detected directional trend. Fallout patterns for tests MET, Priscilla, and Small Boy show a detected direction to the northeast (GE, 1979).

Release mechanisms for the CASs in CAU 541 include neutron activation of soil, release of fission products, and release of unfissioned nuclear fuel from the detonation of nuclear devices. The atmospheric detonations irradiated the surrounding soil with neutrons, causing the activation of some elements in the soil (primarily europium [Eu]-152 and -154). For the atmospheric release, radionuclides with a low melting point (e.g., iodine) traveled significant distances before condensing and falling out of the plume, whereas those with higher melting points (e.g., cesium) condensed earlier and were deposited closer to GZ. The nuclear fuel that did not fission has a very high melting point and is generally found near GZ.

After the Wrangell test at the BFa site, it was reported that clean earth was hauled in and compacted as a decontamination effort before the final Sanford test was conducted four days later (Holmes & Narver, 1959). This activity resulted in the potential for buried contamination due to the mechanical disturbance of soil.

Release mechanisms for the CSM are spills and leaks onto surface soils from equipment or stored materials. Materials stored in containers may have leaked or have been spilled.

### *3.1.4 Migration Pathways*

Potential migration pathways include the lateral migration of contaminants across the soil surface and the vertical migration of potential contaminants into the subsurface soils. Contaminants may also be moved through mechanical disturbance due to maintenance, construction, or decontamination activities at the site.

Surface migration pathways for CAU 541 include the lateral migration of potential contaminants across surface soils since the original deposition. Both CASs of CAU 541 are located on the Frenchman Flat playa (dry) lake bed. The site GZs are the most downgradient locations in the general area. Both immediate GZ areas are also observed to be slightly depressed in elevation when compared to the surrounding lake bed.

Drainages entering Frenchman Flat playa are generally dry but are subject to infrequent precipitation events. These events provide an intermittent mechanism for both vertical infiltration and lateral transport of contaminants. When the Frenchman Flat playa is inundated, residual radionuclides on the typically dry surface may become submerged, allowing water-soil interactions that could provide a mechanism for transport of radionuclides away from known areas of contamination (Hershey et al., 2013). Other migration pathways for contamination from the site include windborne material displaced from the surface.

Migration is influenced by physical and chemical characteristics of the contaminants and media. Contaminant characteristics include, but are not limited to, solubility, density, and adsorption potential. Media characteristics include permeability, porosity, water-holding capacity, sorting, chemical composition, and organic content. In general, contaminants with low solubility, high affinity for media, and high density can be expected to be found relatively close to release points. Contaminants with high solubility, low affinity for media, and low density can be expected to be found farther from release points. These factors affect the migration pathways and potential exposure points for the contaminants in the various media under consideration.

Infiltration and percolation of precipitation serve as driving forces for downward migration of contaminants. However, due to high PET (annual PET at Area 5 has been estimated at 66 in. [BN, 2001]) and limited precipitation for this region (4.88 in. per year [ARL/SORD, 2014]), percolation of infiltrated precipitation at the NNSS does not provide a significant mechanism for vertical migration of COCs to groundwater (DOE/NV, 1992).

Subsurface migration pathways at CAU 541 are expected to be predominately vertical, although spills or leaks at the ground surface may also have limited lateral migration before infiltration. The depth of infiltration (shape of the subsurface contaminant plume) will be dependent upon the type, volume, and duration of the discharge as well as the presence of relatively impermeable layers that could modify vertical or lateral transport pathways, both on the ground surface (e.g., concrete) and in the subsurface (e.g., clay or caliche layers). For surface contamination to reach the water table, the contaminants would have to be dissolved in infiltrating precipitation and then be transported through the alluvium that extends the entire unsaturated thickness of 600 ft bgs at Frenchman Flat playa (Hevesi et al., 2003).

### 3.1.5 Exposure Points

Exposure points for the CSM are expected to be areas of surface contamination where visitors and site workers may come in contact with contaminated surface soil. Subsurface exposure points may exist if construction workers come in contact with contaminated media during excavation activities.

### 3.1.6 Exposure Routes

Exposure routes to site workers include ingestion and inhalation from disturbance of, or direct contact with, contaminated media. Site workers may also be exposed to direct ionizing radiation by performing activities in proximity to radioactive materials.

### 3.1.7 Additional Information

Information concerning topography, geology, climatic conditions, hydrogeology, floodplains, and infrastructure at the CAU 541 sites is presented in Section 2.1 as it pertains to the investigation. This information has been addressed in the CSM and will be considered during the evaluation of CAAs, as applicable. Climatic and site conditions (e.g., surface and subsurface soil descriptions) as well as specific site conditions will be recorded during the CAI. Areas of erosion and deposition will be qualitatively evaluated to provide additional information on potential migration of contamination.

### 3.2 Contaminants of Potential Concern

The COPCs for CAU 541 are defined as the contaminants reasonably expected at the site that could contribute to a dose or risk exceeding FALs. The contaminants that could reasonably be suspected to be present within the BFa test release (Encore, Grable, MET, Priscilla, Wrangell, and Sanford) include cesium (Cs)-137; Eu-152, -154, -155; and U-234 and U-235. The contaminants that could reasonably be suspected to be present within the Small Boy experiment release include the isotopes above as well as U-238; Pu-238, -239/240, -241; and Am-241.

These COPCs were identified during the planning process through the review of site history, process knowledge, personal interviews, past investigation efforts (where available), and inferred activities associated with the CASs and other releases (including those that may be discovered during the investigation). Other specific COPCs (and subsequently the analyses requested) will be determined for discovered potential releases based on the nature of the potential release (e.g., hydrocarbon stain, lead bricks).

Although not suspected to be present, analysis for other COPCs will be performed to eliminate the possibility of their presence due to an incomplete history of site testing operations as discussed in Section A.2.2.2. These COPCs were added to the analysis because they are either activation products in soil or may have been used as tracers and/or surrogates.

These COPCs will be reported by the analytical methods identified in Table A.2-3 for environmental samples taken at each of the sites. The analytes reported for each analytical method are listed in Table A.2-4.

### 3.3 Preliminary Action Levels

The PALs presented in this section are to be used for site screening purposes. They are not necessarily intended to be used as cleanup action levels or FALs. However, they are useful in screening out contaminants that are not present in sufficient concentrations to warrant further evaluation, thereby streamlining the consideration of remedial alternatives. The RBCA process used to establish FALs is described in the Soils RBCA document (NNSA/NFO, 2014). This process conforms with *Nevada Administrative Code* (NAC) 445A.227, which lists the requirements for sites with soil contamination (NAC, 2012a). For the evaluation of corrective actions, NAC 445A.22705 (NAC, 2012b) requires the use of ASTM International (ASTM) Method E1739 (ASTM, 1995) to "conduct an evaluation of the site, based on the risk it poses to public health and the environment, to determine the necessary remediation standards or to establish that corrective action is not necessary." For the evaluation of corrective actions, the FALs are established as the necessary remedial standard.

This RBCA process, summarized in Figure 2-6, defines three tiers (or levels) of evaluation involving increasingly sophisticated analyses:

- **Tier 1 evaluation.** Sample results from source areas (highest concentrations) are compared to action levels based on generic (non-site-specific) conditions (i.e., the PALs established in the CAIP). The FALs may then be established as the Tier 1 action levels, or the FALs may be calculated using a Tier 2 evaluation.
- **Tier 2 evaluation.** Conducted by calculating Tier 2 action levels using site-specific information as inputs to the same or similar methodology used to calculate Tier 1 action levels. The Tier 2 action levels are then compared to individual sample results from reasonable points of exposure (as opposed to the source areas as is done in Tier 1) on a point-by-point basis. Results from total petroleum hydrocarbons analyses will not be used for risk-based decisions under Tier 2 or Tier 3. Rather, the individual chemical constituents of diesel reported from volatile organic compound (VOC) and semivolatile organic compound (SVOC) analyses will be compared to the action levels.
- **Tier 3 evaluation.** Conducted by calculating Tier 3 action levels on the basis of more sophisticated risk analyses using methodologies described in Method E1739 that consider site-, pathway-, and receptor-specific parameters.

This RBCA process includes a provision for conducting an interim remedial action if necessary and appropriate. The decision to conduct an interim action may be made at any time during the investigation and at any level (tier) of analysis. Concurrence of the decision makers listed in Section A.2.1 will be obtained before any interim action is implemented. Evaluation of DQO decisions will be based on conditions at the site after any interim actions are completed. Any interim actions conducted will be reported in the investigation report.

If, after implementation of corrective actions, contamination remains in place that is less than the site-specific exposure scenario based FAL but exceeds 25 millirem per year (mrem/yr) based on the

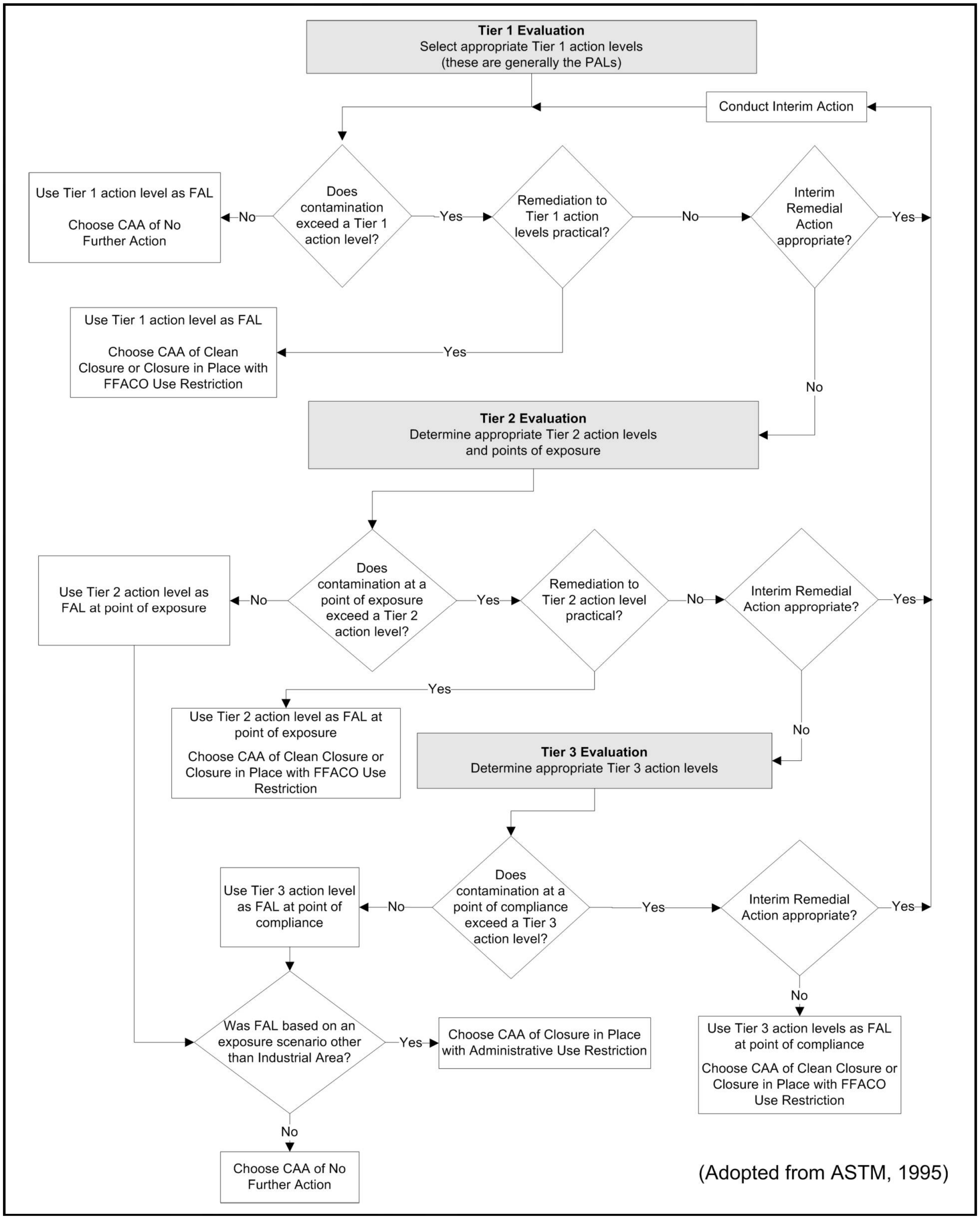


**Figure 2-6**
**RBCA Decision Process**

Ground Troops exposure scenario, an administrative use restriction will be implemented to prevent future industrial use of the area. For this reason, contamination at all sites will be evaluated against Ground Troops scenario based PALs and site-specific exposure scenario based FALs. The FALs (along with the basis for their selection) will be proposed in the investigation report, where they will be compared to laboratory results in the evaluation of potential corrective actions.

### *3.3.1 Chemical PALs*

Except as noted herein, the chemical PALs are defined as the U.S. Environmental Protection Agency (EPA) Region 9 Regional Screening Levels for chemical contaminants in industrial soils (EPA, 2014). Background concentrations for RCRA metals will be used instead of screening levels when natural background concentrations exceed the screening level, as is often the case with arsenic on the NNSS. Background is considered the mean plus two standard deviations of the mean for sediment samples collected by the Nevada Bureau of Mines and Geology throughout the NTTR (NBMG, 1998; Moore, 1999). For detected chemical COPCs without established screening levels, the protocol used by EPA Region 9 in establishing screening levels (or similar) will be used to establish PALs. If used, this process will be documented in the investigation report.

### *3.3.2 Radionuclide PALs*

The PAL for radioactive contaminants is a TED of 25 mrem/yr, based upon the Ground Troops scenario. The Ground Troops exposure scenario is described in Section 3.1.1. The TED is calculated as the sum of external dose and internal dose. External dose is determined directly from TLD measurements. Internal dose is determined by comparing analytical results from soil samples to RRMGs that were established using the RESRAD computer code (Yu et al., 2001). RRMGs are radionuclide-specific values for radioactivity in surface soils. The RRMG is the value, in picocuries per gram of surface soil, for a particular radionuclide that would result in an internal dose of 25 mrem/yr to a receptor (under the appropriate exposure scenario) independent of any other radionuclide (assuming that no other radionuclides contribute dose). The calculated RRMGs for the site-specific exposure scenario are listed in Appendix C. The site-specific input parameters used to calculate the RRMGs are provided in Appendix D. The overall risk-based evaluation process is provided in the Soils RBCA document (NNSA/NFO, 2014).

### 3.4 DQO Process Discussion

This section contains a summary of the DQO process that is presented in Appendix A. The DQO process is a strategic planning approach based on the scientific method that is designed to ensure that the data collected will provide sufficient and reliable information to identify, evaluate, and technically defend the recommendation of viable corrective actions (e.g., no further action, clean closure, or closure in place).

As presented in Section 1.1.2, the DQOs address two types of potential contaminant release types. Although Study Groups 1 and 2 will both be investigated through a combination of probabilistic and judgmental sampling, the differences in radiological releases indicate separate studies to characterize COPCs. Therefore, discussions related to these two types of releases are presented separately.

The DQO strategy for CAU 541 was developed at a meeting on April 1, 2014. DQOs were developed to identify data needs, clearly define the intended use of the environmental data, and to design a data collection program that will satisfy these purposes. During the DQO discussions for this CAU, the informational inputs or data needs to resolve problem statements and decision statements were documented.

The problem statement for CAU 541 is as follows: "Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs in CAU 541." To address this problem statement, resolution of the following decision statements is required:

- **Decision I.** "Is any COC associated with the CAS present in environmental media?" If a COC is detected, then Decision II must be resolved.
- **Decision II.** "Is sufficient information available to evaluate potential CAAs?" Sufficient information is defined to include the following:
  - The lateral and vertical extent of COC contamination
  - The information needed to determine potential remediation waste types
  - The information needed to evaluate the feasibility of remediation alternatives

A corrective action will be determined for any release site containing a COC. The evaluation of the need for corrective action will include the potential for wastes that are present at the site to contain contaminants that, if released, could cause the surrounding environmental media to contain COCs.

Such a waste will be evaluated using the PSM criteria listed in the Soils RBCA document (NNSA/NFO, 2014) to determine the need for corrective action.

The informational inputs and data required to resolve the problem and decision statements were generated as part of the DQO process for this CAU and are documented in Appendix A. The information necessary to resolve the DQO decisions will be generated for each CAU 541 CAS by collecting and analyzing samples generated during a field investigation. The presence of a COC will be determined by collecting and analyzing samples from locations determined most likely to contain a COC (based on the presence of a biasing factor).

The judgmental sampling design will be used to collect samples from biased locations. Results from these locations can only be used to infer a characteristic (e.g., average concentration) of the sampled location (i.e., not an area). The characteristic normally used to define contamination at a location is the contaminant concentration or dose from a single sample or the average if more than one sample is collected from the location. When the sample is collected from the location of the greatest degree of the selected biasing factor (Section A.8.3), this represents the maximum dose or contaminant concentration at the release site.

A probabilistic sampling design will be used to collect samples from unbiased locations within an area that can be readily defined by distinct characteristics where the assumed distribution of contamination is relatively uniform. Results from these locations will be used to infer a characteristic representative of the sampled area as a whole (i.e., representing the average of the entire area, not the maximum at any one location). The characteristic normally used to define contamination within an area is the 95 percent UCL of the mean concentration or dose.

Protection against false-negative decision errors are provided by the following:

- Judgmental sampling when contamination concentrations or dose levels from locations of the greatest degree of the selected biasing factor are used to make decisions for a larger area (e.g., a release site).
- Probabilistic sampling when the 95 percent UCL of the mean concentration or dose is used to make decisions for the defined sampling area.

Decisions are even more conservative when probabilistic results (i.e., 95 percent UCL) from biased locations are used to make a decision on the presence of COCs for the entire release site. This is typically the case when the 95 percent UCL of contamination at a sample plot located in the area of the highest radiation survey values is used to resolve the decision on the presence of COCs (i.e., Decision I).

For the Study Groups 1 and 2, it is unknown whether COCs are present and Decision I sampling will be conducted. If COCs are identified, Decision II must be resolved for these study groups.

For Study Group 3, Decision I samples will be submitted to analytical laboratories to determine the presence of COCs. The specific analyses for samples from Study Group 3 will be selected dependent upon the type and nature of the identified release. Decision II samples for both release scenarios will be submitted as necessary to define the extent of unbounded COCs. In addition, samples will be submitted for analyses, as needed, to support waste management or health and safety decisions.

For the laboratory data, the data quality indicators (DQIs) of precision, accuracy, representativeness, completeness, comparability, and sensitivity needed to satisfy DQO requirements are discussed in the Soils QAP (NNSA/NSO, 2012). Laboratory data will be assessed in the investigation report to confirm or refute the CSM and determine whether the DQO data needs were met.

# 4.0 Field Investigation

This section contains a description of the activities to be conducted to gather and document information from the CAU 541 field investigation.

## 4.1 Technical Approach

The information necessary to satisfy the DQO data needs will be generated for CAU 541 by collecting and analyzing samples generated during a field investigation. The presence and nature of contamination decision (Decision I) will be a judgmental decision determined using sample results from biased locations under a judgmental sampling design. For sample plot locations, each Decision I sample plot will generate a TED value for the judgmental decision that represents the population of doses within the 100-square-meter ($m^2$) area of the sample plot. This representative TED value will be determined using probabilistic sampling design to generate a 95 percent UCL of the average TED within the plot area. For grab sample locations, DQO decisions will be based on a direct comparison of sample results to the FAL.

The extent of COC contamination portion of Decision II will be resolved using one of the methods listed in Section A.4.1. The extent of radiological COC contamination decision (Decision II) will be a probabilistic decision determined using Method 1 by correlating TED and radiological survey values as described in the Soils RBCA document (NNSA/NFO, 2014). This method will only be used if the correlation between TED and the survey values has a coefficient of determination ($r^2$) greater than 0.8. The statistical relationship among the correlated values can then be used to estimate a 95 percent lower confidence limit (LCL) of the correlation. The radiation survey value that intersects the LCL of the correlation at the TED value of 25 mrem/yr (under the appropriate exposure scenario) will be used as the radiation survey isopleth that defines the extent of contamination.

A correlation for each radiation survey will be established to identify the radiation survey that has the best correlation to TED values. This correlation will be used to establish a radiation survey value corresponding to the FAL when establishing a corrective action boundary or the PAL when establishing an administrative use restriction boundary.

The TED will be calculated using the methodologies described in the Soils RBCA document (NNSA/NFO, 2014).

Modifications to the investigative strategy may be required should unexpected field conditions be encountered at any site. Significant modifications must be justified and documented before implementation. If an unexpected condition indicates that conditions are significantly different from the CSM, the activity will be rescoped and the identified decision makers will be notified.

## 4.2 Field Activities

Field activities at CAU 541 include site preparation, sample location selection, sample collection, and demobilization.

### 4.2.1 Site Preparation Activities

Site preparation activities to be conducted before the start of environmental sampling may include relocating or removing minor surface debris; constructing hazardous waste accumulation areas (HWAAs) and site exclusion zones; providing sanitary facilities; constructing decontamination facilities; and moving staged equipment.

Before mobilization for collecting investigation samples, the following preparatory activities will also be conducted:

- Perform radiological surveys to identify bias used in selecting sample locations.
- Install activity-specific environmental monitoring TLDs (see Section 4.2.3 for additional information).
- Perform visual surveys at all sites within CAU 541 to identify any staining, discoloration, disturbance of native soils, or any other indication of potential contamination.

### 4.2.2 Sample Location Selection

Rationale for selecting areas for sampling is discussed in the following subsections. For all investigations, if a spatial boundary is reached, the CSM is shown to be inadequate, or the Site Supervisor determines that extent sampling needs to be reevaluated, then work will be temporarily suspended, NDEP will be notified, and the investigation strategy will be reevaluated.

The sampling strategy and the estimated locations of biased samples are presented in Appendix A. The Task Manager or Site Supervisor may modify the number, location, and spacing of step-outs as warranted by site conditions to achieve DQO criteria stipulated in Appendix A. Where sampling locations are modified, the justification for these modifications will be documented in the investigation report.

#### *4.2.2.1 Study Group 1, BFa Site*

Decision I will be evaluated by measuring TED within a sample plot established within the area of the highest radiological values as determined from the 2010 aerial survey (Stampahar, 2012) and/or a TRS conducted with a handheld instrument. This will be done in an effort to find the location where the internal dose contributes the greatest amount to TED. Based on the results of completed surveys or additional TRSs yet to be conducted, the Decision I sample plot at Study Group 1 will be placed at the location of the highest readings from the aerial survey or the PRM-470 TRS as shown on Figure A.8-2. One sample plot is planned at this location for the collection of soil samples to determine internal dose. A TLD will be placed in the center of the sample plot to determine the external dose. If the 95 percent UCL of the TED at the Decision I sample plot exceeds 25 mrem/IA-yr, a corrective action will be required and Decision II will be resolved. All soil samples collected at each sample plot will be sampled as described in Section 4.2.3.

Information for Decision II will be obtained by measuring TED at sample locations established in a selected pattern as presented in Figure A.8-2. TLDs will be placed in a vector pattern at the BFa site to measure the external dose. A vector pattern is proposed at this site as isotopes released from the tests consist of fission and activation products distributed in a roughly annular pattern around GZ. The sample vectors are designed to provide greater sample coverage closer to the probable decision area. The TLD placement will provide further data of the external dose present at this site.

Radionuclide contaminants that were initially deposited onto the soil surface that may have subsequently been displaced through erosion or mechanical disturbance will be investigated for buried contamination. This will be performed at one location by performing a subsurface analysis as presented in Figure A.8-2. A slight depression at the immediate GZ area is observed at this site that has been observed to collect water in wetter periods. Historical documentation was identified that shows clean soil may have been transported to the BFa site between tests for decontamination purposes (Holmes & Narver, 1959). In this depressed area, one location will be chosen, and samples will be screened at each 5-cm subsurface interval until native material is encountered or a significant reduction in radiological screening levels is measured. Samples will be screened and collected in accordance with Section 4.2.3.

#### *4.2.2.2 Study Group 2, Small Boy Site*

Decision I will be evaluated by measuring TED within a sample plot established within the areas of the highest radiological values at Small Boy and at the anomalous radiologically elevated area to the south. This will be done in an effort to determine whether TED exceeds the FAL. Based on the results of completed surveys or additional TRS yet to be conducted, one Decision I sample plot will be placed at the location of the highest readings at both the Small Boy site and at the anomalous elevated area to the south based upon the aerial survey or the FIDLER TRS. One sample plot is planned at each of these two locations as shown on Figure A.8-3 for the collection of soil samples to determine internal dose and to verify if the anomalous plume is a remnant of the Small Boy test. A TLD will be placed in the sample plot centers to determine the external dose. If the 95 percent UCL of the TED at the Decision I sample plots exceeds 25 mrem/IA-yr, a corrective action will be required and Decision II will be resolved.

Information for Decision II will be obtained by establishing approximately six Decision II sample plot and TLD locations judgmentally throughout the detected Small Boy plume to investigate surface soil contamination resulting from unfissioned nuclear materials. Locations will be selected based on isopleths determined from the FIDLER survey. As the FIDLER survey is a terrestrial radiological survey where the instrument is held at 6 to 8 in. above ground surface, it proves the highest resolution of the radiological surveys performed. Sample plots will be selected within high, medium, and low elevated areas within the Small Boy plume illustrated in Figure A.8-3. Samples will be collected at various low to high elevated areas to best represent the distribution of contamination as a result of the observed scattered pattern of contamination. These locations may be adjusted based on additional terrestrial radiological surveys to be conducted during the CAI. At the anomalous radiologically elevated area to the south, any required Decision II investigation will consist of further sample and TLD location(s) selected outward from the Decision I location. All soil samples collected at each sample plot will be sampled as described in Section 4.2.3.

To further investigate fission products deposited on surface soils at the Small Boy site, TLDs will also be placed in a vector pattern starting from the GZ area and extending northeast through the axis of the detected 2010 aerial man-made plume as illustrated in Figure A.8-4. These TLDs will provide additional external dose data that may be present at this site. Soil samples will be collected at all TLD locations on the Small Boy site to determine internal dose.

Radionuclide contaminants that were initially deposited onto the soil surface that may have subsequently been displaced through disturbance, water, or wind will be investigated for buried contamination. This will be performed at two locations by collecting and screening subsurface soil as presented in Figure A.8-3. One subsurface analysis will be performed at or near the Small Boy GZ where water has been observed to collect in the slightly depressed area. The other subsurface analysis will be performed at the anomalous area south of the Small Boy GZ due to the unknown origin of the radiological contamination. Final locations for the investigation of buried contamination will be chosen based upon site conditions to include radiological surveys. At each location, samples will be screened at each 5-cm subsurface interval until native material is encountered or until a significant decrease in radiological screening values is observed. Samples will be screened and collected in accordance with Section 4.2.3.

#### *4.2.2.3 Study Group 3, Spills and Debris*

For Study Group 3 at CAU 541, a judgmental sampling approach will be used to investigate the likelihood of the soil containing a COC. Biasing factors such as stains, radiological survey results, and/or wastes suspected of containing hazardous or radiological components will be used to select the most appropriate samples from a particular location for collection and analysis. Decision I evaluation for this study group will be based on the feature being investigated to determine the presence of a COC.

If a COC is present at any Study Group 3 scenario sample location, the COC may be removed under an interim action or Decision II sampling will be conducted to define the extent of contamination where COCs have been confirmed. If an interim action removal is conducted, verification samples will be collected to demonstrate that all soils exceeding the FAL were removed. Otherwise, extent (Decision II) sampling locations at each site will be selected based on the CSM, biasing factors, field-survey results, existing data, and the outer boundary sample locations where COCs are detected.

In general, extent sample locations will be arranged in a triangular pattern around areas containing a COC at distances based on site conditions, COC concentrations, process knowledge, and biasing factors. If COCs extend beyond extent locations, additional Decision II samples will be collected from locations farther from the source.

### *4.2.3 Sample Collection*

The CAU 541 sampling program will consist of the following activities:

- Collect soil samples from locations as described in Section 4.2.2.
- Collect required QC samples.
- Collect waste management samples as necessary.
- Collect external dose measurements by hanging TLDs at the sample plots, along vectors, or extent locations.
- Record GPS coordinates for each environmental sample location.

To determine internal dose for the sample plots at Study Groups 1 and 2, a probabilistic sampling approach will be implemented for collecting composite samples within the sample plots. Each composite sample will consist of soil collected from the surface to a depth of 5 cm at nine unbiased subsample locations within a plot. For each composite sample, the first location will be selected randomly; the remaining eight subsample locations will be established on a systematic triangular grid (see Section A.8.0). Samples will be sieved to eliminate material (e.g., fused silica glass) greater than 0.25-in. diameter and the entire volume of the composited material collected will be submitted to the laboratory for analysis. External dose will be sampled from a TLD installed at the approximate center of the sample plot at a height of 1 m and be left in place for approximately 2,000 hours (equivalent to an annual industrial worker exposure). As a determination of minimum sample size cannot be accomplished until after the data have been generated, the sufficiency of the number of samples collected will be evaluated in accordance with the Soils RBCA document (NNSA/NFO, 2014).

At some locations, the CSM includes the possibility of the presence of buried contamination. Buried contamination is defined to be contamination that was originally deposited on the surface and then subsequently covered with less contaminated material. At these locations, soil samples will be collected from the surface and each 5-cm depth interval until native material is encountered. Each sample will be screened with an alpha/beta contamination meter. The surface sample will submitted for analysis. Additionally, if the field-screening reading (FSR) for any depth sample exceeds the daily field screening level (FSL) and is more than 20 percent higher than the FSR of the surface sample, the depth sample with the highest screening value at each sample location will be submitted for analysis. If the FSR of any depth sample does not meet these criteria, only the surface sample will be submitted for analysis.

Decision I Study Group 3 samples will be collected from the locations described in Section 4.2.2.3. If biasing factors are present in soils below locations where Decision I samples were collected, subsurface soil samples will also be collected by augering, backhoe excavation, direct-push, or drilling techniques, as appropriate. Subsurface soil samples will be collected based on biasing factors to a depth where the biasing factors are no longer present.

### *4.2.4 Sample Management*

The laboratory requirements (i.e., minimum detectable concentrations [MDCs], precision, and accuracy) to be used when analyzing the COPCs are presented in the Soils QAP (NNSA/NSO, 2012). The analytical program is presented in Table A.2-3. All sampling activities and QC requirements for field and laboratory environmental sampling will be conducted in compliance with the Soils QAP.

## *4.3 Site Restoration*

Upon completion of CAI and waste management activities, the following actions will be implemented before closure of the site Real Estate/Operations Permit (REOP):

- All equipment, wastes, debris, and materials associated with the CAI will be removed from the site.
- All CAI-related signage and fencing (unless part of a corrective action) will be removed from the site.
- Site will be inspected to ensure restoration activities have been completed.

# 5.0 Waste Management

Waste generated during the CAU 541 field investigation will be managed in accordance with all applicable DOE orders, federal and state regulations, and agreements and permits between DOE and NDEP. Wastes will be characterized based on these regulations using process knowledge, field-screening results (FSRs), and analytical results from investigation and waste samples. Waste types that may be generated during the CAI include industrial, hazardous, hydrocarbon, *Toxic Substances Control Act* (TSCA) regulated (e.g., polychlorinated biphenyls [PCBs], asbestos), low-level radioactive, or mixed wastes.

Disposable sampling equipment, personal protective equipment (PPE), and rinsate are considered potentially contaminated waste only by virtue of contact with potentially contaminated media (e.g., soil) or potentially contaminated debris (e.g., lead). These wastes may be characterized based on associated environmental sample results, waste characterization results, FSRs, or process knowledge.

Chemicals *were not* known to be used or present at this CAU in a manner that would generate listed hazardous waste; therefore, wastes will be characterized *based on their chemical characteristics*. The waste will be managed and disposed of accordingly.

Conservative estimates of total waste contaminant concentrations may be made based on the mass of the waste, the amount of contaminated media contained in the waste, and the maximum concentration of contamination found in the media.

The following subsections discuss how the field investigation will be conducted to minimize the generation of waste, what waste streams are expected to be generated, and how IDW will be managed.

## 5.1 Waste Minimization

The CAI will be conducted in a manner that will minimize the generation of wastes using process knowledge, segregation, visual examination, and/or field screening (e.g., radiological survey and swipe results) to avoid cross-contaminating uncontaminated media or uncontaminated IDW that would otherwise be characterized and disposed of as industrial waste. As appropriate, media and debris will be returned to their original location. To limit unnecessary generation of hazardous or mixed waste, hazardous materials will not be used during the CAI unless required and approved by Environmental Compliance and Health and Safety. Other waste minimization practices will include, as appropriate, avoiding contact with contaminated materials, performing dry decontamination or wet decontamination over source locations, and carefully segregating waste streams.

## *5.2 Potential Waste Streams*

The following is a list of common waste streams that may be generated during the field investigation and that may require management and disposal:

- Disposable sampling equipment and field screening waste
- PPE
- Environmental media (e.g., soil)
- Surface debris (e.g., batteries, lead bricks)
- Decontamination rinsate

## *5.3 IDW Management*

The onsite management of IDW will be determined based on regulations associated with the particular waste type (e.g., industrial, low-level), or the combination of waste types. The following subsections describe how specific waste types will be managed.

### *5.3.1 Industrial Waste*

Industrial solid waste, if generated, will be collected, managed, and disposed in accordance with the solid waste regulations and the permits for operation of the NNSS Solid Waste Disposal Sites. The most commonly generated industrial solid waste includes disposable sampling equipment and PPE that will be collected in plastic bags, and marked in accordance with requirements. This waste, and other waste generated such as debris or soil that is characterized as industrial waste, may be placed in the roll-off box located adjacent to Building 23-310 in Mercury or in another approved container (e.g., drum).

#### 5.3.2 Hazardous Waste

Suspected hazardous waste, if generated, will be containerized and managed in waste accumulation areas in accordance with 40 *Code of Federal Regulations* (CFR) 262.34 (CFR, 2014a).

#### 5.3.3 Hydrocarbon Waste

Suspected hydrocarbon solid waste, if generated, will be managed on site in a drum or other appropriate container until fully characterized and in accordance with the State of Nevada regulations (NDEP, 2006).

#### 5.3.4 Polychlorinated Biphenyls

PCB management is governed by TSCA and its implementing regulations at 40 CFR 761 (CFR, 2014b), and agreements between EPA and NDEP. PCB contamination may be found as a sole contaminant or in combination with any of the types of waste discussed in this document. For example, PCBs may be a co-contaminant in soil that contains a RCRA "characteristic" waste (PCB/hazardous waste), or in soil that contains radioactive wastes (PCB/radioactive waste), or even in mixed waste (PCB/radioactive/hazardous waste). IDW will be initially evaluated using analytical results for media samples from the CAI. If any type of PCB waste is generated, it will be managed in accordance with 40 CFR 761 (CFR, 2014b) as well as State of Nevada requirements (NAC, 2012b), guidance, and agreements with NNSA/NFO.

#### 5.3.5 Low-Level Waste

Low-level radioactive waste, if generated, will be managed in accordance with the contractor-specific waste certification program plan, DOE orders, and the requirements of the current version of the *Nevada National Security Site Waste Acceptance Criteria* (NNSA/NSO, 2013). Potential radioactive waste containers will be staged and managed at a designated RMA.

#### 5.3.6 Mixed Low-Level Waste

Mixed waste, if generated, will be managed in accordance with the permits issued to the NNSA/NFO from NDEP (Murphy, 2004), RCRA requirements (CFR, 2014b), and DOE requirements for radioactive waste (NNSA/NSO, 2013; DOE, 1999). Waste characterized as mixed will not be stored for a period of time that exceeds the RCRA requirements unless subject to agreements between NNSA/NFO and the State of Nevada. The mixed waste must be transported via an approved hazardous waste/radioactive waste transporter to the NNSS transuranic waste storage pad for storage pending treatment or disposal.

# 6.0 QA/QC

The overall objective of the characterization activities described in this CAIP is to collect accurate and defensible data to support the selection and implementation of a closure alternative for CASs in CAU 541. All characterization activities, including those related to TLD measurements, will be conducted in accordance with the Soils QAP (NNSA/NSO, 2012) and the Soils RBCA document (NNSA/NFO, 2014), which define rigorous data quality requirements. Sections 6.1 and 6.2 discuss the collection of required QC samples in the field and QA requirements for soil samples. Other samples or measurements collected during the course of the investigation will be assessed and reported in accordance with the Soils QAP (NNSA/NSO, 2012).

## 6.1 QC Sampling Activities

Field QC samples will be collected in accordance with established procedures. Field QC samples are collected and analyzed to aid in determining the validity of environmental sample results. The number of required QC samples depends on the types and number of environmental samples collected. As determined in the DQO process, the minimum frequency of collecting and analyzing QC samples for this investigation is as follows:

- **Radiological samples**
  - Field duplicates for grab samples (1 per 20 environmental samples)
- **Chemical samples (if collected)**
  - Field duplicates for grab samples (1 per 20 environmental samples)
  - Trip blanks (1 per sample cooler containing VOC environmental samples)
  - Equipment rinsate blanks (1 per VOC wet decontamination event)

Additional QC samples may be submitted based on site conditions at the discretion of the Task Manager or Site Supervisor. Field QC samples must be analyzed using the same analytical procedures implemented for associated environmental samples. Additional details regarding field QC samples are available in the Soils QAP (NNSA/NSO, 2012).

### 6.2 Laboratory/Analytical Quality Assurance

As stated in the DQOs (see Appendix A), and except where noted, laboratory analytical quality data will be used for making DQO decisions. The Soils QAP (NNSA/NSO, 2012) defines and establishes data quality criteria for analytical data. Rigorous QA/QC will be implemented for all laboratory samples, including documentation, data verification and validation of analytical results, and an assessment of DQIs as they relate to laboratory analysis.

Data verification and validation will be performed in accordance with the Soils QAP (NNSA/NSO, 2012), except where otherwise stipulated in this CAIP. All chemical and radiological laboratory data from samples that are collected and analyzed will be evaluated for data quality in accordance with company-specific procedures. The data will be reviewed to ensure that all required samples were appropriately collected and analyzed, and that the results met data validation criteria. Validated data, including estimated data (i.e., J-qualified), will be assessed to determine whether the data meet the DQO requirements of the investigation and the performance criteria for the DQIs. The results of this assessment will be documented in the investigation report. If the DQOs were not met, corrective actions will be evaluated, selected, and implemented (e.g., refine CSM or resample to fill data gaps).

# 7.0 Duration and Records Availability

## 7.1 Duration

Field and analytical activities will require approximately 160 days to complete.

## 7.2 Records Availability

Historical information and documents referenced in this plan are retained in the NNSA/NFO activity files in Las Vegas, Nevada, and can be obtained through written request to the NNSA/NFO Soils Activity Lead. This document is available in the DOE public reading facilities located in Las Vegas and Carson City, Nevada, or by contacting the appropriate DOE Soils Activity Lead.

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# Appendix A

# Data Quality Objectives

# *A.1.0 Introduction*

The DQO process described in this appendix is a seven-step strategic systematic planning method used to plan data collection activities and define performance criteria for the CAU 541, Small Boy, field investigation. DQOs are designed to ensure that the data collected will provide sufficient and reliable information to identify, evaluate, and technically defend recommended corrective actions (i.e., no further action, closure in place, or clean closure). Existing information about the nature and extent of contamination at the CASs in CAU 541 is insufficient to evaluate and select preferred corrective actions; therefore, a CAI will be conducted.

The CAU 541 CAI will be based on the DQOs presented in this appendix as developed by NDEP, USAF, and NNSA/NFO representatives. The seven steps of the DQO process presented in Sections A.2.0 through A.8.0 were developed in accordance with *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA, 2006).

The DQO process presents a combination of probabilistic and judgmental sampling approaches. In general, the procedures used in the DQO process provide the following:

- A method to establish performance or acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of a study.
- Criteria that will be used to establish the final data collection design, such as
    - the nature of the problem that has initiated the study and a conceptual model of the environmental hazard to be investigated;
    - the decisions or estimates that need to be made, and the order of priority for resolving them;
    - the type of data needed; and
    - an analytic approach or decision rule that defines the logic for how the data will be used to draw conclusions from the study findings.
- Acceptable quantitative criteria on the quality and quantity of the data to be collected, relative to the ultimate use of the data.

- A data collection design that will generate data meeting the quantitative and qualitative criteria specified. A data collection design specifies the type, number, location, and physical quantity of samples and data, as well as the QA and QC activities that will ensure that sampling design and measurement errors are managed sufficiently to meet the performance or acceptance criteria specified in the DQOs.

# A.2.0 Step 1 - State the Problem

Step 1 of the DQO process defines the problem that requires study, identifies the planning team, and develops a conceptual model of the environmental hazard to be investigated.

The problem statement for CAU 541 is as follows: "Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs in CAU 541."

## A.2.1 Planning Team Members

The DQO planning team consists of representatives from NDEP, USAF, and NNSA/NFO. The DQO planning team meeting was held on April 1, 2014.

## A.2.2 Conceptual Site Model

The CSM is used to organize and communicate information about site characteristics. It reflects the best interpretation of available information at a point in time. The CSM is a primary vehicle for communicating assumptions about release mechanisms, potential migration pathways, or specific constraints. It provides a summary of how and where contaminants are expected to move and what impacts such movement may have. It is the basis for assessing how contaminants could reach receptors both in the present and future. The CSM describes the most probable scenario for current conditions at each site and defines the assumptions that are the basis for identifying appropriate sampling strategy and data collection methods. An accurate CSM is important as it serves as the basis for all subsequent inputs and decisions throughout the DQO process.

The CSM was developed for CAU 541 using information from the physical setting, potential contaminant sources, release information, historical background information, knowledge from similar sites, and physical and chemical properties of the potentially affected media and COPCs.

The CSM consists of the following:

- Potential contaminant releases, including media subsequently affected
- Release mechanisms (the conditions associated with the release)

- Potential contaminant source characteristics, including contaminants suspected to be present and contaminant-specific properties
- Site characteristics, including physical, topographical, and meteorological information
- Migration pathways and transport mechanisms that describe the potential for migration and where the contamination may be transported
- The locations of points of exposure where individuals or populations may come in contact with a COC associated with a CAS
- Routes of exposure where contaminants may enter the receptor

If additional elements are identified during the CAI that are outside the scope of the CSM, the situation will be reviewed and a recommendation will be made as to how to proceed. In such cases, USAF and NDEP will be notified and given the opportunity to comment on, or concur with, the recommendation.

The applicability of the CSM to each release source is summarized in Table A.2-1 and discussed below. Table A.2-1 provides information on CSM elements that will be used throughout the remaining steps of the DQO process. Figure A.2-1 depicts a representation of the conceptual pathways to receptors from CAU 541 sources. Figure A.2-2 depicts a graphical representation of the CSM.

**Table A.2-1**
**CSM Description of Elements for Each Study Group in CAU 541**
(Page 1 of 2)

| Study Group Identifier | 1 | 2 | 3 |
|---|---|---|---|
| **Study Group Description** | **BFa Site** | **Small Boy Site** | **Spills and Debris** |
| **Site Status** | Sites are inactive and/or abandoned | | |
| **Exposure Scenario** | Ground Troops Scenario | | |
| **Sources of Potential Soil Contamination** | Fallout and soil activation from nuclear detonations | | Leaking containers and surface disposal of discarded equipment and materials |
| **Location of Contamination/ Release Point** | Surface soil at or near location(s) of atmospheric tests; subsurface soil near GZ | Surface soil at or near location(s) of atmospheric tests; subsurface soil near GZ | Surface and subsurface soil at or near location of debris |

**Table A.2-1**
**CSM Description of Elements for Each Study Group in CAU 541**
(Page 2 of 2)

| Study Group Identifier | 1 | 2 | 3 |
|---|---|---|---|
| **Study Group Description** | **BFa Site** | **Small Boy Site** | **Spills and Debris** |
| **Amount Released** | Unknown | | |
| **Affected Media** | Surface and shallow subsurface soil; debris, such as concrete, steel, and wood | | |
| **Potential Contaminants** | Fission Products | Fission and Unfissioned Products | Unknown |
| **Transport Mechanisms** | Percolation of precipitation through subsurface media serves as the major driving force for migration of contaminants. Surface water movement may provide for the transportation of some contaminants within or outside the footprints of the study groups. Include any surface liquids (e.g., ponds) or liquid released over time (e.g., leaks from tanks) that may also have provided a hydraulic driver for percolation and migration of contaminants.Resuspension by wind and mechanical disturbance are also mechanisms for contaminant transport. | | |
| **Migration Pathways** | Lateral migration across surface soils/sediments and vertical migration through subsurface soils due to the potential for the playa to be inundated with water. The large depth to the uppermost aquifer precludes groundwater as a significant pathway. | | |
| **Lateral and Vertical Extent of Contamination** | Contamination is generally expected to have been initially contiguous to the release points. Concentrations are expected to decrease with distance and depth from the source. Lateral and vertical extent of contamination exceeding FALs is assumed to be within the spatial boundaries. | | |
| **Exposure Pathways** | The potential for contamination exposure is limited to industrial and construction workers, and military personnel conducting operations or training. These human receptors may be exposed to COPCs through oral ingestion or inhalation of, or dermal contact (absorption) with soil and/or debris due to inadvertent disturbance of these materials, or irradiation by radioactive materials. | | |

### *A.2.2.1 Release Sources*

The following identifies the release sources (DOE/NV, 2000) specific to CAU 541:

- Encore was a weapons-effect test as part of Operation Upshot-Knothole with a yield of 27 kt. The test was an airdrop test performed on May 8, 1953. Encore was the first of six tests performed at this site.
- Grable was a weapons-related test as part of Operation Upshot-Knothole with a yield of 15 kt. The airburst test fired from a 280 mm artillery gun was performed on May 25, 1953.
- The MET test was a weapons-effect test as part of Operation Teapot. The test was performed on April 15, 1955, from a 400-ft tower with a yield of 22 kt.

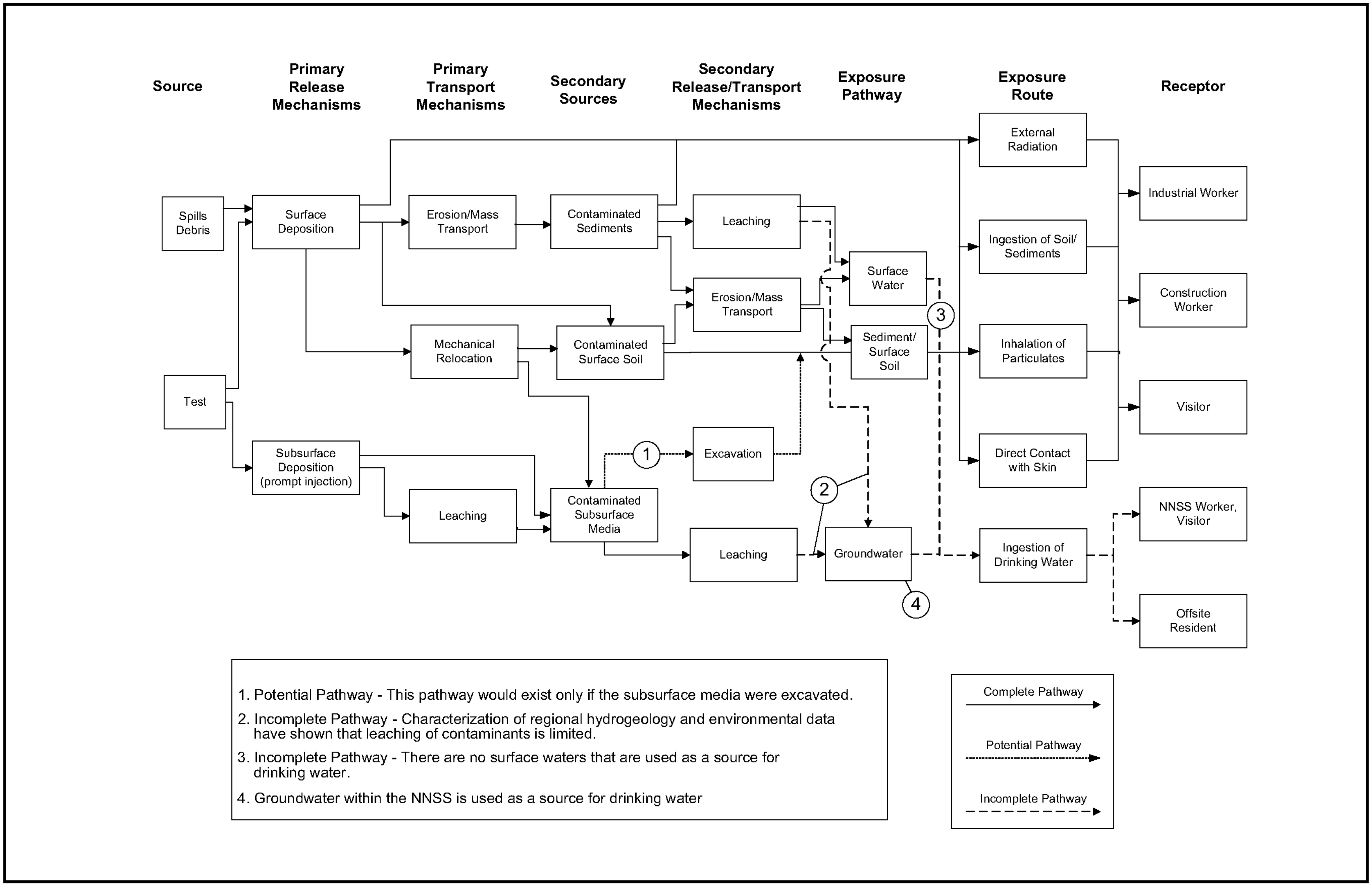


**Figure A.2-1**
**CAU 541 CSM Pathways to Receptors**

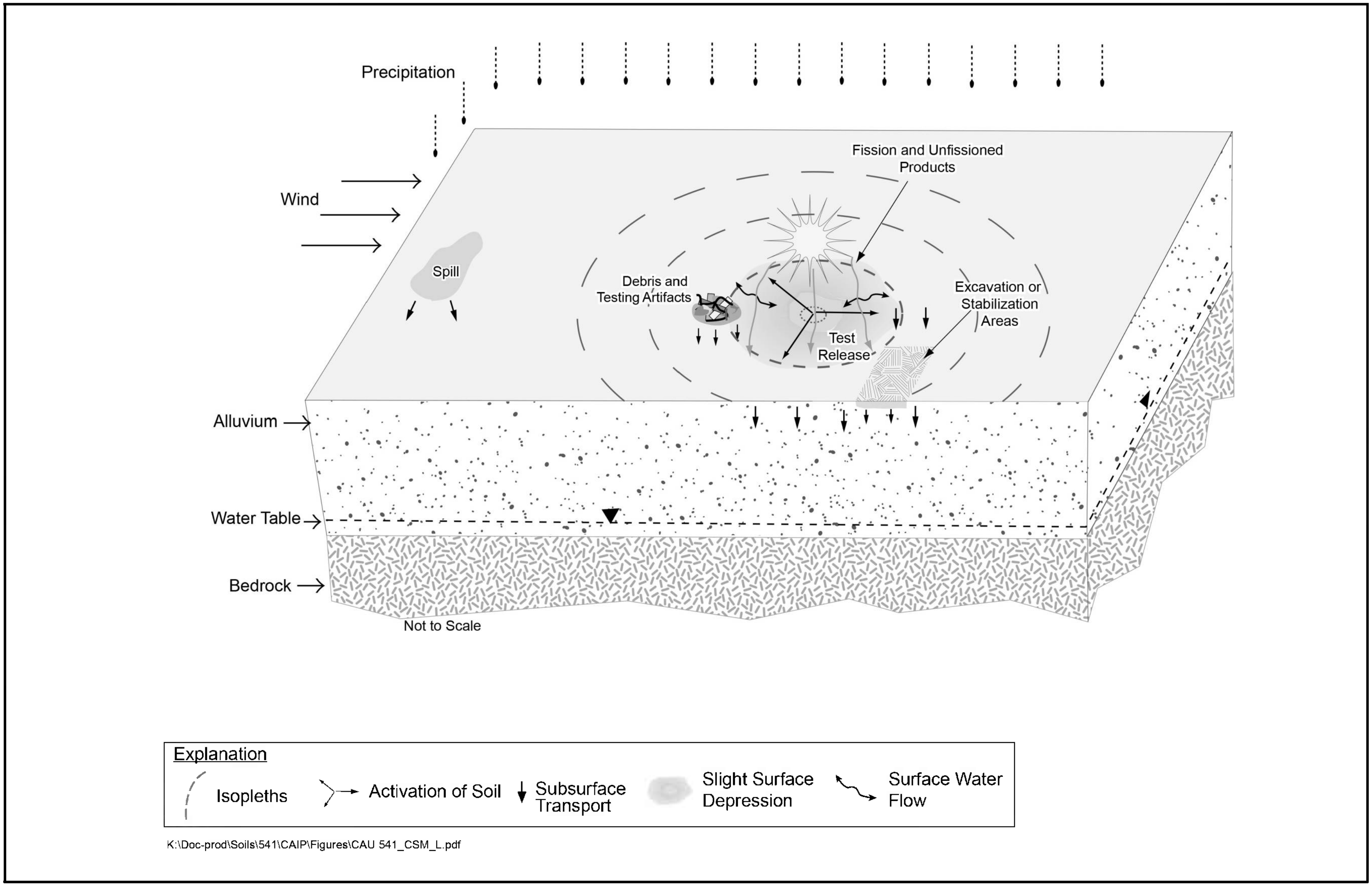


**Figure A.2-2**
**CSM for CAU 541**

- Priscilla was a weapons-related balloon test as part of Operation Plumbbob. The test was conducted at 700 ft with a yield of 37 kt. The yield for Priscilla was the largest observed for CAU 541.

- Wrangell was a weapons-related test as part of Operation Hardtack II with a yield of 115 tons. The balloon test was performed on October 22, 1958, from a height of 1,500 ft.

- Sanford was a weapons-related test performed as part of Operation Hardtack II. The low-yield balloon test was conducted on October 26, 1958. Sanford was the last of six tests performed at this site.

- Small Boy was a weapons-effect test performed as part of Operation Sunbeam conducted on July 14, 1962. Small Boy had a low yield and was conducted from a 10-ft tower.

- An anomalous radiologically elevated area to the south of the Small Boy site is detected. The source of the radionuclides in this area is unknown but suspected to be associated with the Small Boy test.

- Other releases are present at CAU 541. Lead bricks and a lead-acid battery were identified. Additionally, testing structures, instrument stations for diagnostic and test support both above and below the surface grade, underground structures, military fortifications (foxholes), and bridge/railroad infrastructure are extensive. There is the potential to find additional spills or debris that could provide a source for the release of contamination to the surface soil.

The most likely locations of the contamination and releases to the environment are the soils directly below or adjacent to the CSM's surface and subsurface components (i.e., soils impacted by fallout).

To facilitate site investigation and the evaluation of DQO decisions for different CSM components, the releases at each CAS were classified into one of the following study groups:

- **Study Group 1, BFa Site.** This release category is specific to the atmospheric deposition of radionuclide contamination at the BFa site (comprised mainly of fission and activation products) onto the soil surface. The contamination associated with this type of release that has not been displaced through excavation or migration is limited to the top 5 cm of soil. Radionuclide contaminants that were initially deposited onto the soil surface may have subsequently been displaced through wind or water erosion or mechanical disturbance of the soil near GZ.

- **Study Group 2, Small Boy Site.** This release category is specific to the atmospheric deposition of fissioned and unfissioned radionuclide contamination on surface soil at the Small Boy site. The contamination associated with this type of release that has not been displaced through migration will be limited to the top 5 cm of soil. An anomalous radiologically elevated area of unknown origin is observed to the south of the Small Boy site.

Radionuclide contaminants that were initially deposited onto the soil surface may have subsequently been displaced through wind or water erosion.

- **Study Group 3 (Spills and Debris).** This study group investigates any chemical or radiological contamination associated with debris and/or spills including the debris itself.

### *A.2.2.2 Potential Contaminants*

The release-specific COPCs are defined as the contaminants reasonably expected at the site that could contribute to a dose or risk exceeding FALs. Based on the nature of the releases identified in Section 2.4 and previous investigation results presented in Section 2.5, the contaminants that could reasonably be suspected to be present at CAU 541 are listed in Table A.2-2.

**Table A.2-2**
**Contaminants of Potential Concern[a]**

| COPCs | Study Group 1 | Study Group 2 | Study Group 3 |
|---|---|---|---|
| **Organic COPCs** | | | |
| VOCs[b] | -- | -- | X[b] |
| SVOCs[b] | -- | -- | X[b] |
| **Inorganic COPCs** | | | |
| Lead | -- | -- | X[b] |
| **Expected Radionuclide COPCs** | | | |
| U-234/235/238 | X | X | -- |
| Pu-238/239/240 | X | X | -- |
| Eu-152/154/155 | X | X | -- |
| Cs-137 | X | X | -- |
| Am-241 | X | X | -- |
| **Possible, but Not Suspected Radionuclide COPCs** | | | |
| Pu-241 | X | X | -- |
| Sr Analysis | X | X | -- |
| Tc Analysis | X | X | -- |

[a]The COPCs are the constituents that, based on process knowledge and historical documentation, are likely to be present.
[b]COPCs for this study group depend on the nature of release.

Sr = Strontium
Tc = Technetium

X = COPC associated with this study group
-- = COPC not associated with this study group

These COPCs were identified during the planning process through the review of site history, process knowledge, personal interviews, past investigation efforts (where available), and inferred activities associated with the study groups (including those that may be discovered during the investigation).

Additional COPCs for Study Group 3 may be discovered during the investigation. Specific COPCs (and the analyses requested) will be determined for newly discovered releases based on the nature of the release (e.g., hydrocarbon stain, lead bricks).

Although not suspected to be present, analysis for additional COPCs will be performed to eliminate the possibility of their presence due to an incomplete history of site testing operations. The site-specific possible but not suspected COPCs for CAU 541 include the following:

- Co-60
- Sr-90
- Tc-99
- Neptunium (Np)-237
- Pu-241
- Curium (Cm)-243
- Cm-244
- Am-243
- Silver (Ag)-108m
- Aluminum (Al)-26
- Niobium (Nb)-94
- Thorium (Th)-232
- U-233

Cobalt is included on this list because it is a soil and component activation product. Strontium and technetium are included in this list due to their historical presence as fission product radionuclides. Radionuclides such as Am-243, U-233, Np-237, Pu-241, Cm-243, and Cm-244 are included as possible radiological COPCs based on their reported historical use as tracers and/or surrogates. For Sr-90 and Tc-99 analysis, one sample will be analyzed from the expected location of the highest Cs-137 result.

The COPCs applicable to Decision I environmental samples for each of the CAU 541 releases are listed in Table A.2-2. Table A.2-3 lists the analytical methods required for these COPCs, while Table A.2-4 lists the analytes that are reported by the analytical laboratory for each of the analytical methods.

## Table A.2-3
## Analyses Required by Group[a]

| Analyses | Group 1 | Group 2 | Group 3 |
|---|---|---|---|
| **Inorganic COPCs** | | | |
| RCRA Metals | -- | -- | X[b] |
| Hexavalent Chromium | -- | -- | X[b] |
| **Organic COPCs** | | | |
| VOCs | -- | -- | X[b] |
| SVOCs | -- | -- | X[b] |
| **Radionuclide COPCs** | | | |
| Gamma Spectroscopy | X | X | X[c] |
| Isotopic U | X | X | -- |
| Isotopic Pu[d] | X | X | -- |
| Isotopic Am | X | X | -- |
| Pu-241[e] | X | X | -- |
| Sr Analysis[f] | X | X | -- |
| Tc Analysis[f] | X | X | -- |

[a]The analytical method has been determined based on the site-specific COPCs. Analytical methods numbers are shown in Table A.2-4.
[b]Analyses for VOCs, SVOCs, or RCRA metals will be run only as PSM is located.
[c]Results of gamma analysis will be used to determine whether further isotopic analysis is warranted.
[d]Pu ratios used to determine whether analysis for Cm-244 is needed.
[e]Collect a single confirmatory sample at the Small Boy site, using a sample with a higher alpha FSR. Additional sampling based upon the 10% dose rule.
[f]Collect a single confirmatory sample at the expected location of the highest Cs-137 result.

X = Required analytical method as described in Soils QAP (NNSA/NSO, 2012)
-- = Not required

# Table A.2-4
# Analytes Reported Per Method

| Organic COPCs | | | | Inorganic COPCs | Radionuclide COPCs | |
|---|---|---|---|---|---|---|
| **Method 8260[a]** | | **Method 8270[a]** | | **Method 6010[a]** | **Method Ga-01[b]** | **Method U-02[b]** |
| **VOCs** | | **SVOCs** | | **RCRA Metals** | **Gamma Spec** | **Isotopic U** |
| 1,1,1,2-Tetrachloroethane | Carbon tetrachloride | 1,4-Dioxane | Bis(2-ethylhexyl)phthalate | Arsenic | Ac-228 | U-234 |
| 1,1,1-Trichloroethane | Chlorobenzene | 2,3,4,6-Tetrachlorophenol | Butyl benzyl phthalate | Barium | Ag-108m | U-235 |
| 1,1,2,2-Tetrachloroethane | Chloroethane | 2,4,5-Trichlorophenol | Carbazole | Beryllium | Al-26 | U-238 |
| 1,1,2-Trichloroethane | Chloroform | 2,4,6-Trichlorophenol | Chrysene | Cadmium | Am-241 | |
| 1,1-Dichloroethane | Chloromethane | 2,4-Dimethylphenol | Di-n-butyl phthalate | Chromium | Cm-243 | **Method Sr-02[b]** |
| 1,1-Dichloroethene | Chloroprene | 2,4-Dinitrotoluene | Di-n-octyl phthalate | Lead | Co-60 | **Isotopic Sr** |
| 1,2,4-Trichlorobenzene | cis-1,2-Dichloroethene | 2-Chlorophenol | Dibenzo(a,h)anthracene | Selenium | Cs-137 | Sr-90 |
| 1,2,4-Trimethylbenzene | Dibromochloromethane | 2-Methylnaphthalene | Dibenzofuran | Silver | Eu-152 | |
| 1,2-Dibromo-3-chloropropane | Dichlorodifluoromethane | 2-Methylphenol | Dimethyl phthalate | | Eu-154 | **Method Pu-02[b]** |
| 1,2-Dichlorobenzene | Ethyl methacrylate | 2-Nitrophenol | Fluoranthene | **Method 7196[a]** | Eu-155 | **Isotopic Pu** |
| 1,2-Dichloroethane | Ethylbenzene | 3-Methylphenolc (m-cresol) | Fluorene | Chromium VI | K-40 | Pu-238 |
| 1,2-Dichloropropane | Isobutyl alcohol | 4-Methylphenolc (p-cresol) | Hexachlorobenzene | | Nb-94 | Pu-239/240 |
| 1,3,5-Trimethylbenzene | Isopropylbenzene | 4-Chloroaniline | Hexachlorobutadiene | | Pa-233 | |
| 1,3-Dichlorobenzene | Methacrylonitrile | 4-Nitrophenol | Hexachloroethane | | Pb-212 | **Method Am-01[b]** |
| 1,4-Dichlorobenzene | Methyl methacrylate | Acenaphthene | Indeno(1,2,3-cd)pyrene | | Pb-214 | **Isotopic Am** |
| 2-Butanone | Methylene chloride | Acenaphthylene | n-Nitroso-di-n-propylamine | | Th-229 | Am-241 |
| 2-Chlorotoluene | n-Butylbenzene | Aniline | Naphthalene | | Th-234 | Am-243 |
| 2-Hexanone | n-Propylbenzene | Anthracene | Nitrobenzene | | Tl-208 | |
| 4-Isopropyltoluene | sec-Butylbenzene | Benzo(a)anthracene | Pentachlorophenol | | U-235 | |
| 4-Methyl-2-pentanone | Styrene | Benzo(a)pyrene | Phenanthrene | | | |
| Acetone | tert-Butylbenzene | Benzo(b)fluoranthene | Phenol | | **Lab-Specific Methods[c]** | |
| Acetonitrile | Tetrachloroethene | Benzo(g,h,i)perylene | Pyrene | | Pu-241 | |
| Allyl chloride | Toluene | Benzo(k)fluoranthene | Pyridine | | Tc-99 | |
| Benzene | Total xylenes | Benzoic acid | Diethyl phthalate | | | |
| Bromodichloromethane | Trichloroethene | Benzyl alcohol | | | | |
| Bromoform | Trichlorofluoromethane | | | | | |
| Bromomethane | Vinyl acetate | | | | | |
| Carbon disulfide | Vinyl chloride | | | | | |

[a] *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA, 2014b)
[b] *The Procedures Manual of the Environmental Measurements Laboratory*, which includes HASL-300 Methods (DOE, 1997)
[c] The most current EPA, DOE, or equivalent accepted analytical method may be used, including laboratory standard operating procedures approved by the contractor in accordance with industry standards and the contractor's statement of work requirements.

HASL = Health and Safety Laboratory
Ac = Actinium
Co = Cobalt
K = Potassium
Pa = Proactinium
Pb = Lead
Tl = Thallium

### *A.2.2.3 Contaminant Characteristics*

Contaminant characteristics include, but are not limited to, solubility, density, and adsorption potential. In general, contaminants with low solubility, high affinity for media, and high density can be expected to be found relatively close to release points. Contaminants with small particle size, high solubility, low density, and/or low affinity for media are found farther from release points or in low areas where evaporation or ponding will concentrate dissolved contaminants. Radionuclides with a low melting point (e.g., iodine) traveled significant distances before condensing and falling out of the plume, while those with higher melting points (e.g., cesium) condensed earlier and were deposited closer to respective GZs. Generally, nuclear fuel radionuclides that did not fission (e.g., U-235) have a very high melting point and are generally found very near GZ.

An example of the migration potential of radionuclides released from a nuclear detonation was demonstrated in a long-term radionuclide migration study of an underground nuclear test. A well installed into the groundwater 91 m away from the Cambric test GZ (and much closer to the nearest extent of the test cavity) was continuously pumped from 1975 to 1991 in order to draw radionuclides from the detonation cavity. The May 1965 Cambric test released a yield of 750 tons at a depth of 294 m below the land surface and 73 m below the water table (DOE/NV, 2000; Hoffman and Daniels, 1984). No radionuclides associated with nuclear fission tests (including the major contributing radionuclides plutonium, uranium, cesium, europium, strontium, or cobalt) other than tritium and krypton (which are considered to be conservative tracers in groundwater, as they do not interact with the geologic media through which the water moves) were detected in the pumped groundwater during the 16 years of pumping (Bryant, 1992; Hoffman and Daniels, 1984). This test demonstrated the relative immobility of the fission radionuclides under conditions of very high mass flow (more than 1.5 billion gallons of water pumped) in a saturated matrix. Under unsaturated conditions (such as surface soil with atmospheric deposition from nuclear test releases), infiltrating water percolating through the vadose zone provides a small fraction of the migration potential. Therefore, it can be assumed that while the major fission radionuclides are relatively immobile in saturated conditions with an artificial gradient (i.e., under pumping conditions), they will be even less mobile under unsaturated conditions with limited net infiltration of precipitation.

Based on this evidence, the major radionuclide potential contaminants (plutonium, uranium, and fission products) are classified as adsorbing radionuclides with low solubilities that are located within unsaturated media. Therefore, these contaminants are expected to be found relatively close to release points.

#### *A.2.2.4 Site Characteristics*

Site characteristics are defined by the interaction of physical, topographical, and meteorological attributes and properties. Topographical and meteorological properties and attributes include slope stability, precipitation frequency and amounts, precipitation runoff pathways, drainage channels and ephemeral drainages, and PET. Meteorological data are presented in Section 2.1.

CAU 541 is co-located in Area 5 of the NNSS and Range 65C for the NTTR on the Frenchman Flat playa. The area is nearly flat with no discernible slope direction. The area is sparsely vegetated with native plants. The soil in and around CAU 541 consists of sandy-textured alluvial deposits. No perennial drainage channel flow exists in the region; however, the immediate area near each GZ is slightly depressed. Water has been observed to pool in these areas in wet conditions.

#### *A.2.2.5 Migration Pathways and Transport Mechanisms*

Migration pathways include the lateral migration of potential contaminants across surface soils/sediments and vertical migration of potential contaminants through subsurface soils. Stormwater events provide an intermittent mechanism for both vertical and lateral transport of contaminants. No significant ephemeral washes are observed in the area of either CAS. Slightly depressed areas are observed near the GZ at each site. A study by DRI concluded that residual radionuclides on the dry playa surface may become submerged, allowing water-soil interaction that could provide a mechanism for transport of radionuclides away from known area of contamination (Hershey et al., 2013). The study concluded from observations that a significant portion of water (approximately 40 percent) on the playa did not evaporate but rather infiltrated into the subsurface. The study also concluded that infiltration of water from the playa during inundation into the subsurface does not necessarily imply that groundwater recharge is occurring.

Other migration pathways for contamination from the sites include windborne material and mechanical disturbance due to maintenance or construction activities at the site. Specifically, this can include activities such as decontamination and demolition of facilities, investigation and resolution of CASs, and disassembly and removal of equipment and support structures.

Migration is influenced by the chemical characteristics of the contaminants (presented in Section A.2.2.3) and the physical characteristics of the vadose zone material (presented in Section A.2.2.4). In general, the contaminants that are reasonably expected to be present at CAU 541 (i.e., plutonium, uranium, and fission products) have low solubilities and high affinity for media. The physical characteristics of the vadose zone material generally include medium and high adsorbive capacities, low moisture contents (i.e., available water-holding capacity), and relatively long distances to groundwater (e.g., 708 ft). Based on these physical and chemical factors, contamination is expected to be found relatively close to release points.

Infiltration and percolation of precipitation serve as a driving force for downward migration of contaminants. However, due to high PET (annual PET at Area 5 has been estimated at 64 in. [BN, 2001]) and limited precipitation for this region (4.88 in. per year [ARL/SORD, 2014]), percolation of infiltrated precipitation at the NNSS does not provide a significant mechanism for vertical migration of contaminants to groundwater (DOE/NV, 1992). This is supported by the DRI study that concludes that infiltration of water from the playa during inundation into the subsurface does not necessarily imply that groundwater recharge is occurring (Hershey et al., 2013).

Subsurface migration pathways at CAU 541 are expected to be predominately vertical, although spills or leaks at the ground surface may also have limited lateral migration before infiltration. The depth of infiltration (shape of the subsurface contaminant plume) will be dependent upon the type, volume, and duration of the discharge as well as the presence of relatively impermeable layers that could modify vertical or lateral transport pathways, both on the ground surface (e.g., concrete) and in the subsurface (e.g., clay or caliche layers).

### *A.2.2.6 Exposure Scenarios*

Human receptors may be exposed to COPCs through oral ingestion or inhalation of, or dermal contact (absorption) with soil or debris due to inadvertent disturbance of these materials, or external irradiation by radioactive materials. The land-use and exposure scenarios for the CAU 541 CASs are listed in Table A.2-5. These are based on current and future land use at the NNSS (DOE/NV, 1996). Both CASs 05-23-04 and 05-45-03 are located in an area where structures from past activities exist from past testing. Although no facilities are present that would allow these structures to be used as an assigned work station for NNSS site personnel, there is the possibility that activity at the NTTR will result in the USAF need to conduct outdoor troop operations. Troops could occupy these locations as a regular work site on a temporary basis such as for the performance of military exercises. Therefore, the current site usage at CASs 05-23-04 and 05-45-03 are conservatively represented by the site-specific Ground Troops Scenario exposure scenario.

**Table A.2-5**
**Land-Use and Exposure Scenarios**

<table>
<tr><th>CAS</th><th>Land-Use Zone</th><th>Exposure Scenario</th></tr>
<tr><td rowspan="3">05-23-04<br>and<br>05-45-03</td><td rowspan="3">Research Test and Experiment Zone<br>This area of the NNSS is designated for small-scale research and development projects and demonstrations; pilot projects; outdoor tests; and experiments for the development, QA, or reliability of material and equipment under controlled conditions. This zone includes compatible defense and nondefense research, development, and testing projects and activities.</td><td>Industrial Area<br>Worker will be exposed to the site full time (250 days per year, 8 hours per day for 25 years). Active powered buildings with toilets are present at the site.</td></tr>
<tr><td>Remote Work Area<br>Worker will be exposed to the site part time (up to 336 hours per year for 25 years). Site structures are present for shelter and comfort of the worker.</td></tr>
<tr><td>Occasional Use Area<br>Worker will be exposed to the site occasionally (up to 80 hours per year for 5 years). Site structures are not present for shelter and comfort of the worker.</td></tr>
<tr><td>05-23-04<br>and<br>05-45-03</td><td>Military Use<br>This area of the NTTR is designated for operational activities resulting from the USAF need to conduct outdoor troop operations.</td><td>Ground Troops Scenario<br>Workers will be exposed to the site part time (24 hours per day, 14 days per deployment, for 3 deployments per year). Although site structures are not present for shelter and comfort, troops would potentially remain at the site for 24 hours a day.</td></tr>
</table>

# A.3.0 Step 2 - Identify the Goal of the Study

Step 2 of the DQO process states how environmental data will be used in meeting objectives and solving the problem, identifies study questions or decision statement(s), and considers alternative outcomes or actions that can occur upon answering the question(s).

## A.3.1 Decision Statements

The Decision I statement is as follows: "Is any COC associated with the CAS present in environmental media?" For judgmental sampling design, any analytical result for a COPC above the FAL will result in that COPC being designated as a COC. For the probabilistic (unbiased) sampling design, any COPC that has a 95 percent UCL of the average concentration above the FAL will result in that COPC being designated as a COC. A COC may also be defined as a contaminant that, in combination with other like contaminants, is determined to jointly pose an unacceptable risk based on a multiple contaminant analysis (NNSA/NFO, 2014). If a COC is detected, then Decision II must be resolved.

The Decision II statement is as follows: "Is sufficient information available to evaluate potential CAAs?" Sufficient information is defined to include the following:

- The lateral and vertical extent of contamination at levels exceeding the FAL
- The information needed to predict potential remediation waste types and volumes
- Any other information needed to evaluate the feasibility of remediation alternatives

For radiological contaminants, the presence of contamination at levels exceeding the FAL is defined as the condition where the most exposed worker has the potential to receive a TED of at least 25 mrem/yr.

For all study groups, Decision I samples will be submitted to analytical laboratories to determine the presence of a COC. If a COC is present, Decision II samples will be submitted to define the extent of a COC. In addition, samples will be submitted for analyses, as needed, to support waste management or health and safety decisions.

A corrective action may also be required if a combination of contaminants is determined to jointly pose an unacceptable risk or if waste with the potential to result in the introduction of a COC to the surrounding environmental media (defined as PSM in the Soils RBCA document [NNSA/NFO, 2014] is identified.

If sufficient information is not available to evaluate potential CAAs, then site conditions will be reevaluated and additional samples will be collected (as long as the scope of the investigation is not exceeded and any CSM assumption has not been shown to be incorrect).

### *A.3.2 Alternative Actions to the Decisions*

This section identifies actions that may be taken to solve the problem depending on the possible outcomes of the investigation.

#### *A.3.2.1 Alternative Actions to Decision I*

If no COC associated with a release is detected, further assessment of the study group is not required. If a COC associated with a release is detected, the extent of COC contamination will be determined and additional information required to evaluate potential CAAs will be collected.

#### *A.3.2.2 Alternative Actions to Decision II*

If the lateral and vertical extent of COC contamination have not been defined by bounding sample results, then additional bounding samples will be collected.

If sample analytical results are not sufficient to predict potential remediation waste types, then additional waste characterization samples will be collected. If available information is not sufficient to evaluate the potential for migration of COC contamination beyond the corrective action boundary, then additional information will be collected. If sufficient information is not available to evaluate potential CAAs, then additional samples will be collected. Otherwise, collection of additional information is not required.

# A.4.0 Step 3 - Identify Information Inputs

Step 3 of the DQO process identifies the information needed, determines sources for information, and identifies sampling and analysis methods that will allow reliable comparisons with FALs.

## A.4.1 Information Needs

To resolve Decision I (determine whether contamination from the release is present at levels exceeding a FAL), samples will be collected and analyzed following these two criteria:

- Samples must either (a) be collected in areas most likely to contain a COC (judgmental sampling) or (b) properly represent contamination at the study group (probabilistic sampling)
- The analytical suite selected must be sufficient to identify any COC present in the samples.

The extent of COC contamination portion of Decision II will be resolved using one of the following methods:

1. TED rates are established at locations where the TED values bound the FAL dose rate and provide sufficient information to establish an $r^2$ greater than 0.8 between TED values and radiation survey values. A boundary will then be determined around the radiation survey isopleth that correlates to the 25-mrem/yr FAL.
2. TED rates are established at locations where the TED values bound the FAL dose rate and provide sufficient information to determine the extent of contamination.
3. The lateral and vertical extent of COC contamination will be defined by sample results from locations contiguous to the contamination where TED or COC concentrations are less than the FAL.
4. The lateral and vertical extent of COC contamination will be defined by the entire lateral and vertical extent of a material with clearly identifiable physical properties that is assumed to be entirely contaminated at levels exceeding the FAL.

If additional information is needed to evaluate corrective action alternatives, samples will be collected and analyzed to meet the following criteria:

- Samples of the waste or environmental media must provide sufficient information to determine potential remediation waste types.

- Samples of the waste must provide sufficient information to determine whether the waste has the potential to result in the introduction of a COC to the surrounding environmental media.

The analytical suites selected must be sufficient to detect contaminants at concentrations equal to or less than their corresponding FALs.

### A.4.2 Sources of Information

Information to satisfy Decision I and Decision II will be generated by collecting environmental samples. These samples will be submitted to analytical laboratories meeting the quality criteria stipulated in the Soils QAP (NNSA/NSO, 2012). TLDs will be submitted to the Environmental Technical Services group at the NNSS, which is certified by the DOE Laboratory Accreditation Program for dosimetry. Only validated data from analytical laboratories will be used to make DQO decisions. Sample collection and handling activities will follow standard procedures.

#### A.4.2.1 Sample Locations

Design of the sampling approaches for the CAU 541 study groups must ensure that the data collected are sufficient for selection of the CAAs (EPA, 2002). To meet this objective, the samples collected from each site should either be from locations that most likely contain a COC, if present (judgmental), or from locations that properly represent overall contamination at the study group (probabilistic). These sample locations, therefore, can be selected by means of either (a) biasing factors used in judgmental sampling as discussed in Section A.8.3 or (b) randomly using a probabilistic sampling design. The implementation of a judgmental approach for sample location selection, and of a probabilistic sampling approach, for CAU 541 are discussed in Section A.8.0.

#### A.4.2.2 Analytical Methods

Analytical methods are available to provide the data needed to resolve the decision statements. The analytical methods and laboratory requirements (e.g., precision, and accuracy) for soil samples are provided in the Soils QAP (NNSA/NSO, 2012).

# A.5.0 Step 4 - Define the Boundaries of the Study

Step 4 of the DQO process defines the target population of interest and its relevant spatial boundaries, specifies temporal and other practical constraints associated with sample/data collection, and defines the sampling units on which decisions or estimates will be made.

## A.5.1 Target Populations of Interest

The population of interest to resolve Decision I ("determine whether a COC from the release is present") is contaminant concentrations exceeding a FAL at any location or area within the release. The populations of interest to resolve Decision II (If corrective action is required, is sufficient information available to evaluate potential CAAs?) are as follows:

- For radiological contamination, TED and corresponding radiation survey values from locations where TED varies from above the FAL to below the FAL
- For chemical contamination, COC concentrations for each one of a set of locations bounding contamination in lateral and vertical directions
- Investigation waste and potential remediation waste characteristics

## A.5.2 Spatial Boundaries

Spatial boundaries are the maximum lateral and vertical extent of expected contamination that can be supported by the CSM. These boundaries were agreed to in the DQO meeting with decision makers. Decision II spatial boundaries are as follows:

- **Vertical (for Study Groups 1 and 2).** 0 to 5 cm bgs for atmospheric release. 15 ft bgs for sedimentation or mechanical disturbance
- **Vertical (for Study Group 3).** 15 ft bgs
- **Lateral (for all study groups).** 1 mi from defined plume

Contamination found beyond these boundaries may indicate a flaw in the CSM and may require reevaluation of the CSM before the investigation can continue.

### A.5.3 Practical Constraints

Practical constraints (e.g., access restrictions, activities by other organizations in the area, utilities, and/or sensitive animals and plants) may affect the ability to investigate this site. Practical constraints that have been identified specific to CAU 541 include access restrictions to Area 5 of the NNSS and to Range 65C on the NTTR, the presence of desert tortoise or other sensitive species, and the presence of items/debris and/or native vegetation.

### A.5.4 Define the Sampling Units

The scale of decision making refers to the smallest, most appropriate area or volume for which decisions will be made. The scale of decision making in Decision I is the CAS component (defined by a specific release). The presence of a COC associated with a CAS component will cause the determination that the CAS component is contaminated and needs further evaluation. The scale of decision making for Decision II is defined as a contiguous area containing a COC originating from the CAS component. Resolution of Decision II requires this contiguous area to be bounded laterally and vertically.

# A.6.0 Step 5 - Develop the Analytic Approach

Step 5 of the DQO process specifies appropriate population parameters for making decisions, defines action levels, and generates a decision rule.

## A.6.1 Population Parameters

Population parameters are defined for judgmental and probablistic sampling designs in the following subsections. Population parameters are the parameters compared to action levels.

### A.6.1.1 Judgmental Sampling Design

The judgmental design will be implemented as described in the Soils RBCA document (NNSA/NFO, 2014). For chemical contaminants, the population parameter is the observed concentration of each contaminant from each individual analytical sample. For radiological contaminants, the population parameter is the calculated TED from each location. Each sample result will be compared to the FALs to determine the appropriate resolution to Decision I and Decision II. A single sample result for any contaminant exceeding a FAL would cause a determination that a corrective action is required (for Decision I), or that the extent of COC contamination is not bounded (for Decision II).

If good prior information about the target site of interest is available, then the sampling may be designed to collect samples only from areas known to have the highest concentration levels on the target site. If the observed concentrations from these samples are below the action level, then a decision can be made that the site contains safe levels of the contaminant without the samples being truly representative of the entire area (EPA, 2006).

### A.6.1.2 Probabilistic Sampling Design

For probabilistic sampling results, the population parameter is the true TED over the area of the sample plot. Resolution of DQO decisions associated with the probabilistic sampling design requires determining, with a specified degree of confidence, whether the true TED at the site in question exceeds the FAL. Because a calculated TED is an estimate of the true (unknown) TED, it is uncertain how well the calculated TED represents the true TED. If the calculated TED were significantly different than the true TED, a decision based on the calculated TED could result in a decision error.

To reduce the probability of making a false-negative decision error, a conservative estimate of the true TED is used to compare to the FAL instead of the calculated TED. This conservative estimate (overestimation) of the true TED will be calculated as the 95 percent UCL of the average TED values (Section 4.1). By definition, there will be a 95 percent probability that the true TED is less than the 95 percent UCL of the calculated TED.

The computation of appropriate UCLs will be accomplished as described in the Soils RBCA document (NNSA/NFO, 2014).

### A.6.2 Action Levels

The PALs presented in this section are to be used for site screening purposes. They are not necessarily intended to be used as cleanup action levels or FALs. However, they are useful in screening out contaminants that are not present in sufficient concentrations to warrant further evaluation and, therefore, streamline the consideration of remedial alternatives.

The FALs will be established using the RBCA process described in the Soils RBCA document (NNSA/NFO, 2014). This process conforms with NAC 445A.227, which lists the requirements for sites with soil contamination (NAC, 2012a). For the evaluation of corrective actions, NAC 445A.22705 (NAC, 2012b) requires the use of ASTM Method E1739 (ASTM, 1995) to "conduct an evaluation of the site, based on the risk it poses to public health and the environment, to determine the necessary remediation standards or to establish that corrective action is not necessary." For the evaluation of corrective actions, the FALs are established as the necessary remedial standard. The RBCA process as described in the Soils RBCA document (NNSA/NFO, 2014) defines three tiers (or levels) of evaluation involving increasingly sophisticated analyses.

The comparison of laboratory results to FALs and the evaluation of potential corrective actions will be included in the investigation report. The FALs will be defined (along with the basis for their definition) in the investigation report.

#### A.6.2.1 Chemical PALs

Except as noted herein, the chemical PALs are defined as the Region 9 Regional Screening Levels for chemical contaminants in industrial soils (EPA, 2014a). Background concentrations for RCRA metals will be used instead of screening levels when natural background concentrations exceed the screening level (e.g., arsenic on the NNSS). Background is considered the average concentration plus two standard deviations of the average concentration for sediment samples collected by the Nevada Bureau of Mines and Geology throughout the NTTR (NBMG, 1998; Moore, 1999). For detected chemical COPCs without established screening levels, the protocol used by EPA Region 9 in establishing screening levels (or similar) will be used to establish PALs. If used, this process will be documented in the investigation report.

#### *A.6.2.2 Radionuclide PALs*

The PAL for radioactive contaminants is a TED of 25 mrem/yr, based upon the Ground Troops exposure scenario. The Ground Troops exposure scenario is described in Section 3.1.1.

### *A.6.3 Decision Rules*

The decision rules applicable to both Decision I and Decision II are as follows:

- If contamination levels are inconsistent with the CSM or extends beyond the spatial boundaries identified in Section A.5.2, then work will be suspended and the investigation strategy will be reconsidered, else the decision will be to continue sampling.

The decision rules for Decision I are as follows:

- If the population parameter of any COPC in the Decision I population of interest (defined in Step 4) exceeds the corresponding FAL, then Decision II will be resolved and a corrective action will be determined, else no further action will be necessary for that COPC in that population.
- If a waste is present that, if released, has the potential to cause the future contamination of site environmental media, then a corrective action will be determined, else no further action will be necessary.

The decision rules for Decision II are as follows:

- If the spatial extent of any COC has not been defined, then additional samples will be collected, else no further investigation will be necessary.
- If sufficient information is not available to determine potential remediation waste types and evaluate the feasibility of remediation alternatives, additional waste characterization samples will be collected, else no further investigation will be necessary.

# A.7.0 Step 6 - Specify Performance or Acceptance Criteria

Step 6 of the DQO process defines the decision hypotheses, specifies controls against false rejection and false acceptance decision errors, examines consequences of making incorrect decisions from the test, and places acceptable limits on the likelihood of making decision errors.

## A.7.1 Decision Hypotheses

The baseline condition (i.e., null hypothesis) and alternative condition for Decision I are as follows:

- **Baseline condition.** A COC is present.
- **Alternative condition.** A COC is not present.

The baseline condition (i.e., null hypothesis) and alternative condition for Decision II are as follows:

- **Baseline condition.** The extent of a COC has not been defined.
- **Alternative condition.** The extent of a COC has been defined.

Decisions and/or criteria have false-negative or false-positive errors associated with their determination. The impact of these decision errors and the methods that will be used to control these errors are discussed in the following subsections. In general terms, confidence in DQO decisions based on judgmental sampling results will be established qualitatively by the following:

- Developing a CSM (based on process knowledge) that is agreed to by decision maker participants during the DQO process.
- Testing the validity of the CSM based on investigation results.
- Evaluating the quality of data based on DQI parameters.

## A.7.2 False-Negative Decision Error

The false-negative decision error would mean deciding that a COC is not present when it actually is (Decision I), or deciding that the extent of a COC has been defined when it has not (Decision II). In both cases, the potential consequence is an increased risk to human health and environment.

#### *A.7.2.1 False-Negative Decision Error for Judgmental Sampling*

In judgmental sampling, the selection of the number and location of samples is based on knowledge of the feature or condition under investigation and on professional judgment (EPA, 2002). Judgmental sampling conclusions about the target population depend upon the validity and accuracy of professional judgment.

The false-negative decision error (where consequences are more severe) for judgmental sampling designs is controlled by meeting these criteria:

- For Decision I, having a high degree of confidence that the sample locations selected will identify a COC if present anywhere within the study group. For Decision II, having a high degree of confidence that the sample locations selected will identify the extent of a COC.
- Having a high degree of confidence that analyses conducted will be sufficient to detect any COC present in the samples.
- Having a high degree of confidence that the dataset is of sufficient quality and completeness.

To satisfy the first criterion, Decision I samples must be collected in areas most likely to be contaminated by a COC (supplemented by unbiased samples where appropriate). Decision II samples must be collected in areas that represent the lateral and vertical extent of contamination (above FALs). The following characteristics must be considered to control decision errors for the first criterion:

- Source and location of release
- Chemical nature and fate properties
- Physical transport pathways and properties
- Hydrologic drivers

These characteristics were considered during the development of the CSM and selection of sampling locations. The field-screening methods and biasing factors (e.g., a stain or area likely containing a spilled substance as discussed in Section A.8.3) will be used to further ensure that appropriate sampling locations are selected to meet these criteria. The investigation report will present an assessment on the DQI of representativeness that samples were collected from those locations that best represent the populations of interest as defined in Section A.5.1.

To satisfy the second criterion, Decision I soil samples will be analyzed for the chemical and radiological parameters listed in Section 3.2. Decision II soil samples will be analyzed for unbounded COCs. The DQI of sensitivity will be assessed for all analytical results to ensure that all sample analyses had measurement sensitivities (detection limits) that were less than or equal to the corresponding FALs. If this criterion is not achieved, the affected data will be assessed (for usability and potential impacts on meeting site characterization objectives) in the investigation report.

To satisfy the third criterion, the entire dataset of soil sample results, as well as individual soil sample results, will be assessed against the DQIs of precision, accuracy, comparability, and completeness as defined in the Soils QAP (NNSA/NSO, 2012). The DQIs of precision and accuracy will be used to assess overall analytical method performance as well as to assess the need to potentially “flag” (qualify) individual contaminant results when corresponding QC sample results are not within the established control limits for precision and accuracy. Data qualified as estimated for reasons of precision or accuracy may be considered to meet the analyte performance criteria based on an assessment of the data. The DQI for completeness will be assessed to ensure that all data needs identified in the DQO have been met. The DQI of comparability will be assessed to ensure that all analytical methods used are equivalent to standard EPA methods so that results will be comparable to regulatory action levels that have been established using those procedures. Strict adherence to established procedures and QA/QC protocol protects against false negatives.

To provide information for the assessment of the DQIs of precision and accuracy, QC samples will be collected and analyzed in every batch of up to 20 samples per matrix as defined below.

#### *A.7.2.2 False-Negative Decision Error for Probabilistic Sampling*

The false-negative decision error rate goal was established by the DQO meeting participants at 5 percent. Upon validation of the analytical results, statistical parameters will be calculated for each significant COPC identified at each site. Protection against a false-negative decision error is contingent upon the following:

- Sample size
- Actual variability
- Measurement error

Control of the false-negative decision error for probabilistic sampling designs is accomplished by ensuring that the following requirements are met for each of the significant COPCs:

- A sufficient sample size was collected (see Section A.8.1.2).
- The actual standard deviation is calculated.
- Analyses conducted were sufficient to detect contamination exceeding FALs.

### A.7.3 False-Positive Decision Error

The false-positive decision error would mean deciding that a COC is present when it is not, or a COC is unbounded when it is not, resulting in increased costs for unnecessary sampling and analysis.

False-positive results are typically attributed to laboratory and/or sampling/handling errors that could cause cross contamination. To control against cross contamination, decontamination of sampling equipment will be conducted in accordance with established and approved procedures, and only clean sample containers will be used. To determine whether a false-positive analytical result may have occurred, the following QC samples will be collected (as established in the CAU 541 DQOs):

- Field duplicates (1 per 20 environmental samples)
- Trip blanks (1 per sample cooler containing VOC environmental samples)
- Equipment rinsate blanks (1 per VOC sampling event)

For probabilistic sampling, false-positive decision error rate goal was established by the DQO meeting participants at 0.20 (or 20 percent probability). Protection against this decision error is also afforded by the controls listed in Section A.7.2 for probabilistic sampling designs.

# A.8.0 Step 7 - Develop the Plan for Obtaining Data

Step 7 of the DQO process selects and documents a design that will produce data that exceeds performance or acceptance criteria. Judgmental sampling schemes will be implemented to select sample plot locations for Study Groups 1 and 2. Probabilistic sampling schemes will be implemented to select the sample locations within each of the sample plots and submitted for laboratory analysis. Judgmental sampling will also be used to investigate any newly discovered releases as described in Section A.2.2.1. Investigation results will be compared to FALs to determine the need for corrective action. Waste with the potential to result in the introduction of a COC to the surrounding environmental media will be evaluated against the criteria listed in Section A.3.1 to determine the need for corrective action.

For each sample collected within a sample plot for Study Groups 1 and 2, randomly selected subsample locations will be chosen based on a random start, triangular pattern (see Figure A.8-1 for an example of this sampling scheme) in accordance with Section 7.0 of the Soils RBCA document (NNSA/NFO, 2014). If sufficient sample material cannot be collected at a specified location (e.g., rock, caliche, buried concrete), the Site Supervisor will establish the location at the nearest place that a surface sample can be obtained. A TLD will be placed at each sample plot location to measure the external dose. All samples will be analyzed for the expected COPCs as discussed in Section A.2.2.2. Dose will be calculated in accordance with Section A.8.4.

## A.8.1 Study Group 1, BFa Site

The sampling design for Study Group 1 will consist of a sample plot, multiple TLD placement, and sampling for possible buried contamination at GZ. Additional TRSs will be completed during the CAI to assist in the selection of sample locations. At each area, the sampling locations will be further refined using a PRM-470, FIDLER, or equivalent radiation survey instrument to determine the location of highest radioactivity.

### A.8.1.1 Decision I Sample Selection

A judgmental sampling design will be implemented for locating a Decision I sample plot for Study Group 1. One sample plot location at the BFa site will be identified based on the highest results of the

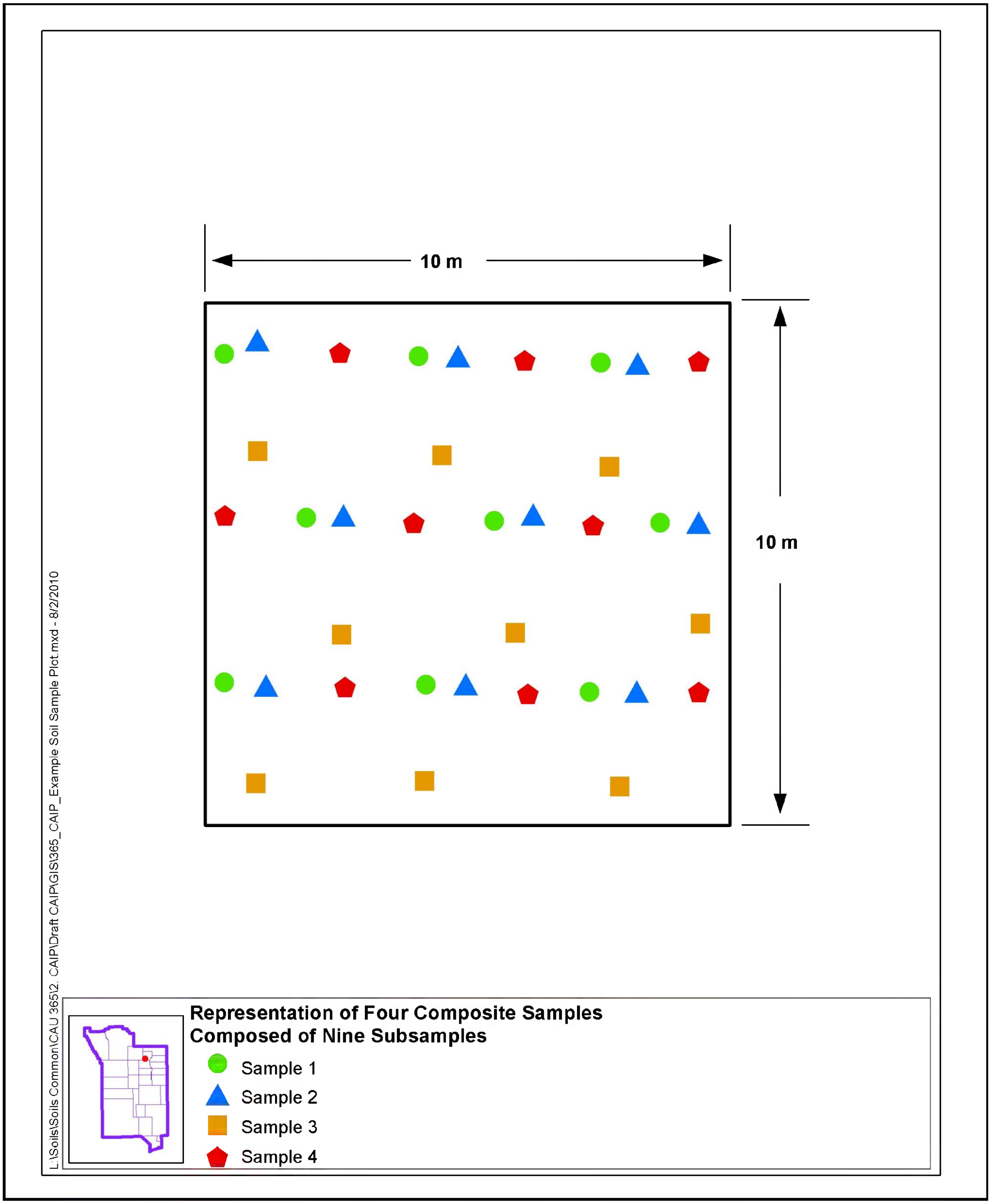


**Figure A.8-1**
**Sample Plot Sample Collection Layout**

aerial or PRM-470 TRS. This will be done in an effort to find the locations where TED is the highest. The proposed Decision I sampling plot location is depicted on Figure A.8-2. These locations will be refined when additional surveys are conducted during the CAI.

#### A.8.1.2 Decision II Sample Selection

Decision II sample locations, if necessary, will be selected judgmentally based on TRSs and/or aerial radiological surveys. Approximately 40 TLDs will be established judgmentally along three vectors radiating outward from GZ across the radiation survey isopleths with the constraint that, on each vector, at least two TLDs will present a TED less than the FAL. The Decision II TLD locations are shown on Figure A.8-2. These data will be used to establish patterns of contaminant distribution and determine a correlation of TED to radiation survey values.

#### A.8.1.3 Determination of Buried Contamination

As the CSM includes the possibility of buried contamination within the BFa site, it will be determined whether buried contamination exists. Historical documentation was identified which shows that clean soil may have been transported to the BFa site between tests for decontamination purposes (Holmes & Narver, 1959). A depression at the immediate GZ area is observed at this site that has been observed to collect water and associated sedimentation in wetter periods. Samples will be screened and collected in accordance with Section A.8.5 to investigate buried contamination at the depressed area near GZ and at the sample plot location. Figure A.8-2 shows the proposed locations that will be investigated for subsurface contamination.

### A.8.2 Study Group 2, Small Boy Site

The sampling design for Study Group 2 will consist of several sample plots, the placement of multiple TLDs, and sampling for possible buried contamination near GZ. Additional TRSs will be completed during the CAI to assist in the selection of sample locations. The sampling locations will be further refined using a PRM-470, FIDLER, or equivalent radiation survey instrument to determine the location of highest radioactivity or to best represent the distribution of contamination.

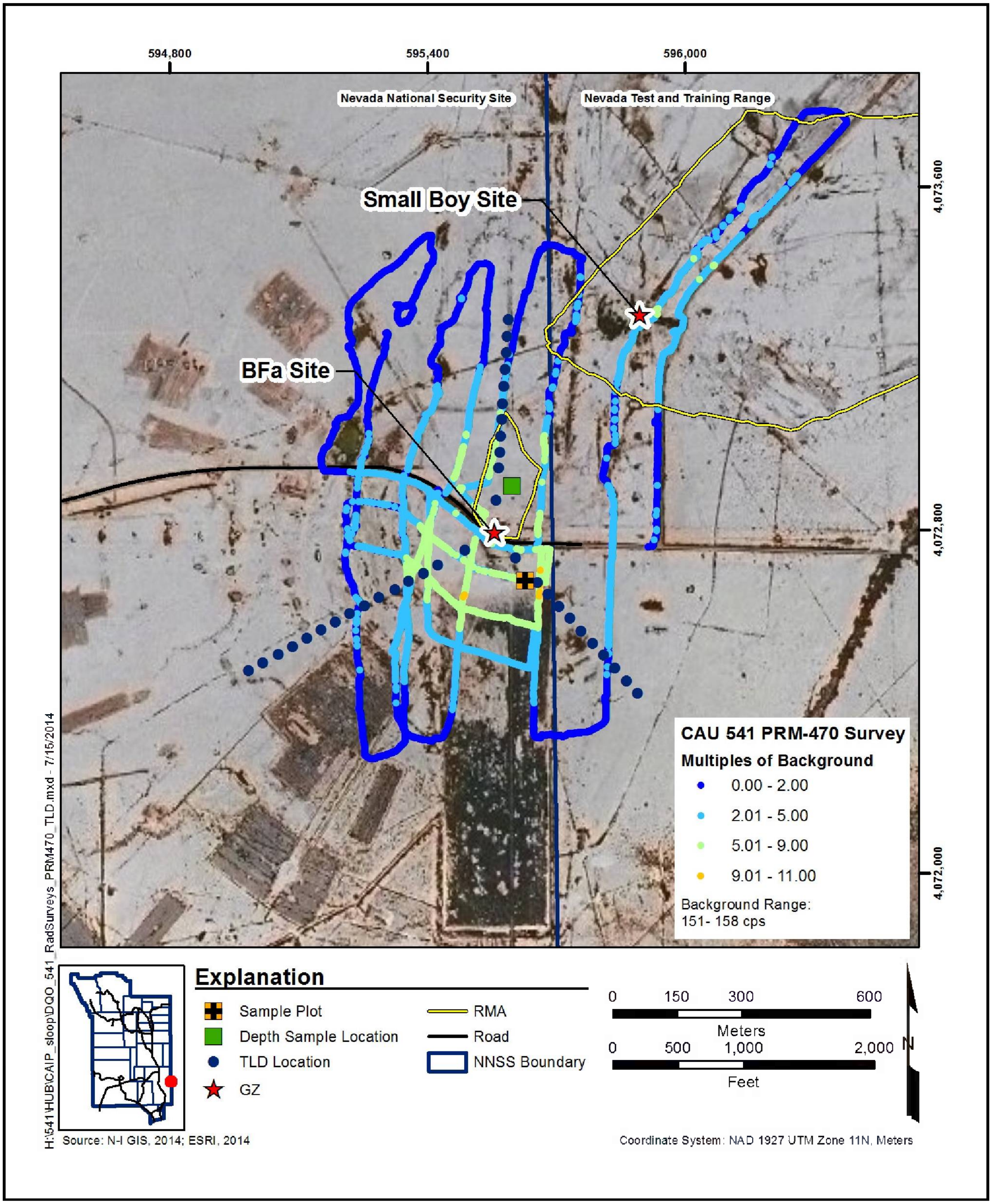


**Figure A.8-2**
**CAU 541 Decision I and II Sample Location for Study Group 1**

#### *A.8.2.1 Decision I Sample Selection*

A judgmental sampling design will be implemented for locating a Decision I sample plot for Study Group 2. One sample plot and TLD location will be determined at each of the defined radiological survey signature at the Small Boy and the anomalous radiologically elevated site to the south based on the highest results of the aerial or FIDLER TRSs. This will be done in an effort to find the locations where TED is the highest at each site. The proposed Decision I sampling plot locations are depicted on Figure A.8-3. These locations will be refined when additional TRS are conducted during the CAI.

#### *A.8.2.2 Decision II Sample Selection*

Decision II sample plot locations will be selected judgmentally based on TRSs and/or aerial radiological surveys. The release of radionuclides from the Small Boy test (Study Group 2) was distributed in a defined, but irregular, pattern of surface contamination. This pattern extends from GZ in a northeast pattern that generally decreases in concentration with increased distance from the release location. Approximately six Decision II sample plots will be established at the Small Boy site and the data used to establish a pattern of contamination distribution based upon a correlation of TED to radiation survey values. The approximate location of the proposed sampling plots are shown on Figure A.8-3. Note that the elevated area directly west of the Small Boy GZ shown on this figure is the location of the Hamilton test, which will be handled as a separate CAU and investigation.

Decision II sample plots will be selected within high, medium, and low elevated areas within the Small Boy plume illustrated in Figure A.8-3. Samples will be collected at various low to high radiologically elevated areas to best represent the distribution of contamination. Adjustments to these locations may be implemented based on additional TRS to be conducted during the CAI. At the anomalous radiologically elevated area to the south, any required Decision II investigation will consist of further sample and TLD location(s) selected outward from the Decision I location.

To further investigate fission products deposited on surface soils at the Small Boy site, TLDs will be placed in a vector pattern starting from the GZ area and extending northeast through the axis of the detected man-made radiological plume (2010 aerial radiological survey) as illustrated in Figure A.8-4. These TLDs will provide further data of the external dose that may be present at this

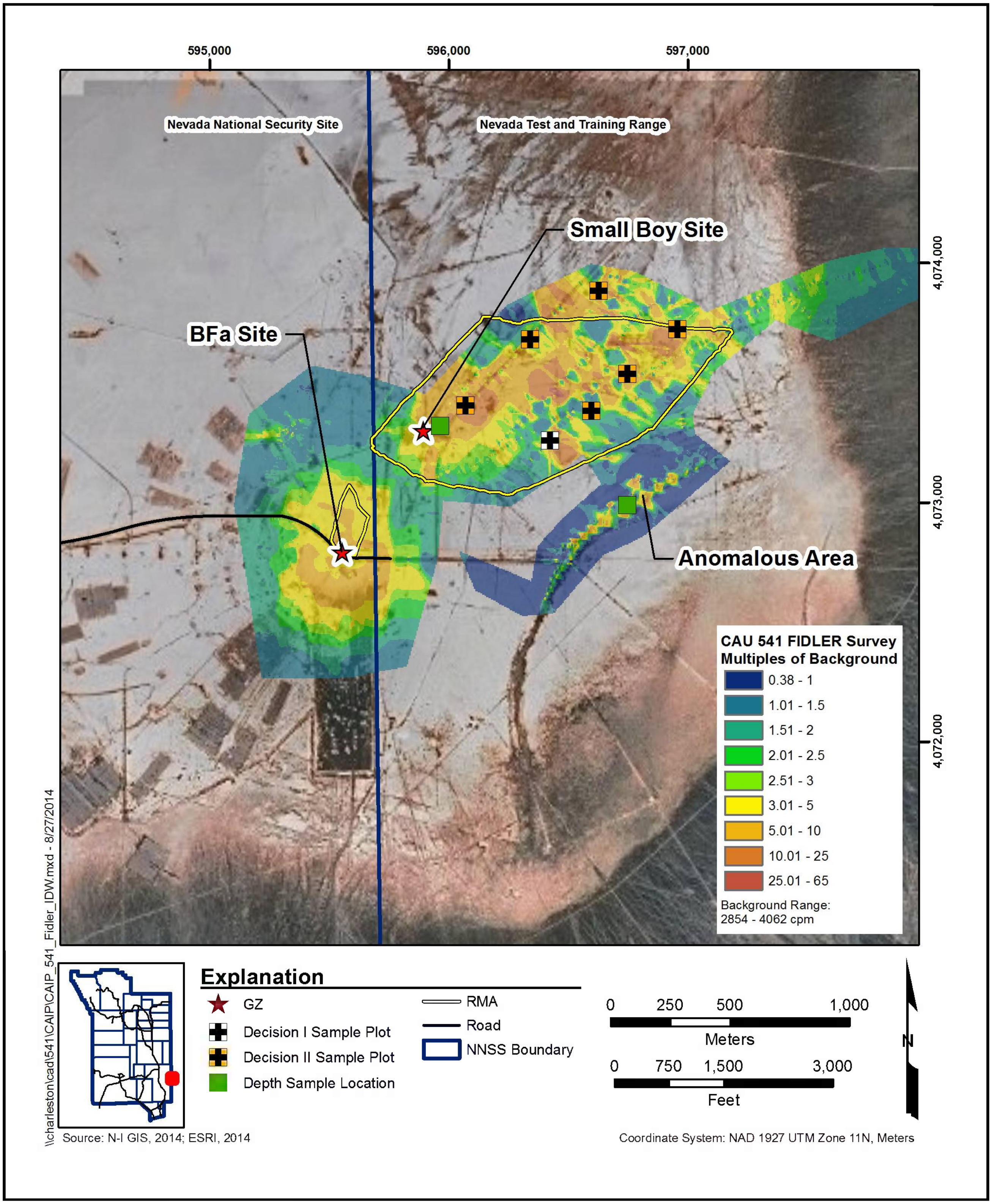


**Figure A.8-3**
**CAU 541 Sample Plot Locations for Study Group 2**

site. Soil samples will be collected at all TLD locations on the Small Boy site to determine internal dose.

#### *A.8.2.3 Determination of Buried Contamination*

As the CSM includes the possibility of buried contamination within the CAU area, it will be determined whether buried contamination exists due to mechanical, wind, and/or sedimentation disturbance. A slight depression located to the immediate north of the Small Boy GZ has been observed to collect water and associated sedimentation in wetter periods. Screening at depth will be performed in this area. Due to the unknown origin of the radiological contamination at the anomalous area to the south, screening at depth will be performed at this location also. Samples will be screened and collected at these two locations in accordance with Section A.8.5. See Figure A.8-3 for the suggested location that will be investigated for subsurface contamination.

### *A.8.3 Study Group 3, Spills and Debris*

Sample locations for Study Group 3 will be determined based upon the likelihood of a contaminant release at the study group. These locations will be selected based on the identification of biasing factors during the investigation. These biasing factors may include the following:

- *Stains.* Any spot or area on the soil surface that may indicate the presence of a potentially hazardous liquid. Stains at NNSS sites typically indicate an organic liquid, such as an oil, that has reached the soil and possibly spread vertically and laterally.
- *Radiological survey anomalies.* Radiological survey results that are significantly higher than the surrounding area.
- *Drums, containers, equipment, or debris.* Materials that contain or may have contained hazardous or radioactive substances.
- *Pre-selected areas based on process knowledge of the site.* Locations for which evidence such as the 2010 aerial radiological survey (Stampahar, 2012) provides a basis upon which sample plots can be designated (e.g., man-made gross counts).
- *Lithology.* Locations where variations in lithology (soil or rock) indicate that different conditions or materials exist.

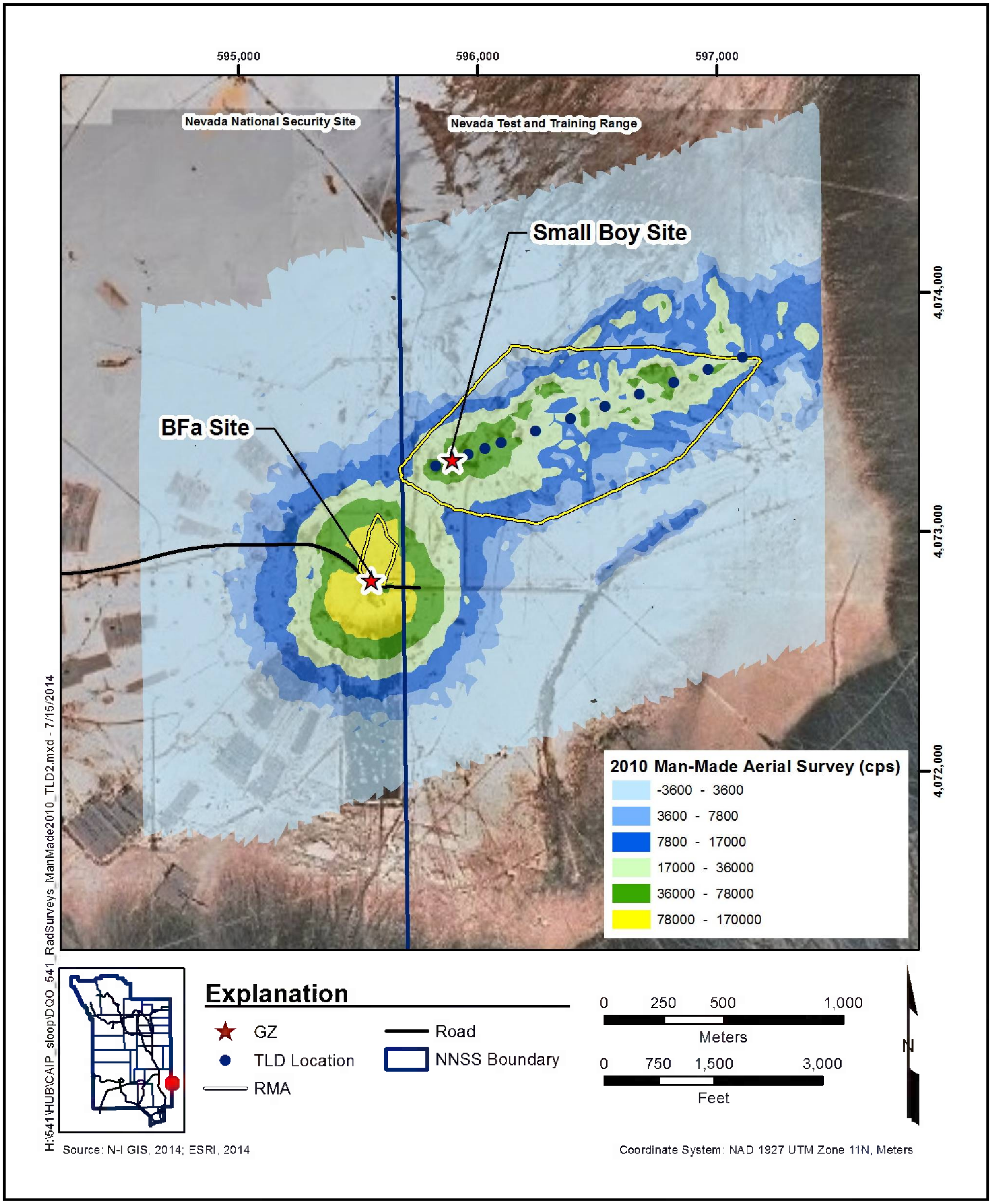


**Figure A.8-4**
**CAU 541 TLD Locations for Study Group 2**

- *Preselected areas based on process knowledge of the site.* Locations for which evidence such as historical photographs, experience from previous investigations, or input from interviewee(s) exists that a release of hazardous or radioactive substances may have occurred.
- *Preselected areas based on process knowledge of the contaminant(s).* Locations that may reasonably have received contamination, selected on the basis of the chemical and/or physical properties of the contaminant(s) in that environmental setting.
- Visual indicators such as discoloration, textural discontinuities, disturbance of native soils, or any other indication of potential contamination.
- *Other biasing factors.* Factors not previously defined that become evident during the CAI.

#### *A.8.3.1 Decision I*

A judgmental sampling design will be implemented for Study Group 3 to establish sample locations and evaluate sample results. For Study Group 3, individual sample results, rather than an average concentration, will be used to compare to FALs. Therefore, statistical methods to generate site characteristics will not be needed.

Adequate representativeness of the entire target population may not be a requirement in developing a sampling design. If good prior information about the target site of interest is available, then the sampling may be designed to collect samples only from areas known to have the highest concentration levels on the target site. If the observed concentrations from these samples are below the action level, then a decision can be made that the site contains safe levels of the contaminant without the samples being truly representative of the entire area (EPA, 2006).

A biased sampling strategy will be used to target areas with the highest potential to contain a COC, if it is present anywhere in the study group. Sample locations will be determined based on process knowledge, previously acquired data, or the field-screening and biasing factors listed in this section. If biasing factors are present in soils below locations where Decision I samples were removed, additional Decision I soil samples will be collected at depth intervals selected by the Site Supervisor based on biasing factors to a depth where the biasing factors are no longer present. The Site Supervisor has the discretion to modify the judgmental sample locations, but only if the modified locations meet the decision needs and criteria stipulated in these DQOs.

#### A.8.3.2 Decision II

Decision II judgmental samples will be collected from locations where a COC was detected. In general, sample locations will be arranged in a triangular pattern around the area containing a COC at distances based on site conditions, process knowledge, and biasing factors. If a COC extends beyond the initial step-outs, Decision II samples will be collected from incremental step-outs. Initial step-outs will be at least as deep as the vertical extent of contamination defined at the Decision I location and the depth of the incremental step-outs will be based on the deepest contamination observed at any location within the release. A clean sample (i.e., contamination levels less than FALs) collected from each step-out direction (lateral or vertical) will define extent of contamination in that direction.

### A.8.4 Calculation of Dose

Internal, external, and TED will be calculated using the appropriate exposure scenario and the methodologies described in the Soils RBCA document (NNSA/NSO, 2012b). The TED will be determined by summing the calculated internal and external dose at each sample location. The internal dose is calculated as the sum of the doses associated with each radionuclide present in the sample. This value is determined by summing the activity concentrations of individual radionuclides that would cause a receptor to receive an internal dose equal to the radiological FAL. The internal doses from each of the radionuclides are summed to produce the total potential internal dose. For probabilistic sampling of radiological contamination, DQO decisions will be based on the 95 percent UCL of the average TED. For judgmental sampling, DQO decisions will be based on a direct calculation of TED from sample results.

The value for the natural background dose to be subtracted from the TLD results will be obtained from an area determined to be unaffected by man-made activities at the NNSS. Approximate background TLD locations chosen for CAU 541 are shown in Figure A.8-5.

### A.8.5 Evaluation of Buried Contamination

As the CSM includes the possibility of buried contamination within the CAU area, it will be determined whether buried contamination exists due to mechanical, wind, and/or sedimentation disturbance. Because the most probable locations for buried contamination are where soil has been disturbed at the GZ, radiological screening and judgmental samples will be taken at those locations.

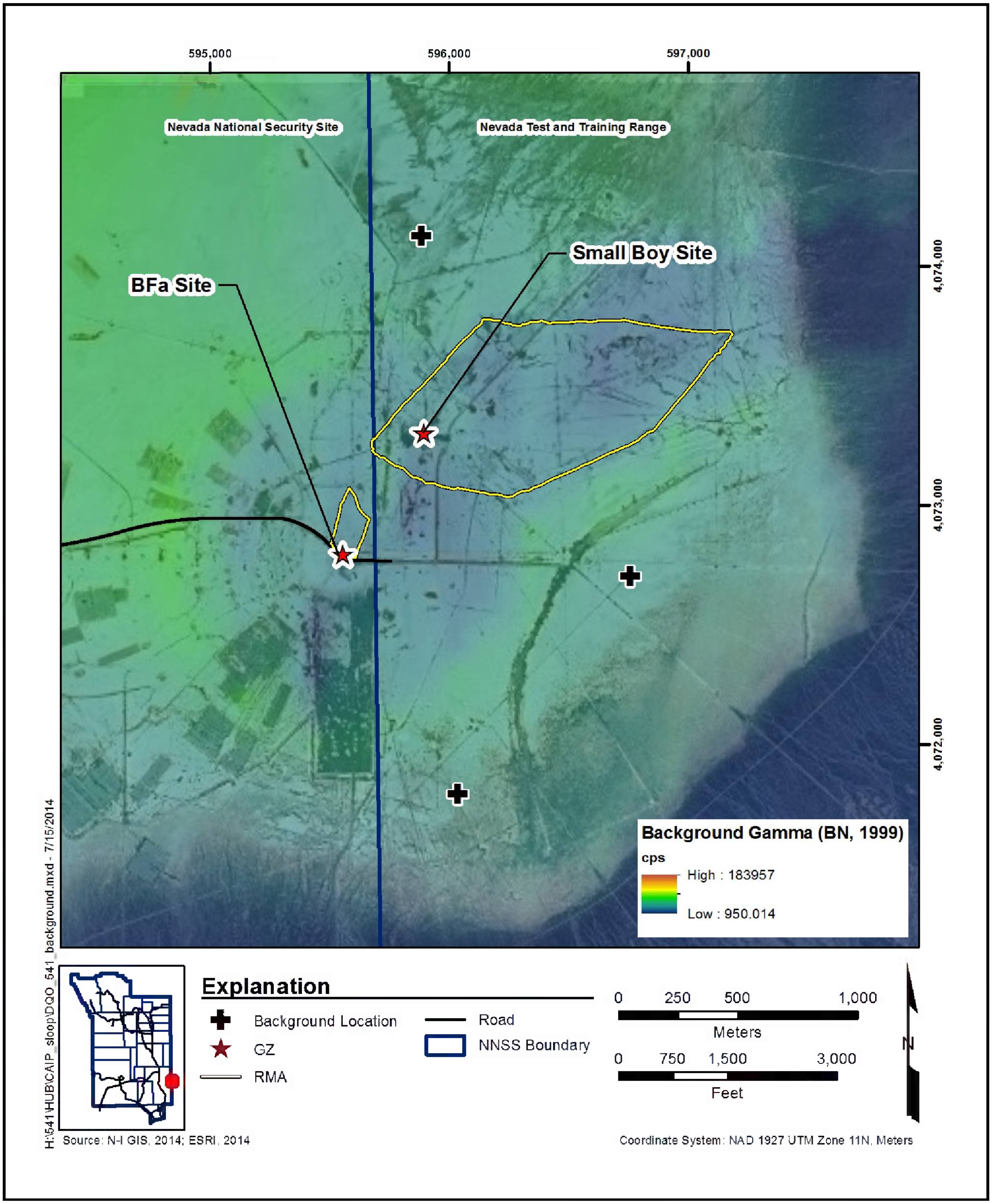


**Figure A.8-5**
**CAU 541 Background TLD Locations**

Figures A.8-2 and A.8-3 show the proposed location at each site that has been identified for evaluation. At each area, the screening and sampling location will be further refined by the Site Supervisor by using the most appropriate radiation survey instrument to determine the area of highest radioactivity and/or area exhibiting localized biasing factors. When sample locations have been identified, screening will be performed and samples collected in the following manner:

- At each sample location within the sediment accumulation or suspected buried contamination area, a sample will be collected from each 5-cm depth interval until native material is encountered or until a significant reduction in radiological screening levels is measured.
- Each sample will be field screened with an alpha/beta contamination meter and compared to the established background FSL for the site.
- If the depth sample with the highest FSR is not significantly different (at least 20 percent difference) than the FSR of the surface sample, then only the surface sample will be submitted for analysis. If the FSR is greater than 20 percent higher than the surface sample, then both the surface sample and the depth sample with the highest elevated FSR will be submitted for analysis.
- If the FSL is not exceeded in any depth sample, then only the surface sample will be submitted for analysis.
- A TLD will be placed at each sample location.

If screening results are not significantly different from the surface results, it will be assumed that buried contamination does not exist. If screening results are significantly different from the surface results, it will be assumed that buried contamination exists. For subsurface screening and sampling, it will be conservatively assumed that the highest TED from either surface or subsurface samples will be used to resolve DQO decisions. If a subsurface sample results in a higher internal dose than a surface sample, a TLD-equivalent external dose will be calculated for the subsurface sample. This will be accomplished by establishing a correlation between RESRAD-calculated external dose from surface samples and the RESRAD-calculated external dose from the subsurface samples. This surface TLD reading will be increased by this proportion to estimate a TLD-equivalent external dose for the subsurface soil.

### *A.8.6 Establishment of Final Corrective Action Boundary*

The final corrective action boundary will be established to include areas that exceed the FAL.

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U.S. Environmental Protection Agency. 2002. *Guidance for Quality Assurance Project Plans*, EPA QA/G5, EPA/240/R-02/009. Washington, DC: Office of Environmental Information.

U.S. Environmental Protection Agency. 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA QA/G-4, EPA/240/B-06/001. Washington, DC: Office of Environmental Information.

U.S. Environmental Protection Agency. 2014a. *Pacific Southwest, Region 9: Regional Screening Levels (Formerly PRGs), Screening Levels for Chemical Contaminants.* As accessed at http://www.epa.gov/region9/superfund/prg on 5 February. Prepared by EPA Office of Superfund and Oak Ridge National Laboratory.

U.S. Environmental Protection Agency. 2014b. *SW-846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.* As accessed at http://www.epa.gov/epawaste/hazard/testmethods/sw846 on 5 February.

# Appendix B

# Activity Organization

# B.1.0 Activity Organization

The NNSA/NFO Soils Activity Lead is Tiffany Lantow. She can be contacted at (702) 295-7645.

The identification of the activity Health and Safety Officer and the Quality Assurance Officer can be found in the appropriate plan. However, personnel are subject to change, and it is suggested that the NNSA/NFO Soils Activity Lead be contacted for further information. The Task Manager will be identified in the FFACO Monthly Activity Report prior to the start of field activities.

# Appendix C

# Pre-calculated Exposure Scenario-Specific RRMGs

## Table C.1-1
## Total Effective Dose RRMGs (pCi/g)
## for the Ground Troops Exposure Scenario

| Radionuclide | Ground Troops Exposure Scenario |
|---|---|
| Ag-108m | 4.80E+01 |
| Al-26 | 3.10E+01 |
| Am-241 | 2.87E+03 |
| Am-243 | 3.47E+02 |
| Cm-243 | 5.66E+02 |
| Cm-244 | 9.84E+03 |
| Co-60 | 3.25E+01 |
| Cs-137 | 1.29E+02 |
| Eu-152 | 6.77E+01 |
| Eu-154 | 6.33E+01 |
| Eu-155 | 1.70E+03 |
| Nb-94 | 4.98E+01 |
| Np-237 | 3.28E+02 |
| Pu-238 | 5.06E+03 |
| Pu-239/240 | 4.63E+03 |
| Pu-241 | 2.29E+05 |
| Sr-90 | 1.20E+04 |
| Tc-99 | 1.25E+06 |
| Th-232 | 9.14E+02 |
| U-233 | 2.45E+04 |
| U-234 | 2.74E+04 |
| U-235 | 4.49E+02 |
| U-238 | 2.46E+03 |

A soil sample at this RRMG value would present a TED potential of 25 mrem per calendar year.

mrem = Millirem

**Table C.1-2**
**Internal Dose RRMGs (pCi/g)**
**for the Ground Troops Exposure Scenario**

| Radionuclide | Ground Troops Exposure Scenario |
|---|---|
| Ag-108m | 1.59E+07 |
| Al-26 | 9.39E+06 |
| Am-241 | 6.13E+03 |
| Am-243 | 5.92E+03 |
| Cm-243 | 1.29E+04 |
| Cm-244 | 2.11E+04 |
| Co-60 | 6.95E+06 |
| Cs-137 | 1.98E+05 |
| Eu-152 | 3.26E+06 |
| Eu-154 | 3.96E+06 |
| Eu-155 | 8.70E+07 |
| Nb-94 | 1.91E+07 |
| Np-237 | 1.07E+04 |
| Pu-238 | 5.95E+03 |
| Pu-239/240 | 4.65E+03 |
| Pu-241 | 1.99E+05 |
| Sr-90 | 8.59E+04 |
| Tc-99 | 5.09E+07 |
| Th-232 | 1.44E+03 |
| U-233 | 2.69E+04 |
| U-234 | 2.87E+04 |
| U-235 | 2.96E+04 |
| U-238 | 2.95E+04 |

A soil sample at this RRMG value would present an internal dose potential of 25 mrem per calendar year.

# Appendix D

# RESRAD Input Parameter Review

# D.1.0 Methodology

All RESRAD input parameters for the modeled pathways were identified and reviewed to ensure that appropriate values would be used in the development of RRMGs. These input parameters are presented in Table D.1-1 with their RESRAD default values and the values for the site-specific Ground Troops Scenario. The parameter values that changed from the default values are identified with a gray shading.

**Table D.1-1**
**RESRAD Input Parameters**
(Page 1 of 2)

| Parameter | Default | Site-Specific Value | Units |
|---|---|---|---|
| Area of contaminated zone | 10,000 | **1,000** | $m^2$ |
| Thickness of contaminated zone | 2 | **0.05** | m |
| Cover depth | 0 | 0 | m |
| Density of contaminated zone | 1.5 | 1.5 | $g/cm^3$ |
| Contaminated zone erosion rate | 0.001 | **0** | m/yr |
| Contaminated zone total porosity | 0.4 | **0.43** | None |
| Contaminated zone field capacity | 0.2 | 0.2 | None |
| Contaminated zone hydraulic conductivity | 10 | **1,090** | m/yr |
| Contaminated zone b parameter | 5.3 | **4.9** | None |
| Evapotranspiration coefficient | 0.5 | **0.98** | None |
| Wind speed | 2 | **2.85** | m/sec |
| Precipitation | 1 | **0.123** | m/yr |
| Irrigation | 0.2 | **0** | m/yr |
| Runoff coefficient | 0.2 | **0.4** | None |
| Inhalation rate | 8,400 | **8,906** | $m^3/yr$ |
| Mass loading for inhalation | 0.0001 | **0.0000272** | $g/m^3$ |
| Exposure duration | 30 | **25** | years |
| Indoor dust filtration factor | 0.4 | **1** | None |
| External gamma shielding factor | 0.7 | **1** | None |

**Table D.1-1**
**RESRAD Input Parameters**
(Page 2 of 2)

| Parameter | Default | Site-Specific Value | Units |
|---|---|---|---|
| Indoor time fraction | 0.5 | **0.00** | None |
| Outdoor time fraction | 0.25 | **0.115** | None |
| Soil ingestion | 36.5 | 36.5 | g/yr |
| Depth of soil mixing layer | 0.15 | **0.05** | m |

Gray shaded cells = Parameter values changed from default values

$g/cm^3$ = Grams per cubic centimeter
g/m = Grams per meter
$g/m^3$ = Grams per cubic meter
g/yr = Grams per year
m/sec = Meters per second
m/yr = Meters per year
$m^3/yr$ = Cubic meters per year

Each parameter was reviewed for the following factors:

- Its role in the model
- How it affects model results
- How it relates to NNSS-specific conditions

While all parameters were reviewed, the parameters that had more effect on RRMG values received more scrutiny. Based on this review, values were determined and justified for each parameter that was considered to be conservatively representative of CAU 541 conditions. The development of recommended values for each of the input parameters is presented in the following section.

## D.2.0 Review of Individual Parameters

The RESRAD Title Screen as shown in Figure D.2-1 presents some basic options for setting up the model run and formatting the output. Input options for this title screen are discussed in Section D.2.1.

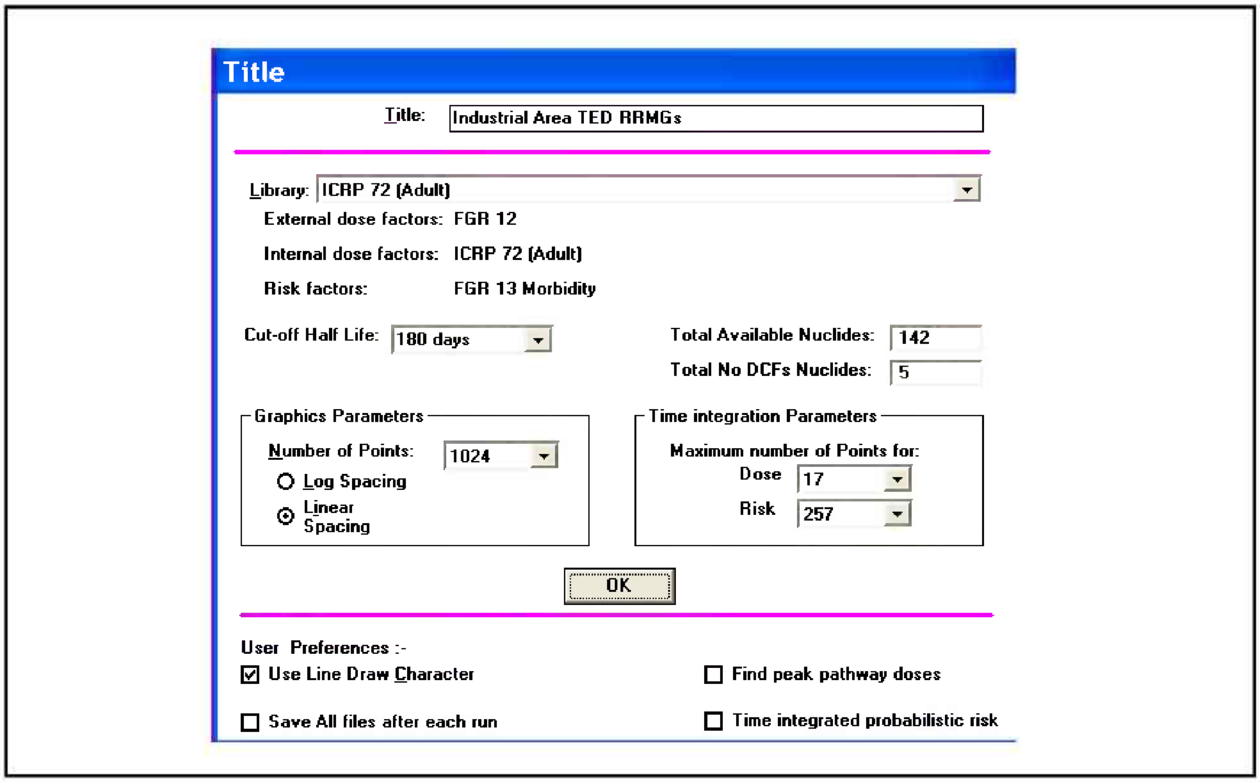


**Figure D.2-1**
**RESRAD Title Screen**

The following RESRAD input parameters were determined to be sensitive parameters and are discussed in Sections D.2.2 through D.2.10:

- Area of contaminated zone
- Thickness of contaminated zone
- Wind speed
- Inhalation rate
- Mass loading for inhalation
- Indoor dust filtration factor
- External gamma shielding factor
- Indoor time fraction and Outdoor time fraction
- Soil ingestion

The following RESRAD input parameters were determined to not be sensitive parameters and are discussed in Sections D.2.11 through D.2.19.

- Cover depth, Irrigation, and Contaminated zone erosion rate
- Density of contaminated zone and Contaminated zone total porosity
- Contaminated zone field capacity
- Contaminated zone hydraulic conductivity and Contaminated zone b parameter
- Evapotranspiration coefficient
- Precipitation
- Runoff coefficient
- Exposure duration
- Depth of soil mixing layer

How a change in a parameter value affects the RRMGs is addressed for each input parameter in the "Model Response to Parameter" subsections (e.g., Sections D.2.2.1, D.2.3.1, D.2.4.1) throughout this appendix. This evaluation is based on a sensitivity analysis based on the change of a single parameter value while keeping the other parameter values fixed. This was accomplished as described in Kamboj et al. (2005), where the influence of a parameter considers both the change it makes on the RRMGs as well as the range of its values. Therefore, a reasonable minimum and maximum value for each parameter was determined along with the recommended value presented herein. The influence of each input parameter was calculated as a percent normalized dose difference (NDD) defined as the difference in RRMG values based on the minimum (Dlow) and maximum (Dhigh) input parameter values divided by the RRMG value based on the recommended input parameter value (Dbase), as follows:

$$NDD = [(Dhigh - Dlow)/Dbase] \times 100\%$$

An NDD was calculated for each input parameter and each radionuclide in the RRMG list. The NDDs for the TED are presented in Table D.2-1, and the NDDs for the internal dose are presented in Table D.2-2. If the NDD was greater than 10, the parameter was defined as a sensitive parameter for that radionuclide and is identified in the tables with a dark gray shading. For NDD values between 5 and 10, the parameter was defined as moderately sensitive and is identified in the tables with a gray shading. Parameters with NDDs less than 5 were defined to be not sensitive.

Source: Kamboj, S., J-J. Cheng, and C. Yu. 2005. "Deterministic vs. Probabilistic Analyses To Identify Sensitive Parameters in Dose Assessment Using RESRAD." In *Health Physics*, Vol. 88: pp. S104-S106.

## Table D.2-1
## Parameter NDD for TED

| Parameter | Am-241 | Cs-137 | Eu-155 | Pu-239 | Sr-90 | Th-232 | U-234 | U-235 | U-238 |
|---|---|---|---|---|---|---|---|---|---|
| Area of contaminated zone | 70.0 | 38.8 | 23.8 | 372.6 | 65.4 | 57.2 | 444.1 | 32.5 | 42.5 |
| Wind speed | 4.0 | 0.0 | 0.0 | 10.1 | 0.0 | 1.3 | 4.0 | 0.0 | 0.3 |
| Contaminated zone b parameter | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Contaminated zone erosion rate | 0.6 | 0.8 | 0.5 | 1.0 | 0.7 | 1.0 | 1.0 | 0.6 | 0.7 |
| Contaminated zone field capacity | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Contaminated zone hydraulic conductivity | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Density of contaminated zone and Contaminated zone total porosity | 0.1 | 0.8 | 0.5 | 0.0 | 0.6 | 0.7 | 0.0 | 0.7 | 0.6 |
| Evapotranspiration coefficient | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 |
| Exposure duration | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Inhalation rate | 4.3 | 0.0 | 0.0 | 10.0 | 0.0 | 1.4 | 4.3 | 0.0 | 0.3 |
| Mass loading for inhalation | 41.9 | 0.0 | 0.0 | 75.5 | 0.4 | 17.5 | 42.6 | 0.7 | 3.7 |
| Precipitation | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Runoff coefficient | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| External gamma shielding factor | 23.8 | 40.0 | 40.0 | 0.2 | 32.2 | 33.7 | 2.1 | 39.5 | 37.3 |
| Indoor dust filtration factor | 3.7 | 0.0 | 0.0 | 9.3 | 0.0 | 1.2 | 3.7 | 0.0 | 0.2 |
| Soil ingestion | 46.2 | 0.1 | 0.0 | 117.9 | 27.1 | 19.0 | 126.8 | 1.6 | 9.1 |
| Thickness of contaminated zone | 2.6 | 43.8 | 18.4 | 0.2 | 30.9 | 44.6 | 0.9 | 31.0 | 39.0 |

Dark gray shaded cells = Sensitive parameters
Light gray shaded cells = Moderately sensitive parameters

## Table D.2-2
## Parameter NDD for Internal Dose

| Parameter | Am-241 | Cs-137 | Eu-155 | Pu-239 | Sr-90 | Th-232 | U-234 | U-235 | U-238 |
|---|---|---|---|---|---|---|---|---|---|
| Area of contaminated zone | 380.4 | 892.0 | 844.8 | 380.3 | 886.0 | 413.0 | 574.3 | 587.8 | 604.5 |
| Wind speed | 10.2 | 0.1 | 0.5 | 10.2 | 0.1 | 8.8 | 4.3 | 4.0 | 3.7 |
| Contaminated zone b parameter | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Contaminated zone erosion rate | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 | 1.0 | 1.0 | 1.0 |
| Contaminated zone field capacity | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Contaminated zone hydraulic conductivity | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Density of contaminated zone and Contaminated zone total porosity | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Evapotranspiration coefficient | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Exposure duration | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Inhalation rate | 10.0 | 0.1 | 0.6 | 10.0 | 0.1 | 8.8 | 4.6 | 4.3 | 4.0 |
| Mass loading for inhalation | 75.7 | 1.1 | 7.4 | 75.8 | 1.9 | 69.7 | 44.3 | 42.4 | 40.0 |
| Precipitation | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Runoff coefficient | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Indoor dust filtration factor | 9.4 | 0.1 | 0.4 | 9.4 | 0.1 | 8.1 | 4.0 | 3.7 | 3.4 |
| Soil ingestion | 118.8 | 151.6 | 149.9 | 118.8 | 151.4 | 122.5 | 136.2 | 137.2 | 138.2 |
| Thickness of contaminated zone | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Dark gray shaded cells = Sensitive parameters
Light gray shaded cells = Moderately sensitive parameters

### D.2.1 RESRAD Title Screen Inputs

The RESRAD Title Screen input options as shown in Figure D.2-1 are discussed in this section.

#### D.2.1.1 Library

The International Commission on Radiological Protection 72 (Adult) internal dose conversion factor (DCF) library in RESRAD was selected for the following reasons:

- It reflects the updated dosimetric models referenced in 10 CFR 835 (CFR, 2014).
- It was developed for receptors in an outdoor environment.
- It is for an adult receptor, consistent with the Ground Troops Scenario selected for evaluation.

#### D.2.1.2 Cut-Off Half-Life

The use of a larger cut-off half-life value results in some RRMGs that are slightly lower. The value of 180 days is a RESRAD default value and the maximum available value. This option is available to limit the impact of radionuclides with very short half-lives. As the most recent nuclear test addressed by CAU 541 was conducted in 1962, radionuclides with very short half-lives are not of concern. Selection of the maximum available cut-off half-life value of 180 days was determined to be reasonable and conservative because a radionuclide with this half-life value would have decayed more than 100 half-lives since the last atmospheric nuclear test (99.999 percent of a radionuclide will have decayed away in 18 half-lives).

#### D.2.1.3 Graphics Parameters, Time Integration Parameters, and User Preferences

These input parameters are for visual presentation of RESRAD outputs and have no effect on RRMG values.

### D.2.2 Area of Contaminated Zone

This is defined in the User's Manual for RESRAD Version 6 (Yu et al., 2001) as a compact area that contains the locations of all soil samples with radionuclide concentrations that are clearly (two standard deviations) above background.

### *D.2.2.1 Model Response to Parameter*

As demonstrated by Figure D.2-2, increasing area of contaminated zone values up to approximately 1,000 $m^2$ significantly reduce RRMG values. This was determined to be a sensitive parameter for both the internal and total dose pathways.

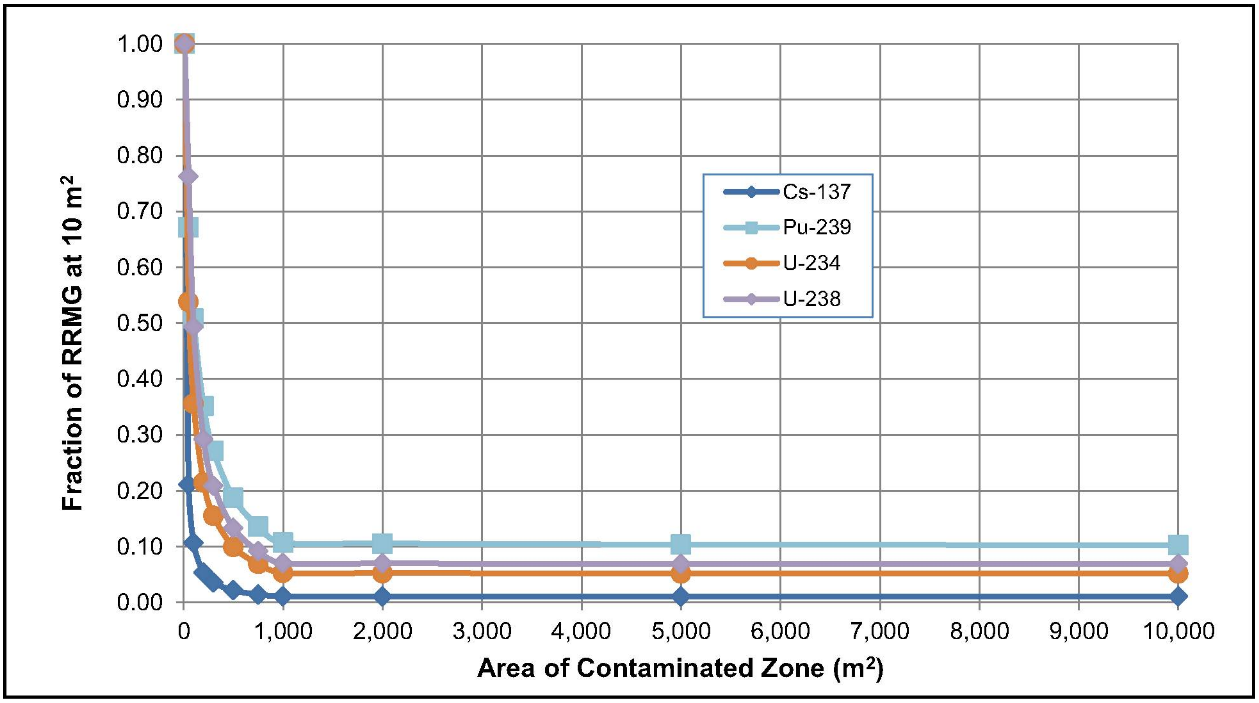


**Figure D.2-2**
**Effect of Area of Contaminated Zone on RRMG Values**

### *D.2.2.2 Recommended Value*

At Soils Activity sites, soil samples used to calculate dose are generally collected to represent an area of 100 $m^2$. For determining whether any 100-$m^2$ area exceeds the action level, these areas are selected from locations of the highest radiation survey readings. Expanding the 100-$m^2$ area could include areas of lower radioactivity and thus result in a lower average dose. To avoid this from occurring, DOE Order 458.1, *Radiation Protection of the Public and the Environment*, requires that the area for dose measurements be limited to no more than 100 $m^2$ (DOE, 2013). Therefore, the Soils Activity will not measure dose for any area exceeding 100 $m^2$. However, if the area of contaminated zone is set to 100 $m^2$, RESRAD considers the adjacent soil to be free of contamination that could contribute to the total dose received. As the locations where dose is measured at Soils Activity sites generally have adjacent contamination that could contribute to dose, the area of contaminated zone should be increased to include this area. This is a conservative approach, as RESRAD would consider this additional area as equally contaminated and would overestimate the resulting dose. To estimate the effect of the area of contaminated zone on RRMG values, RRMGs were determined using RESRAD for several area of contaminated zone values. The RESRAD response to increasing area of contamination values is shown in Figure D.2-2. This demonstrates that the presence of adjacent contamination does not have a significant impact on dose for areas larger than 1,000 $m^2$. Therefore, Soils Activity will conservatively use the value of 1,000 $m^2$ for the area of contaminated zone.

#### D.2.2.3 Sources

U.S. Department of Energy. 2013. *Radiation Protection of the Public and the Environment*, DOE Order 458.1, Change 3. Washington, DC: Office of Health, Safety and Security.

And this input parameter value was agreed to by decision makers during the DQO process for CAU 541.

### D.2.3 Thickness of Contaminated Zone

This is defined as the distance between the shallowest and the deepest depth of contamination. This parameter value is a starting thickness of uniform contaminant concentration that is reduced by the model based on erosion.

#### D.2.3.1 Model Response to Parameter

Higher values of the thickness of the contaminated zone provide lower RRMG values for the radionuclides that emit significant amounts of gamma radiation. This was determined to be a sensitive parameter for the total dose pathway. For the internal dose pathway, although four radionuclides (Ag-108, Al-26, Nb-94, and Tc-99) that are not common to Soils Activity sites showed moderate sensitivity, no significant changes in RRMG values were observed for any other radionuclide. Therefore, this is not considered to be a sensitive parameter for the internal dose pathway.

The significantly different effect this parameter has on the total dose and internal dose pathways show that changes in this parameter only affect external dose. When external dose is calculated using TLDs, changing the depth of contamination value will have no effect on dose calculations.

#### D.2.3.2 Recommended Value

Research at the NNSS shows that 90 percent or more of the radioactive contamination is located in the top 5 cm of soil. Concentrating contamination in the top 5 cm and setting the erosion rate to 0 will result in lower RRMGs. Therefore, it is recommended that the Soils Activity use a value of 5 cm (0.05 m) for the thickness of the contaminated zone.

#### D.2.3.3 Sources

Gilbert, R.O., E.H. Essington, D.N. Brady, P.G. Doctor, and L.L Eberhardt. 1977. "Statistical Activities during 1976 and the Design and Initial Analysis of Nuclear Site Studies." In *Transuranics in Desert Ecosystems*, NVO-181. pp. 331-366. November. Las Vegas, NV: U.S. Department of Energy, Nevada Operations Office.

And this input parameter value was agreed to by decision makers during the DQO process for CAU 541.

### D.2.4 Wind Speed

The wind speed number reflects the overall average of the wind speed, measured near the ground, in a one-year period.

#### D.2.4.1 Model Response to Parameter

Lower values of wind speed provide lower RRMG values. This is considered to be a sensitive parameter for the plutonium isotopes under both the internal and total dose pathways as well as for Am-241, Am-243, and Cm-244 under the internal dose pathway. It is also moderately sensitive for Cm-244 under the total dose pathway and for Cm-243, Np-237, and Th-232 under the internal dose pathway.

#### D.2.4.2 Recommended Value

As shown in Table D.2-3, the value of 2.85 m/sec represents the average annual wind speed measured at the weather station located at Well 5B (W5B) located just north of the Frenchman Flat playa. This value also reflects the lowest annual wind speed measure at any NNSS Soils Activity site location. This value is an average over approximately 40 years of measurements at a weather station on Frenchman Flat.

**Table D.2-3**
**NNSS Weather Station Average Annual Wind Speed**

| Station | W5B | UCC | A18 | MCY | 4JA | MVY | BJY | LTH | PM1 | A12 | YMR | A27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average (m/sec) | 2.85 | 3.03 | 3.49 | 3.77 | 3.73 | 3.85 | 3.86 | 4.07 | 4.82 | 5.17 | 4.89 | 5.80 |

Source: Soulé, 2006

### D.2.4.3 Source

Soulé, D.A. 2006. *Climatology of the Nevada Test Site*, SORD Technical Memorandum 2006-03. Silver Spring, MD: National Oceanographic and Atmospheric Administration, Air Resources Laboratory.

### D.2.5 Inhalation Rate

The inhalation rate is an average yearly rate in cubic meters per year ($m^3/yr$) that accounts for different activity levels performed outdoors. A site-specific value can be obtained with the assumed exposure scenario and an activity profile.

### D.2.5.1 Model Response to Parameter

Higher inhalation rate values provide lower RRMG values for most radionuclides. For the internal dose pathway, this parameter is considered to be sensitive for the americium and plutonium isotopes; and moderately sensitive for Np-237, Th-232, and the curium isotopes. For the total dose pathway, this parameter is considered to be moderately sensitive for Cm-244 and the plutonium isotopes. It is not sensitive for the remaining radionuclides under either pathway.

### D.2.5.2 Recommended Value

The recommended values for this parameter were developed using the methodology in the RESRAD Data Collection Handbook (Yu et al., 1993, Section 43.1).

The average breathing rates are taken from the values listed for 20- to 34-year-old males in Table 7 of “Metabolically Consistent Breathing Rates for Use in Dose Assessments” (Layton, 1993) and the DOE transmittal of soil-related information for USAF Land Uses (DOE, 1993). The breathing rates for “light work” activities were conservatively used for “resting” activity, and the rate for “moderate physical labor” activity was used for “hard physical labor” activities.

The average time spent (in hours) at different levels of activity per day for Ground Troops listed in Table D.2-4 was also obtained from these sources. It is assumed that all activities under the Ground Troops exposure scenario will be conducted outdoors. The inhalation rate was projected over 24 hours per day and 365 days per year, resulting in the recommended annual inhalation rate of 8,906 $m^3$/yr for Ground Troops activities. These results are shown in Table D.2-4.

**Table D.2-4**
**Ground Troops Inhalation Rate Calculation**

| Activity Level | Average Time Spent per Day at This Activity Level (hr/day) | Average Breathing Rate during This Time ($m^3$/hr) | Average Breathing Rate per Day ($m^3$/day) | Annual Inhalation Rate ($m^3$/yr) |
|---|---|---|---|---|
| Resting | 8 | 0.65 | 5.2 | -- |
| Light Work | 8 | 0.65 | 5.2 | -- |
| Moderate Physical Labor | 6 | 1.75 | 10.5 | -- |
| Hard Physical Labor | 2 | 1.75 | 3.5 | -- |
| Very Hard Physical Labor | 0 | 0 | 0 | -- |
| Total | 24 | -- | 24.4 | 8,906 |

Source: Layton, 1993; DOE/NV, 1998; Yu et al., 1993

hr/day = Hours per day
$m^3$/day = Cubic meters per day
$m^3$/hr = Cubic meters per hour

-- = Not applicable

Based upon these assumptions, the recommended value to be used for the Ground Troops exposure scenario inhalation rate parameter is 8,906 $m^3$/yr.

#### *D.2.5.3 Sources*

Layton, D.W. 1993. "Metabolically Consistent Breathing Rates for Use in Dose Assessments." In *Health Physics*, Vol. 64(1): pp. 23–36. Baltimore, MD.

U.S. Department of Energy, Nevada Operations Office. 1998. "Transmittal, Soil Related Information, Attachments A, B, C, and D: Air Force Land Uses," 7 January. Las Vegas, NV.

Yu, C., C. Loureiro, J.-J. Cheng, L.G. Jones, Y.Y. Wang, Y.P. Chia, and E. Faillace. 1993. *Data Collection Handbook To Support Modeling the Impacts of Radioactive Material in Soil*, ANL/EAIS-8. Argonne, IL: Environmental Assessment and Information Sciences Division, Argonne National Laboratory.

### *D.2.6 Mass Loading for Inhalation*

The mass loading parameter is the concentration of soil particles in the air and is obtained directly from empirical data for locations and conditions similar to those applicable for the scenario used.

#### *D.2.6.1 Model Response to Parameter*

Higher values of mass loading provide lower RRMG values for most radionuclides. For the internal dose pathway, this parameter is considered to be sensitive for Np-237, Th-232, and the americium, plutonium, uranium, and curium isotopes; and moderately sensitive for Tc-99, Nb-94, Ag-108m, and the europium isotopes. For the total dose pathway, this parameter is considered to be sensitive for Th-232, U-234, U-235, Cm-244, Am-241, and the plutonium isotopes; and moderately sensitive to Am-243 and Cm-243. It is not sensitive for the remaining radionuclides under either pathway.

#### *D.2.6.2 Recommended Value*

The values for mass loading of contaminated respirable dust particles outdoors is presented in Table D.2-5. The mass loading values for resting and light work is from the annual average mass loading measurements in data from the Tonopah Test Range (TTR) (Shinn, 1994). This study measured resuspension at the Clean Slate III Site at TTR from October 1990 through August 1991. The mass loading for moderate physical labor was assumed to be twice that for resting and light work. The mass loading for hard physical labor was assumed to be 10 times higher than that for light work and resting.

**Table D.2-5**
**Ground Troops Mass Loading**

| Activity Level | Average time Spent per Day at This Activity Level (hr/day) | Mass Loading Outdoors of Respirable Particles Associated with Contaminated Surface Soils during this Activity Level ($g/m^3$) | Mass Loading for This Activity ($g/m^3$) | Mass Loading Weighted Average ($g/m^3$) |
|---|---|---|---|---|
| Resting | 8 | 1.36E-05 | 1.09E-04 | -- |
| Light Work | 8 | 1.36E-05 | 1.09E-04 | -- |
| Moderate Physical Labor | 6 | 2.72E-05 | 1.63E-04 | -- |
| Hard Physical Labor | 2 | 1.36E-04 | 2.72E-04 | -- |
| Very Hard Physical Labor | 0 | 0 | 0 | -- |
| Total | 24 | -- | 6.53E-04 | 2.72E-05 |

Source: Shinn, 1994; DOE/NV, 1998

-- = Not applicable

### *D.2.6.3 Sources*

Shinn, J.H., Lawrence Livermore National Laboratory. 1994. Letter to R. Smiecinski titled “Data from Tonopah Test Range,” 14 September. Livermore, CA.

U.S. Department of Energy, Nevada Operations Office. 1998. “Transmittal, Soil Related Information, Attachments A, B, C, and D: Air Force Land Uses,” 7 January. Las Vegas, NV.

## *D.2.7 Indoor Dust Filtration Factor*

This factor is the ratio of airborne dust concentration indoors on site to the concentration outdoors on site. It is based on the fact that a building would provide shielding against entry of wind-blown dust particles.

### *D.2.7.1 Model Response to Parameter*

Higher values of indoor dust filtration factor provide lower RRMG values for some radionuclides. This parameter is moderately sensitive for Cm-244 and the plutonium isotopes under both the internal and total dose pathways. It is also moderately sensitive for Am-241, Am-243, Cm-243, Np-237, and

Th-232 under the internal dose pathway. It is not sensitive for the remaining radionuclides under either pathway.

#### *D.2.7.2 Recommended Value*

It is assumed that all activities under the Ground Troops Scenario will be conducted outdoors. Therefore, the recommended value for the indoor dust filtration factor parameter would be 1 (which would make the concentration of indoor dust equal to the concentration of outdoor dust).

#### *D.2.7.3 Source*

This input parameter value was agreed to by decision makers during the DQO process for CAU 541.

### *D.2.8 External Gamma Shielding Factor*

This factor is the ratio of the external gamma radiation level indoors on site to the radiation level outdoors on site. It is based on the fact that a building would provide shielding against penetration of gamma radiation.

#### *D.2.8.1 Model Response to Parameter*

Higher values of external gamma shielding factor provide lower RRMG values under the total dose pathway. This is not an active parameter under the internal dose pathway, so it is considered for the total dose pathway only. It is a sensitive parameter for all radionuclides except the plutonium isotopes, Cm-244, U-233, and U-234. It is moderately sensitive for U-233.

#### *D.2.8.2 Recommended Value*

The default external gamma shielding factor value in the RESRAD code is 0.7, which assumes that an external gamma radiation level indoors is 30 percent lower than an outdoor gamma radiation level. As the Ground Troops exposure scenario does not include indoor work, there will be no shielding of gamma radiation. Therefore, an external gamma shielding factor of 1 will be used for calculating RRMGs.

#### *D.2.8.3 Sources*

Yu, C., C. Loureiro, J.-J. Cheng, L.G. Jones, Y.Y. Wang, Y.P. Chia, and E. Faillace. 1993. *Data Collection Handbook To Support Modeling the Impacts of Radioactive Material in Soil*, ANL/EAIS-8. Argonne, IL: Environmental Assessment and Information Sciences Division, Argonne National Laboratory.

Yu, C., A.J. Zielen, J.-J. Cheng, D.J. LePoire, E. Gnanapragasam, S. Kamboj, J. Arnish, A. Wallo, III, W.A. Williams, and H. Peterson. 2001. *User's Manual for RESRAD Version 6*, ANL/EAD-4. Argonne, IL: Argonne National Laboratory, Environmental Assessment Division. (Version 6.5 released in October 2009.)

### *D.2.9 Indoor Time Fraction and Outdoor Time Fraction*

The fraction of time spent indoors and outdoors on site is the average fractions of time in a year during which an individual stays inside and outside a building on the contaminated site.

#### *D.2.9.1 Model Response to Parameter*

Higher values for the indoor and outdoor time fractions provide lower RRMG values. Changing these parameter values changes the amount of time exposed to the contamination. These are considered to be sensitive parameters for both the internal and total dose pathways.

#### *D.2.9.2 Recommended Value*

For the Ground Troops exposure scenario, it is assumed that shelter is not present and the entire workday is spent outdoors. Therefore, the values for the indoor and outdoor time fractions is a simple calculation of the total hours spent at the contaminated site divided by 8,760 (the total number of hours in a year). This results in the indoor and outdoor time fractions at the contaminated site as presented in Table D.2-6 for the Ground Troops standard Soils Activity exposure scenario.

**Table D.2-6**
**Annual Indoor and Outdoor Times Spent on Site**

| Exposure Scenario | Work Hours | Indoor Hours | Outdoor Hours | Indoor Time Fraction | Outdoor Time Fraction |
|---|---|---|---|---|---|
| Ground Troops | 1,008 | 0 | 1,008 | 0 | 0.115 |

#### *D.2.9.3 Source*

This input parameter value was agreed to by decision makers during the DQO process for CAU 541.

### *D.2.10 Soil Ingestion*

This parameter is the accidental ingestion rate of soil material or soil dust.

#### *D.2.10.1 Model Response to Parameter*

Higher values for the soil ingestion provide lower RRMG values. This is considered to be a sensitive parameter for all radionuclides under the internal dose pathway. For the total dose pathway, it is a sensitive parameter for Am-241, Cm-244, Sr-90, Tc-99, Th-232, U-233, U-234, and the plutonium isotopes. It is moderately sensitive for Am-243, Cm-243, and U-238. It is not sensitive for the remaining radionuclides.

#### *D.2.10.2 Recommended Value*

The values for soil ingestion are dependent upon the time spent indoors and outdoors. The EPA recommends a soil ingestion rate of 100 milligrams per day (mg/day) for outdoor activities. Because it is assumed that all work under the Ground Troops Scenario is performed outside, a soil ingestion rate of 100 mg/day (0.1 grams per day) is used based upon this EPA guidance (EPA, 2002). When this rate is extrapolated into a yearly rate, it results in a value of 36.5 g/yr.

#### *D.2.10.3 Source*

U.S. Environmental Protection Agency. 2002. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, OSWER 9355.4-24. Washington, DC: Office of Emergency and Remedial Response

### *D.2.11 Cover Depth, Irrigation, and Contaminated Zone Erosion Rate*

The cover depth is the distance from the ground surface to the location of the uppermost soil sample with radionuclide concentrations that are clearly above background. Irrigation is the practice of supplying water artificially to the soil in order to permit agricultural use of the land in an arid region or to compensate for occasional droughts in semidry or semihumid regions. The erosion rate is the average volume of soil material that is removed from one place to another by running water, waves and currents, wind, or moving ice.

#### *D.2.11.1 Model Response to Parameter*

Less clean cover soil depth overlying the contamination provides lower RRMG values. Lower irrigation values also provide lower RRMG values. Lower erosion rates will remove the contaminated material slower, leading to lower RRMG values. These are not considered to be sensitive parameters for either the internal or total dose pathways, as they are not considered to be applicable to Soils Activity sites.

#### *D.2.11.2 Recommended Value*

The Soils Activity assumes that the contamination is on the surface (no cover) and that no irrigation or erosion will occur. Assuming no erosion may not be realistic, but it will provide a more conservative dose estimate. It is recommended that the Soils Activity use values of 0 for the cover depth, irrigation, and contaminated zone erosion rate.

#### *D.2.11.3 Source*

This input parameter value was agreed to by decision makers during the DQO process for CAU 541.

### *D.2.12 Density of Contaminated Zone and Contaminated Zone Total Porosity*

These two parameters have the following relationship:

$$total\ \ porosity\ =\ 1-\frac{bulk\ \ density}{particle\ \ density}$$

Therefore, a change in the value of one of these parameters necessitates a change in the other using this relationship. The value of the particle density is considered to be a constant for silica-based material at 2.65 g/cm$^3$.

#### *D.2.12.1 Model Response to Parameter*

The use of a higher bulk density (and a corresponding lower porosity) results in slightly lower RRMG values. These are not considered to be sensitive parameters for either the internal or total dose pathways.

#### *D.2.12.2 Recommended Values*

The value of 1.5 g/cm$^3$ is a standard value used in EPA's Soil Screening Level Supplemental Guidance (EPA, 2002). Table D.2-7 presents the bulk density statistics of 93 soil samples collected in the Death Valley region (including the NNSS) that had a rock content of less than 50 percent. This shows very little variability in bulk density and an average bulk density value that is equal to the EPA standard value. Therefore, it is recommended that the Soils Activity use a value of 1.5 g/cm$^3$ for the density of the contaminated zone and the resulting total porosity of 0.43.

**Table D.2-7**
**Bulk Density Statistics for Samples from Death Valley Region**

| | Average | STDEV | n | $t_{\alpha/2}$ | $LCL_{95}$ | $UCL_{95}$ |
|---|---|---|---|---|---|---|
| Bulk Density | 1.50 | 0.0771 | 93 | 1.66 | 1.49 | 1.51 |

#### *D.2.12.3 Source*

Hevesi, J.A., A.L. Flint, and L.E. Flint. 2003. *Simulation of Net Infiltration and Potential Recharge Using a Distributed-Parameter Watershed Model of the Death Valley Region, Nevada and California*, Water-Resources Investigations Report 03-4090. Sacramento, CA: U.S. Geological Survey.

U.S. Environmental Protection Agency. 2002. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, OSWER 9355.4-24. Washington, DC: Office of Emergency and Remedial Response.

### *D.2.13 Contaminated Zone Field Capacity*

The field capacity sets the lower limit of the volumetric water content and is used to replace the calculated value when the calculated value is smaller. This is used to calculate percolation of infiltrating water through the contaminated zone.

#### *D.2.13.1 Model Response to Parameter*

There are no significant impacts to RRMG values by changing the value of this parameter for either the internal or total dose pathways. This parameter is moderately sensitive for four radionuclides (Ag-108, Al-26, Nb-94, and Tc-99) that are not common to Soils Activity sites under both pathway scenarios. Therefore, this is not considered to be a sensitive parameter for either the internal or total dose pathways.

#### *D.2.13.2 Recommended Value*

It is recommended that the Soils Activity use the default RESRAD value of 0.2 (unitless) for the contaminated zone field capacity.

#### *D.2.13.3 Source*

Yu, C., C. Loureiro, J.-J. Cheng, L.G. Jones, Y.Y. Wang, Y.P. Chia, and E. Faillace. 1993. *Data Collection Handbook To Support Modeling the Impacts of Radioactive Material in Soil*, ANL/EAIS-8. Argonne, IL: Environmental Assessment and Information Sciences Division, Argonne National Laboratory.

### *D.2.14 Contaminated Zone Hydraulic Conductivity and Contaminated Zone b Parameter*

The hydraulic conductivity of a soil is a measure of the soil's ability to transmit water when submitted to a hydraulic gradient. The soil-specific b parameter is an empirical and dimensionless parameter that is used to evaluate the saturation ratio (or the volumetric water saturation) of the soil, according to a soil characteristic function called the conductivity function (i.e., the relationship between the unsaturated hydraulic conductivity, K, and the saturation ratio). The soil-specific exponential b parameter is one of several hydrological parameters used to calculate the radionuclide leaching rate of the contaminated zone.

#### *D.2.14.1 Model Response to Parameters*

There are no significant impacts to RRMG values by changing the value of these parameters for either the internal or total dose pathways. These are not considered to be sensitive parameters.

#### D.2.14.2 Recommended Value

It is recommended that the Soils Activity use the representative values for a sandy loam from Clapp and Hornberger (1978) (as shown in Table D.2-8) to select the values for the contaminated zone hydraulic conductivity (1,090 m/yr) and for the contaminated zone b parameter (4.9).

**Table D.2-8**
**Hydraulic Properties of Soil Types**

| Texture | Hydraulic Conductivity (m/yr) | Saturated Water Content | Soil-Specific Exponential Parameter, b |
|---|---|---|---|
| Sand | 5,550 | 0.395 | 4.05 |
| Loamy sand | 4,930 | 0.41 | 4.38 |
| Sandy loam | 1,090 | 0.435 | 4.9 |
| Silty loam | 227 | 0.485 | 5.3 |
| Loam | 219 | 0.451 | 5.39 |
| Sandy clay loam | 199 | 0.42 | 7.12 |
| Silty clay loam | 53.6 | 0.477 | 7.75 |
| Clay loam | 77.3 | 0.476 | 8.52 |
| Sandy clay | 68.4 | 0.426 | 10.4 |
| Silty clay | 32.6 | 0.492 | 10.4 |
| Clay | 40.5 | 0.482 | 11.4 |

Source: Clapp and Hornberger, 1978

#### D.2.14.3 Source

Clapp, R.B., and G.M. Hornberger. 1978. "Empirical Equations for Some Soil Hydraulic Properties." In *Water Resources Research*, Vol. 14(4): pp. 601-604. Washington, DC: American Geophysical Union.

### D.2.15 Evapotranspiration Coefficient

Evapotranspiration represents the combination of two separate processes: (1) evaporation (i.e., the change of phase of water near the ground surface and the direct transfer of water vapor from the ground to the atmosphere) and (2) transpiration (i.e., the transfer of water from the ground to the atmosphere through the plants and their foliage).

#### *D.2.15.1 Model Response to Parameter*

Higher values of the evapotranspiration coefficient provide lower RRMG values for some radionuclides. This parameter is sensitive for four radionuclides (Ag-108, Al-26, Nb-94, and Tc-99) that are not common to Soils Activity sites under both pathway scenarios. No significant changes in RRMG values were observed for any other radionuclide. Therefore, this is not considered to be a sensitive parameter for either the internal or total dose pathways.

#### *D.2.15.2 Recommended Value*

It is recommended that the Soils Activity use the average value of the evapotranspiration coefficient from 61 locations in the Death Valley region (including the NNSS) from the Hevesi et al. (2003) study. As shown in Table D.2-9, the statistics for this parameter was very constant with an 95 percent LCL of 0.98 and a 95 percent UCL of 0.99. Therefore, it is recommended that the Soils Activity use the average value of 0.98.

**Table D.2-9**
**Evapotranspiration Coefficient Statistics from the Death Valley Region**

| | Average | STDEV | n | $t_{"/2}$ | $LCL_{95}$ | $UCL_{95}$ |
|---|---|---|---|---|---|---|
| Evapotranspiration Coefficient | 0.98 | 0.013671 | 61 | 1.67 | 0.98 | 0.99 |

Source: Hevesi et al., 2003

#### *D.2.15.3 Source*

Hevesi, J.A., A.L. Flint, and L.E. Flint. 2003. *Simulation of Net Infiltration and Potential Recharge Using a Distributed-Parameter Watershed Model of the Death Valley Region, Nevada and California*, Water-Resources Investigations Report 03-4090. Sacramento, CA: U.S. Geological Survey.

### *D.2.16 Precipitation*

The average annual precipitation is the average of the total amount of precipitation received in a one-year period.

#### *D.2.16.1 Model Response to Parameter*

Lower values of precipitation provide lower RRMG values for some radionuclides. This parameter is sensitive for four radionuclides (Ag-108, Al-26, Nb-94, and Tc-99) that are not common to Soils Activity sites under both pathway scenarios. No significant changes in RRMG values were observed for any other radionuclide. Therefore, this is not considered to be a sensitive parameter for either the internal or total dose pathways.

#### *D.2.16.2 Recommended Value*

As shown in Table D.2-10, the value of 0.123 m/yr represents the average annual precipitation measured at Well 5B (W5B), which is located just north of the Frenchman Flat playa. This value is an average over approximately 40 years of measurements at the weather station on Frenchman Flat.

**Table D.2-10**
**NNSS Weather Station Average Annual Precipitation**

| Station | 40M | BJY | CS | DRA | 4JA | MV | PHS | PM1 | A12 | RV | TS2 | W5B | UCC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average (m/yr) | 0.204 | 0.161 | 0.195 | 0.144 | 0.138 | 0.228 | 0.188 | 0.197 | 0.326 | 0.156 | 0.216 | 0.123 | 0.168 |

Source: Soulé, 2006

#### *D.2.16.3 Source*

Soulé, D.A. 2006. *Climatology of the Nevada Test Site*, SORD Technical Memorandum 2006-03. Silver Spring, MD: National Oceanographic and Atmospheric Administration, Air Resources Laboratory.

### *D.2.17 Runoff Coefficient*

The runoff coefficient is the fraction of the average annual precipitation in excess of the deep percolation and evapotranspiration that becomes surface flow and ends up in either perennial or intermittent surface water bodies.

#### *D.2.17.1 Model Response to Parameter*

While higher runoff coefficient values provide slightly lower RRMG values for some radionuclides, there are no significant impacts to RRMG values by changing the value of this parameter. This is not considered to be a sensitive parameter for either the internal or total dose pathways.

#### *D.2.17.2 Recommended Value*

A methodology for estimating the runoff coefficient is presented in the RESRAD Data Collection Handbook based on the type of soil and land utilization. The best estimate of the runoff coefficient using this methodology is 0.4. As this is not a sensitive parameter, this is the recommended value to use for the runoff coefficient.

#### *D.2.17.3 Source*

Yu, C., C. Loureiro, J.-J. Cheng, L.G. Jones, Y.Y. Wang, Y.P. Chia, and E. Faillace. 1993. *Data Collection Handbook To Support Modeling the Impacts of Radioactive Material in Soil*, ANL/EAIS-8. Argonne, IL: Environmental Assessment and Information Sciences Division, Argonne National Laboratory.

### *D.2.18 Exposure Duration*

The exposure duration is the span of time, in years, during which an individual is expected to spend time on the site.

#### *D.2.18.1 Model Response to Parameter*

The value for the exposure duration does not affect RRMG values. This is not considered to be a sensitive parameter for either the internal or total dose pathways.

#### *D.2.18.2 Recommended Value*

It is recommended that the exposure duration of 25 years be used for the Ground Troops exposure scenario. The default value used by EPA in risk assessments for industrial workers is 25 years.

#### D.2.18.3 Source

U.S. Environmental Protection Agency. 1991. *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors" Interim Final,* OSWER Directive 9285.6-03. Washington, DC: Office of Emergency and Remedial Response, Toxics Integration Branch.

### D.2.19 Depth of Soil Mixing Layer

The depth of the soil mixing layer is the depth of surface soil available for resuspension and is used in the calculation of the activity associated with resuspended particles. This parameter reflects an assumed surface layer that is sufficiently disturbed to uniformly distribute contamination within this layer. This is intended for situations of subsurface contamination that is covered by less contaminated soil. The soil mixing layer provides a modeled pathway for subsurface contamination to be brought to the surface.

#### D.2.19.1 Model Response to Parameter

For sites with surface contamination (typical of Soils Activity sites), soil mixing layer depths that are greater than the thickness of the contaminated zone will effectively dilute the concentration of radionuclides by mixing the additional thickness of uncontaminated soil. This will result in higher RRMG values. Soil mixing layer depths that are less than the thickness of the contaminated zone do not have an effect on RRMG values. Therefore, as long as the depth of the soil mixing layer is less than the thickness of the contaminated zone, this is not a sensitive parameter for either the internal or total dose pathways.

#### D.2.19.2 Recommended Value

The most conservative value for the depth of soil mixing layer is equal to or less than the thickness of the contaminated zone. Therefore, it is recommended that the Soils Activity use a value of 0.05 m for the depth of soil mixing layer (equal to the thickness of the contaminated zone).

#### D.2.19.3 Source

This input parameter value was agreed to by decision makers during the DQO process for CAU 541.

## *D.3.0 References*

CFR, see *Code of Federal Regulations.*

Clapp, R.B., and G.M. Hornberger. 1978. "Empirical Equations for Some Soil Hydraulic Properties." In *Water Resources Research*, Vol. 14(4): pp. 601-604. Washington, DC: American Geophysical Union.

*Code of Federal Regulations*. 2014. Title 10 CFR, Part 835, "Occupational Radiation Protection." Washington, DC: U.S. Government Printing Office.

DOE, see U.S. Department of Energy.

EPA, see U.S. Environmental Protection Agency.

Gilbert, R.O., E.H. Essington, D.N. Brady, P.G. Doctor, and L.L Eberhardt. 1977. "Statistical Activities during 1976 and the Design and Initial Analysis of Nuclear Site Studies." In *Transuranics in Desert Ecosystems*, NVO-181. pp. 331-366. November. Las Vegas, NV: U.S. Department of Energy, Nevada Operations Office.

Hevesi, J.A., A.L. Flint, and L.E. Flint. 2003. *Simulation of Net Infiltration and Potential Recharge Using a Distributed-Parameter Watershed Model of the Death Valley Region, Nevada and California*, Water-Resources Investigations Report 03-4090. Sacramento, CA: U.S. Geological Survey.

Kamboj, S., J-J. Cheng, and C. Yu. 2005. "Deterministic vs. Probabilistic Analyses To Identify Sensitive Parameters in Dose Assessment Using RESRAD." In *Health Physics*, Vol. 88: pp. S104-S106.

Layton, D.W. 1993. "Metabolically Consistent Breathing Rates for Use in Dose Assessments." In *Health Physics*, Vol. 64(1): pp. 23–36. Baltimore, MD.

Shinn, J.H., Lawrence Livermore National Laboratory. 1994. Letter to R. Smiecinski titled "Data from Tonopah Test Range, 14 September. Livermore, CA.

Soulé, D.A. 2006. *Climatology of the Nevada Test Site*, SORD Technical Memorandum 2006-03. Silver Spring, MD: National Oceanographic and Atmospheric Administration, Air Resources Laboratory.

U.S. Department of Energy. 2013. *Radiation Protection of the Public and the Environment*, DOE Order 458.1, Change 3. Washington, DC: Office of Health, Safety and Security.

U.S. Department of Energy, Nevada Operations Office. 1998. "Transmittal, Soil Related Information, Attachments A, B, C, and D: Air Force Land Uses," 7 January. Las Vegas, NV.

U.S. Environmental Protection Agency. 1991. *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors" Interim Final,* OSWER Directive 9285.6-03. Washington, DC: Office of Emergency and Remedial Response, Toxics Integration Branch.

U.S. Environmental Protection Agency. 2002. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, OSWER 9355.4-24. Washington, DC: Office of Emergency and Remedial Response.

Yu, C., C. Loureiro, J.-J. Cheng, L.G. Jones, Y.Y. Wang, Y.P. Chia, and E. Faillace. 1993. *Data Collection Handbook To Support Modeling the Impacts of Radioactive Material in Soil*, ANL/EAIS-8. Argonne, IL: Environmental Assessment and Information Sciences Division, Argonne National Laboratory.

Yu, C., A.J. Zielen, J.-J. Cheng, D.J. LePoire, E. Gnanapragasam, S. Kamboj, J. Arnish, A. Wallo, III, W.A. Williams, and H. Peterson. 2001. *User's Manual for RESRAD Version 6*, ANL/EAD-4. Argonne, IL: Argonne National Laboratory, Environmental Assessment Division. (Version 6.5 released in October 2009.)

# Appendix E

# Nevada Division of Environmental Protection Comments

(5 Pages)

# Nevada Environmental Management Operations Activity
## DOCUMENT REVIEW SHEET

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Investigation Plan for Corrective Action Unit 541: Small Boy, Nevada National Security Site and Nevada Test and Training Range, Nevada | **2. Document Date:** | 7/21/2014 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro-INTERA |
| **5. Responsible NNSA/NSO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | 8/20/2014 |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres & Scott Page, NDEP, 486-2850 exts. 232 and 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Locatio | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 1.) Section 1.0, Page 1, 3rd Paragraph | Mandatory | Reference Frenchman Flat playa in the location description. | Frenchman Flat playa was referenced in the cited paragraph. The second sentence was replaced with the following, "CAU 541 is located on the Frenchman Flat playa and comprises the two corrective action sites (CASs) shown on Figure 1-2 and listed in Table 1-1. " | Accept |
| 2.) Figure 1-1, Page 2 | Mandatory | Add the location of CAU 541 since there is a reference given in Section 1, Paragraph 1. | The figure was revised to include the location of CAU 541. | Accept |
| 3.) Section 1.1.2, Page 6, 2nd Paragraph | Mandatory | Second sentence: replace "will be in the top..." with "is expected to be in the top..." | The sentence was revised with "is expected to be in the top…" | Accept |
| 4.) Section 1.1.2, Page 6, 3rd Paragraph | Suggested | First sentence: Replace existing sentence with: "Aerial radiological surveys of the area south of the Small Boy site detected an anomalous area of elevated radiological readings spatially separate from the radiological contamination plume associated with BFa and Small Boy." | The sentence will be replaced with a slightly modified version of the suggested text. "Aerial radiological surveys of the area south of the Small Boy site detected an anomalous area of elevated radiological readings spatially separate from the larger radiological contamination plume associated with the BFa and Small Boy sites. " | Accept |
| 5.) Section 2.2.2, Page 12, 2nd Paragraph | Mandatory | Last sentence: "...is detected": tense and sentence construction is awkward. Revise. | The sentence will be revised as follows, "Aerial radiological surveys identified two distinct areas of radiological contamination. A larger area encompasses the Small Boy test location and a smaller area is located to the south of the Small Boy site as shown on Figure 2-1. " | Accept |

# Nevada Environmental Management Operations Activity
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| | | | |
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| **5. Responsible NNSA/NSO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | 8/20/2014 |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres & Scott Page, NDEP, 486-2850 exts. 232 and 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Locatio | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 6.) Section 2.4, Page 13, 2nd Paragraph | Mandatory | Last sentence: "...receive an S from..."; correct this apparent editorial error. | The mistake in the sentence was revised as follows, “Therefore, the CSM will include the potential for receptors to receive an internal dose from contaminated soil and an external dose from contaminated soil and debris.” | Accept |
| 7.) Section 2.4.1, Page 14, Figure 2-1 | Suggested | Due to extensive references throughout the document to "anomalous area", consider labeling this feature to improve clarity in this and subsequent figures as appropriate. | The cited area was labeled on this and other applicable figures. | Accept |
| 8.) Section 2.4.2, Page 15, 2nd Paragraph | Mandatory | Third sentence: restate what is known about this area. Include a discussion about possible origins, including a hypothesis presented in DQO meeting that Aeolian processes and/or waterborne sedimentation on the playa could have transported radionuclides from Small Boy area into "Anomalous Area" where they may have become fixed by vegetation and/or slight topographic declivity. | Section 2.4.2 of the CAIP was revised to include probable transport mechanisms for the source of the contamination. The following was included after the fourth sentence of the second paragraph, "The anomalous area is believed to be part of the original deposition plume from the Small Boy Test. Preliminary analytical information provided in Section 2.5.5 indicates that there is no significant difference between the plutonium (Pu)-239/240 to americium (Am)-241 ratios at each site. The physically separate anomalous area is more heavily vegetated than the surrounding area and is believed to have resisted erosion of the original plume and may have trapped some of the contamination eroded from the interstitial area." | Accept |

# Nevada Environmental Management Operations Activity
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| **5. Responsible NNSA/NSO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | 8/20/2014 |
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| **8. Reviewer/Organization/Phone No:** | Chris Andres & Scott Page, NDEP, 486-2850 exts. 232 and 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Locatio | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 9.) Section 2.5.4, Page 22, 1st Paragraph | Mandatory | Other than proximity to CAU 541, clarify why this section about CAU 106 is relevant to this CAIP. | Section 2.5 of the FFACO CAIP outline requires the inclusion of all investigative studies that could provide pertinent information. The Able site investigation from the CAU 106 study provides useful information due to the similar environmental setting, proximity to the site, and to review the subsurface investigation performed as part of the Able study. This provides insight as to the distribution of contaminants that may be relevant to the planned CAU 541 investigation. | Accept |
| 10.) Section 3.3.1, Page 28, 2nd Paragraph | Mandatory | Add the following statement: "A section of the western boundary of the Desert National Wildlife Range lies approximately 1.7 miles east of the Small Boy GZ". Verify this, and if correct, further state that this portion of DNWR is used for military purposes and is closed to public entry. | The following sentence was added after the fourth sentence of paragraph three in Section 3.1.1, "The western boundary of the Desert National Wildlife Range lies approximately 1.9 mi east of the NNSS boundary. The range is used for military purposes and is not open to the public." | Accept, with the following modification to Response sentence 2: "This portion of the range is used for military purposes and is not open to the public." |

# Nevada Environmental Management Operations Activity
## DOCUMENT REVIEW SHEET

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|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Investigation Plan for Corrective Action Unit 541: Small Boy, Nevada National Security Site and Nevada Test and Training Range, Nevada | **2. Document Date:** | 7/21/2014 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro-INTERA |
| **5. Responsible NNSA/NSO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | 8/20/2014 |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres & Scott Page, NDEP, 486-2850 exts. 232 and 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Locatio | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 11.) Section A.2.2, Page A-5, Table A.2-1 | Mandatory | Migration Pathways row: regarding the dominance of vertical transport - add brief statement(s) regarding the tendency of standing water to infiltrate the playa subsurface providing a mechanism for moving residual radionuclides downward into the subsurface of Frenchman Flat playa IAW with Section 2.5.3. | The first sentence of the Migration Pathways discussion was revised as follows, “Lateral migration across surface soils/sediments and vertical migration through subsurface soils due to the potential for the playa to be inundated with water.” | Accept |
| 12.) Section A.8.2.2, Page A-36, Figure A.8-3 | Mandatory | Figure 2-5 and Figure A.8-3 are presumably the same FIDLER survey data; clarify why 2-5 appears to display discrete FOV measurements while A.8-3 appears to show measurements beyond the survey tracks shown in 2-5. | An explanation of the difference in presenting radiation survey information as point data or as a spatial distribution was added to Section 2.5. The following was added after the 4th sentence in the first paragraph, “The radiation surveys generated discrete measurement points (point data) with the spatial resolutions described in Table 2-3. See Figures 2-4, 2-5, and A.8-2 for the terrestrial radiological survey (TRS) point data results. For all aerial radiation surveys and for the field instrument for the detection of low-energy radiation (FIDLER) survey data (presented in Figure A.8-3), continuous spatial distributions (i.e., interpolated surfaces) are presented. These were estimated from the point data using an inverse distance weighted interpolation technique.” | Accept |
| 13.) Section A.8.2.3, Page A-37, 1st Paragraph | Mandatory | Second sentence: "...is observed...": tense and sentence is awkward. Revise. | The sentence was revised as follows, “A slight depression located to the immediate north of the Small Boy GZ has been observed to collect water and associated sedimentation in wetter periods.” | Accept |

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| **10. Comment Number/Locatio** | **11. Type*** | **12. Comment** | **13. Comment Response** | **14. Accept** |
|---|---|---|---|---|
| 14.) Section D.2.1.2, Page D-7, 4th Sentence | | An additional comment was received from a reviewer which states:<br><br>This sentence reads “As the Ground Troops Scenario only considers sites that are historical in nature, radionuclides with very short half-lives are not of concern.”<br><br>Earlier in the document (page 29) where the Ground Troops Scenario is described – it does not state anything about the scenario only considering "sites that are historical in nature”. Is this statement in section D.2.1.2 correct? If so, I think it should be called out in the description of the Ground Troops Scenario. | The reference to “sites historical in nature” was a poor choice of words to convey the intent that the source of radionuclides did not result from recent testing activities. The sentence was revised to read as follows, “As the most recent nuclear test addressed by CAU 541 was conducted in 1962, radionuclides with very short half-lives are not of concern." Also, the next sentence was revised to explain this conclusion as follows, "Selection of the maximum available cut-off half-life value of 180 days was determined to be reasonable and conservative because a radionuclide with this half-life value would have decayed more than 100 half-lives since the last atmospheric nuclear test (99.999 percent of a radionuclide will have decayed away in 18 half-lives)." | Accept |
| 15.) Page D-9 through D-25 | | An additional comment was received from a reviewer which states:<br><br>In several sections in this Appendix in the “Source” sections it is stated “By Agreement”. Who agreed? It is not clear what/who is meant in “by agreement" – Shouldn’t this be clearly stated somewhere in this section who agreed to the parameters? | These statements in Appendix D were replaced with "This input parameter value was agreed to by decision-makers during the DQO process for CAU 541." | Accept |

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