Nevada
Environmental
Restoration
Project

DOE/NV--1364

National Nuclear Security Administration

Corrective Action Investigation Plan for Corrective Action Unit 375: Area 30 Buggy Unit Craters Nevada Test Site, Nevada

Controlled Copy No.: ___
Revision No.: 0

March 2010

Approved for public release; further dissemination unlimited.

Environmental Restoration
Project

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

UNCONTROLLED when Printed

Available for sale to the public from:

U.S. Department of Commerce
National Technical Information Service
5301 Shawnee Road
Alexandria, VA, 22312-0002
Telephone: 800.553.6847
Fax: 703.605.6900
E-mail: *orders@ntis.gov*
Online Ordering: *http://www.ntis.gov/help/ordermethods.aspx*

Available electronically at *http://www.osti.gov/bridge*

Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
Phone: 865.576.8401
Fax: 865.576.5728
Email: *reports@adonis.osti.gov*

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Printed on recycled paper

UNCONTROLLED When Printed

DOE/NV--1364

CORRECTIVE ACTION INVESTIGATION PLAN FOR CORRECTIVE ACTION UNIT 375: AREA 30 BUGGY UNIT CRATERS NEVADA TEST SITE, NEVADA

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

Controlled Copy No.: ___

Revision No.: 0

March 2010

Approved for public release; further dissemination unlimited.

Reviewed and determined to be UNCLASSIFIED.
Derivative Classifier: Joseph P. Johnston/NNES CO
(Name/personal identifier and position title)
Signature: /s/Joseph P. Johnston
Date: 3/9/2010

UNCONTROLLED when Printed

**CORRECTIVE ACTION INVESTIGATION PLAN
FOR CORRECTIVE ACTION UNIT 375:
AREA 30 BUGGY UNIT CRATERS
NEVADA TEST SITE, NEVADA**

Approved by: Tiffany Lantow for   Date: 3/9/2010

Kevin J. Cabble
Federal Sub-Project Director
Soils Sub-Project

Approved by: Robert F. Boehlecke   Date: 3/9/2010

Robert F. Boehlecke
Federal Project Director
Environmental Restoration Project

Table of Contents

Table of Contents (Continued)

Table of Contents *(Continued)*

Table of Contents *(Continued)*

Table of Contents *(Continued)*

List of Figures

List of Figures (Continued)

Number	Title	Page

List of Tables

List of Acronyms and Abbreviations

4JA	Jackass Flats
40MI	40 Mile Canyon
Ac	Actinium
Am	Americium
amsl	Above mean sea level
ASTM	American Society for Testing and Materials
bgs	Below ground surface
Bi	Bismuth
CAA	Corrective action alternative
CADD	Corrective action decision document
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*
Ci	Curie
cm	Centimeter
Co	Cobalt
COC	Contaminant of concern
COPC	Contaminant of potential concern
cps	Counts per second
Cs	Cesium
CSM	Conceptual site model

List of Acronyms and Abbreviations *(Continued)*

D&D	Decontamination and decommissioning
DCG	Derived Concentration Guideline
DEM	Digital elevation model
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DQI	Data quality indicator
DQO	Data quality objective
DRI	Desert Research Institute
DRO	Diesel-range organics
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
ft	Foot
G-M	Geiger-Mueller
GPS	Global Positioning System
GZ	Ground zero
HSU	Hydrostratigraphic unit
IDW	Investigation-derived waste
in.	Inch
K	Potassium
km	Kilometer

List of Acronyms and Abbreviations *(Continued)*

kt	Kiloton
LCS	Laboratory control sample
m	Meter
m^2	Square meter
MDC	Minimum detectable concentration
mi	Mile
mm	Millimeter
mrem/IA-yr	Millirem per Industrial Access year
mrem/yr	Millirem per year
MS	Matrix spike
MSD	Matrix spike duplicate
NAC	*Nevada Administrative Code*
NAD	North American Datum
NAEG	Nevada Applied Ecology Group
Nb	Niobium
ND	Normalized difference
NDEP	Nevada Division of Environmental Protection
NEPA	*National Environmental Policy Act*
NNES	Navarro Nevada Environmental Services, LLC
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
Np	Neptunium
NRDS	Nuclear Rocket Development Station
NTS	Nevada Test Site

List of Acronyms and Abbreviations *(Continued)*

PAL	Preliminary action level
Pb	Lead
PCB	Polychlorinated biphenyl
pCi/g	Picocuries per gram
PET	Potential evapotranspiration
PPE	Personal protective equipment
PSM	Potential source material
Pu	Plutonium
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
R/hr	Roentgens per hour
RBCA	Risk-based corrective action
RBSL	Risk-based screening level
RCRA	*Resource Conservation and Recovery Act*
RESRAD	Residual Radioactive
RIDP	Radionuclide Inventory and Distribution Program
RL	Reporting limit
RMA	Radioactive material area
RPD	Relative percent difference
RSL	Remote Sensing Laboratory
RWMS	Radioactive waste management site
Sm	Samarium
Sr	Strontium

List of Acronyms and Abbreviations (Continued)

SSTL	Site-specific target level
SVOC	Semivolatile organic compound
TCA	Test Cell A
TCLP	Toxicity Characteristic Leaching Procedure
TED	Total effective dose
Th	Thorium
Tl	Thallium
TLD	Thermoluminescent dosimeter
TPH	Total petroleum hydrocarbons
U	Uranium
UCL	Upper confidence limit
UST	Underground storage tank
UTM	Universal Transverse Mercator
VOC	Volatile organic compound
VSP	Visual Sample Plan
μR/hr	Microroentgens per hour
%R	Percent recovery

Executive Summary

Corrective Action Unit (CAU) 375 is located in Areas 25 and 30 of the Nevada Test Site, which is approximately 65 miles northwest of Las Vegas, Nevada. Corrective Action Unit 375 comprises the two corrective action sites (CASs) listed below:

- 25-23-22, Contaminated Soils Site
- 30-45-01, U-30a, b, c, d, e Craters

Existing information on the nature and extent of potential contamination present at the CAU 375 CASs is insufficient to evaluate and recommend corrective action alternatives (CAAs). This document details an investigation plan that will provide for the gathering of sufficient information to evaluate and recommend CAAs.

Corrective Action Site 25-23-22 is composed of the releases associated with nuclear rocket testing at Test Cell A (TCA). Test Cell A was used to test and develop nuclear rocket motors as part of the Nuclear Rocket Development Station from its construction in 1958 until 1966, when rocket testing began being conducted at Test Cell C. The rocket motors were built with an unshielded nuclear reactor that produced as much as 1,100 kilowatts (at full power) to heat liquid hydrogen to 4,000 degrees Fahrenheit, at which time the expanded gases were focused out a nozzle to produce thrust. The fuel rods in the reactor were not clad and were designed to release fission fragments to the atmosphere, but due to vibrations and loss of cooling during some operational tests, fuel fragments in excess of planned releases became entrained in the exhaust and spread in the immediate surrounding area. Cleanup efforts have been undertaken at times to collect the fuel rod fragments and other contamination. Previous environmental investigations in the TCA area have resulted in the creation of a number of use restrictions. The industrial area of TCA is encompassed by a fence and is currently posted as a radioactive material area.

Corrective Action Site 30-45-01 (releases associated with the Buggy Plowshare test) is located in Area 30 on Chukar Mesa. It was a Plowshare test where five nuclear devices were buried 140 feet (ft) deep in a row at 150-ft intervals. These devices were detonated on March 12, 1968, to produce a trench 254 ft wide, 865 ft long, and 70 ft deep. The mesa where the test was conducted is surrounded on three sides by ravines, and the entire end of the mesa is fenced and posted as a contamination area.

These sites are being investigated because existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend 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 Corrective Action Decision Document.

The sites will be investigated based on the data quality objectives (DQOs) developed on December 2, 2009, by representatives of the Nevada Division of Environmental Protection and the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Site 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 375.

The environmental impacts at CASs 25-23-22 and 30-45-01 are radiological contamination that was released and distributed as a result of the nuclear tests conducted at TCA and the Buggy site. The presence and nature of contamination at CAU 375 will be evaluated based on information collected from a field investigation. Surface-deposited radiological contamination will be evaluated based on a comparison of the total effective dose at sample plot 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 collected from sample plots will be used to calculate internal radiological dose. Thermoluminescent dosimeters placed at the center of each sample plot will be used to measure external radiological dose.

The presence and nature of contamination from other types of releases (such as migration, excavation, as well as any potential releases discovered during the investigation) will be evaluated using soil samples collected from the locations most likely containing contamination, if present.

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

The scope of the corrective action investigation for CAU 375 includes the following activities:

- Conduct radiological surveys.

- Collect and submit environmental samples for laboratory analysis to determine whether contaminants of concern are present.

- If contaminants of concern are present, collect additional samples to define the extent of the contamination.

- Collect samples of investigation-derived waste, as needed, for waste management purposes.

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 following approval of the plan.

1.0 Introduction

This Corrective Action Investigation Plan (CAIP) contains project-specific information, including facility descriptions, environmental sample collection objectives, and criteria for conducting site investigation activities at Corrective Action Unit (CAU) 375: Area 30 Buggy Unit Craters, Nevada Test Site (NTS), Nevada.

This CAIP has been developed in accordance with the *Federal Facility Agreement and Consent Order* (FFACO) 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 (FFACO, 1996; as amended February 2008).

Corrective Action Unit 375 is located in Areas 25 and 30 of the NTS, which is approximately 65 miles (mi) northwest of Las Vegas, Nevada (Figure 1-1). Corrective Action Unit 375 comprises the two corrective action sites (CASs) shown on Figure 1-2 and listed below:

- 25-23-22, Contaminated Soils Site
- 30-45-01, U-30a, b, c, d, e Craters

The Corrective Action Investigation (CAI) will include field inspections, radiological surveys, sampling of environmental media, analysis of samples, and assessment of investigation results. Data will be obtained to support corrective action alternative (CAA) evaluations and waste management decisions.

1.1 Purpose

The CASs in CAU 375 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.

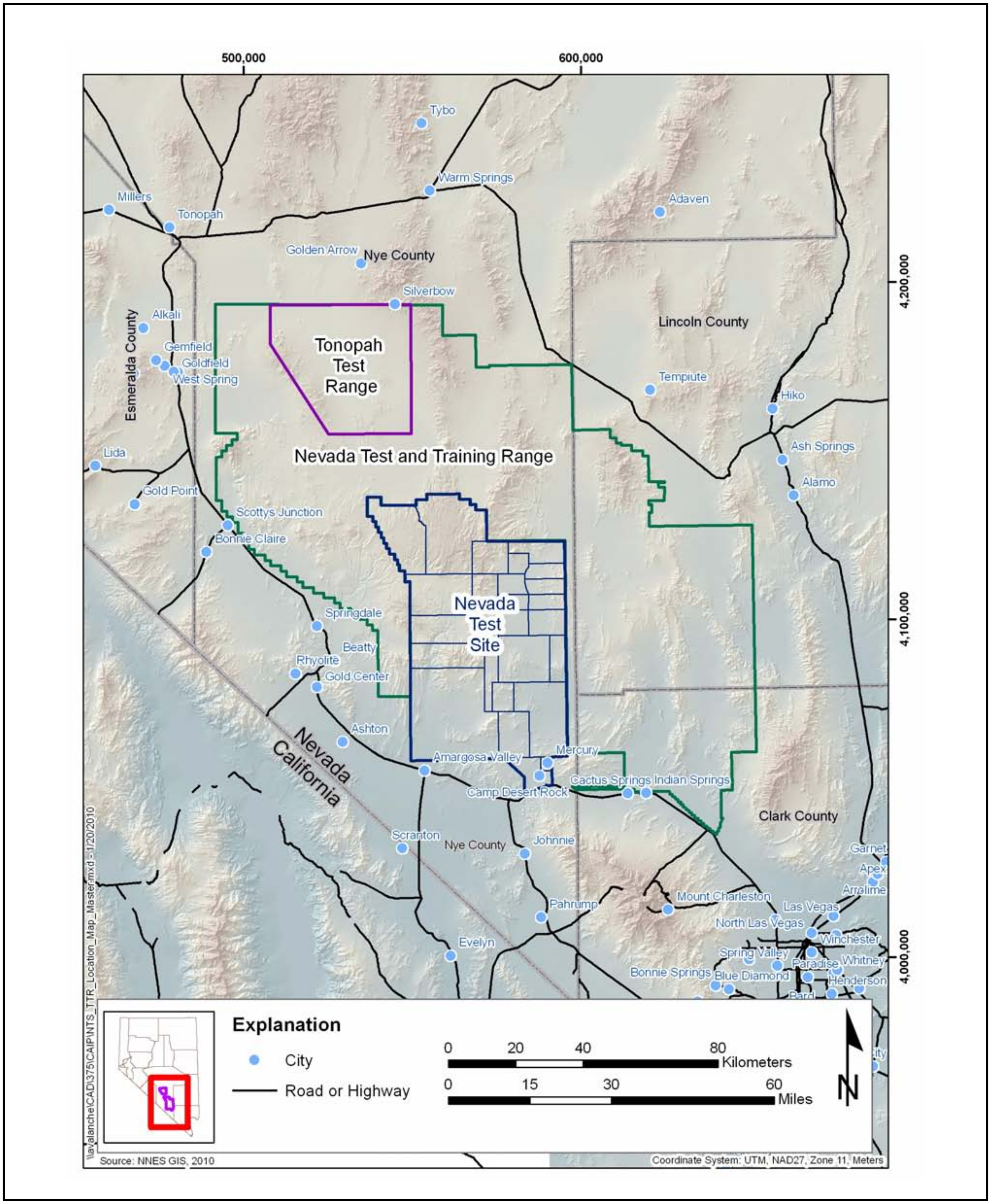


Figure 1-1
Nevada Test Site

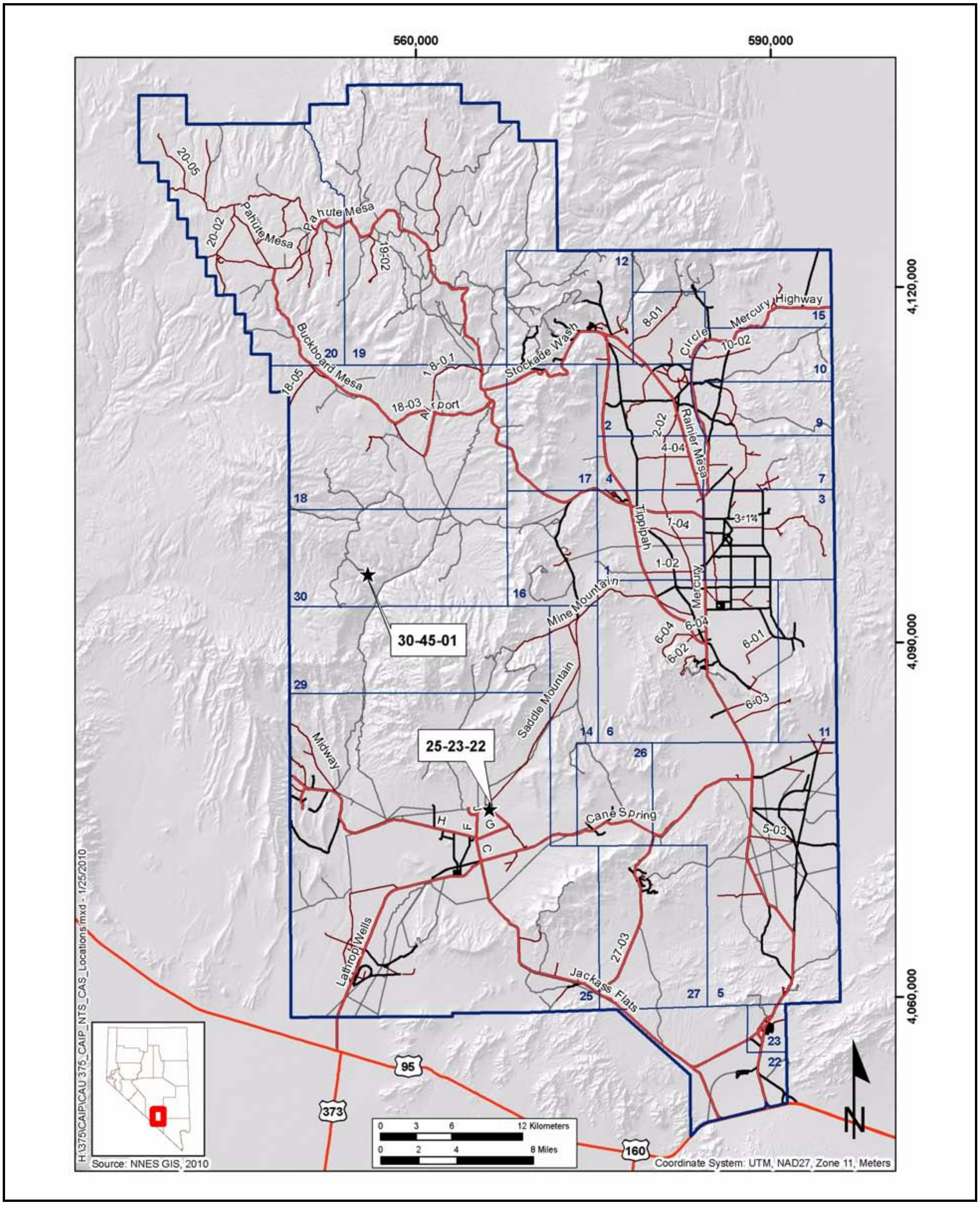


Figure 1-2
CAU 375, CAS Location Map

1.1.1 CAU 375 History and Description

Corrective Action Unit 375, Area 30 Buggy Unit Craters, consists of two inactive sites located in the central portion of Area 25 and the south-central portion of Area 30. The CAU 375 CASs consist of the following releases from nuclear tests conducted in the 1960s:

- Corrective Action Site 25-23-22 - Release of radioactive material from the testing of nuclear rocket motors at Test Cell A (TCA).
- Corrective Action Site 30-45-01 - Release of radioactive material from the Buggy Plowshare test.

Operational histories for each CAU 375 CAS 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) and the DOE, National Nuclear Security Administration Nevada Site Office (NNSA/NSO). The DQOs are used to identify and define the type, amount, and quality of data needed to develop and evaluate appropriate corrective actions for CAU 375. This CAIP describes the investigative approach developed to collect the data needs identified in the DQO process. While a detailed discussion of the DQO methodology and the DQOs specific to each CAS are presented in Appendix A, a summary of the DQO process is provided below.

The DQO problem statement for CAU 375 is: "Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs in CAU 375." 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 of potential concern (COPC) 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 COPC 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/NSO, 2006b).

- Decision II: "If a COC is present, is sufficient information available to evaluate potential CAAs?" Sufficient information is defined to include:

  - 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 needs to resolve the problem statement and the 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 375 CAS by collecting and analyzing samples generated during a field investigation. The presence of a COC will be determined by collecting and analyzing samples following these two criteria:

- For judgmental sampling decisions, samples must be collected in areas most likely to contain a COC.

- For probabilistic sampling decisions, samples must be collected from random locations that represent contamination within the sampling unit.

The DQOs for CAU 375 defined the following two release scenarios to appropriately address the different types of releases that may be present at the CASs:

- The test release is defined as the initial atmospheric deposition of radiological contaminants from nuclear tests. The initial test release is generally observed as an annular geometric pattern of contamination from soil particle activation and initial fallout that generally decreases in intensity with distance from the source.

- The non-test release is defined as the subsequent movement of radiological contamination from the test release (either migration or mechanical displacement) and other potential releases of contaminants from site operations (e.g., spills and abandoned materials).

The conceptual site model assumes that a large mass of subsurface contamination is present within the Buggy crater due to the prompt injection of radionuclides from the nuclear tests (see Section 3.1.3.2). This large mass of contamination is present at a depth that would be infeasible to remove under a corrective action of clean closure. This contamination is currently effectively contained in unsaturated media beneath and around the crater, and is covered within the crater by less contaminated material that has eroded into the crater. This provides a stable configuration for the contamination in the crater (see Section A.2.2.5). Therefore, information required to evaluate the corrective action of clean closure for crater contamination will not be collected during the investigation. Sampling within and beneath the crater would require the use of large drilling equipment and would pose significant technical and safety challenges. The contamination in the crater is assumed to exceed the FAL and will require a corrective action. This area will be defined as a default contamination boundary (see Section 3.4.1) that is encompassed by the crater and ejecta mounds at the crater rim. The area outside the default contamination area will be investigated as described in this document.

1.2 Scope

To generate information needed to resolve the decision statements identified in the DQO process, the scope of the CAI for CAU 375 includes the following activities:

- Move surface debris and/or materials, as needed, to facilitate sampling.
- 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 COCs are present.
- Collect and submit environmental samples for laboratory analysis to determine the nature and extent of any COCs released at each CAS.
- Collect samples of source 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 conceptual site model (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 Corrective Action Investigation Plan Contents

Section 1.0 presents the purpose and scope of this CAIP, while Section 2.0 provides background information about CAU 375. 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 for this project 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 Industrial Sites Quality Assurance Project Plan (QAPP) (NNSA/NV, 2002). The project 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 project organization. Appendix C contains responses to NDEP comments on the draft version of this document.

2.0 Facility Description

Corrective Action Unit 375 comprises two CASs that were grouped together based on the agency responsible for closure and an effort to close Soils CASs in the western half of the NTS.

The following two CASs that comprise CAU 375 are located in Areas 25 and 30 of the NTS, as shown in Figure 1-2:

- 25-23-22, Contaminated Soils Site
- 30-45-01, U-30a, b, c, d, e Craters

The following sections provide background information for CAU 375 including the CAS description, physical setting, operational history, release information, and previous investigation results for each CAS in CAU 375.

2.1 Physical Setting

The following sections describe the general physical settings of Areas 25 and 30 of the NTS. General background information pertaining to topography, geology, hydrogeology, and climatology are provided for these specific areas of the NTS region in the *Geologic Map of the Nevada Test Site, Southern Nevada* (USGS, 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, 1996b).

Geological and hydrological setting descriptions for each of the CASs are detailed in the following subsections based on the hydrogeographic area in which they are located.

2.1.1 Area 25, Jackass Flats

Test Cell A is located in Area 25 within the Jackass Flats basin. The site is partially paved and generally flat with sparse vegetation. The soil surrounding the TCA site is typical desert alluvium composed of mostly fine soil and loose rocks. Depth to bedrock and the existence of localized caliche is unknown in this area.

A review of the Area 25 drainages near the TCA facility indicates that stormwater runoff from the site flows southward merging with a larger surface drainage that flows southwest across the Jackass Flats valley. Approximately 9 kilometers (km) to the southwest, this larger drainage connects with the regional Topopah Wash (Jackass Flats 7.5 Minute Quadrangle) (USGS, 1964). Drainage ultimately flows into the Death Valley dry lake.

Precipitation data collected from 1958 to 2009 at the nearest rain gauge, Jackass Flats (4JA), produced an average annual rainfall of 5.66 inches (in.) (ARL/SORD, 2009). Average annual potential evapotranspiration (PET) for the NTS has been estimated for the Area 3 Radioactive Waste Management Site (RWMS) as 1,567 millimeters (mm) (61.8 in.) (Shott et al., 1997; Laczniak et al., 1996). Additional rainfall and PET information is presented in Table 2-1. It is expected that vertical migration of contaminants would be very limited at this site due to the low annual rate of precipitation and high annual PET rate.

Table 2-1
Rainfall and PET Information

	PET (in.)	Jackass Flats (4JA) Precipitation (in.)	40 Mile Canyon (40MI) Precipitation (in.)
Minimum	59.1	0.98	1.91
Maximum	63.3	14.40	17.24
Mean	61.8	5.66	8.06
95% UCL	62.8	6.50	9.00

Area 25 (Jackass Flats) is an intermontane valley of the NTS bordered by highlands on all sides except for a large drainage (Topopah Wash) outlet to the southwest towards the Death Valley and Ash Meadows discharge areas. Elevations range from 3,400 to 5,600 feet (ft) above mean sea level (amsl). The Jackass Flats basin is underlain by alluvium, colluvium, and volcanic rocks. The alluvium and colluvium (with a thickness upwards of 1,000 ft) are above the saturated zone throughout most of Jackass Flats. Depths to groundwater for the three water supply wells located within Area 25 are 1,039 ft below ground surface (bgs), 927 ft bgs, and 740 ft bgs (USGS, 1995). The soil at CAS 25-23-22 appears to be native and consists of sand to cobble-sized alluvium of various lithologies. Native vegetation is present throughout the area and is consistent in density with vegetation throughout the Jackass Flats area (Figure 2-1).

Figure 2-1
Test Cell A Area - Current Ground View

2.1.2 Area 30

The Buggy site consists of a release of radionuclides to the surrounding soil from the Buggy Plowshare test conducted on Chukar Mesa on March 12, 1968. Buggy was the first row detonation of nuclear devices conducted in the Plowshare effort to determine the feasibility of using nuclear explosions for peaceful means (i.e., excavation). The test created a large oblong crater approximately 865 ft long by 254 ft wide by 70 ft deep (Figure 2-2). Chukar Mesa east of the westernmost edge of the radiation plume created when the Buggy test was detonated is fenced and posted as a contamination area. The far southeast point of Chukar Mesa overlooks Fortymile Canyon from an elevation of 800 ft above the bottom of the canyon. Figure 2-3 shows an aerial view of the area to be addressed in this investigation.

The Buggy site is located within the Alkali Flat Furnace Creek Ranch Sub-basin. The groundwater in this area primarily flows through volcanic aquifers in a south-southwest direction towards the Death Valley and Ash Meadows discharge areas. Based on available Geographic Information Systems information obtained from the U.S. Geological Survey Data Repository (USGS, 1982), ephemeral

Figure 2-2
Northeast-Facing Aerial Photo of CAS 30-45-01
Source: RSL, 1977b

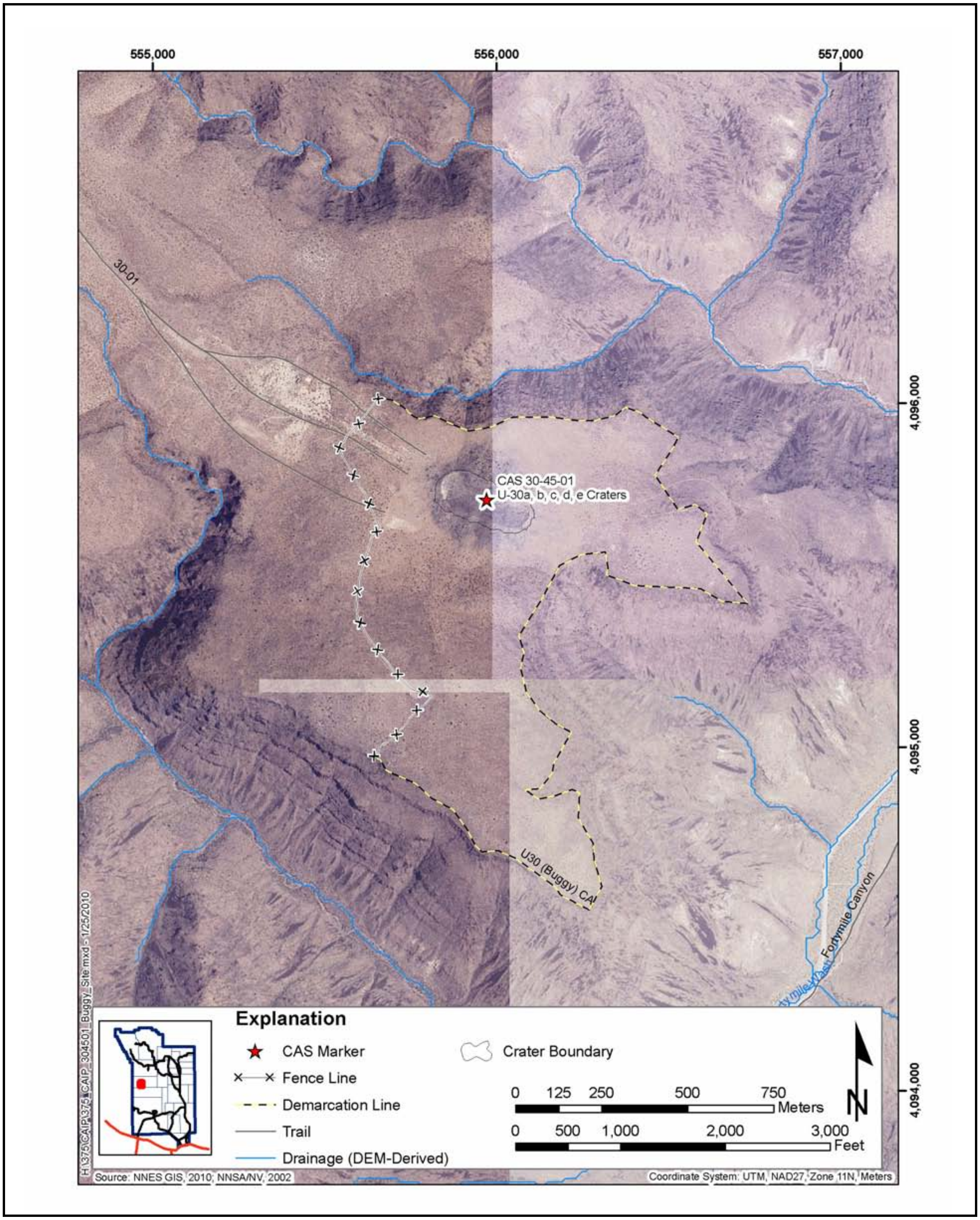


Figure 2-3
Enhanced Aerial Photo of CAS 30-45-01

streams are present approximately 800 meters (m) north and 1.2 km south of CAS 30-45-01. The area gently slopes away from the crater towards ravines running in a general southeast direction. In addition, one ephemeral stream begins approximately 465 m southeast of the CAS and flows in a general southeast direction. The flow from Fortymile Canyon eventually empties into Area 25 of the NTS and combines with the Topopah Wash close to the border of the NTS. Drainage ultimately flows into the Death Valley dry lake.

Precipitation data collected from 1958 to 2009 at the nearest rain gauge, 40 Mile Canyon (40MI), indicates an average annual rainfall of 8.09 in. (ARL/SORD, 2009). Average annual PET for the NTS has been estimated for the Area 3 RWMS as 1,567 mm (61.8 in.) (Shott et al., 1997; Laczniak et al., 1996). Additional rainfall and PET information is presented in Table 2-1. It is expected that vertical migration of contaminants would be very limited at this site due to the low annual rate of precipitation and high annual PET rate. The limited recharge to groundwater from precipitation does not provide a significant mechanism for vertical migration of contaminants to groundwater (DOE/NV, 1992).

Corrective Action Site 30-45-01 is located in Area 30, atop a mesa above Fortymile Canyon identified as Chukar Mesa. The geology of Chukar Mesa is fractured volcanic basalt (LRL, date unknown) with the surface being composed of uncompacted clay with small- to medium-size volcanic gravel and rocks with sparse vegetation.

The nearest water well is ER-30-1, where the depth to the uppermost aquifer is 450 ft bgs (NNES GIS, 2010). The well is located 4.28 mi northeast of the crater at an elevation approximately 500 ft lower than the Buggy site. Therefore, depth to groundwater at the Buggy site is estimated to be approximately 950 ft. The average elevation of the site is approximately 5,200 ft amsl (NNES GIS, 2010). The direction of precipitation runoff flow is into gullies and washes that generally drain to the south. Drainage channels are generally dry but are subject to infrequent, potentially intense, stormwater flows. Sedimentation entrained by these stormwater events would be carried by the streamflow to locations where the flowing water loses energy and the sediments drop out. These locations are readily identifiable as sedimentation areas.

The document *A Hydrostratigraphic Model and Alternatives for the Groundwater Flow and Contaminant Transport Model of Corrective Action Units 101 and 102: Central and Western Pahute Mesa, Nye County, Nevada* (BN, 2002) points out that although the interstitial porosity in such formations may be high, the interconnectivity of the pore space is poor, and these relatively incompetent rocks tend not to support open fractures. Secondary alteration ultimately yields a very impermeable unit. Additionally, these formations tend to have very low hydraulic conductivity. Though these rocks can be moderately fractured, the fractures are typically sealed by secondary mineralization.

That same document further states:

> "Of particular importance are the type and distribution in the rock, of alteration minerals such as clays, zeolites, and iron oxides. Not only do these minerals reduce the interstitial porosity of rocks, many of them have a capacity to sorb radionuclides, depending on their chemical nature, and they show markedly different sorptive capacities. Work in Frenchman Flat has identified the importance of zeolites and clays in retarding the movement of radionuclides via sorption and ion exchange. Various types of alteration minerals can make up a large percentage of the rocks that compose most of the volcanic HSUs defined as confining units. Zeolites and clay minerals may be present in the matrix of tuffs as a result of alteration of the glass in the original vitric tuff, or can be components of the mineral coatings on fracture surfaces.
>
> The presence of coatings or fillings in fractures not only reduces hydraulic conductivity by reducing the volume of fracture openings, but specific fracture-filling minerals may act to sorb radionuclides to various degrees. A few data are available for NTS rocks from studies conducted to investigate the nature and mineralogy of fracture fillings. The sorption of radionuclides by zeolites, clays, and iron oxides in fracture coatings may impede the diffusion of nuclides out of the fracture into the matrix. Thus, though the presence of sorptive minerals in the rock matrix can slow diffusion by trapping radionuclides, the presence of these minerals in fracture coatings may increase transport by preventing the diffusion of radionuclides from the fracture into the rock matrix. Matrix diffusion can slow the movement of any radionuclide, reactive or not, and thus is another very important process to consider in the modeling of radionuclide migration."

The road to the Buggy site is classified as an unmaintained trail and requires a four-wheel-drive vehicle for access. The site is fenced with triple-strand yellow wire and posted with "Controlled Area" and "Caution Contamination Area" signs. The area is a gently sloping mesa with a moderate amount of vegetation surrounded on three sides by ravines. The ejecta consists of fragmented basalt with metal, cable, and wood debris (Figure 2-4).

Figure 2-4
Site from beyond Fence Looking toward Crater

2.2 Operational History

The following subsections provide a description of the use and history of each CAS in CAU 375 that may have resulted in releases of contaminants to the environment. The CAS-specific summaries are designed to describe the current definition of each CAS and document all significant, known activities.

2.2.1 CAS 25-23-22, Contaminated Soils Site

This CAS is defined as the release of contaminants associated with testing of nuclear rocket motors at TCA. Test Cell A was built to support nuclear rocket motor development as part of the Nuclear Rocket Development Station (NRDS). The TCA facility was operational from 1959 to 1966, at which time the facility was closed. The area was used for a series of open-air nuclear reactor, nuclear engine, and nuclear furnace tests and for the High Energy Neutron Reactions Experiment. Equipment and facilities remain from some of these activities, and some limited areas of contaminated soils exist. The TCA facility was permanently removed from operation in 1973. In 2004, TCA buildings and facilities associated with the testing of the nuclear rockets were demolished and removed (CAU 115, CAS 25-41-04; NNSA/NSO, 2006a). Only the concrete building pads, the water tower, a bunker, and the piping from the tank farm remain. Figure 2-5 shows the locations of the structures at the site as they were before 2004.

The rocket motors tested at TCA used an unshielded portable nuclear reactor to heat liquid hydrogen to 4,000 degrees Fahrenheit, expanding the liquid hydrogen that was directed out a nozzle generating thrust. During its operational life, TCA was used to test the Kiwi, Nerva, and Phoebus reactors. The rockets motors were fired with the exhaust pointing up and venting directly to the atmosphere (Figure 2-6). The rocket motors contained uranium, graphite, and niobium. Niobium was used to line the cooling pipes within the reactor to reduce wear and oxidation. All tests were conducted on a concrete test pad that was shielded on one side by a concrete wall. Initial Kiwi rocket motor designs generated vibrations during operation, causing small pieces of the fuel rods to detach and be entrained with the exhaust (Figure 2-7). The following description of the cleanup is taken from the Kiwi B4A Reactor Operation (REECo, 1962):

> "Fractured fuel material was ejected from the reactor during the operation of the KIWI B4A and resulted in contaminating approximately 18 acres of land around the test stand. The contamination existed as an uneven deposit of ejected material. The size ranged from large, identifiable to microscopic pieces. Radiation levels greater than 500 R/hr were measured at near contact with the larger pieces one day after the reactor operation… The road was decontaminated first to permit entry of survey and recovery vehicles into the test cell area. Fire hoses were connected to the hydrants near the Dewar vessel area. High-pressure streams of water removed the contamination from the pavement. Approximately 2,600 feet of hard-surface roads were decontaminated in this manner… The decontamination effort required locating, recovering, and transporting identifiable pieces to the disassembly bay in the R-MAD Building. A portion of the ejected material was located visually. However, the majority was located by using radiation-survey instruments because most of the pieces were obscured by vegetation. Many pieces were so small that they were not visually detectable. High-range gamma detectors were used for surveying and for locating the larger pieces of material. G-M instruments, with the detector probes on long handles, were used to search for the smaller pieces of radioactive material. A variety of tongs, several long handle shovels, a dozen 20-quart pails, and 26 small lead lined boxes were used for handling and storing the collected radioactive material."

The topography at TCA is generally flat; no crater was formed as a result of the testing; and multiple tests were conducted at a single location. Unlike other previously investigated Soils CASs, the release was from a rocket motor; the contamination source material is related to reactor fuel;

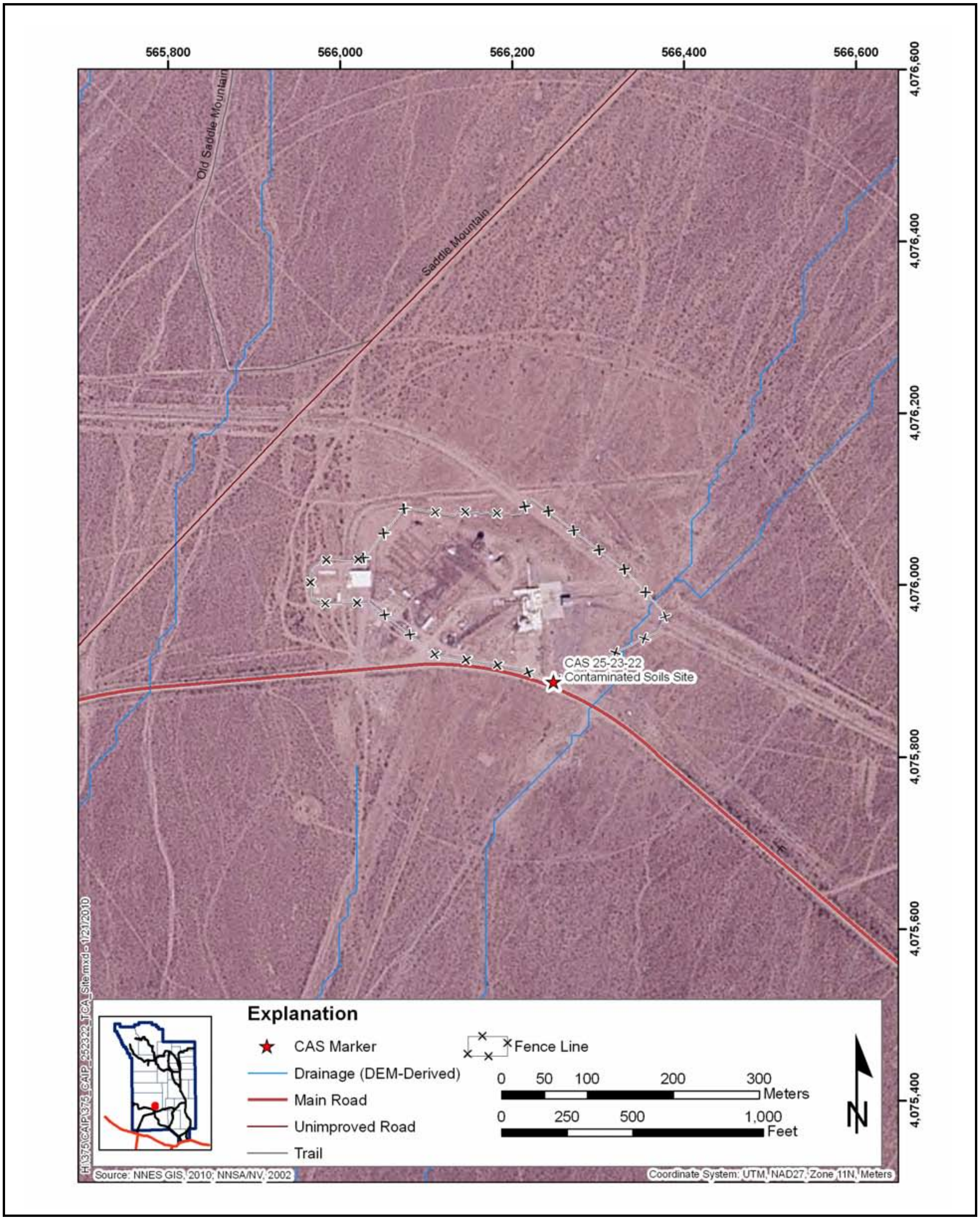


Figure 2-5
Site Sketch of TCA

Figure 2-6
Kiwi - Normal Operation
Source: LASL, 1962

Figure 2-7
Kiwi - Upset Operation
Source: LASL, 1962

cleanups have been conducted to remove contamination; and the tests were conducted within an industrial complex.

The scope of the investigation at TCA includes the soils in the immediate area of TCA contaminated during the testing of nuclear rockets, the railroad tracks inside the TCA fence line, all drainages or sediment collection areas where migration of contaminants may have occurred, and the TCA bunker. The items present at TCA but not included as part of this investigation are releases addressed by other CASs (e.g., rocket motor test pad, septic system, leachfield, the railroad tracks outside the TCA fence line) as listed in Table 2-2.

Table 2-2
Other TCA Investigations
(Page 1 of 2)

Description	CAS #	CAU #	Closure Strategy	Functional Category
Septic Tank/System	25-04-05	500	No Further Action with Use Restriction	Septic Tank
Lead Bricks	25-26-10	463	Clean Closure	Housekeeping Waste
Lead Bricks	25-26-26	463	Clean Closure	Housekeeping Waste
UST 25-3124-1	25-02-11	418	Clean Closure	Underground Storage Tank
UST 25-3127-1	25-02-12	418	Clean Closure	Underground Storage Tank
Spill	25-44-02	398	Clean Closure	Other Spill Site
Lead Bricks; Paraffin	25-19-01	386	Clean Closure	Waste Disposal Site
Lead Bricks (24)	25-26-03	386	Clean Closure	Housekeeping Waste
Lead	25-26-23	386	Clean Closure	Housekeeping Waste
Gas Cylinder	25-99-01	381	Clean Closure	Housekeeping Waste
Gas Cylinders (2)	25-99-13	381	Clean Closure	Housekeeping Waste
Drums (2)	25-22-02	354	Clean Closure	Housekeeping Waste
Drums (35)	25-22-03	354	Clean Closure	Housekeeping Waste
Gas Bottles (4)	25-99-17	354	Clean Closure	Housekeeping Waste
Bldg 3113A Outfall	25-60-01	300	Clean Closure	Surface Release Point
Bldg 3124 Contaminated Soil	25-62-01	300	Clean Closure	Surface Release Point
Radioactive Contaminated Debris	25-23-05	288	Clean Closure	Rad Contamination Area
Miscellaneous Chemicals	25-29-02	288	Clean Closure	Abandoned Chemicals
Miscellaneous Chemicals	25-29-03	288	Clean Closure	Abandoned Chemicals
Leachfield	25-05-09	266	Clean Closure	Leachfield
Leachfield	25-05-01	261	Closure in Place with Administrative Controls	Leachfield

Table 2-2
Other TCA Investigations
(Page 2 of 2)

Description	CAS #	CAU #	Closure Strategy	Functional Category
Acid Waste Leach Pit	25-05-07	261	No Further Action	Leachfield
Underground Electrical Vault	25-02-03	135	No Further Action	Other
Underground Storage Tank	25-02-10	135	No Further Action	Underground Storage Tank
Test Cell A Facility	25-41-04	115	Closure In Place	D&D Facility
Asbestos Wrapped Pipes	25-99-04	115	Clean Closure	Housekeeping Waste
Asbestos Wrapped Pipes	25-99-05	115	Clean Closure	Housekeeping Waste
Asbestos Wrapped Pipes	25-99-06	115	Clean Closure	Housekeeping Waste
Area 25 Railroad	25-99-21	114	Clean Closure	Other
Drum	25-22-04	89	Clean Closure	Housekeeping Waste
Batteries (26)	25-24-07	70	Clean Closure	Housekeeping Waste
Lead	25-26-01	70	Clean Closure	Housekeeping Waste
Lead Bricks	25-26-04	70	Clean Closure	Housekeeping Waste

D&D = Decontamination and decommissioning
UST = Underground storage tank

2.2.2 CAS 30-45-01, U-30a, b, c, d, e Craters

The Buggy site was established as part of Operation Crosstie to demonstrate the use of nuclear explosions for trench excavation. The test consisted of five nuclear devices buried in a line 150 ft apart at a depth of approximately 140 ft bgs, each of which had a yield of 1.08 kilotons (kt) (DOE/NV, 2000). The devices were detonated simultaneously on March 12, 1968, and resulted in a crater 254 ft wide by 865 ft long by 70 ft deep (LRL, 1970). Figure 2-2 shows an overall aerial view of the site. Figure 2-4 shows how the area has become naturally re-vegetated in the time since the test. The test was conducted on Chukar Mesa.

The top of Chukar Mesa is composed of relatively flat terrain but is surrounded on three sides by deep ravines that feed into Fortymile Canyon. Possible sedimentation areas will be investigated in all three ravines. A disposal pit that is present in the area has been closed in the Closure Report for CAU 42, CAS 30-15-01, Area 30 Disposal Site (DOE/NV, 1996a). The area is located in a remote, seldom-used area of the NTS that is only accessible by an unmaintained trail. The remainder of the mesa beyond the location of the test has been fenced and posted as contamination area as shown in Figure 2-3.

Corrective Action Site 30-45-01 consists of the release of radionuclides to the surrounding soil from the nuclear detonation, gas cylinders located outside the contamination area near two heavy timber temporary structures, a retention basin located adjacent to the gas cylinders, a battery located near the fence line across the mesa west of the crater, a lead box located near the previously mentioned battery, and drainages where sediment from the test area may have migrated and deposited contamination.

2.3 Waste Inventory

Available documentation, interviews with former site employees, process knowledge, and general historical NTS practices were used to identify wastes that may be present. Wastes generated during the CAI may include debris, investigation-derived waste (IDW), and contaminated soils. The potential waste types for the Buggy and TCA CASs are hazardous, low-level, mixed, sanitary, and hydrocarbon.

2.3.1 CAS 25-23-22, Contaminated Soils Site

Solid waste items identified at CAS 25-23-22 include a small amount of miscellaneous building material debris, empty drums, abandoned piping, and equipment and supplies from previous cleanup efforts. Additional waste may include debris, IDW, decontamination liquids, and soils.

2.3.2 CAS 30-45-01, U-30a, b, c, d, e Craters

Solid waste items identified at CAS 30-45-01 include a small amount of miscellaneous building material debris, battery, lead box, and any equipment and supplies remaining onsite. Additional waste may include debris, IDW, decontamination liquids, and soils.

2.4 Release Information

Known or suspected releases, including potential release mechanisms and migration routes associated with each of the CASs, are described in the following subsections.

Potentially affected media for all CASs include surface and shallow subsurface soil. Exposure routes to site workers include ingestion, inhalation, and/or dermal contact (absorption) from disturbance of contaminated soils, debris, and/or structures. Site workers also may also be exposed to radiation by performing activities in proximity to radiologically contaminated materials.

The following subsections contain CAS-specific descriptions of known or suspected releases associated with CAU 375.

2.4.1 CAS 25-23-22, Contaminated Soils Site

Release of contamination at the site from the test releases includes fallout due to the rocket tests, neutron activation of rocket elements such as graphite and niobium, and elements within the soil or concrete such as europium and cobalt. Releases of radionuclides from the exhaust of the nuclear rocket tests resulted in a roughly annular distribution pattern. Radioactive contamination for TCA includes activation of soil, components of the test pad and surrounding buildings, as well as fallout of fuel fragments and fission products from the exhaust cloud of radioactive particles. Due to significant excavation activities inside the TCA fence line, deposited contamination may have been buried or covered by soil or pavement, or may have migrated with stormwater runoff. Other potential releases such as spills, soil piles, or wastes may also be present.

2.4.2 CAS 30-45-01, U-30a, b, c, d, e Craters

Release of contamination at the site from the test release includes fallout from the initial detonation, neutron activation of elements such as europium and cobalt present within the rock and soil, and ejected fractured rock and sands containing radioactive slag and Trinity glass. Lead from within a battery and from a lead box identified approximately 1/4 mi west of ground zero (GZ) may have released lead to the surface soil. In addition, a small retention basin located north of GZ also may have released contaminants to the surface soil. The initial release of radionuclides from the Buggy test were distributed in a roughly annular pattern as illustrated in flyover surveys (BN, 1999). The potential exists for deposited contamination to have migrated with stormwater runoff. Other potential releases such as spills, or wastes may also be present.

The release of radioactive contamination to the soil from nuclear weapons testing at the Buggy site includes prompt injection, fallout of fuel fragments and fission products, neutron activation of soils and debris or structures, and ejected contaminated native materials.

2.5 Investigative Background

The following subsections summarize the investigations conducted at the CAU 375 sites.

2.5.1 CAS 25-23-22, Contaminated Soils Site

The following subsections summarize previous investigations conducted at TCA. These investigations include the 1994 flyover survey (BN, 1999); data from the Radionuclide Inventory and Distribution Program (RIDP) (DRI, 1989 and 2007) and Nevada Applied Ecology Group (NAEG) (Friesen, 1992); and the investigation of other TCA CASs.

2.5.1.1 1994 Flyover Survey

Flyover surveys have been conducted at the NTS measuring the type and intensity of radioactive exposure. The most recent flyover survey performed by the Remote Sensing Laboratory (RSL) in 1994 will be referenced, although it is noted that the data have not changed significantly from the initial 1976 flyover survey. The aerial radiological survey flown in 1994 exhibited an exposure rate at TCA between 120 to 270 microroentgens per hour (μR/hr), and its spectrum exhibited cesium (Cs)-137 and europium (Eu)-152 photopeaks with possible photopeaks for cobalt (Co)-60 (BN, 1999). Figure 2-8 shows that the area of highest radiological readings falls slightly to the east of the TCA test pad, which is unexpected. This shift may be due to a combination of aircraft flight path and the shielding provided by a concrete shield wall that was present to the west of the test pad at the time of the flyover survey.

2.5.1.2 RIDP and NAEG

As part of an effort to assess the implications of contamination on future uses of the NTS, the RIDP was established in 1981 to make a comprehensive survey of the important man-made radionuclides of NTS origin in the NTS surface soil (DRI, 1989).

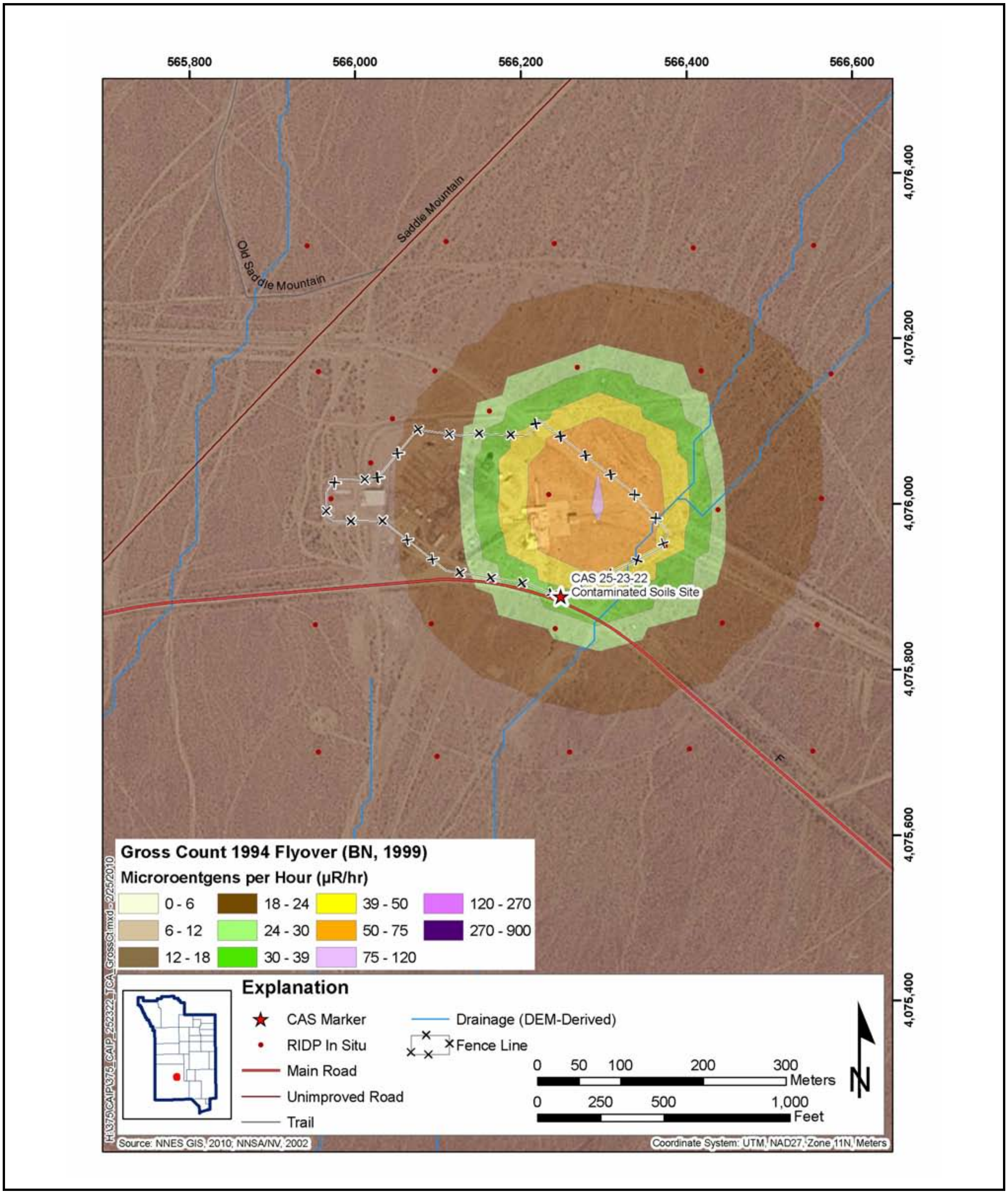


Figure 2-8
Test Cell A Aerial Survey

Note: Area of highest readings offset from test pad as discussed in Section 2.5.1.1.

The stated purpose of the NAEG (Friesen, 1992) was to coordinate the ecological radiation monitoring and other environmental programs necessary to support continued nuclear testing activities, and to provide the mechanism to effectively comply with requirements of *The National Environmental Policy Act* (NEPA) *of 1969*.

Data collected for the RIDP and by the NAEG in the 1980s allowed for estimates of surface soil inventories throughout the NTS. The RIDP estimated the inventory through *in situ* soil measurements by gamma spectroscopy and limited confirmatory soil sampling (DRI, 1989 and 2007). Estimates of radionuclides released to local surface soils at TCA are as follows: Co-60 at 0.083 curies (Ci), Cs-137 at 0.088 Ci, strontium (Sr)-90 at 0.074 Ci, and Eu-152 at 0.33 Ci. The total estimated inventory of radionuclides remaining in the soils in this area is about 1 Ci. The primary soil contaminants are enriched uranium, strontium, cesium, cobalt, and europium. Because of aging and weathering, these materials have become relatively fixed (ORAU, 2007).

2.5.1.3 Previous Investigations

Building 3113A, which is located at TCA, was included in the CAU 300 CAI. As part of the investigation, five soil screening samples were collected from the Bldg 3113A Outfall and analyzed using gamma spectroscopy. Results indicated that Cs-137, niobium (Nb)-94, Eu-152, and bismuth (Bi)-211 were present above background levels (IT, 2002).

It was determined from the laboratory results that the Cs-137 and Eu-152 contamination present at the outfall was not consistent with any releases associated with the outfall being investigated (CAS 25-60-01). The contamination was identified in soils that were above pipe depth and not contiguous to the outfall location. Subsurface radiological contamination was subsequently attributed to prior TCA rocket motor testing activities and was further reasoned to be present in subsurface soil due to excavation activities at the site (NNSA/NSO, 2005).

Other previous investigations of CASs throughout the TCA area primarily addressed housekeeping issues (Table 2-2). Two use restrictions remain as a result of two of the investigations: one on the test pad and the soils beneath the pad (CAU 115), and one on the underground piping of a septic system (CAU 261). The perimeter fence line is posted as a radioactive material area (RMA). In 2009, Navarro Nevada Environmental Services, LLC (NNES) conducted limited radiation surveys of TCA, both inside and outside the fenced area, during a site walkdown. Areas of elevated radiation were confirmed on the concrete test pad inside the test pad inside the fenced area. Also, a region of measurable dose rate in excess of the background levels was also identified to the north-northeast of the test pad, outside the fence, along the fence line. This area is remote from the test pad, is consistent with the location of the radiation plume as shown in the 1994 aerial radiological survey (BN, 1999), and is evidence of the atmospheric deposition of radioactive materials as a result of operation of the nuclear rocket motor system.

2.5.2 CAS 30-45-01, U-30a, b, c, d, e Craters

The following subsections summarize previous investigations conducted at CAS 30-45-01. Investigations conducted since the original test include the 1994 flyover survey (BN, 1999); and data from RIDP (DRI, 1989 and 2007), NAEG (Friesen, 1992), and Desert Research Institute (DRI) (DRI, 1985).

2.5.2.1 1994 Flyover Survey

Flyover surveys of the NTS conducted by RSL in 1994 measured the type and intensity of radioactive exposure. The most recent aerial radiological survey for the Buggy site flown in 1994 exhibited an exposure rate between 120 to 270 uR/hr (Figure 2-9), and its spectrum exhibited Cs-137 and Co-60 photopeaks with a well-defined region of americium (Am)-241 located within, but slightly west of, the man-made activity isopleths (BN, 1999) (Figure 2-10).

2.5.2.2 RIDP and NAEG

The data collected through *in situ* soil measurements by gamma spectroscopy and limited confirmatory soil sampling during the RIDP investigation provided information sufficient to estimate the radionuclide inventory at the NTS (DRI, 1989 and 2007). Estimates of radionuclides released to local surface soils in and around the Buggy site as identified in the RIDP document are as follows: Am-241 at 3.2 Ci, plutonium (Pu)-238 at 4.5 Ci, Pu-239/240 at 14 Ci, Co-60 at 1.4 Ci, Cs-137 at 1.7 Ci, Sr-90 at 1.6 Ci, Eu-152 at 0.90 Ci, Eu-154 at 0.40 Ci, and Eu-155 at 0.18 Ci (DRI, 1989).

Soil samples were collected from around the NTS in behalf of the NAEG to define depth of plutonium penetration and determine the total amount of plutonium deposited throughout the area of

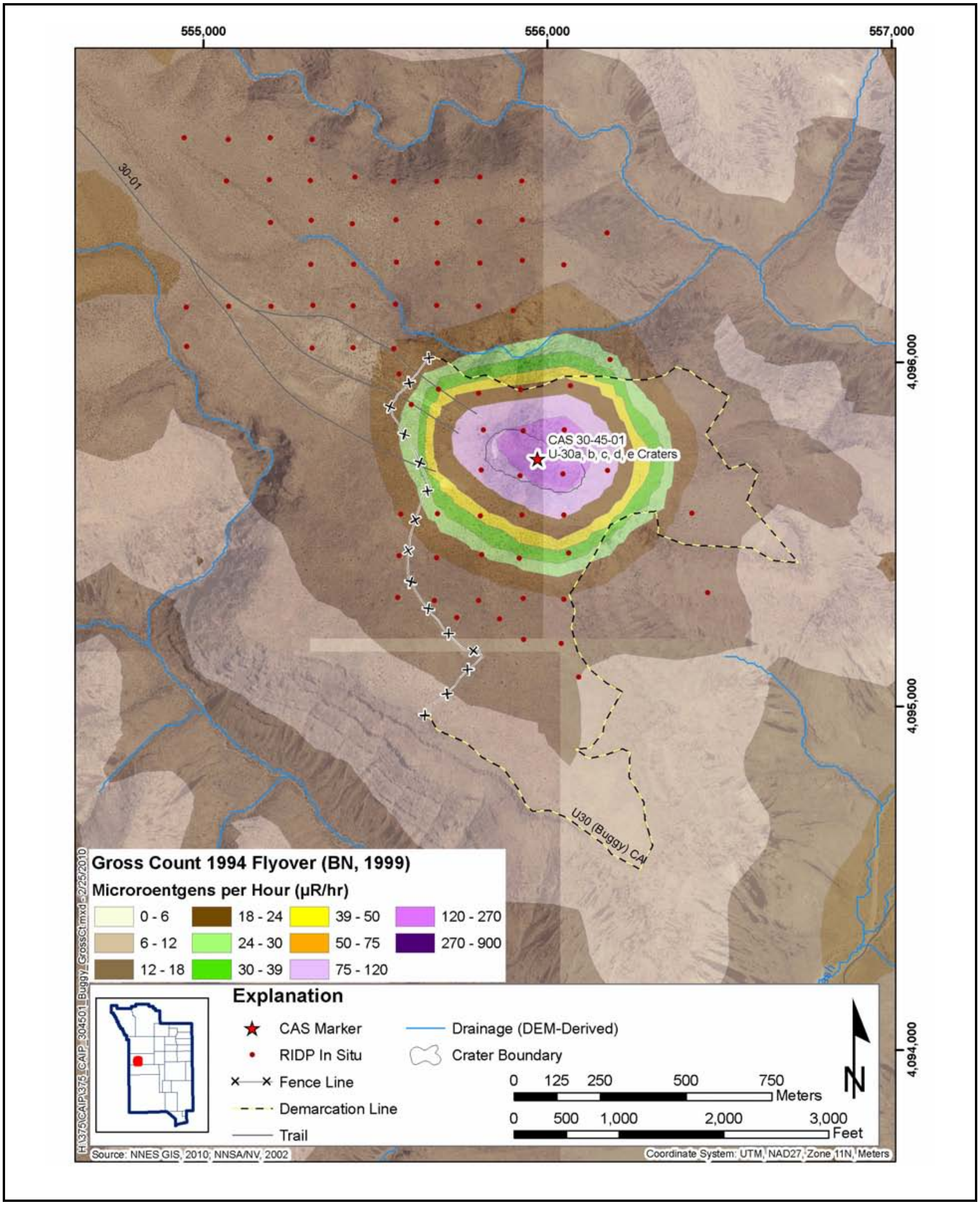


Figure 2-9
Buggy Site Gross Count Flyover

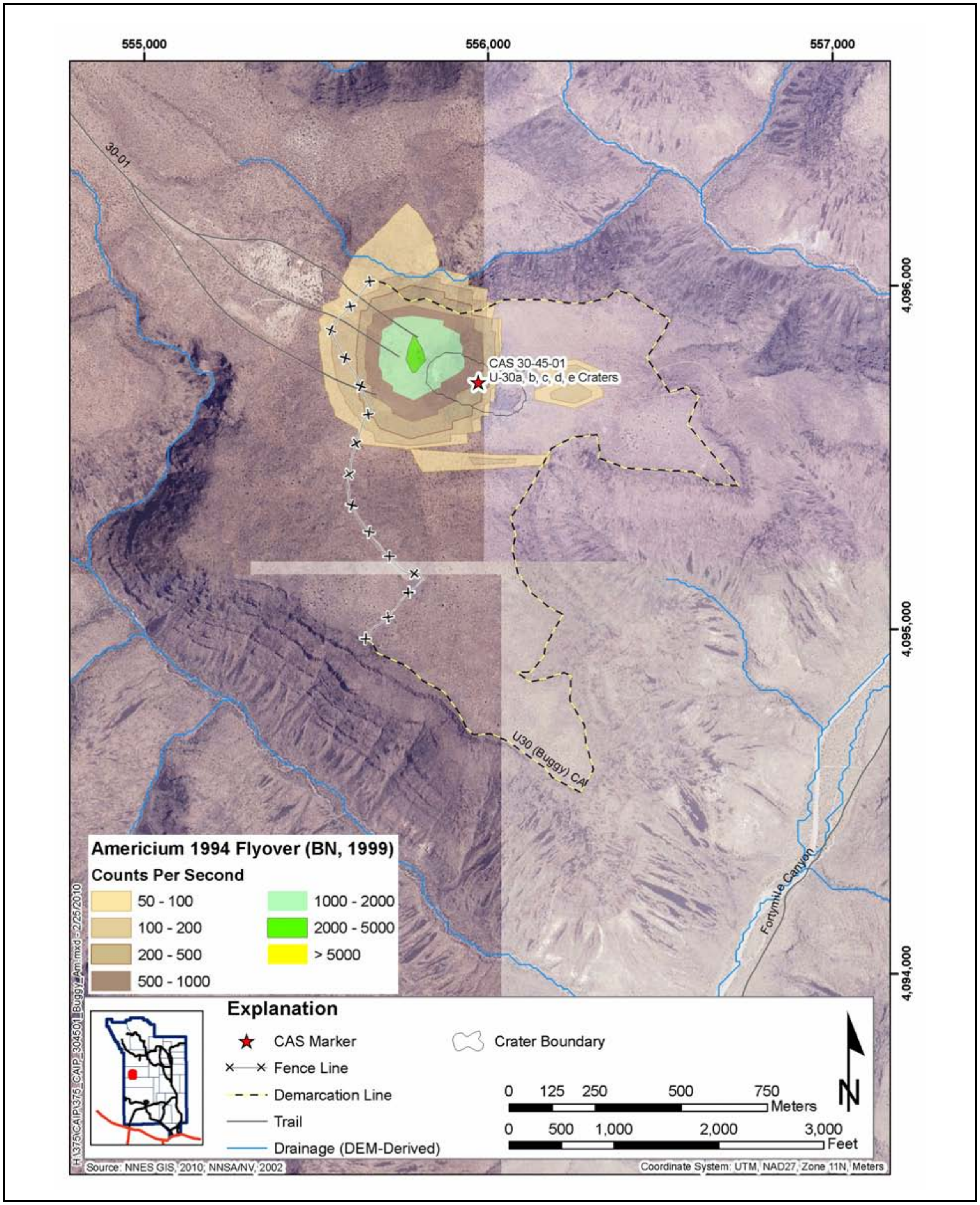


Figure 2-10
Buggy Site Americium Flyover

the NTS and surrounding area. Vertical profile sampling showed that 90 percent or more of the plutonium resides within the top 3 centimeters (cm) of soil (Friesen, 1992).

2.5.2.3 Desert Research Institute

Desert Research Institute conducted a preliminary investigation of the potential for radionuclide transport in ephemeral streams and washes in the vicinity of the Buggy site in 1985 (DRI, 1985). The investigators examined a length of the Fortymile Canyon downstream of the Buggy site via dose-rate meters and sediment sampling. The sediment results were presented in terms of gross radioactivity. Although the report does not provide reliable evidence that radioactive contamination is being transported in the canyon, the report states a “possible interpretation of the data” is that some transport of radionuclides is occurring.

2.5.3 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, 1996b) includes site investigation activities such as those proposed for CAU 375.

In accordance with the NNSA/NSO NEPA Compliance Program, a NEPA checklist will be completed before beginning site investigation activities at CAU 375. This checklist requires NNSA/NSO project personnel to evaluate their proposed project 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/NSO 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 375 and formulation of the CSM. Also presented is a summary listing of the 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.

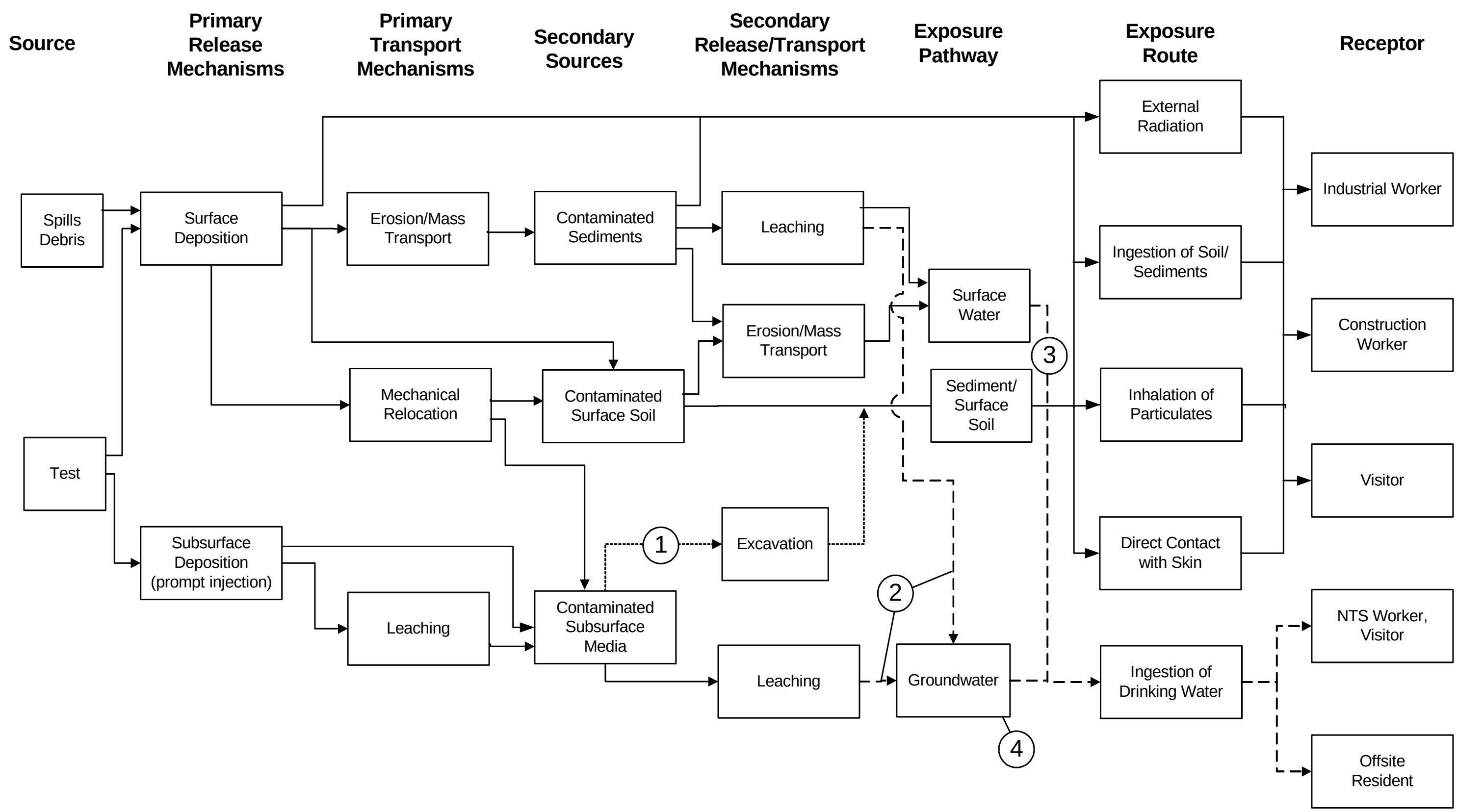
3.1 Conceptual Site Model

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 375 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. Figure 3-1 depicts a representation of the conceptual pathways to receptors from CAU 375 sources. Figure 3-2 depicts 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, the CSM will be revised, the DQOs will be reassessed, and a recommendation will be made as to how best to proceed. In such cases, NDEP and NNSA/NSO will be notified and given the opportunity to comment on and/or concur with the recommendation.

The following sections 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 375.

3.1.1 Land-Use and Exposure Scenarios

Land-use zones where the CAU 375 CASs are located dictate future land use and restrict current and future land use to nonresidential (i.e., industrial) activities. Corrective Action Site 25-23-22 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



1. Potential Pathway - This pathway would exist only if the subsurface media were excavated.
2. Incomplete Pathway - Characterization of regional hydrogeology and environmental data have shown that leaching of contaminants is limited.
3. Incomplete Pathway - There are no surface waters that are used as a source for drinking water.
4. Groundwater within the NTS is used as a source for drinking water.

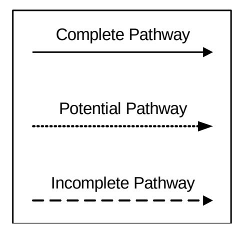


Figure 3-1
Conceptual Site Model Diagram

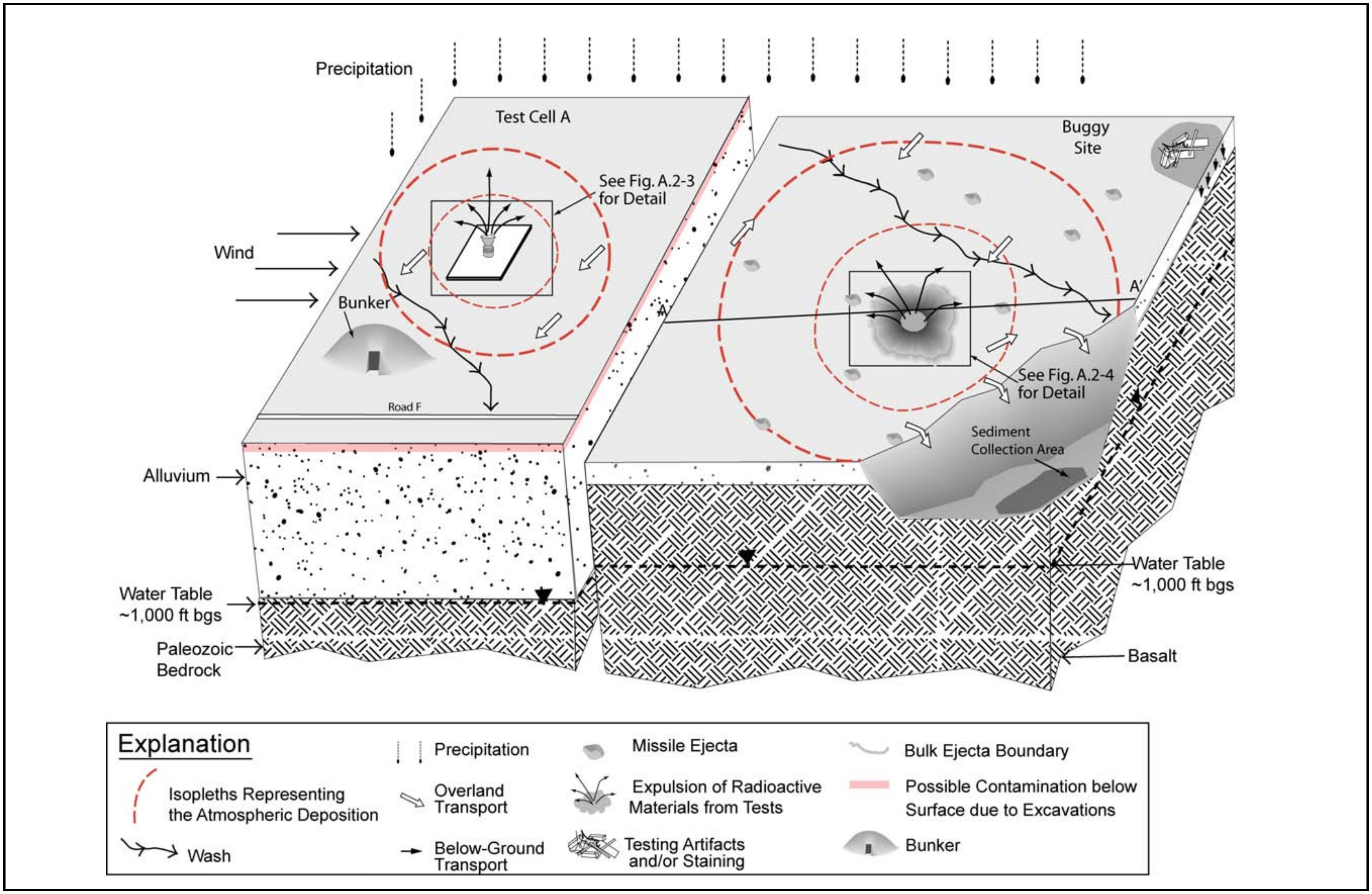


Figure 3-2
CAU 375 Conceptual Site Model

under controlled conditions. This zone includes compatible research, development, and testing activities (DOE/NV, 1998).

Corrective Action Site 30-45-01 is located in the land-use zone described as “Reserved” within the NTS. This area includes land and facilities that provide widespread flexible support for diverse short-term testing and experimentation. The reserved zone is also used for short-duration exercises and training such as nuclear emergency response, Federal Radiological Monitoring and Assessment Center training, and U.S. Department of Defense exercises and training (DOE/NV, 1998).

The exposure scenario for both CASs are Occasional Use Area based on current and projected future land uses. This exposure scenario assumes exposure to industrial workers who are not assigned to the area as a regular work location, but may occasionally use the area for intermittent or short-term activities. Site workers under this scenario are assumed to be on the site for an equivalent of 8 hours per day, 10 days per year, for 5 years.

3.1.2 Contaminant Sources

The contamination sources for CAU 375 CASs are releases of radiological contamination to the atmosphere and soil as a result of NRDS nuclear rocket tests (CAS 25-23-22) and Plowshare nuclear tests (CAS 30-45-01). Contamination on the soil surface may be sources for future migration.

3.1.3 Release Mechanisms

3.1.3.1 CAS 25-23-22, Contaminated Soils Site

Release mechanisms for CAS 25-23-22 include neutron activation of soil and structural components and release of fission products and release of unfissioned nuclear fuel through atmospheric exhausting of the nuclear rocket. Fission fragments were released in an annular pattern around GZ with a bias toward the prevailing wind direction at the time of operation. Multiple tests over a period of eight years provided for the generated exhaust plume to generally bias towards the north. 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 the test pad. Any nuclear fuel that has a very high melting point and did not fission would be expected to be found closer to the test pad.

3.1.3.2 CAS 30-45-01, U-30a, b, c, d, e Craters

Release mechanisms for CAS 30-45-01 include neutron activation of soil, and the release of fission products and release of unfissioned nuclear fuel from the detonation of nuclear devices. Fission fragments were released in an annular pattern around GZ with a bias toward the prevailing wind direction at the time of detonation (to the north). 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 GZ. The nuclear fuel that did not fission (e.g., Pu-237) has a very high melting point and is generally found very near to GZ. Release mechanisms for radioactive contamination for the Buggy test include the prompt injection of material into the soils forming the crater that occurred from the detonation, as well as the fallout found around GZ.

3.1.4 Migration Pathways

Potential migration pathways include the lateral migration of contaminants across surface soils/sediments and accumulation in drainages and craters, and vertical migration of potential contaminants into subsurface soils. Contaminants from CAS 30-45-01 could migrate down the ravines surrounding GZ and flow into Fortymile Canyon. The flow from Fortymile Canyon eventually empties into Area 25 of the NTS and combines with the Topopah Wash close to the border of the NTS. Drainages at TCA eventually (after approximately 5 mi) combine with the Topopah Wash. Drainages from both CASs may ultimately flow into the Death Valley dry lake. The drainage channels are generally dry but are subject to infrequent, potentially intense, stormwater flows. These stormwater flow events provide an intermittent mechanism for both vertical and horizontal transport of contaminants. Contaminated sediments entrained by these stormwater events would be carried by the streamflow to locations where the flowing water loses energy and the sediments drop out. These locations are readily identifiable as sedimentation areas.

Translocation of contamination may have also occurred during industrial activities inside the TCA fence line due to site maintenance, construction, site cleanup, and D&D activities. Excavation from construction and site operations may have relocated or buried contaminants at other surface and/or to subsurface locations.

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 further 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 the Area 3 RWMS has been estimated at 62.6 in. [Shott et al., 1997]) and limited precipitation for this region (5.66 in. per yr at Station 4JA in Area 25 and 8.06 in. per year at Station 40MI in Area 30 [ARL/SORD, 2009]), percolation of infiltrated precipitation at the NTS does not provide a significant mechanism for vertical migration of contaminants to groundwater (DOE/NV, 1992).

Subsurface migration pathways at CASs 25-23-22 and 30-45-01 are expected to be predominately lateral into drainage, although spills or leaks at the ground surface may also have limited vertical migration (see Section A.2.2.5). The depth of infiltration (shape of the subsurface contaminant plume) is limited by the presence of relatively impermeable layers that limit vertical transport and the relatively immobile characteristics of the contaminants.

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, debris, or other media. 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 375 CASs 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 structure descriptions will be recorded during the CAI. Areas of erosion and deposition within the washes will be qualitatively evaluated to provide additional information on potential offsite migration of contamination. Movement of ephemeral stream channels may be identified based on a comparison of historical photographs and visual observations where erosion and deposition have occurred within the washes.

3.2 Contaminants of Potential Concern

Based on the suspected contaminants identified in Section 2.4, the COPCs for CAU 375 are defined as the list of analytes represented by the analytical methods identified in Table 3-1 for Decision I environmental samples taken at each of the CASs. The analytes reported for each analytical methods are listed in Table 3-2.

The list of COPCs is intended to encompass all contaminants that could potentially be present at each CAS. 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 non-test releases that may be discovered during the investigation. Specific COPCs (and subsequently the analyses requested) will be determined for other potential releases based on the nature of the potential release (e.g., hydrocarbon stain, lead bricks).

Table 3-1
Analytical Program[a]

Analyses	CAS 25-23-22		CAS 30-45-01	
	Non-test Release[b]	Test Release	Non-test Release[b]	Test Release
Organic COPCs				
PCBs	X	--	X	--
SVOCs	X	--	X	--
VOCs	X	--	X	--
Inorganic COPCs				
RCRA Metals	X	--	X	--
Total Beryllium	X	--	X	--
Radionuclide COPCs				
Gamma Spectroscopy[c]	X	X	X	X
Isotopic U	X	X	X	X
Isotopic Am	--	--	X	X
Isotopic Pu	--	--	X	X
Sr-90	X	X	X	X

[a]The COPCs are the constituents reported from the analytical methods listed.
[b]Selection based on type of release, indicators, process knowledge, etc.
[c]Results of gamma analysis will be used to determine whether further isotopic analysis is warranted.

X = Required analytical method
-- = Not required

PCB = Polychlorinated biphenyl
RCRA = *Resource Conservation and Recovery Act*
SVOC = Semivolatile organic compound
U = Uranium
VOC = Volatile organic compound

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 *Industrial Sites Project Establishment of Final Action Levels* (NNSA/NSO, 2006b). This process conforms with *Nevada Administrative Code* (NAC) Section 445A.227, which lists the requirements for sites with soil contamination (NAC, 2008a). For

Table 3-2
COPCs Reported by Analytical Methods

VOCs		SVOCs		PCBs	Metals	Radionuclides
1,1,1,2-Tetrachloroethane	Carbon tetrachloride	2,3,4,6-Tetrachlorophenol	Di-n-octyl phthalate	Aroclor 1016	Arsenic	Am-241
1,1,1-Trichloroethane	Chlorobenzene	2,4,5-Trichlorophenol	Dibenzo(a,h)anthracene	Aroclor 1221	Barium	Pu-238
1,1,2,2-Tetrachloroethane	Chloroethane	2,4,6-Trichlorophenol	Dibenzofuran	Aroclor 1232	Beryllium	Pu-239/240
1,1,2-Trichloroethane	Chloroform	2,4-Dimethylphenol	Diethyl phthalate	Aroclor 1242	Cadmium	Sr-90
1,1-Dichloroethane	Chloromethane	2,4-Dinitrotoluene	Dimethyl phthalate	Aroclor 1248	Chromium	U-234
1,1-Dichloroethene	Chloroprene	2-Chlorophenol	Fluoranthene	Aroclor 1254	Lead	U-235
1,2,4-Trichlorobenzene	cis-1,2-Dichloroethene	2-Methylnaphthalene	Fluorene	Aroclor 1260	Mercury	U-238
1,2,4-Trimethylbenzene	Dibromochloromethane	2-Methylphenol	Hexachlorobenzene	Aroclor 1268	Selenium	
1,2-Dibromo-3-chloropropane	Dichlorodifluoromethane	2-Nitrophenol	Hexachlorobutadiene		Silver	Gamma-Emitting
1,2-Dichlorobenzene	Ethyl methacrylate	3-Methylphenol[a] (m-cresol)	Hexachloroethane			Ac-228 (Th-232)
1,2-Dichloroethane	Ethylbenzene	4-Methylphenol[a] (p-cresol)	Indeno(1,2,3-cd)pyrene			Am-241
1,2-Dichloropropane	Isobutyl alcohol	4-Chloroaniline	n-Nitroso-di-n-propylamine			Co-60
1,3,5-Trimethylbenzene	Isopropylbenzene	4-Nitrophenol	Naphthalene			Cs-137
1,3-Dichlorobenzene	Methacrylonitrile	Acenaphthene	Nitrobenzene			Eu-152
1,4-Dichlorobenzene	Methyl methacrylate	Acenaphthylene	Pentachlorophenol			Eu-154
1,4-Dioxane	Methylene chloride	Aniline	Phenanthrene			Eu-155
2-Butanone	n-Butylbenzene	Anthracene	Phenol			Nb-94
2-Chlorotoluene	n-Propylbenzene	Benzo(a)anthracene	Pyrene			Pb-212
2-Hexanone	sec-Butylbenzene	Benzo(a)pyrene	Pyridine			Pb-214
4-Isopropyltoluene	Styrene	Benzo(b)fluoranthene				Tl-208
4-Methyl-2-pentanone	tert-Butylbenzene	Benzo(g,h,i)perylene				Th-234 (U-238)
Acetone	Tetrachloroethene	Benzo(k)fluoranthene				U-235
Acetonitrile	Toluene	Benzoic acid				
Allyl chloride	Total xylenes	Benzyl alcohol				
Benzene	Trichloroethene	Bis(2-ethylhexyl)phthalate				
Bromodichloromethane	Trichlorofluoromethane	Butyl benzyl phthalate				
Bromoform	Vinyl acetate	Carbazole				
Bromomethane	Vinyl chloride	Chrysene				
Carbon disulfide		Di-n-butyl phthalate				

[a]May be reported as 3,4-Methylphenol or m,p-cresol.

Ac = Actinium
K = Potassium
Pb = Lead
Th = Thorium
Tl = Thallium

the evaluation of corrective actions, NAC Section 445A.22705 (NAC, 2008b) requires the use of American Society for Testing and Materials (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 (i.e., FALs) or to establish that corrective action is not necessary.”

This RBCA process, summarized in Figure 3-3, 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.

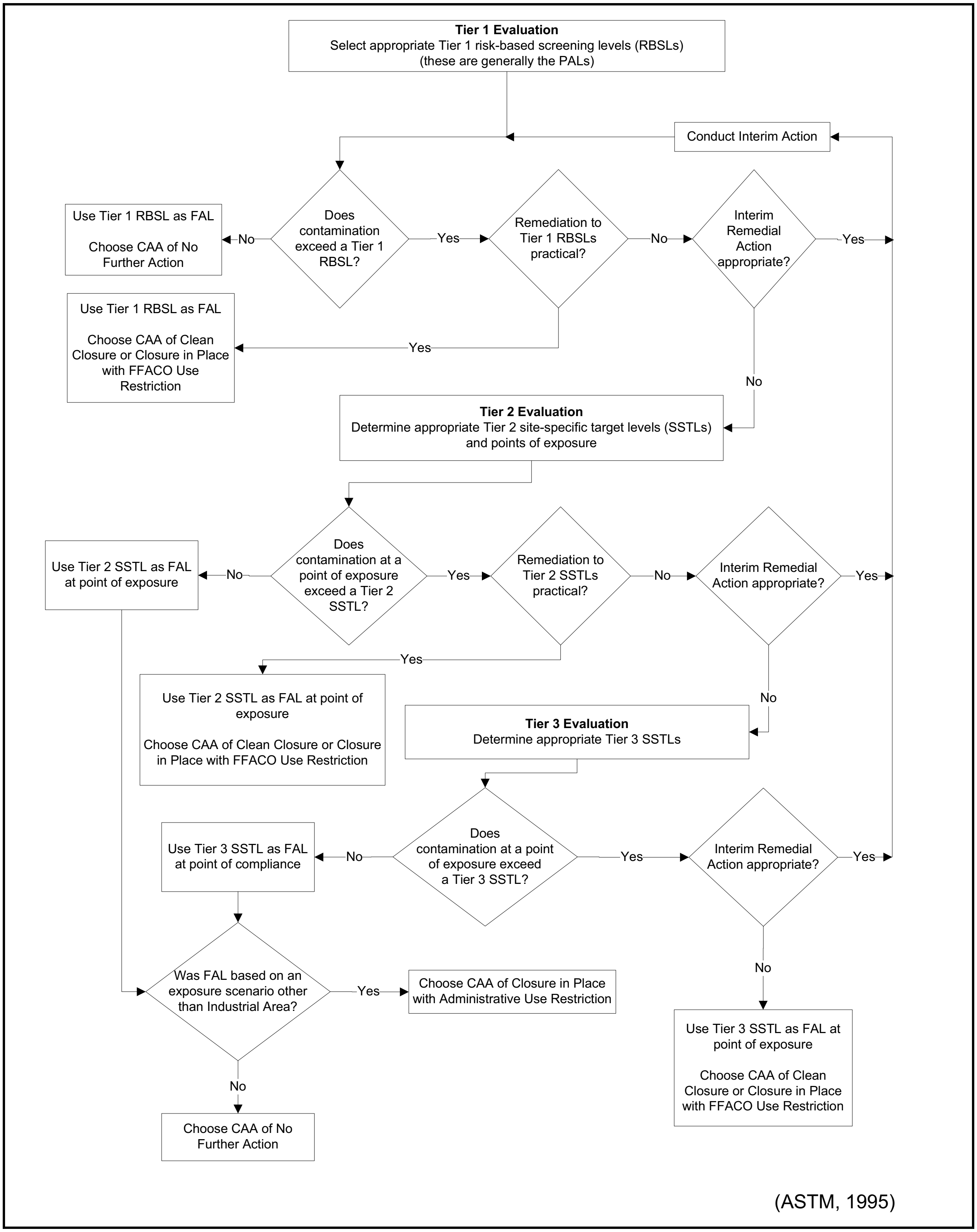


Figure 3-3
Risk-Based Corrective Action Decision Process

- Tier 2 evaluation - Conducted by calculating Tier 2 site-specific target levels (SSTLs) using site-specific information as inputs to the same or similar methodology used to calculate Tier 1 action levels. The Tier 2 SSTLs 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. Total concentrations of total petroleum hydrocarbons (TPH) will not be used for risk-based decisions under Tier 2 or Tier 3. Rather, the individual chemical constituents of diesel will be compared to the SSTLs.

- Tier 3 evaluation - Conducted by calculating Tier 3 SSTLs 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 following completion of any interim actions. Any interim actions conducted will be reported in the Corrective Action Decision Document (CADD).

If, following implementation of corrective actions, contamination remains in place that is less than the site-specific exposure scenario but exceeds an industrial area exposure scenario; a corrective action of 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 industrial exposure scenario based FALs and, if applicable, site-specific exposure scenario based FALs. The FALs (along with the basis for their selection) will be proposed in the CADD, 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: Superfund, Regional Screening Levels for Chemical Contaminants* in industrial soils (EPA, 2009). 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 NTS. 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 Nevada Test and Training Range (formerly the Nellis Air Force Range) (NBMG, 1998; Moore, 1999). For detected chemical COPCs without established screening levels, the protocol used by the EPA Region 9 in establishing screening levels (or similar) will be used to establish PALs. If used, this process will be documented in the CADD.

3.3.2 Radionuclide PALs

The PAL for radioactive contaminants is 25-millirem-per-year (mrem/yr) total effective dose (TED) based upon the Industrial Area exposure scenario.

The Industrial Area exposure scenario is described in *Industrial Sites Project Establishment of Final Action Levels* (NNSA/NSO, 2006b). That document establishes the default exposure conditions and Residual Radioactive (RESRAD) computer code input parameters to be used to calculate the potential radiation dose over a land area. Several input parameters are not specified so that site-specific information can be used.

For test releases, the Industrial Area scenario has been modified by pre-specifying values for several input parameters (such as an area of contamination of 100 square meters [m^2] and a depth of contamination of 5 cm). In addition, Derived Concentration Guideline (DCG) values for each individual radionuclide COPC were calculated (Table 3-3). The DCG is the value, in picocuries per gram for surface soil, for a particular radionuclide, that would result in a dose of 25 mrem/yr. Using DCGs in site evaluation facilitates the determination of a radiation dose estimate for each soil sample.

3.4 Data Quality Objective 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).

Table 3-3
Derived Concentration Guideline Values

Radionuclide	DCG (pCi/g)
Am-241	2.816 E+03
Co-60	5.513 E+05
Cs-137	1.409 E+05
Eu-152	1.177 E+06
Eu-154	8.469 E+05
Eu-155	5.588 E+06
Pu-238	2.423 E+03
Pu-239	2.215 E+03
Pu-240	2.215 E+03
Sr-90	5.947 E+04
Th-232	2.274 E+03
U-234	1.960 E+04
U-235	2.089 E+04
U-238	2.120 E+04

pCi/g = Picocuries per gram

As presented in Section 1.1.2, the DQOs address two types of potential contaminant release scenarios:

- Test releases of contaminants are defined as the initial atmospheric release of radionuclides from the nuclear rocket motor tests or the nuclear test detonations.
- Non-test releases of contamination include the translocation of contamination deposited under the test release scenario (e.g., migration in stormwater runoff, excavated soil, and grading of roads) and other potential releases (e.g., spills, lead bricks, and potential source material [PSM]).

The test releases will be investigated through a combination of probabilistic and judgmental sampling, and the non-test releases will be investigated through judgmental sampling. Therefore, discussions related to these two release scenarios are presented separately.

The DQO strategy for CAU 375 was developed at a meeting on December 2, 2009. The 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 375 is: "Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs in CAU 375." To address this problem statement, resolution of the following decision statements is required:

- Decision I: "Is any COC present in environmental media within the CAS?" 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 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

The presence of a COC would require a corrective action. A corrective action may also be necessary if there is a potential for wastes that are present at a site that may result in the introduction of COCs into site environmental media (PSM). To evaluate the potential for wastes to result in the introduction of a COC to the surrounding environmental media, the following conservative assumptions were made:

- Any containment of waste (e.g., fuel/oil reservoirs, pipe, concrete vaults and walls, drums) will fail at some point, and the waste will be released to the surrounding soil.

- A waste, regardless of concentration or configuration, may be assumed to be PSM and handled under a corrective action.

- Based on process knowledge and/or professional judgment, some waste may be assumed to not be PSM if it is clear that it cannot result in soil contamination exceeding a FAL.

- If assumptions about the waste cannot be made, then the waste material will be sampled, and the results will be compared to FALs based on the following criteria:
  - For non-liquid wastes, the concentration of any chemical contaminant in soil (following degradation of the waste and release of contaminants into soil) would be equal to the mass of the contaminant in the waste divided by the mass of the waste.
  - For liquid wastes, the resulting concentration of contaminants in the surrounding soil will be calculated based on the concentration of contaminants in the wastes and the liquid-holding capacity of the soil.

3.4.1 Test Release

For the Buggy site, it is assumed that TED within the area of the crater, crater rim, and related mounding around the crater exceeds the FAL. Process knowledge from test data indicates that much of the radioactivity associated with the test was captured within the crater and in fractures around the crater. The extent of the subsurface contamination in and around the crater has not been determined, but has been conservatively estimated through the establishment of a default contamination boundary that includes the area of the crater and ejecta mounds at the crater rim. Figure 3-4 shows an example of a default contamination boundary at the Buggy site. For this area, Decision I is resolved and corrective action is required.

Decision I sampling will be conducted for TCA and the area outside the default contamination boundary at the Buggy site to determine whether contaminants are present at concentrations in excess of FALs. If no contaminants are found to be present in concentrations greater than FALs, then no further action is necessary. If it is established that contaminants are present in concentrations greater than FALs, Decision II samples will be collected to determine the extent of the COCs.

Within the fence at TCA, Decision I samples will be collected under the non-test release scenario due to the amount of migration caused by excavation and construction activity. Outside the fence at TCA, Decision I samples will be collected under the test release scenario.

Decision II samples will not be collected within the fence as it will be assumed that any contamination found within the fence could also be present anywhere within the fenced industrial area due to the potential for relocation or burial of contaminants.

Figure 3-4
Buggy Default Contamination Boundary Example
Source: RSL, 1977a

If contamination is found to be present outside the TCA fence in concentrations exceeding FALs, then Decision II samples will be collected from areas outside the fence to determine extent.

Corrective Action Site 25-23-22 Decision I test release samples will be submitted to analytical laboratories for gamma spectroscopy, isotopic U, and Sr-90 analyses. Corrective Action Site 30-45-01 Decision I test release samples will be submitted to analytical laboratories for gamma spectroscopy, isotopic U, isotopic Pu, and Sr-90 analyses. Decision II samples will be submitted for the analysis of all unbounded COCs. In addition, samples will be submitted for analyses, as needed, to support waste management or health and safety decisions.

3.4.2 Non-test Releases

Decision I non-test scenario samples will also be collected at both CASs. Non-test release sampling will be conducted based upon biasing factors. Biasing factors — such as stains, radiological survey results, and wastes suspected of containing hazardous or radiological components — will be used to select the most appropriate sampling locations. Decision II sampling will be conducted to define the extent of contamination where COCs have been confirmed in areas other than the extensively disturbed area within the fence at TCA or sedimentation areas.

For the areas investigated under the non-test release scenario, Decision I samples will be submitted to analytical laboratories to determine the presence of COCs. The specific analyses for samples from other non-test releases 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.

3.4.3 Data Quality Indicators

For laboratory data, the data quality indicators (DQIs) of precision, accuracy, representativeness, completeness, comparability, and sensitivity needed to satisfy DQO requirements are discussed in Section 6.2. Laboratory data will be assessed in the CADD to confirm or refute the CSM and determine whether the DQO data needs were met.

Analytical methods and target minimum detectable concentrations (MDCs) for each CAU 375 COPC are provided in Tables 3-4 and 3-5. The criteria for precision and accuracy listed in Tables 3-4 and 3-5 may vary from information in the QAPP as a result of the laboratory used or updated/new methods (NNSA/NV, 2002).

Table 3-4
Analytical Requirements for Radionuclides for CAU 375

Analysis[a]	Medium or Matrix	Analytical Method	MDC[b]	Laboratory Precision	Laboratory Accuracy
Gamma-Emitting Radionuclides					
Gamma Spectroscopy	Aqueous	EPA 901.1[c]	10% of DCGs[d]	RPD 35% (non-aqueous)[e] 20% (aqueous)[e] ND -2<ND<2[f]	LCS Recovery (%R) 80-120[g]
	Non-aqueous	GA-01-R[h]			
Other Radionuclides					
Isotopic U	All	U-02-RC[h]	10% of DCGs[d]	RPD 35% (non-aqueous)[e] 20% (aqueous)[e] ND -2<ND<2[f]	Chemical Yield Recovery (%R) 30-105[i] LCS Recovery (%R) 80-120[i]
Isotopic Pu	Aqueous	Pu-10-RC[h]			
	Non-aqueous	Pu-02-RC[h]			
Isotopic Am	Aqueous	Am-03-RC[h]			
	Non-aqueous	Am-01-RC[h]			
Sr-90	Aqueous	EPA 905.0[c]			
	Non-aqueous	Sr-02-RC[h]			
Gross Alpha/Beta	Aqueous	EPA 900.0[c]		RPD 35% (non-aqueous)[e] 20% (aqueous)[e] ND -2<ND<2[f]	MS Recovery (%R) Lab-specific[j] LCS Recovery (%R) 80-120[i]
	Non-aqueous	SM 7110 B[k]			
Tritium	Aqueous	EPA 906.0[c]			
	Non-aqueous	Laboratory Procedure[l]			

[a]A list of constituents reported for each method is provided in Table 3-2.
[b]The MDC is the minimum concentration of a constituent that can be measured and reported with 95% confidence (Standard Methods)[k].
[c]*Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (EPA, 1980).
[d]The DCG is the value, in picocuries per gram for surface soil, for a particular radionuclide that would result in a dose of 25 mrem/IA-yr (e.g., the PAL).
[e]*Sampling and Analysis Plan Guidance and Template* (EPA, 2000).
[f]*Evaluation of Radiochemical Data Usability* (Paar and Porterfield, 1997).
[g]*Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA, 2008).
[h]*The Procedures Manual of the Environmental Measurements Laboratory* (DOE, 1997).
[i]Professional judgment and other industry acceptance criteria are used.
[j]Accuracy criteria are developed in-house using approved laboratory standard operating procedures in accordance with industry standards and the NNES Statement of Work requirements.
[k]*Standard Methods for the Examination of Water and Wastewater* (Clesceri et al., 1998).
[l]Laboratory standard operating procedures in accordance with industry standards and the NNES Statement of Work requirements (NNES, 2009).

LCS = Laboratory control sample
mrem/IA-yr = Millirem per Industrial Access year
MS = Matrix spike
ND = Normalized difference
RPD = Relative percent difference
%R = Percent recovery

Table 3-5
Analytical Requirements for Chemical COPCs for CAU 375

Analysis[a]	Medium or Matrix	Analytical Method	MDC[b]	Laboratory Precision	Laboratory Accuracy
Organics					
VOCs	All	8260[c]	< FALs	Lab-specific[d]	Lab-specific[d]
TCLP VOCs	Leachate	1311/8260[c]	< Regulatory Levels	Lab-specific[d]	Lab-specific[d]
SVOCs	All	8270[c]	< FALs	Lab-specific[d]	Lab-specific[d]
TCLP SVOCs	Leachate	1311/8270[c]	< Regulatory Levels	Lab-specific[d]	Lab-specific[d]
PCBs	All	8082[c]	< FALs	Lab-specific[d]	Lab-specific[d]
TPH-DRO	All	8015 Modified[c]		Lab-specific[d]	Lab-specific[d]
Explosives	All	8330[c]		Lab-specific[d]	Lab-specific[d]
Inorganics					
Metals	All	6010/6020[c]	< FALs	RPD 35% (non-aqueous) 20% (aqueous)[e] Absolute Difference ±2x RL (non-aqueous)[f] ±1x RL (aqueous)[f]	MS Recovery (%R) 75-125[c] LCS Recovery (%R) 80-120[c]
Mercury	Aqueous	7470[c]			
	Non-aqueous	7471[c]			
TCLP Metals	Leachate	1311/6010/7470[c]	< Regulatory Levels		

[a]A list of constituents reported for each method is provided in Table 3-2.
[b]The MDC is the minimum concentration of a constituent that can be measured and reported with 99% confidence (SW-846).
[c]*Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA, 2008).
[d]Precision and accuracy criteria are developed in-house using approved laboratory standard operating procedures in accordance with industry standards and the NNES Statement of Work requirements (NNES, 2009).
[e]*Sampling and Analysis Plan Guidance and Template* (EPA, 2000).
[f]*USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 2004).

DRO = Diesel-range organics
RL = Reporting limit
TCLP = Toxicity Characteristic Leaching Procedure

4.0 Field Investigation

This section contains a description of the activities to be conducted to gather and document information from the CAU 375 field investigation.

4.1 Technical Approach

The information necessary to satisfy the DQO data needs will be generated for CAU 375 by collecting and analyzing samples generated during a field investigation. The investigation will generate information required to evaluate potential CAAs for CASs 25-23-22 and 30-45-01 outside the default contamination area. The potential CAA of no further action will not be evaluated inside the Buggy default contamination area as it is assumed through process knowledge that a large volume of subsurface contamination exceeding the FAL is present within and around the crater. A default contamination boundary has been defined around the Buggy crater that bounds this contamination (Section 3.4). Information needed to evaluate the corrective action of clean closure for the contamination within the default contamination area at the Buggy site will not be generated during the investigation due to the technical infeasibility of excavating such a large mass of subsurface contamination. This contamination is currently effectively contained in surface or near-surface unsaturated media and is sufficiently isolated so no exposure pathway to site workers or the public exists.

The presence and nature of contamination for test releases will be evaluated using a combination of judgmental and probabilistic approaches. The sample plots will be selected and evaluated judgmentally, and the samples collected within the sample plots will be collected and evaluated probablistically. All non-test releases will be located and samples analyzed based on judgmental criteria.

If it is determined that a COC is present at any CAS, that CAS will be further addressed by determining the extent of contamination before evaluating CAAs with the exception of within the fence line at TCA as previously addressed.

For test releases, DQO decisions will be based on the 95 percent UCL of the average TED for each sample plot. The TED will be determined by summing internal and external dose measurements from each sample plot location. Sample results for individual radionuclides will be used to calculate internal dose using RESRAD computer code (Yu et al., 2001). External dose will be determined by collecting *in situ* measurements using a TLD. The TLD will be installed at the approximate center of the sample plot at a height of 1 m and be left in place for approximately 2,250 hours (equivalent to an annual industrial worker exposure). Each TLD contains three elements from which external dose measurements will be reported. The 95 percent UCL of the average TED for each plot will be the sum of the 95 percent UCL of the three TLD element estimates of external dose and the 95 percent UCL of the estimates of internal dose from the soil samples.

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

4.2 Field Activities

Field activities at CAU 375 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 surface debris, equipment, and structures; constructing hazardous waste accumulation areas and site exclusion zones; providing sanitary facilities; constructing decontamination facilities; and moving staged equipment.

Before mobilizing to collect investigation samples, the following preparatory activities will also be conducted:

- Perform radiological surveys at CAU 375 CASs.
- Perform visual surveys at all CAU 375 CASs to identify any staining, discoloration, disturbance of native soils, or any other indication of potential contamination.
- Install project-specific environmental monitoring TLDs (see Section 4.2.3 for additional information).

4.2.2 Sample Location Selection

Rationale for selecting areas for sampling is discussed in the following sections.

4.2.2.1 Test Releases

CAS 25-23-22, Contaminated Soils Site

For the TCA test releases (outside the industrial fence), the Decision I sample plot will be located outside the perimeter fence and determined judgmentally based on the highest results of a radiological survey. Four composite soil samples will be collected from the plot. Internal and external dose measurements will be used to estimate TED at the plot.

If the 95 percent UCL of the TED at the Decision I sample plot exceeds the 25-mrem/IA-yr dose, additional sample plots will be required for Decision II. For Decision II, a minimum of one additional sample plot located along each of three sampling vectors, outward from the common Decision I sample plot, will be located based upon a radiological survey (SNJV, 2008). The outermost sample plot on each vector will be placed beyond the anticipated 25-mrem/IA-yr dose boundary. If the initial Decision II sample plots do not define the 25-mrem/IA-yr dose boundary, additional sample plots will be established until a sample plot is located beyond the 25-mrem/IA-yr dose boundary on each vector.

CAS 30-45-01, U-30a, b, c, d, e Craters

At the Buggy site, it is assumed that TED within the area of the crater, crater rim, and related mounding around the crater exceeds the FAL (i.e., the default contamination boundary). Process knowledge from test data indicates that much of the radioactivity associated with the test was captured within the crater and in fractures around the crater. The extent of the subsurface contamination within the default contamination boundary (Decision II) has been conservatively estimated by including the area of the crater and ejecta mounds at the crater rim. For this area, Decision I is resolved and corrective action is required.

Outside the default contamination boundary, Decision I will be evaluated by measuring TED within a sample plot established at the location of the highest americium values as determined from the 1994 flyover survey (BN, 1999), and/or a radiological survey conducted with a handheld FIDLER unit and the lowest gamma values as determined using a Bicron handheld instrument. This will be done in an effort to find the location where the internal dose contributes the greatest amount to TED. The highest americium signature is an indicator of the greatest concentration of plutonium. This sample plot will be sampled as described in Section 4.2.3 and TED calculated as described in Section 4.1.

If the 95 percent UCL of the TED at the Decision I sample plot exceeds 25 mrem/IA-yr, three Decision II sample plot locations will be determined judgmentally along each of three vectors that are approximately normal to the gamma radiation survey isopleths. The Decision II sample plot location must meet the criterion that at least one sample plot on each vector will be located outside the 25-mrem/IA-yr boundary.

Experience at the T-4 site (CAU 370) and the Johnnie Boy site (CAU 371) have shown that internal dose rates contribute very little to TED at these types of tests (nuclear test devices designed for high-yield efficiencies). The concentrations of Am-241, Pu-238, and Pu-239 (which contribute significantly to the internal dose) at this type of site are generally low and not in a configuration in which they are readily inhaled or ingested (e.g., incorporated into fused soil conglomerates such as Trinity glass) and thus do not provide a readily available source of exposure. The dose as a percentage of TED at the T-4 site and the Johnnie Boy site are presented in Table 4-1. The highest internal dose as a percentage of TED is 3.8. The mean internal dose as a percentage of TED is 1.04.

Table 4-1
Internal Dose as a Percentage of TED at Two Soils Sites
(Page 1 of 2)

Sample Plot	Internal Dose	External Dose	TED	Internal Dose as a Percentage of TED
CAU 370, T-4 Atmospheric Test Site[a]				
A	1.95	173	175	1.1%
B	1.61	118	120	1.3%
C	1.30	132	133	1.0%
D	0.17	45	45	0.4%
E	0.09	10	10	0.9%
F	1.40	141	142	1.0%
G	2.42	99	101	2.4%
H	0.73	166	167	0.4%
I	0.12	30	30	0.4%
J	0.07	10	10	0.7%

Table 4-1
Internal Dose as a Percentage of TED at Two Soils Sites
(Page 2 of 2)

Sample Plot	Internal Dose	External Dose	TED	Internal Dose as a Percentage of TED
K	2.14	218	220	1.0%
L	6.78	174	181	3.8%
M	3.80	153	157	2.4%
N	0.12	28	28	0.4%
P	0.08	21	21	0.4%
CAU 371, Johnnie Boy Crater and Pin Stripe[b]				
BA	0.02	49.8	49.8	0.04%
BB	0.02	37.9	38.0	0.05%
BC	0.07	37.7	37.8	0.19%
BD	0.02	28.9	29.0	0.07%
BE	0.03	62.9	63.0	0.05%
BF	0.02	23.2	23.3	0.09%
BG	0.02	15.6	16.0	0.13%
BH	0.02	3.2	3.2	0.63%
BJ	0.03	63.0	63.0	0.05%
BK	0.04	45.0	45.0	0.09%
BL	0.02	14.9	15.0	0.13%
BM	0.03	5.4	5.4	0.56%
BP	0.03	30.1	30.1	0.10%

[a]Source: NNSA/NSO, 2009
[b]Source: Sloop, 2010

Based on the very low internal dose rates expected to be present at the Buggy site, TED rates at each of the Buggy site plots can be accurately established using the measured external dose rates from the TLDs. This will be accomplished by measuring the external dose at each plot using the TLD and adding an estimate of internal dose for the plot. The conservative estimate of internal dose for each sample plot will be calculated based on a ratio of internal dose to external dose. This ratio will be conservatively established at a selected test sample plot located in an area determined to have the highest concentration of plutonium (based on the americium signature from the 1994 flyover survey [BN, 1999] or the highest readings from a FIDLER radiation survey). Use of this internal dose ratio will overestimate internal dose (and therefore TED) at all other sample plots with lower concentrations of plutonium. The estimate of internal dose at the test sample plot will be calculated from soil sample results. Then TED for each of the other sample plots will be calculated as the total of the external dose measured by the TLD and the internal dose estimated using internal/external dose ratio from the test sample plot (Figure 4-1).

4.2.2.2 Non-test Releases

For non-test releases at CAU 375, a judgmental sampling approach will be used to investigate the likelihood of the soil containing a COC if biasing factors are present. Biasing factors — such as stains, radiological survey results, and 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. As biasing factors are identified and used for selection of sampling locations, they will be documented in the appropriate field documents.

Drainages at both CASs will be visually surveyed for the presence of sediment accumulation areas. A sampling location will be established at the center of the nearest two sediment accumulation areas outside the initial corrective action boundary. At each location a sample will be collected from each 5-cm depth interval until native material is encountered. Each sample will be screened with an alpha/beta contamination meter. If the field-screening level (FSL) is exceeded in any depth sample, the sample with the highest screening value at each sample location will be submitted for analysis. If the FSL is not exceeded in any depth sample, the surface sample will be submitted for analysis. If a COC is present at a sediment collection area, additional downstream sedimentation areas will be sampled until at least two consecutive downgradient sedimentation areas do not contain a COC. Decision II will be resolved by the assumption that the entire volume of sediment in each sediment collection area where a COC is identified contains the COC.

Both areas inside and outside the fence at TCA will be sampled for non-test releases. These samples will be collected from locations where bias is present. Bias can be determined through visual survey, radiological survey, odor, process knowledge, soil piles, debris, staining, or any other accepted method of bias determination. Any contamination found within the fence line will be assumed to be present throughout the entire area within the fence line. With the area inside the fence line at TCA having been disturbed so many times in the past, efforts to bound contamination are not practical.

The Buggy site will be sampled for Decision I non-test releases. These samples will be collected from locations where bias is present. Bias can be determined through visual survey, radiological

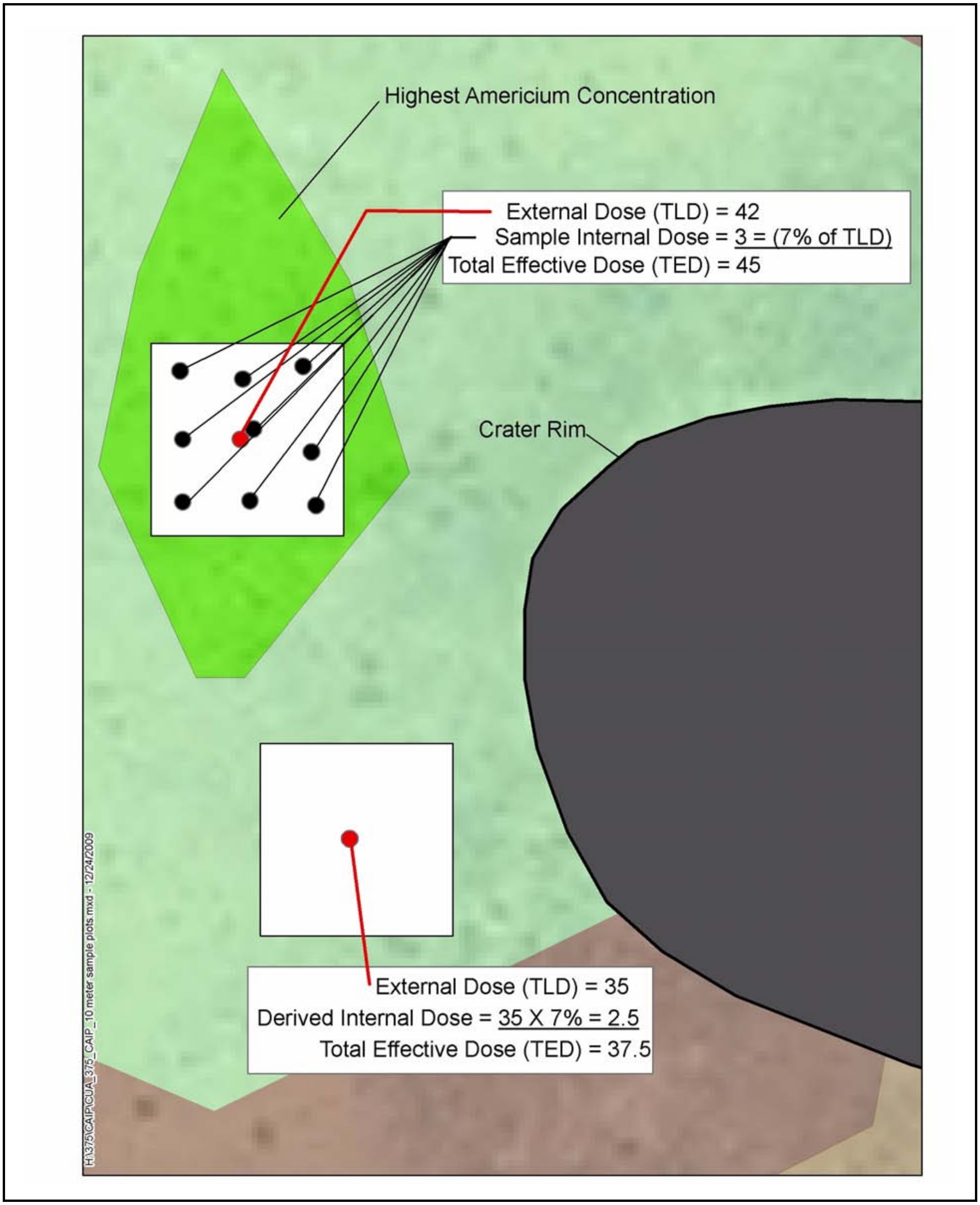


Figure 4-1
Internal Dose Determination Example

survey, odor, process knowledge, soil piles, debris, staining, or any other accepted method of determining bias.

If a COC is present at any non-test release scenario sample location with the exception of within the TCA fence, Decision II sampling will be conducted to define the extent of contamination where COCs have been confirmed. Extent (Decision II) sampling locations at each CAS 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 further from the source. If a spatial boundary is reached, the CSM is shown to be inadequate, or the Site Supervisor determines that extent sampling needs to be re-evaluated, then work will be temporarily suspended, NDEP will be notified, and the investigation strategy will be re-evaluated. A minimum of one analytical result less than the action level from each lateral and vertical direction will be required to define the extent of COC contamination. The lateral and vertical extent of COCs will only be established based on validated laboratory analytical results (i.e., not field screening).

The CAS-specific sampling strategy and the estimated locations of biased samples for each CAS are presented in Appendix A. The Task Manager or Site Supervisor may modify the number, location, and spacing of extent samples 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 CADD.

4.2.3 Sample Collection

The CAU 375 sampling program will consist of the following activities:

- Collect and analyze samples from locations as described in this section.
- Collect required QC samples.

- Collect waste management samples as necessary.
- Record Global Positioning System (GPS) coordinates for each environmental sample location.

For test release internal dose soil sampling, the probabilistic sampling approach will be implemented for the sampling of composite samples within the sample plots. Each composite sample will consist of soil collected from nine random subsample locations within the 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 (Section A.8.0). Probabilistic subsample design is discussed in Section A.6.1.2. Sections A.8.1.1.2 and A.8.2.1.2 describe the sample location selection process. External dose will be measured from a TLD installed at the approximate center of each sample plot at a height of 1 m and left in place for approximately 2,250 hours (equivalent to an annual industrial worker exposure).

Decision I non-test samples will be collected from the locations specified in Section 4.2.2. If biasing factors are present in soils below locations where Decision I samples are 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 at depth intervals selected by the Site Supervisor based on biasing factors to a depth where the biasing factors are no longer present.

As discussed in Section 4.2.2.2, Decision II sampling will not be conducted for CAS 25-23-22 within the fenced area. If a COC is present within the fenced area, it will be assumed that the entire fenced area contains the COC and requires corrective action.

Decision II sampling will also not be conducted for the drainage sedimentation areas for both CASs. If a COC is present in the sediment, the entire volume of the sediment will be assumed to contain the COC and require corrective action.

If the TED near Road F in Area 25 in the immediate area of TCA exceeds the FAL, Decision II sampling will be conducted for the investigation of contamination along the shoulders of the road. Decision II sampling will consist of further defining the extent of the area where corrective actions are necessary to protect motorists and road maintenance workers.

4.2.4 Sample Management

The laboratory requirements (i.e., MDCs, precision, and accuracy) to be used when analyzing the COPCs are presented in Tables 3-4 and 3-5. The analytical program for each CAS is presented in Table 3-1. All sampling activities and QC requirements for field and laboratory environmental sampling will be conducted in compliance with the Industrial Sites QAPP (NNSA/NV, 2002) and other applicable, approved procedures.

4.3 Safety

A site-specific health and safety document will be prepared and approved before the field effort. This document defines the requirements for protecting the health and safety of the workers and the public. The following safety issues will be taken into consideration when evaluating the hazards and associated control procedures for field activities:

- Potential hazards to site personnel and the public including, but not limited to, radionuclides, chemicals (e.g., heavy metals, VOCs, SVOCs, and TPH), adverse and rapidly changing weather, remote location, and motor vehicle and heavy equipment operations.
- Proper training of site personnel to recognize and mitigate the anticipated hazards.
- Work controls to reduce or eliminate the hazards, including engineering controls, substitution of less hazardous materials, and use of appropriate personal protective equipment (PPE).
- Occupational exposure monitoring to prevent overexposures to hazards such as radionuclides, chemicals, and physical agents (e.g., heat, cold, and high wind).
- Radiological surveying for alpha/beta and gamma emitters to minimize and/or control personnel exposures; use of the “as-low-as-reasonably-achievable” principle when addressing radiological hazards.
- Emergency and contingency planning to include medical care and evacuation, decontamination, spill control measures, and appropriate notification of project management. The same principles apply to emergency communications.

4.4 Site Restoration

Upon completion of CAI and waste management activities, the following actions will be implemented before closure of the site.

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

5.0 Waste Management

Management of the waste generated during the CAU 375 field investigation will be in accordance with applicable DOE orders, U.S. Department of Transportation (DOT) regulations, state and federal waste regulations, and agreements and permits between DOE and NDEP. Wastes will be characterized based on these regulations using process knowledge, field-screening results, and analytical results from investigation and waste samples. Waste types that may be generated during the CAI include sanitary, industrial, low-level radioactive, hazardous, hydrocarbon, or mixed wastes.

Disposable sampling 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., metal and concrete). Therefore, these wastes may be characterized based on CAI sample results. 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 sections discuss how the field investigation will be conducted to minimize the generation of waste, the waste streams that are expected to be generated, and the management of IDW.

5.1 Waste Minimization

The CAI will be conducted in a manner that will minimize the generation of wastes by using process knowledge, visual examination, and/or radiological survey and swipe results to avoid collecting uncontaminated media or characterizing uncontaminated IDW as other than industrial or sanitary 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. 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 expected waste streams to be generated during the CAU 375 field investigation include sanitary and low-level wastes and radioactive wastes from the sampling activities. However, because of the uncertainty about what is present within the CAS boundaries (e.g., lead debris, batteries, historical spills), the following waste streams have been included as potential waste streams that may require management and disposal:

- Disposable sampling equipment, and/or PPE
- Environmental media (e.g., soil)
- Surface debris in investigation area (e.g., metal, concrete, batteries)
- Decontamination rinsate

5.3 Investigation-Derived Waste Management

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

5.3.1 Industrial and Sanitary Waste

Sanitary and industrial IDW, if generated, will be collected, managed, and disposed of in accordance with the sanitary waste management regulations and the permits for operation of the NTS Waste Landfills.

5.3.2 Hydrocarbon Waste

Hydrocarbon soil wastes, if generated, will be managed on site in a drum or other appropriate container until fully characterized. Hydrocarbon waste may be disposed of at a designated hydrocarbon landfill, an appropriate hydrocarbon waste management facility (e.g., recycling facility) or other method in accordance with the State of Nevada regulations (NDEP, 2006).

5.3.3 Low-Level Waste

Low-level radioactive wastes, 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 Test Site Waste Acceptance Criteria* (NNSA/NSO, 2008). Potential radioactive waste drums containing soil, PPE, disposable sampling equipment, and/or rinsate may be staged and managed at an RMA.

5.3.4 Hazardous Waste

Suspected hazardous wastes, if generated, will be placed in DOT-compliant containers. All containerized hazardous waste will be handled, inspected, and managed in accordance with Title 40 *Code of Federal Regulations* (CFR) 265 Subpart I (CFR, 2009b).

5.3.5 Mixed Low-Level Waste

Mixed wastes, if generated, shall be managed according to the requirements for both hazardous wastes and low-level radioactive waste.

5.3.6 Polychlorinated Biphenyls

Polychlorinated biphenyl wastes, if generated, will be managed according to 40 CFR 761 (CFR, 2009c), State of Nevada requirements (NAC, 2008a), and DOE guidance.

6.0 Quality Assurance/Quality Control

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 CAU 375 CASs. The data from the TLD measurements will also meet rigorous data quality requirements. The TLDs will be obtained from, and measured by, the Environmental Technical Services group at the NTS. This group is responsible for a routine environmental monitoring program at the NTS. The routine program includes a campaign of TLDs that are emplaced at pre-established locations across the NTS for the monitoring of external dose. The routine TLDs are replaced and read quarterly. Details of this campaign can be found in the *Nevada Test Site Environmental Report 2006* (NNSA/NSO, 2007). The CAU 375 TLDs will be submitted to the Environmental Technical Services group for inclusion in their routine quarterly read of the NTS environmental monitoring TLDs. All TLDs will be analyzed using automated TLD readers that are calibrated and maintained by the National Security Technologies, LLC, Radiological Control Department in accordance with existing QC procedures for TLD processing. A summary of the routine environmental monitoring TLD quality control efforts and results can be found in Section 5.2.1 of the *Nevada Test Site Environmental Report 2006* (NNSA/NSO, 2007). Certification is maintained through the DOE Laboratory Accreditation Program for dosimetry.

The determination of the external dose component of the TED by TLDs was determined to be the most accurate method because:

1. The TLDs will be exposed at the sample plots for the 2,250 hours of exposure time used for the Industrial Area exposure scenario. This eliminates errors in reading dose-rate meter scale graduations and needle fluctuations. These errors would be magnified when as-read meter values are multiplied from units of “per-hour” to 2,250 hours.

2. The use of a TLD to determine an individual’s external exposure is the standard in radiation safety and serves as the “legal dose of record” when other measurements are available. Specifically, 10 CFR Part 835.402 (CFR, 2009a) indicates that personal dosimeters shall be provided to monitor individual exposures and that the monitoring program that uses the dosimeters shall be accredited in accordance with a DOE Laboratory Accreditation Program.

Sections 6.1 and 6.2 discuss the collection of required QC samples in the field and QA requirements for soil samples.

6.1 Quality Control 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 are:

- For radiological samples:
  - Field duplicates (1 per 20 environmental samples or 1 per CAS per matrix, if less than 20 collected)
  - Laboratory QC samples (1 per 20 environmental samples or 1 per CAS per matrix, if less than 20 collected)
- For chemical samples (if collected):
  - Trip blanks (1 per sample cooler containing VOC environmental samples)
  - Equipment rinsate blanks (1 per sampling event for each type of decontamination procedure)
  - Source blanks (1 per lot of uncharacterized source material that contacts sampled media)
  - Field duplicates (1 per 20 environmental samples or 1 per CAS per matrix, if less than 20 collected)
  - Field blanks (may be 1 per 20 environmental samples, 1 per day, or 1 per CAS depending on site conditions and agreement of DQO participants)
  - Laboratory QC samples (1 per 20 environmental samples or 1 per CAS per matrix, if less than 20 collected)

Additional QC samples may be submitted based on site conditions at the discretion of the Task Manager or Site Supervisor. Field QC samples shall be analyzed using the same analytical procedures implemented for associated environmental samples. Additional details regarding field QC samples are available in the Industrial Sites QAPP (NNSA/NV, 2002).

6.2 Laboratory/Analytical Quality Assurance

As stated in the DQOs (Appendix A), and except where noted, laboratory analytical quality data will be used for making DQO decisions. 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.

6.2.1 Data Validation

Data verification and validation will be performed in accordance with the Industrial Sites QAPP (NNSA/NV, 2002), 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 according to company-specific procedures. The data will be reviewed to ensure that all required samples were appropriately collected, analyzed, and 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 CADD. If the DQOs were not met, corrective actions will be evaluated, selected, and implemented (e.g., refine CSM or resample to fill data gaps).

6.2.2 Data Quality Indicators

The DQIs are qualitative and quantitative descriptors used in interpreting the degree of acceptability or utility of data. Data quality indicators are used to evaluate the entire measurement system and laboratory measurement processes (i.e., analytical method performance) as well as to evaluate individual analytical results (i.e., parameter performance). The quality and usability of data used to make DQO decisions will be assessed based on the following DQIs:

- Precision
- Accuracy/bias
- Representativeness
- Completeness
- Comparability
- Sensitivity

Table 6-1 provides the established analytical method/measurement system performance criteria for each of the DQIs and the potential impacts to the decision if the criteria are not met. The following subsections discuss each of the DQIs that will be used to assess the quality of laboratory data. The criteria for precision and accuracy in Tables 3-4 and 3-5 may vary from corresponding information in the Industrial Sites QAPP as a result of changes in analytical methodology and laboratory contracts (NNSA/NV, 2002).

Table 6-1
Laboratory and Analytical Performance Criteria for CAU 375 DQIs

DQI	Performance Metric	Potential Impact on Decision If Performance Metric Not Met
Precision	At least 80% of the sample results for each measured contaminant are not qualified for precision based on the criteria for each analytical method-specific and laboratory-specific criteria presented in Section 6.2.3.	The affected analytical results from each affected CAS will be assessed to determine whether there is sufficient confidence in analytical results to use the data in making DQO decisions.
Accuracy	At least 80% of the sample results for each measured contaminant are not qualified for accuracy based on the method-specific and laboratory-specific criteria presented in Section 6.2.4.	The affected analytical results from each affected CAS will be assessed to determine whether there is sufficient confidence in analytical results to use the data in making DQO decisions.
Representativeness	Samples contain contaminants at concentrations present in the environmental media from which they were collected.	Analytical results will not represent true site conditions. Inability to make appropriate DQO decisions.
Decision I Completeness	80% of the CAS-specific COPCs have valid results.	Cannot support/defend decision on whether COCs are present.
Decision II Completeness	100% of COCs used to define extent have valid results.	Extent of contamination cannot be accurately determined.
Comparability	Sampling, handling, preparation, analysis, reporting, and data validation are performed using standard methods and procedures.	Inability to combine data with data obtained from other sources and/or inability to compare data to regulatory action levels.
Sensitivity	Minimum detectable concentrations are less than or equal to respective FALs.	Cannot determine whether COCs are present or migrating at levels of concern.

The TLDs will be analyzed using automated TLD readers that are calibrated and maintained in accordance with existing QC procedures for TLD processing (Section 6.0) by a laboratory that is certified through the DOE Laboratory Accreditation Program for dosimetry. The data from this system meet rigorous data quality requirements and will be assessed for the listed DQIs before inclusion in the CAU 375 dataset. Therefore, a separate evaluation of the TLD data against the DQIs will not be conducted.

6.2.3 Precision

Precision is a measure of the repeatability of the analysis process from sample collection through analysis results and is used to assess the variability between two equal samples.

Determinations of precision will be made for field duplicate samples and laboratory duplicate samples. Field duplicate samples will be collected simultaneously with samples from the same source under similar conditions in separate containers. The duplicate sample will be treated independently of the original sample in order to assess field impacts and laboratory performance on precision through a comparison of results. Laboratory precision is evaluated as part of the required laboratory internal QC program to assess performance of analytical procedures. The laboratory sample duplicates are an aliquot, or subset, of a field sample generated in the laboratory. They are not a separate sample but a split, or portion, of an existing sample. Typically, laboratory duplicate QC samples may include matrix spike duplicate (MSD) and LCS duplicate samples for organic, inorganic, and radiological analyses.

Precision is a quantitative measure used to assess overall analytical method and field-sampling performance as well as to assess the need to "flag" (qualify) individual parameter results when corresponding QC sample results are not within established control limits.

The criteria used for the assessment of inorganic chemical precision when both results are greater than or equal to 5x reporting limit (RL) are 20 percent and 35 percent for aqueous and soil samples, respectively. When either result is less than 5x RL, a control limit of ±1x RL and ±2x RL for aqueous and soil samples, respectively, is applied to the absolute difference.

The criteria used for the assessment of organic chemical precision are based on professional judgment using laboratory-defined control limits. The criteria used for the assessment of radiological precision when both results are greater than or equal to 5x MDC are 20 percent and 35 percent for aqueous and soil samples, respectively. When either result is less than 5x MDC, the ND should be between -2 and +2 for aqueous and soil samples. The parameters to be used for assessment of precision for duplicates are listed in Table 3-5.

Any values outside the specified criteria do not necessarily result in the qualification of analytical data. It is only one factor in making an overall judgment about the quality of the reported analytical results. The performance metric for assessing the DQI of precision on DQO decisions (Table 6-1) is that at least 80 percent of sample results for each measured contaminant are not qualified due to duplicates exceeding the criteria. If this performance is not met, an assessment will be conducted in the CADD on the impacts to DQO decisions specific to affected contaminants at specific CASs.

6.2.4 Accuracy

Accuracy is a measure of the closeness of an individual measurement to the true value. It is used to assess the performance of laboratory measurement processes.

Accuracy is determined by analyzing a reference material of known parameter concentration or by reanalyzing a sample to which a material of known concentration or amount of parameter has been added (spiked). Accuracy will be evaluated based on results from three types of spiked samples: MS, LCS, and surrogates (organics). The LCS sample is analyzed with the field samples using the same sample preparation, reagents, and analytical methods employed for the samples. One LCS will be prepared with each batch of samples for analysis by a specific measurement.

The criteria used for the assessment of inorganic chemical accuracy are 75 to 125 percent for MS recoveries and 80 to 120 percent for LCS recoveries. For organic chemical accuracy, MS and LCS laboratory-specific percent recovery criteria developed and generated in-house by the laboratory according to approved laboratory procedures are applied. The criteria used for the assessment of radiochemical accuracy are 80 to 120 percent for LCS and MS recoveries.

Any values outside the specified criteria do not necessarily result in the qualification of analytical data. It is only one factor in making an overall judgment about the quality of the reported analytical results. Factors beyond laboratory control, such as sample matrix effects, can cause the measured values to be outside of the established criteria. Therefore, the entire sampling and analytical process may be evaluated when determining the usability of the affected data.

The performance metric for assessing the DQI of accuracy on DQO decisions (Table 6-1) is that at least 80 percent of the sample results for each measured contaminant are not qualified for accuracy. If this performance is not met, an assessment will be conducted in the CADD on the impacts to DQO decisions specific to affected contaminants and CASs.

6.2.5 Representativeness

Representativeness is the degree to which sample characteristics accurately and precisely represent characteristics of a population or an environmental condition (EPA, 2002). Representativeness is assured by carefully developing the CAI sampling strategy during the DQO process such that false negative and false positive decision errors are minimized. The criteria listed in DQO Step 6 (Specify Performance or Acceptance Criteria) are:

- For Decision I judgmental sampling, having a high degree of confidence that the sample locations selected will identify COCs if present anywhere within the CAS.
- For Decision I probabilistic sampling, having a high degree of confidence that the sample locations selected will represent contamination of the CAS.
- Having a high degree of confidence that analyses conducted will be sufficient to detect any COCs if present in the samples.
- For Decision II, having a high degree of confidence that the sample locations selected will identify the extent of COCs.

These are qualitative measures that will be used to assess measurement system performance for representativeness. The assessment of this qualitative criterion will be presented in the CADD.

6.2.6 Completeness

Completeness is defined as generating sufficient data of the appropriate quality to satisfy the data needs identified in the DQOs. For judgmental sampling, completeness will be evaluated using both a quantitative measure and a qualitative assessment. The quantitative measurement to be used to evaluate completeness is presented in Table 6-1 and is based on the percentage of measurements made that are judged to be valid.

For the judgmental sampling approach, the completeness goal is 80 percent. If this goal is not achieved, the dataset will be assessed for potential impacts on making DQO decisions. For the probabilistic sampling approach, the completeness goal is a calculated minimum sample size required to produce a valid statistical comparison of the sample mean to the FAL.

The qualitative assessment of completeness is an evaluation of the sufficiency of information available to make DQO decisions. This assessment will be based on meeting the data needs identified in the DQOs and will be presented in the CADD. Additional information will be collected if it is determined that DQO decisions cannot be resolved with the available information.

6.2.7 Comparability

Comparability is a qualitative parameter expressing the confidence with which one dataset can be compared to another (EPA, 2002). The criteria for the evaluation of comparability will be that all sampling, handling, preparation, analysis, reporting, and data validation were performed and documented in accordance with approved procedures that are in conformance with standard industry practices. Analytical methods and procedures approved by DOE will be used to analyze, report, and validate the data. These methods and procedures are in conformance with applicable methods used in industry and government practices. An evaluation of comparability will be presented in the CADD.

6.2.8 Sensitivity

Sensitivity is the capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest (EPA, 2002). The evaluation criterion for this parameter will be that measurement sensitivity (i.e., MDCs) will be 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. This assessment will be presented in the CADD.

As presented in Section 3.4, the evaluation criterion for this parameter will be that the analytical methods must be sufficient to detect contamination that is present in the samples at concentration levels less than or equal to corresponding FALs. The target MDC for each COPC is provided in Tables 3-4 and 3-5.

Although the data quality for TLD measurements is assessed via the routine environmental monitoring program (Section 6.0), the sensitivity evaluation criteria for TLD measurements is 50 percent of the FAL (i.e., 12.5 net mrem/yr).

7.0 Duration and Records Availability

7.1 Duration

Field and analytical activities will require approximately 120 days to complete.

7.2 Records Availability

Historical information and documents referenced in this plan are retained in the NNSA/NSO project files in Las Vegas, Nevada, and can be obtained through written request to the NNSA/NSO Federal Sub-Project Director. This document is available in the DOE public reading rooms located in Las Vegas and Carson City, Nevada, or by contacting the appropriate DOE Federal Sub-Project Director.

8.0 References

ARL/SORD, see Air Resources Laboratory/Special Operations and Research Division.

ASTM, see American Society for Testing and Materials.

Air Resources Laboratory/Special Operations and Research Division. 2009. *NTS Climatological Rain Gauge Data.* As accessed at http://www.sord.nv.doe.gov/home_climate_rain.htm on 18 November.

American Society for Testing and Materials. 1995 (reapproved 2002). *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*, ASTM E1739 - 95(2002). Philadelphia, PA.

BN, see Bechtel Nevada.

Bechtel Nevada. 1999. *An Aerial Radiological Survey of the Nevada Test Site,* DOE/NV/11718--324. Prepared for U.S. Department of Energy, Nevada Operations Office. Las Vegas, NV: Remote Sensing Laboratory.

Bechtel Nevada. 2002. *A Hydrostratigraphic Model and Alternatives for the Groundwater Flow and Contaminant Transport Model of Corrective Action Units 101 and 102: Central and Western Pahute Mesa, Nye County, Nevada*, DOE/NV/11718--706. Prepared for the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. Las Vegas, NV.

CFR, see *Code of Federal Regulations.*

Clesceri, L.S., A.E. Greenberg, and A.D. Eaton, eds. 1998. *Standard Methods for the Examination of Water and Wastewater,* 20th edition. Published by American Public Health Association, American Water Works Association, and Water Environmental Federation.

Code of Federal Regulations. 2009a. Title 10 CFR, Part 835, "Occupational Radiation Protection." Washington, DC: U.S. Government Printing Office.

Code of Federal Regulations. 2009b. Title 40 CFR, Parts 260 to 282, "Hazardous Waste Management System: General." Washington, DC: U.S. Government Printing Office.

Code of Federal Regulations. 2009c. Title 40 CFR, Part 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions." Washington, DC: U.S. Government Printing Office.

DOE, see U.S. Department of Energy.

DOE/NV, see U.S. Department of Energy, Nevada Operations Office.

DRI, see Desert Research Institute.

Desert Research Institute. 1985. *Radionuclide Transport by Surface Water: Preliminary Studies in Fortymile Canyon*, DOE/NV/10384--06. Prepared by R.H. French and J.W. Hess. Las Vegas, NV.

Desert Research Institute. 1988. *CERCLA Preliminary Assessment of DOE's Nevada Operations Office Nuclear Weapons Testing Areas.* April. Las Vegas, NV.

Desert Research Institute. 1989. *Nevada Test Site Radionuclide Inventory and Distribution Program: Report #5, Areas 5, 11, 12, 15, 17, 18, 19, 25,26, and 30*, DOE/NV/10384--26. Prepared by R.D. McArthur and S.W. Mead. Las Vegas, NV.

Desert Research Institute. 2007. *Radionuclide Inventory and Distribution (RIDP) Database*, Rev. 2. April. Prepared by K. Gray, D.S. Shafer, K. Self, C. Martin, and R. McArthur. Las Vegas, NV.

EPA, see U.S. Environmental Protection Agency.

ERDA, see Energy Research and Development Administration.

Energy Research and Development Administration. 1977. *Final Environmental Impact Statement, Nevada Test Site, Nye County, Nevada,* ERDA-1551. Washington, DC.

FFACO, see *Federal Facility Agreement and Consent Order.*

Federal Facility Agreement and Consent Order. 1996 (as amended February 2008). Agreed to by the State of Nevada; U.S. Department of Energy, Environmental Management; U.S. Department of Defense; and U.S. Department of Energy, Legacy Management.

Friesen, H.N. 1992. *Summary of the Nevada Applied Ecology Group and Correlative Programs*, DOE/NV-357. Prepared for the U.S. Department of Energy, Nevada Operations Office. Las Vegas, NV.

IT, see IT Corporation.

IT Corporation. 2002. Written communication. Subject: "Radiological Soil Survey of CAU 516 Selected Sites, 29 and 30." January. Las Vegas, NV.

LASL, see Los Alamos Scientific Laboratory.

LRL, see Lawrence Radiation Laboratory.

Laczniak, R.J., J.C. Cole, D.A. Sawyer, and D.A. Trudeau. 1996. *Summary of Hydrogeologic Controls Ground-Water flow at the Nevada Test Site, Nye County, Nevada*. As accessed at http://water.usgs.geo/pubs/wri/wri964109/report.htm on 19 November 2009.

Lawrence Radiation Laboratory. Date unknown. *Description of Craters Nevada Test Site*, 173664. Prepared by the U.S. Army Engineer Nuclear Cratering Group. Livermore, CA.

Lawrence Radiation Laboratory. 1970. *Project Buggy Gamma Fallout Field*, URCL-50832. 11 March. Livermore, CA: University of California.

Los Alamos Scientific Laboratory. 1962. *Kiwi B-1B*, Film Y-87. Sponsored by U.S. Atomic Energy Commission and National Aeronautics and Space Administration. Los Alamos, NM: University of California.

Moore, J., Science Applications International Corporation. 1999. Memorandum to M. Todd (SAIC) entitled, “Background Concentrations for NTS and TTR Soil Samples,” 3 February. Las Vegas, NV: IT Corporation.

NAC, see *Nevada Administrative Code*.

NBMG, see Nevada Bureau of Mines and Geology.

NDEP, see Nevada Division of Environmental Protection.

NNES, see Navarro Nevada Environmental Services, LLC.

NNES GIS, see Navarro Nevada Environmental Services Geographic Information Systems.

NNSA/NSO, see U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office.

NNSA/NV, see U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office.

Navarro Nevada Environmental Services, LLC. 2009. *Statement of Work for Analytical Laboratories*, Section C. Las Vegas, NV.

Navarro Nevada Environmental Services Geographic Information Systems. 2010. ESRI ArcGIS Software.

Nevada Administrative Code. 2008a. NAC 445A.227, “Contamination of Soil: Order by Director for Corrective Action; Factors To Be Considered in Determining Whether Corrective Action Required.” Carson City, NV. As accessed at http://www.leg.state.nv.us/nac on 18 November 2009.

Nevada Administrative Code. 2008b. NAC 445A.22705, "Contamination of Soil: Evaluation of Site by Owner or Operator; Review of Evaluation by Division." Carson City, NV. As accessed at http://www.leg.state.nv.us/nac on 18 November 2009.

Nevada Bureau of Mines and Geology. 1998. *Mineral and Energy Resource Assessment of the Nellis Air Force Range*, Open-File Report 98-1. Reno, NV.

Nevada Division of Environmental Protection. 2006 (as amended in August 2000). *Class III Solid Waste Disposal Site for Hydrocarbon Burdened Soils, Area 6 of the NTS,* Permit SW 13-097-02, Rev. 7. Carson City, NV.

ORAU, see Oak Ridge Associated Universities.

Oak Ridge Associated Universities. 2007. *Nevada Test Site - Site Description*, ORAUT-TKBS-0008-2. October. Oak Ridge, TN.

Paar, J.G., and D.R. Porterfield. 1997. *Evaluation of Radiochemical Data Usability*, ES/ER/MS-5. April. Oak Ridge, TN: U.S. Department of Energy.

REECo, see Reynolds Electrical & Engineering Co., Inc.

RSL, see Remote Sensing Laboratory.

Remote Sensing Laboratory. 1977a. Aerial Photograph "D07_0092 Buggy 1977," Date Unknown. Las Vegas, NV.

Remote Sensing Laboratory. 1977b. Aerial Photograph "D07_0093 Buggy 1977," Date Unknown. Las Vegas, NV.

Reynolds Electrical & Engineering Co., Inc. 1962. *Kiwi B4A Reactor Operation, November 30, 1962, On-Site Radiological Safety Report*, NVO-162-12. Prepared between the Atomic Energy Commission and Reynolds Electrical & Engineering Co., Inc. Mercury, NV.

SNJV, see Stoller-Navarro Joint Venture.

Shott, G.J., V. Yucel, M.J. Sully, L.E. Barker, S.E. Rawlinson, and B.A. Moore. 1997. *Performance Assessment/Composite Analysis for the Area 3 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada*, Rev. 2.0. Las Vegas, NV.

Sloop, C., Navarro Nevada Environmental Services, LLC. 2010. Personal communication regarding information for internal dose as a percentage of TED for the CAU 371, Johnnie Boy Crater and Pin Stripe sites, 20 January. Las Vegas, NV.

Stoller-Navarro Joint Venture. 2008. Written communication. Subject: "Soils Field Information Sheet," 22 July. Las Vegas, NV.

USGS, see U.S. Geological Survey.

U.S. Department of Energy. 1997. *The Procedures Manual of the Environmental Measurements Laboratory*, HASL-300, 28th Ed., Vol. I. February. New York, NY.

U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office. 2002. *Industrial Sites Quality Assurance Project Plan, Nevada Test Site, Nevada*, Rev. 3, DOE/NV--372. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2005. *Corrective Action Decision Document for Corrective Action Unit 300: Surface Release Areas, Nevada Test Site, Nevada*, DOE/NV-1039. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2006a. *Closure Report for Corrective Action Unit 115: Area 25 Test Cell A Facility, Nevada Test Site, Nevada*, DOE/NV--1109. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2006b. *Industrial Sites Project Establishment of Final Action Levels*, Rev. 0, DOE/NV--1107. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2007. *Nevada Test Site Environmental Report 2006*, DOE/NV 25946--259. Prepared by National Security Technologies, LLC.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2008. *Nevada Test Site Waste Acceptance Criteria*, DOE/NV-325-Rev. 7. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2009. *Corrective Action Decision Document/Closure Report for Corrective Action Unit 370: T-4 Atmospheric Test Site, Nevada Test Site, Nevada*, DOE/NV--1320. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1992. *Remedial Investigation and Feasibility Study for the Plutonium Contaminated Soils at Nevada Test Site, Nellis Air Force Range and Tonopah Test Range*, April. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1996a. *Closure Report for the Area 30 Disposal Site (CAS 30-15-01)*. Prepared by Bechtel Nevada. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1996b. *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada*, DOE/EIS 0243. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1998. *Nevada Test Site Resource Management Plan*, DOE/NV--518. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 2000. *United States Nuclear Tests, July 1945 through September 1992*, DOE/NV--209-Rev 15. Las Vegas, NV.

U.S. Environmental Protection Agency. 1980. *Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA 600/4-80-032. Cincinnati, OH: Environmental Monitoring and Support Laboratory Office of Research and Development.

U.S. Environmental Protection Agency. 2000. *Sampling and Analysis Plan Guidance and Template*, R9QA/002.1. As accessed at http://www.epa.gov/region09/qa/projplans.html on 19 November 2009.

U.S. Environmental Protection Agency. 2002. *Guidance for Quality Assurance Project Plans,* EPA QA/G5. Washington, DC.

U.S. Environmental Protection Agency. 2004. *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, OSWER 9240.1-45/EPA 540-R-04-004. October. Washington, DC: Office of Solid Waste and Emergency Response.

U.S. Environmental Protection Agency. 2008. *SW-846 On-Line, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.* As accessed at http://www.epa.gov/epaoswer/hazwaste/test/main.htm on 19 November 2009.

U.S. Environmental Protection Agency. 2009. *Region 9: Superfund, Preliminary Remediation Goals, Screening Levels for Chemical Contaminants*. As accessed at http://www.epa.gov/region09/waste/sfund/prg/index.html on 19 November. Prepared by EPA Office of Superfund and Oak Ridge National Laboratory.

U.S. Geological Survey. 1964. *Geology of the Jackass Flats Quadrangle, Nye County, Nevada*. Prepared by E.J. McKay and W.P. Williams for the U.S. Atomic Energy Commission. Las Vegas, NV.

U.S. Geological Survey. 1982. *Timber Mountain Quadrangle, Nevada - Nye County, 7.5 Minute Series (Topographic),* U.S. Geological Survey Geologic Quadrangle Map, scale 1:24,000.

U.S. Geological Survey. 1990. *Geologic Map of the Nevada Test Site, Southern Nevada*, USGS Map I-2046. Denver, CO.

U.S. Geological Survey. 1995. *Selected Groundwater Data for Yucca Mountain Region, Southern Nevada and Eastern California*, Calendar Year 1993, USGS-OFR-95-58. Prepared by G.S. Hale and C.L. Westenburg. Denver, CO.

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 6.4 released in December 2007.)

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 375, Area 30 Buggy Unit Craters, field investigation. The 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 375 is insufficient to evaluate and select preferred corrective actions; therefore, a CAI will be conducted.

The CAU 375 CAI will be based on the DQOs presented in this appendix as developed by representatives of NDEP and NNSA/NSO. 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:

- 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.
    - 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 375 is: "Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs in CAU 375."

A.2.1 Planning Team Members

The DQO planning team consists of representatives from NDEP and NNSA/NSO. The DQO planning team met on December 2, 2009, for the DQO meeting.

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 375 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:

- 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, NDEP will be notified and given the opportunity to comment on, or concur with, the recommendation.

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 represents site conditions applicable to the CSM. Figure A.2-2 depicts a representation of the conceptual pathways to receptors from CAU 375 sources.

A.2.2.1 Release Sources

The releases of contamination to CAU 375 are directly or indirectly associated with the TCA nuclear rocket motor tests and the Buggy nuclear tests. The test release scenarios consist of the releases of radioactivity to surrounding soils from prompt injection of nuclear material, neutron activation of soils and debris, and the atmospheric deposition of fuel fragments and fission products.

The following identifies the test release sources specific to each CAS:

- The TCA source was the expulsion of radionuclides and fuel particles through the exhaust of nuclear rocket motors. Tests were conducted from 1959 through 1966.
- The Buggy site source was the prompt injection of radionuclides into subsurface media and the subsequent expulsion of radioactive materials from a Plowshare test with five detonations occurring simultaneously, each with a yield of 1.08 kt (DOE/NV, 2000) buried at a depth of 41.2 m that was detonated on March 12, 1968.

Table A.2-1
Conceptual Site Model Description of Elements for Each CAS in CAU 375

CAS Identifier	25-23-22	30-45-01
CAS Description	**Contaminated Soils Site**	**U-30a, b, c, d, e Craters**
Site Status	Sites are inactive and/or abandoned	
Exposure Scenario	Occasional	Occasional
Sources of Potential Soil Contamination	Fallout and soil activation from surface operation of nuclear rocket	Fallout and soil activation from near surface nuclear detonation
Location of Contamination/ Release Point	Deposited material from the exhaust plume, placement due to excavation, or covering of contaminated surfaces	Interface between contaminated soil/ejecta/debris and native soil
Amount Released	Unknown	
Affected Media	Surface and shallow subsurface soil	Subsurface around and beneath crater, surface soil
Potential Contaminants	Fuel particles, activation and fission products	Unburned fuel, activation and fission products
Transport Mechanisms	Surface water runoff may provide for the transportation of some contaminants within or outside the boundaries of the CAS, through ephemeral drainages near the CAS. Infiltration of precipitation through subsurface media serves as a minor driving force for migration of contaminants. Inside fence includes mechanical displacement (e.g., excavation).	Surface water runoff may provide for the transportation of some contaminants within or outside the boundaries of the CAS, through ephemeral drainages near the CAS. Infiltration of precipitation through subsurface media serves as a minor driving force for migration of contaminants. Mechanical displacement.
Migration Pathways	Lateral transport is expected to dominate over vertical transport due to the relatively large PET value as compared to the annual precipitation rate, and depth to uppermost aquifer.	
Lateral and Vertical Extent of Contamination	Contamination, if present, is expected to be contiguous to the release points. Concentrations are expected to decrease with distance and depth from the source. Groundwater contamination is not expected. Lateral and vertical extent of COC contamination is assumed to be within the spatial boundaries of the CAS.	
Exposure Pathways	The potential for contamination exposure is limited to industrial and construction workers, and military personnel conducting training. These human receptors may be exposed to COPCs through oral ingestion, inhalation, and dermal contact (absorption) of soil and/or debris due to inadvertent disturbance of these materials or irradiation by radioactive materials.	

Non-test releases are defined as all other types of releases such as those resulting from spills or wastes found at the site during the investigation or contaminated materials that have migrated as a result of wind, water, excavation, or some other influence. Non-test release scenarios consist of the contamination of soils from migration, spills, or other non-test related activities or events. Non-test scenarios may have occurred during water flow or flooding events, excavation of soils during construction or investigation/cleanup events, or any other event that may have caused the surface movement or burial of existing contamination.

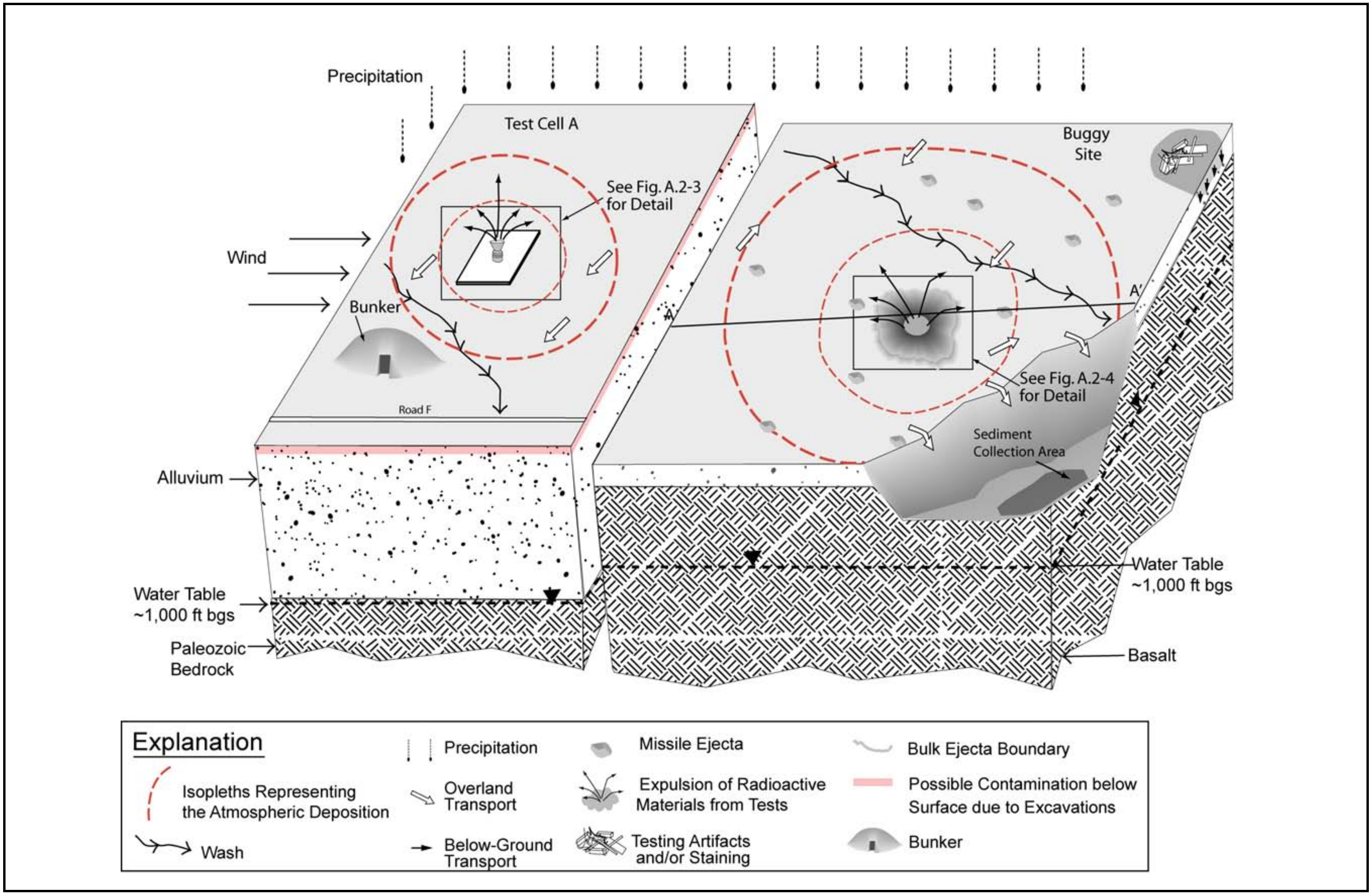
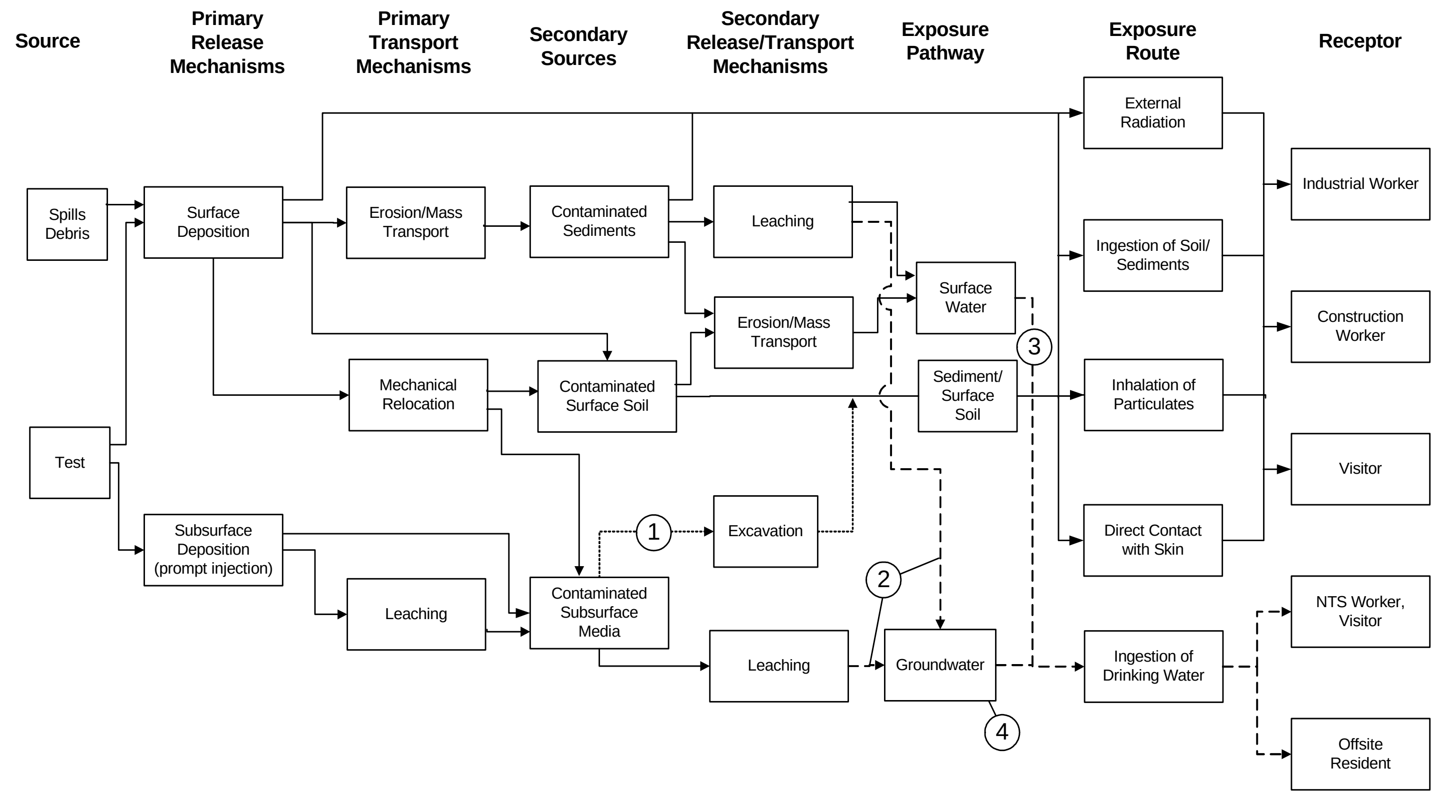


Figure A.2-1
CAU 375 Conceptual Site Model



1. Potential Pathway - This pathway would exist only if the subsurface media were excavated.
2. Incomplete Pathway - Characterization of regional hydrogeology and environmental data have shown that leaching of contaminants is limited.
3. Incomplete Pathway - There are no surface waters that are used as a source for drinking water.
4. Groundwater within the NTS is used as a source for drinking water.

Complete Pathway

Potential Pathway

Incomplete Pathway

Figure A.2-2
Conceptual Site Model Diagram

For CAS 25-23-22, the location for deposition of contamination from the test was at the soil surface. However, due to the amount of disruption of the soil from construction and demolition activities inside the perimeter fence since the original deposition, the contamination may also be present in shallow subsurface soils in various locations (Figure A.2-3). Contamination may also be present at downstream sedimentation areas due to contaminant migration.

For CAS 30-45-01, the most likely locations for deposition of contamination from the tests are the subsurface soils within and around the crater and the surface soil outside the crater. Contamination is expected at the base of the crater in the ejecta created from the original detonation (due to prompt injection) as well as a layer of fallout deposited from the cloud of dust and debris formed as a result of test detonation (Figure A.2-4).

A.2.2.2 Potential Contaminants

The COPCs are based on a conservative evaluation of possible site activities considering the incomplete site histories and considering contaminants found at similar NTS sites. The 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. Because complete information regarding activities performed at the CAU 375 sites is not available, contaminants detected at similar NTS sites were included in the contaminant lists. The list of COPCs is intended to encompass all of the significant contaminants that could potentially be present. Significant contaminants are defined as contaminants that are present at concentrations exceeding the PAL. The COPCs applicable to Decision I environmental samples from test release scenario samples are defined as the analytes reported from the analytical methods stipulated in Table A.2-2. The COPCs applicable to non-test release scenario samples at both CASs will include the COPCs listed for the test release scenario samples and other chemical COPCs based on the nature of the identified potential release (e.g., stains, lead bricks).

A.2.2.3 Contaminant Characteristics

Contaminant characteristics include, but are not limited to, solubility and adsorption potential. In general, contaminants with low solubility and high affinity for media can be expected to be found relatively close to release points. Contaminants with high solubility and low affinity for media are

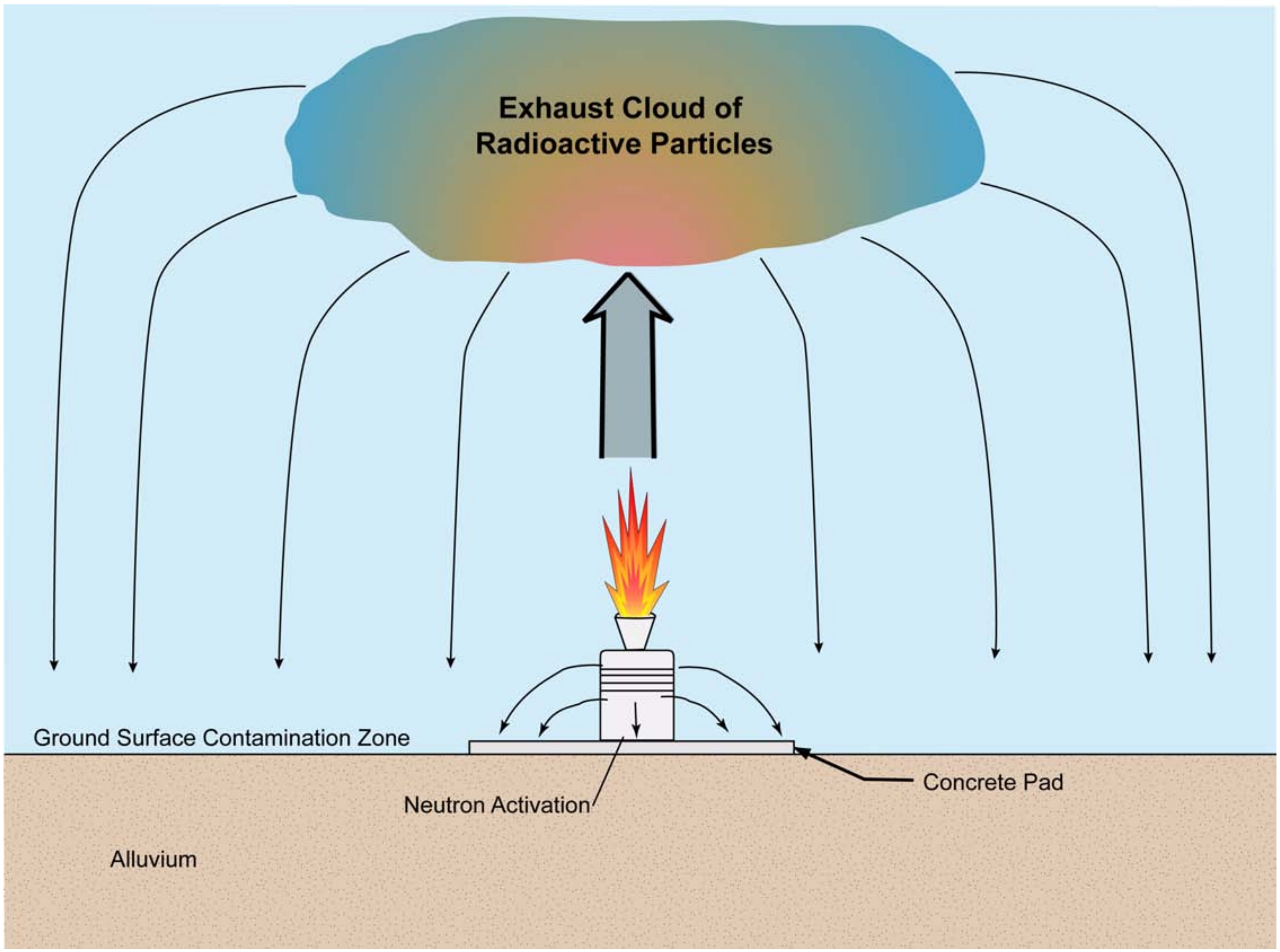


Figure A.2-3
Rocket Test, CAS 25-23-22

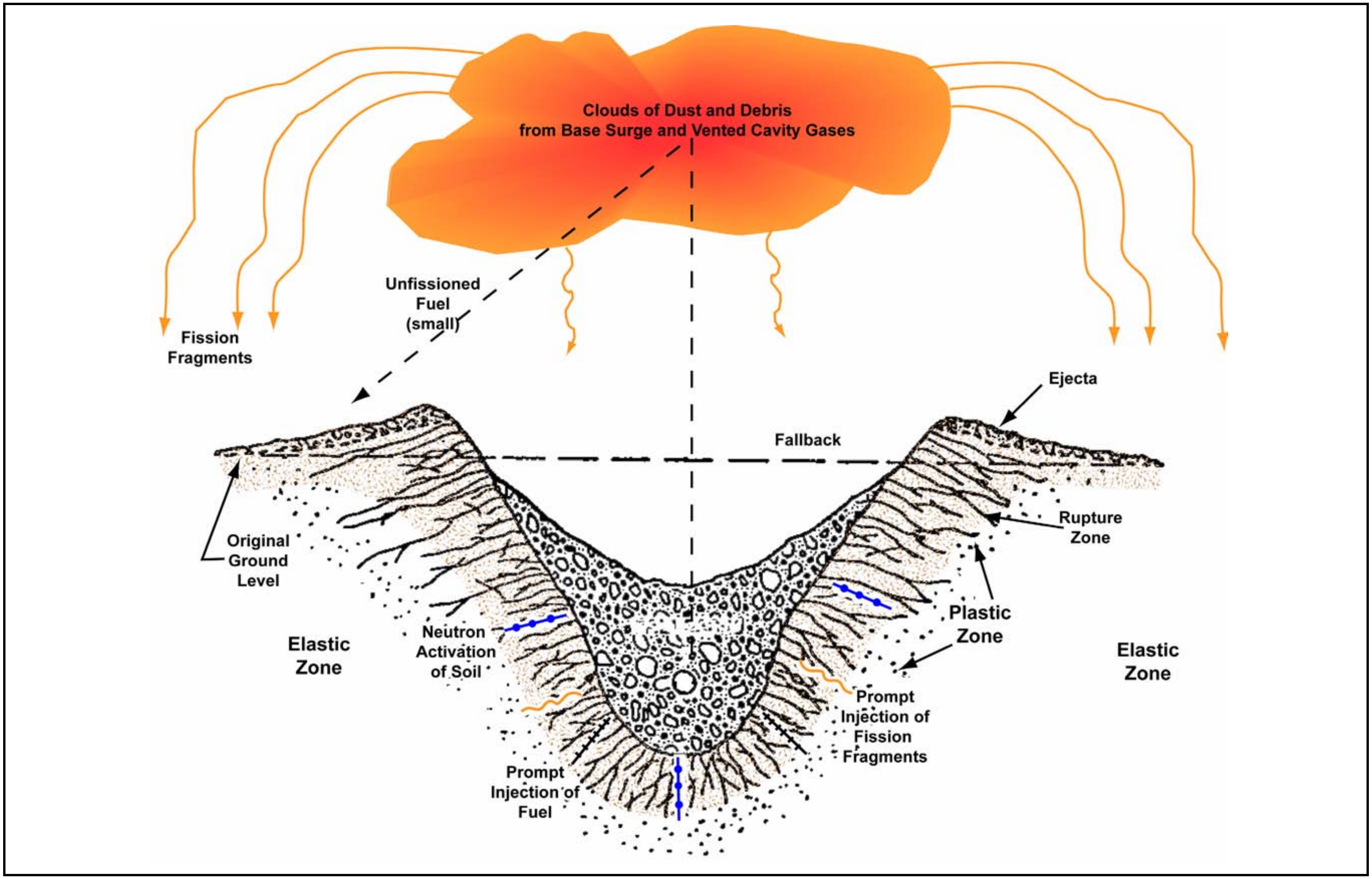


Figure A.2-4
Test Crater, CAS 30-45-01

Table A.2-2
Radionuclide Analytical Program[a]

Analyses	CAS 25-23-22	CAS 30-45-01
Radionuclide COPCs		
Gamma Spectroscopy[b]	X	X
Isotopic U	X	X
Isotopic Pu	--	X
Isotopic Am	--	X
Sr-90	X	X

[a]The COPCs are the constituents reported from the analytical methods listed.
[b]Results of gamma analysis will be used to determine whether further isotopic analysis is warranted.

X = Required analytical method
-- = Not required

found further from release points or in low areas where evaporation of ponding will concentrate dissolved contaminants.

As stated in the document *Subsurface Nobel Gas Transport at the Nevada Test Site* (Thompson et al., 1997), the Cambric test at the NTS was used to study long-term radionuclide migration from the underground detonation of a nuclear device. The Cambric test (with a yield of 750 tons) was conducted below the water table in Frenchman Flat in 1965. A well installed into the groundwater 91 m away from GZ was continuously pumped for 16 years (from 1975 to 1991) in order to draw radionuclides from the detonation cavity. The extracted water was tested for radionuclides. None of the adsorbing radionuclides (Am-241, Ca-41, Cs-137, Eu-154, Pu-241, samarium [Sm]-151, neptunium [Np]-237, or Sr-90) were detected in the pumped groundwater (attesting to their low solubility and affinity to adsorb to media). The radionuclides tritium and krypton detected in the pumped groundwater are considered to be conservative tracers in groundwater (i.e., they do not interact with the geologic media through which the water moves). The evaluation of the characteristics of the radionuclide contaminants associated with TCA and the Buggy site are based on the results of the Cambric test. This test conservatively demonstrated the potential for migration of the targeted contaminants in media similar to that of TCA and the Buggy site (i.e., similar pH and mineralogy), and under conditions more likely to cause migration than that of TCA and the Buggy site (i.e., saturated versus unsaturated conditions). This test demonstrated the relative immobility of the adsorbing radionuclides under saturated conditions where an artificial hydraulic gradient (pumping) was imposed. The contaminants at TCA and the Buggy site are located in unsaturated media (i.e., vadose) hundreds of feet above the shallowest aquifer. The contaminants generated by the Cambric test include the contaminants reasonably expected to be present at the TCA and the Buggy site (i.e., americium, cesium, plutonium, and uranium). Because these contaminants did not migrate from the Cambric cavity in pumped groundwater into to the adjacent test well during a period of 16 years, this demonstrates that the CAU 375 radionuclide contaminants are relatively immobile even under conditions of saturated flow with an imposed gradient.

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 streams, and evapotranspiration potential.

Corrective Action Site 25-23-22, Contaminated Soils Site, is located in Area 25 of the NTS in Jackass Flats. The area is nearly flat but slopes very gently towards the southwest. The area is sparsely vegetated with native plants. The soil in and around TCA is made up of sand to cobble-sized alluvium of various lithologies. No perennial streamflow exists in the region. Any streamflow in the area flows in natural flow paths that combine with Topopah Wash after approximately 5 mi. The Topopah Wash is the closest major dry wash in the vicinity and runs southwesterly through Jackass Flats off the NTS and toward the Death Valley lake bed.

Corrective Action Site 30-45-01, U-30a, b, c, d, e Craters, is located in Area 30 of the NTS on Chukar Mesa above Fortymile Canyon in the Fortymile Wash drainage basin (USGS, 1982). The area gently slopes away from the crater towards ravines that are located within 400 ft of each side of the crater and flow into Fortymile Canyon. The ravines are lined with rocks from gravel to boulders in size and contain small sedimentation areas. The area around the crater and the ravines is sparsely vegetated with native plants. Runoff from the area around the crater flows into two primary ravines. The ravine to the northeast of the crater flows approximately 3 mi before entering Fortymile Canyon while the ravine to the southwest of the crater flows approximately 1 mi before entering Fortymile Canyon. The far southeast point of Chukar Mesa overlooks Fortymile Canyon from an elevation of approximately 800 ft above the bottom of the canyon.

Corrective Action Site 30-45-01 is located in Area 30, atop a mesa above Fortymile Canyon identified as Chukar Mesa. The geology of Chukar Mesa is fractured volcanic basalt (LRL, date unknown) with the surface being composed of uncompacted clay with small- to medium-size volcanic gravel and rocks with sparse vegetation.

The nearest water well is ER-30-1, where the depth to the uppermost aquifer is 450 ft bgs (NNES GIS, 2010). The well is located 4.28 mi northeast of the crater at an elevation approximately 500 ft lower than the Buggy site. Therefore, depth to groundwater at the Buggy site is estimated to be approximately 950 ft. The average elevation of the site is approximately 5,200 ft amsl (NNES GIS, 2010). The direction of precipitation runoff flow is into gullies and washes that generally drain to the south. Drainage channels are generally dry but are subject to infrequent, potentially intense, stormwater flows. Sedimentation entrained by these stormwater events would be carried by the streamflow to locations where the flowing water loses energy and the sediments drop out. These locations are readily identifiable as sedimentation areas.

The document *A Hydrostratigraphic Model and Alternatives for the Groundwater Flow and Contaminant Transport Model of Corrective Action Units 101 and 102: Central and Western Pahute Mesa, Nye County, Nevada* (BN, 2002) points out that although the interstitial porosity in such formations may be high, the interconnectivity of the pore space is poor, and these relatively incompetent rocks tend not to support open fractures. Secondary alteration ultimately yields a very impermeable unit. Additionally, these formations tend to have very low hydraulic conductivity. Though these rocks can be moderately fractured, the fractures are typically sealed by secondary mineralization.

That same document further states:

> “Of particular importance are the type and distribution in the rock, of alteration minerals such as clays, zeolites, and iron oxides. Not only do these minerals reduce the interstitial porosity of rocks, many of them have a capacity to sorb radionuclides, depending on their chemical nature, and they show markedly different sorptive capacities. Work in Frenchman Flat has identified the importance of zeolites and clays in retarding the movement of radionuclides via sorption and ion exchange. Various types of alteration minerals can make up a large percentage of the rocks that compose most of the volcanic HSUs defined as confining units. Zeolites and clay minerals may be present in the matrix of tuffs as a result of alteration of the glass in the original vitric tuff, or can be components of the mineral coatings on fracture surfaces.

The presence of coatings or fillings in fractures not only reduces hydraulic conductivity by reducing the volume of fracture openings, but specific fracture-filling minerals may act to sorb radionuclides to various degrees. A few data are available for NTS rocks from studies conducted to investigate the nature and mineralogy of fracture fillings. The sorption of radionuclides by zeolites, clays, and iron oxides in fracture coatings may impede the diffusion of nuclides out of the fracture into the matrix. Thus, though the presence of sorptive minerals in the rock matrix can slow diffusion by trapping radionuclides, the presence of these minerals in fracture coatings may increase transport by preventing the diffusion of radionuclides from the fracture into the rock matrix. Matrix diffusion can slow the movement of any radionuclide, reactive or not, and thus is another very important process to consider in the modeling of radionuclide migration."

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. Contaminants present in ephemeral washes are subject to much higher transport rates than contaminants present in other surface areas. These ephemeral washes are generally dry but are subject to infrequent stormwater flows. These stormwater flow events provide an ephemeral mechanism for both vertical and horizontal transport of contaminants. Contaminated sediments entrained by these stormwater events would be carried by the streamflow to locations where the flowing water loses energy and the sediments drop out. These locations are readily identifiable as sedimentation areas. The area around the Buggy site drains into Fortymile Canyon, which flows through the Jackass Flats region of Area 25. The area around TCA drains into the Topopah Wash area, which also flows through the Jackass Flats region of Area 25. The drainage from both CASs ultimately drain into the Death Valley dry lake. Other migration pathways for contamination from the sites include windborne material and materials displaced from maintenance activities (e.g., moved during road maintenance). Contaminants may also be moved through mechanical disturbance due to maintenance or construction activities at the site. Specifically, this can include activities such as D&D of facilities, investigation and resolution of CASs, and disassembly and removal of equipment and support structures.

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 further 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 the Area 3 RWMS has been estimated at 62.6 in. [Shott et al., 1997]) and limited precipitation for this region (5.66 in. per year at Station 4JA in Area 25 and 8.06 in. per year at Station 40MI in Area 30 [ARL/SORD, 2009]), percolation of infiltrated precipitation at the NTS does not provide a significant mechanism for vertical migration of contaminants to groundwater (DOE/NV, 1992).

Subsurface migration pathways at CAU 375 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 horizontal transport pathways, both on the ground surface (e.g., concrete) and in the subsurface (e.g., caliche layers).

Migration is influenced by the chemical characteristics of the contaminants (presented in Section A.2.2.3) and the physical characteristics of the vadose media (presented in Section A.2.2.4). As shown in these sections, the contaminants reasonably expected to be present at CAU 375 (i.e., americium, cesium, plutonium, and uranium) are relatively immobile even under conditions of saturated flow with an imposed gradient. However, the only driver for contaminant migration in the vadose zone at TCA and the Buggy site is the percolation of infiltrated stormwater through the media. As shown in Section 2.1, percolation through the vadose is expected to be very limited due to high evapotranspiration potentials and low precipitation rates typical of the NTS. Therefore, the CAU 375 radionuclide contaminants are expected to be even less mobile in the vadose zone as water movement through the vadose zone is much less than in the saturated conditions of the aquifer. The physical characteristics of the vadose media generally include medium to high adsorptive capacities, low moisture contents (i.e., available water-holding capacity), and relatively long distances to groundwater (e.g., approximately 950 to 1,000 ft bgs). Based on these physical and chemical factors, contamination is expected to be found relatively close to release points.

A.2.2.6 Exposure Scenarios

Human receptors may be exposed to COPCs through oral ingestion, inhalation, dermal contact (absorption) of 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 375 CASs are listed in Table A.2-3. Corrective Action Site 25-23-22 is located in an area with an improved road and old building footings, pads, and support infrastructure. No regular work is performed in the area. Corrective Action Site 30-45-01 is a remote location without any site improvements and where no regular work is performed. The possibility still exists at both CASs that site workers could occupy these locations on an occasional and temporary basis for such activities as military exercises. Therefore, these sites are classified as occasional work areas.

Table A.2-3
Land-Use and Exposure Scenarios

CAS	Record of Decision Land-Use Zone	Exposure Scenario
25-23-22	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 defense and nondefense research, development, and testing projects and activities.	Occasional Use Area 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.
30-45-01	Reserved Zone This area includes land and facilities that provide widespread flexible support for diverse short-term testing and experimentation. The reserved zone is also used for short duration exercises and training such as nuclear emergency response and Federal Radiological Monitoring and Assessment Center training and U.S. Department of Defense land-navigation exercises and training.	Occasional Use Area 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.

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: "Is any COC present in environmental media within the CAS?" For test releases, the presence of a COC is defined as a location where the 95 percent UCL of the average dose exceeds 25 mrem/yr (based on an appropriate exposure scenario). For non-test releases, any analytical result for a COPC 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/NSO, 2006). If a COC is detected, then Decision II must be resolved.

The Decision II statement is: "If a COC is present, is sufficient information available to evaluate potential CAAs?" Sufficient information is defined to include:

- 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 (bioassessment if natural attenuation or biodegradation is considered, and geotechnical data if construction or evaluation of barriers is considered)

A corrective action will be determined for any site containing a COC. For the Buggy crater area, the DQO process resulted in an assumption that TED within the areas of the crater, crater rim, and related mounding around the crater exceeds the FAL and requires corrective action. A default contamination boundary was established that includes these areas (Section 3.4). Therefore, Decision I for the Buggy site default contamination boundary is resolved, and corrective action is necessary. Decision I will be resolved for the Buggy site area outside the default contamination boundary and for TCA. The evaluation of the need for corrective action will include the potential for wastes that are present at a site to cause the future contamination of site environmental media if the wastes were to be released.

To evaluate the potential for wastes to result in the introduction of a COC to the surrounding environmental media, the following conservative assumptions were made:

- Any containment of waste (e.g., fuel/oil reservoirs, pipe, concrete vaults and walls, drums) would fail at some point, and the waste would be released to the surrounding soil.
- A waste, regardless of concentration or configuration, may be assumed to be PSM and handled under a corrective action.
- Based on process knowledge and/or professional judgment, some waste may be assumed to not be PSM if it is clear that it could not result in soil contamination exceeding a FAL.
- If assumptions about the waste cannot be made, then the waste material will be sampled and the results will be compared to FALs based on the following criteria:
  - For non-liquid wastes, the concentration of any chemical contaminant in soil (following degradation of the waste and release of contaminants into soil) would be equal to the mass of the contaminant in the waste divided by the mass of the waste.
  - For non-liquid wastes, the dose resulting from radioactive contaminants in soil (following degradation of the waste and release of contaminants into soil) would be calculated using the activity of the contaminant in waste divided by the mass of the waste (for each radioactive contaminant) and calculating the combined resulting dose using the RESRAD code (Murphy, 2004). Note: As an initial screening tool, if building materials are primarily externally contaminated and do not present a dose exceeding the FAL to a nearby worker in its current configuration, it will not be considered to meet PSM criteria.
  - For liquid wastes, the resulting concentration of contaminants in the surrounding soil would be calculated based on the concentration of contaminants in the wastes and the liquid-holding capacity of the soil.

If sufficient information is not available to evaluate potential CAAs, then site conditions will be re-evaluated 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 from the CAS is detected, then further assessment of the CAS is not required. If a COC associated with a release from the CAS is detected, then 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 sufficient information is available to evaluate potential CAAs, then further assessment of the CAS is not required. If sufficient information is not available to evaluate potential CAAs, then additional samples will be collected.

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 a COC is present at a CAS), 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 CAS (probabilistic sampling)
- The analytical suite selected must be sufficient to identify any COCs present in the samples.

To resolve Decision II for test release contamination, samples need to be collected and analyzed to meet the following criterion:

- A decreasing trend of TED rates from more than 25 mrem/IA-yr to less than 25 mrem/IA-yr in three directions (vectors) needs to be established sufficiently to determine a correlation to radiation survey isopleths such that a boundary can be determined around the area posing a more than 25-mrem/yr dose.

To resolve Decision II for non-test release contamination (determine whether sufficient information is available to evaluate potential CAAs at each CAS), samples need to be collected and analyzed to meet the following criteria:

- Samples must be collected in areas contiguous to the contamination but where contaminant concentrations are below FALs.
- 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 they contain PSM.
- The analytical suites selected must be sufficient to detect contaminants at concentrations equal to or less than their corresponding FALs.

Decision II sampling will not be conducted inside the industrial fence at TCA because the industrial or construction activities that may have moved or buried contamination in this area are not well known. Therefore, if a COC is present anywhere within this area, the entire area inside the TCA fence will be assumed to contain the COC and will be included in the corrective action. Decision II sampling will also not be conducted for the drainage sedimentation areas. If a COC is present in the sediment, the entire volume of the sediment will be assumed to contain the COC and will require corrective action.

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 Industrial Sites QAPP (NNSA/NV, 2002). The TLDs will be submitted to the Environmental Technical Services group at the NTS, 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 375 CASs must ensure that the data collected are sufficient for selection and evaluation of the CAAs (EPA, 2002b). 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 CAS (probabilistic). These sample locations, therefore, can be selected by means of either (a) biasing factors used in judgmental sampling (e.g., a stain likely containing a spilled substance) or (b) randomly using a probabilistic sampling design.

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., detection limits, precision, and accuracy) for soil samples are provided in Tables 3-4 and 3-5.

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 ("Is any COC present in environmental media within the CAS?") is any location or area within the site that contains contaminant concentrations exceeding a FAL. The populations of interest to resolve Decision II ("If a COC is present, is sufficient information available to evaluate potential CAAs?") are:

- Each one of a set of locations bounding contamination in lateral and vertical directions
- Investigation waste and potential remediation waste
- Environmental media where natural attenuation or biodegradation or construction/evaluation of barriers is considered.

A.5.2 Spatial Boundaries

Spatial boundaries are the maximum lateral and vertical extent of expected contamination that can be supported by the CSM. Decision II spatial boundaries are as follows:

- Vertical: Test release - 2 ft below original ground surface
- Vertical: Non-test release - 15 ft bgs
- Horizontal: Test and non-test release - 3 mi from GZ

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

A.5.3 Practical Constraints

Practical constraints such as military activities at the NTS, utilities, threatened or endangered animals and plants, unstable or steep terrain, and/or access restrictions may prevent the ability to investigate this site.

A.5.4 Define the Sampling Units

The scale of decision making in Decision I is defined as the CAS. Any COC detected at any location will cause the determination that the CAS is contaminated and needs further evaluation. The scale of decision making for Decision II is defined as a contiguous area contaminated with any COC originating from the CAS. 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 an "If … then … else" decision rule that involves it.

A.6.1 Population Parameters

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

A.6.1.1 Judgmental Sampling Design

For judgmental sampling results, the population parameter is the observed concentration of each contaminant from each individual analytical sample. Each sample result will be compared to the FALs to determine the appropriate resolution to Decision I and Decision II. For Decision I, a single sample result for any contaminant exceeding a FAL would cause a determination that a COC is present within the CAS (for Decision I), or that the COC is not bounded (for Decision II).

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 measured TED is an estimate of the true (unknown) TED, it is uncertain how well the calculated TED represents the true TED. If the measured TED were significantly different than the true TED, a decision based on the measured 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 measured TED. This conservative estimate (overestimation) of the true TED will be calculated as the 95 percent UCL of the average TED measurements. By definition, there will be a 95 percent probability that the true TED is less than the 95 percent UCL of the measured TED.

The computation of appropriate UCLs depends upon the data distribution, the number of samples, the variability of the dataset, and the skewness associated with the dataset. A statistical package will be used to determine the appropriate probability distribution (e.g., normal, lognormal, gamma) and/or a suitable non-parametric distribution-free method and then to compute appropriate UCLs. To ensure that the appropriate UCL computational method is used, the sample data will be tested for goodness-of-fit to all of the parametric and non-parametric UCL computation methods described in *Calculating the Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (EPA, 2002a).

Computation of an appropriate UCL of the average TED for each sample plot requires that:

- A minimum number of samples are collected.
- The data originate from a symmetric, but not necessarily normally distributed, population.
- The estimation of the variability is reasonable and representative of the population being sampled.
- The population values are not spatially correlated.

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 RBCA process used to establish FALs is described in *Industrial Sites Project Establishment of Final Action Levels* (NNSA/NSO, 2006). This process conforms with NAC Section 445A.227, which lists the requirements for sites with soil contamination (NAC, 2009a). For the evaluation of corrective actions, NAC Section 445A.22705 (NAC, 2009b) 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 (i.e., FALs) or to establish that corrective action is not necessary.”

This RBCA process 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 SSTLs using site-specific information as inputs to the same or similar methodology used to calculate Tier 1 action levels. The Tier 2 SSTLs 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. Total TPH concentrations will not be used for risk-based decisions under Tier 2 or Tier 3. Rather, the individual chemicals of concern will be compared to the SSTLs.

- Tier 3 evaluation - Conducted by calculating Tier 3 SSTLs on the basis of more sophisticated risk analyses using methodologies described in Method E1739 that consider site-, pathway-, and receptor-specific parameters.

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: Superfund, Regional Screening Levels for Chemical Contaminants* in industrial soils (EPA, 2009). Background concentrations for RCRA metals and zinc will be used instead of screening levels when natural background concentrations exceed the screening levels, as is often the case with arsenic on the NTS. 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 Nevada Test and Training Range (formerly the Nellis Air Force Range) (NBMG, 1998; Moore, 1999). For detected chemical COPCs without established screening levels, the protocol used by the 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 25 mrem/yr based upon the modified Industrial Area exposure scenario.

The Industrial Area exposure scenario is described in *Industrial Sites Project Establishment of Final Action Levels* (NNSA/NSO, 2006). That document establishes the default exposure conditions and RESRAD computer code input parameters to be used to calculate the potential radiation dose over a land area.

For test releases, the Industrial Area scenario has been modified by pre-specifying values for several input parameters (such as an area of contamination of 100 m^2 and a depth of contamination of 5 cm). In addition, DCG values for each individual radionuclide COPC were calculated. The DCG is the value, in picocuries per gram for surface soil, for a particular radionuclide, that would result in a dose of 25 mrem/yr. Using DCGs in site evaluation facilitates the determination of a radiation dose estimate for each soil sample.

A.6.3 Decision Rules

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

- If COC contamination is 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:

- If the population parameter of any COPC in the Decision I population of interest (defined in Step 4) exceeds the corresponding FAL, then that contaminant is identified as a COC, and Decision II samples will be collected, else no further investigation is needed for that COPC in that population.
- If a COC exists at any CAS, then a corrective action will be determined, else no further action will be necessary.
- 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:

- If the population parameter (the observed concentration of any COC) in the Decision II population of interest (defined in Step 4) exceeds the corresponding FAL in any bounding direction or potential remediation wastes have not been adequately defined, then additional samples will be collected to complete the Decision II evaluation, else the extent of the COC contamination has been defined.
- If valid analytical results are available for the waste characterization samples defined in Section A.8.0, then the decision will be that sufficient information exists to determine potential remediation waste types and evaluate the feasibility of remediation alternatives, else collect additional waste characterization samples.

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:

- 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:

- Developing a CSM (based on process knowledge) that is agreed to by stakeholder 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, 2002b). 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 COCs if present anywhere within the CAS. For Decision II, having a high degree of confidence that the sample locations selected will identify the extent of COCs.
- Having a high degree of confidence that analyses conducted will be sufficient to detect any COCs 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 COCs (supplemented by random 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 listed in Section A.4.2.1 will be used to further ensure that appropriate sampling locations are selected to meet these criteria. Radiological survey instruments and field-screening equipment will be calibrated and checked in accordance with the manufacturer's instructions and approved procedures. 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 samples will be analyzed for those chemical and radiological parameters that identified 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 Industrial Sites QAPP (NNSA/NV, 2002) and in Section 6.2. 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. Site-specific DQIs are discussed in more detail in Section 6.2.

To provide information for the assessment of the DQIs of precision and accuracy, the following QC samples will be collected as required by the Industrial Sites QAPP (NNSA/NV, 2002):

- Field duplicates (minimum of 1 per matrix per 20 environmental samples)
- Laboratory QC samples (minimum of 1 per matrix per 20 environmental samples or 1 per CAS per matrix, if less than 20 collected)

A.7.2.2 False Negative Decision Error for Probabilistic Sampling

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

- Population distribution
- 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:

- The population distributions fit the applied UCL determination method.
- A sufficient sample size was collected.
- 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 according to 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 required by the Industrial Sites QAPP (NNSA/NV, 2002):

- Trip blanks (1 per sample cooler containing VOC environmental samples)
- Equipment blanks (1 per sampling event)
- Source blanks (1 per uncharacterized source lot per lot)
- Field blanks (minimum of 1 per CAS, additional if field conditions change)

The positive decision error rate goal was established by DQO participants at 20 percent. Protection against this decision error is also afforded by the controls listed in Section A.7.2.

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

Step 7 of the DQO process selects and documents a design that will yield data that will best achieve performance or acceptance criteria. Judgmental sampling schemes will be implemented to select the Decision II sample plot locations for the test releases. Probabilistic sampling schemes will be implemented to select the sample locations within each of the sample plots. Judgmental sampling will also be used to investigate any non-test releases based on site biasing factors (staining, historical knowledge, debris). Investigation results will be compared to FALs to determine the need for corrective action. Potential source material sample results will be evaluated against the PSM criteria listed in Section 3.4 to determine the need for corrective action.

A.8.1 CAS 25-23-22 Test Release

The following subsections describe the plans for determining internal dose, external dose, and TED for the test releases at TCA. The TED will be determined at specific sample plot locations and used to resolve DQO decisions.

A.8.1.1 Internal Dose Sampling

Internal dose will be determined from analytical results of soil samples using RESRAD. Four soil samples will be collected within each sample plot. The sample plot locations will be determined judgmentally and the sample locations within each sample plot will be established randomly (probabilistic sampling).

A.8.1.1.1 Judgmental Sample Plot Locations

A judgmental sampling design will be implemented for locating Decision I sample plots for the test release scenario. The Decision I sample plot will be located outside the TCA perimeter fence and determined judgmentally based on the highest results of a radiological survey. This will be done in an effort to find the location of the maximum TED.

If necessary, a judgmental sampling design will also be implemented for locating Decision II sample plots. Sample plot locations will be selected judgmentally based on radiological surveys and applicable historical sample results. These data include existing aerial radiological surveys, GPS-assisted gamma walkover surveys, NAEG data, and RIDP data. These data will be used to establish patterns of contaminant distribution.

Two additional sample plots will be established on each of three vectors with the constraint that on each vector at least one sample plot will present a TED less than the FAL. Due to the location of the isopleths in relation to the existing fence surrounding TCA, all three vectors may use the common Decision I sample plot.

The approximate proposed sampling vectors and sample plots for TCA are shown in Figure A.8-1.

A.8.1.1.2 Sample Collection

The probabilistic sampling scheme will be implemented to select sample locations within each sample plot and to evaluate the analytical results. For each sample collected within each sample plot, nine randomly selected subsample locations will be chosen using the Visual Sample Plan (VSP) software (PNNL, 2005) based on a random start, triangular pattern (Figure A.8-2 shows an example of this sampling scheme). If sufficient sample material cannot be collected at a specified location (e.g., rock, caliche, or buried concrete), the Site Supervisor will establish the location at the nearest place that a surface sample can be obtained.

Statistical methods that generate site characteristics will be used to establish internal dose estimates that represent the sample plot as a whole. Composite samples will be collected at each sample plot in the following manner:

- Each composite sample will be composed of nine aliquots taken from randomly selected locations within each plot. These locations will be predetermined using a random start with a triangular grid pattern.
- Samples will be sieved to eliminate material (e.g., Trinity glass) greater than 0.25 in. diameter that cannot effectively be inhaled or ingested.
- The entire volume of the composited material collected will be submitted to the laboratory for analysis.

As determination of the minimum sample size (as required in Section A.6.1.2) cannot be accomplished until after the data have been generated, the sufficiency of the number of samples

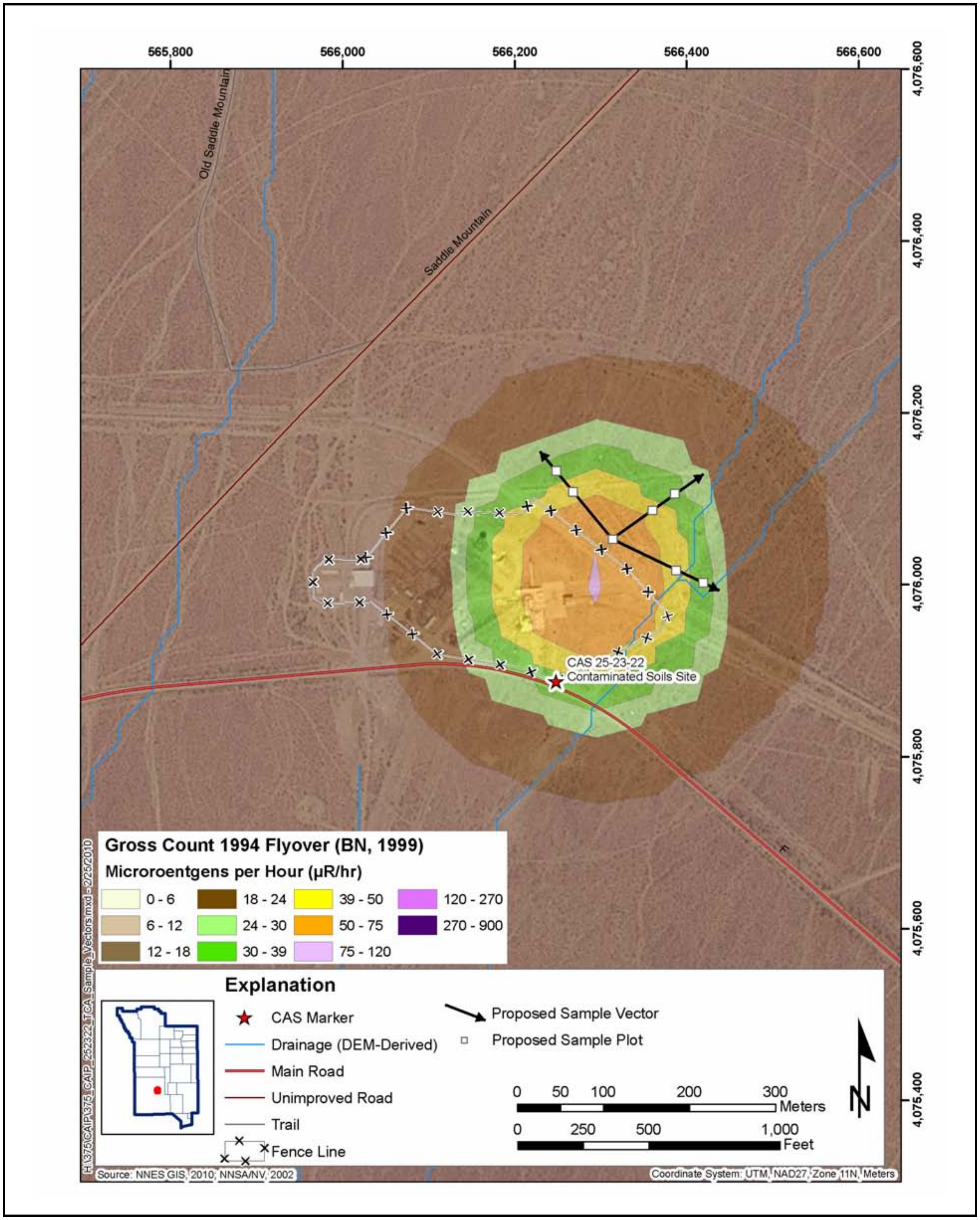


Figure A.8-1
CAS 25-23-22 Example Sample Plot Location Map

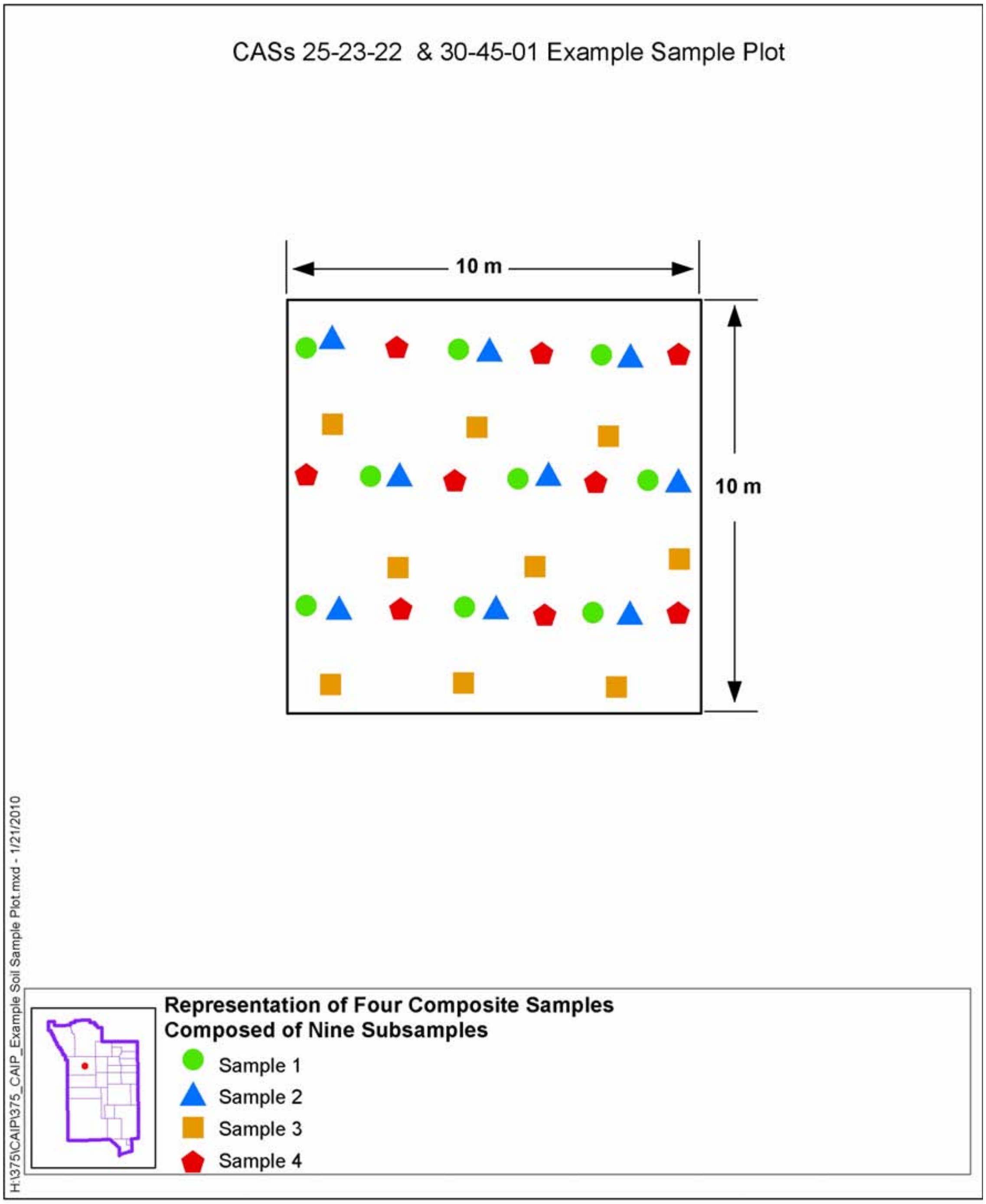


Figure A.8-2
Example Sample Plot Location Map

collected will be evaluated. This will be evaluated based on TED results (composed of individual internal dose rates associated with each of the four composite samples added to the external dose rates from the TLD elements). The required number of samples will be calculated using the VSP software (PNNL, 2005). This software was developed by Pacific Northwest National Laboratory for the DOE and EPA to determine the minimum number of samples needed to characterize a site based on the type of test to be performed, the distribution of the data, the variability of the data, and the acceptable false positive and false negative error rates.

The input parameters to be used in calculating the minimum sample size are:

- A confidence level that a false negative error will not occur will be set at 95 percent.
- A confidence level that a false positive error will not occur will be set at 80 percent.
- A gray region width equal to 50 percent of the FAL (e.g., 12.5 mrem/yr).
- The standard deviation of the TEDs at each plot.

All calculations for the determination of sample size sufficiency will be provided in the investigation report. If the criteria established in this section results in a determination that the minimum sample size was not met for a plot, one of the following actions may be taken:

- Additional composite sample(s) may be collected.
- Conservatively assume that the TED for the plot exceeds the FAL.

If this criteria cannot be met, justifications for use of the resulting TED without meeting the criteria will be made in the CADD.

If buried contamination exists, it will be conservatively assumed that the highest level of contamination observed (from surface or subsurface samples) provides dose to site workers. Therefore, in addition to the surface samples described above, subsurface samples will be collected at each composite location in 5-cm increments until native soil or buried horizon is encountered. The subsurface soil subsample with the highest screening value at each composite location will be composited into a sample submitted for analysis.

A.8.1.2 External Dose Sampling for Test Releases

External dose (penetrating radiation dose for the purposes of this document) will be determined by collecting *in situ* measurements using TLDs. External dose measurements will be taken at the approximate center of each sample plot at a height of 1 m.

The TLD placement and processing will follow the protocols established in *Nevada Test Site Routine Radiological Environmental Monitoring Plan* (NNSA/NSO, 2003). The TLDs will be in place for a targeted total exposure time of 2,250 hours, or the resulting data will be adjusted to be equivalent to an exposure time of 2,250 hours.

The radiation FAL is defined as the dose from releases of radioactivity from NTS activities and does not include the dose that is present from naturally occurring terrestrial and cosmic radiation (i.e., background). Estimates of external dose, in millirem per Industrial Area year, will be presented as net values. The value for the natural background to be subtracted from the TLD results will be obtained from an area determined to be unaffected by man-made activities at the NTS as determined by radiation surveys. Ten such areas are identified in Section 5.0 of the *Nevada Test Site Environmental Report 2006* (NNSA/NSO, 2007) and are routinely monitored for external radiation exposure via environmental monitoring TLDs.

The project-specific TLDs are subjected to the same QA checks as the routine NTS environmental monitoring TLDs, as described in Section 6.0. The Panasonic UD-814 TLD used in the NTS environmental monitoring program contains four individual elements. The readings from each element are compared as part of the routine QA checks during the TLD processing. External dose at each TLD location is then determined using the readings from TLD elements 2, 3, and 4. Element 1 is designed to measure dose to the skin and is not relevant to the determination of the external dose.

A.8.1.3 Evaluation of TED

As discussed in Section A.6.1.2, the 95 percent UCL of the TED from each sample plot will be used to establish the corrective action boundary. The 95 percent UCL of the TED for each sample plot will be established as the sum of the 95 percent UCL of the internal dose and the 95 percent UCL of the external dose. These 95 percent UCL dose estimates will be calculated using the three external dose measurements from the TLD and the RESRAD-calculated internal dose estimates from the soil samples.

The initial corrective action boundary area will be calculated using the 95 percent UCL of the TED from each plot along each vector and an appropriate gamma radiation survey isopleth. A relationship will be established of the 95 percent UCL of the TED with gamma radiation survey values along each vector such that a gamma radiation survey value along each vector can be established that corresponds to the 25-mrem/yr FAL (using the appropriate exposure scenario). An isopleth from the radiological survey that encompasses the lowest value corresponding to the 25-mrem/yr FAL will be chosen as the initial corrective action boundary.

A.8.2 CAS 30-45-01 Test Release

The following subsections describe the plans for determining internal dose, external dose, and TED for the test releases at the Buggy site. The TED will be determined at specific sample plot locations and used to resolve DQO decisions.

A.8.2.1 Internal Dose Sampling

Internal dose will be determined from analytical results of soil samples using RESRAD. Four soil samples will be collected within each sample plot. The sample plot locations will be determined judgmentally and the sample locations within each sample plot will be established randomly (probabilistic sampling).

A.8.2.1.1 Judgmental Sample Plot Location

A judgmental sampling design will be implemented for locating Decision I sample plots for the test release scenario. For test releases outside the default contamination boundary, a Decision I sample plot will be established within the area of the highest americium values as determined from the 1994 flyover survey (BN, 1999) or a radiological survey 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.

If necessary, a judgmental sampling design will also be implemented for locating Decision II sample plots. Sample plot locations will be selected judgmentally based on radiological surveys and applicable historical sample results. These data include existing aerial radiological surveys, GPS-assisted gamma walkover surveys, NAEG data, and RIDP data. These data will be used to establish patterns of contaminant distribution. Additional Decision II sample plots may need to be established based on Am-241 radiation survey results.

At CAS 30-45-01, three sample plots will be established on each of three vectors that are approximately normal to the gamma radiation survey isopleths with the constraint that on each vector at least one sample plot will present a TED less than the FAL. To meet this constraint, it will be necessary to determine a preliminary estimate of the locations where TED may be equal to the FAL. This was accomplished by plotting the estimates of external dose from the correlation of existing NTS environmental monitoring TLD dose measurements to the radiological readings collected with the PRM470 radiation meter as presented in Section 4.2.2.1. The approximate proposed sampling vectors and sample plots are shown in Figure A.8-3.

A.8.2.1.2 Sample Locations

The probabilistic sampling scheme will be implemented to select sample locations within the sample plots and evaluate the analytical results. Soil samples from sample plots at CAS 30-45-01 will be collected and internal dose determined as described in Section A.8.1.1.2 for CAS 25-23-22.

A.8.2.2 External Dose Sampling for Test Releases

External dose (penetrating radiation dose for the purposes of this document) will be determined by collecting *in situ* measurements using TLDs. The TLDs from sample plots at CAS 30-45-01 will be managed and external dose determined as described in Section A.8.1.2 for CAS 25-23-22.

A.8.2.3 Evaluation of TED

The TED and the initial corrective action boundary will be determined as described in Section A.8.1.3 for CAS 25-23-22.

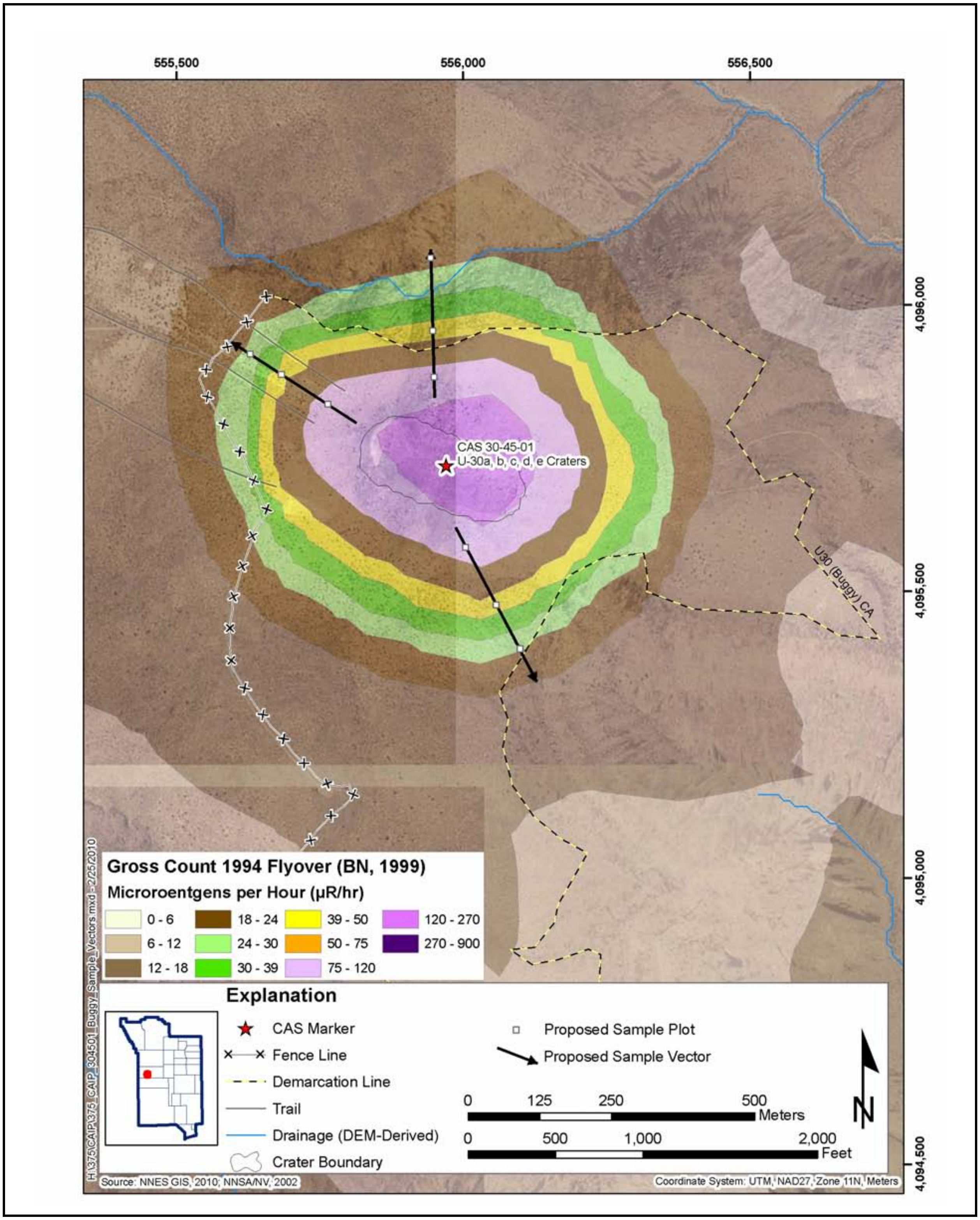


Figure A.8-3
CAS 30-45-01 Example Sample Plot Location Map

A.8.3 Sampling for Non-test Releases

Sample locations for non-test releases will be determined based upon the likelihood of a contaminant release at the CAS. These locations will be selected based on the identification of biasing factors during the investigation. For non-test releases, biasing factors such as stains, radiological survey results, and wastes suspected of containing hazardous or radiological components will be used to select the most appropriate samples from a particular location for submittal to the analytical laboratory. Biasing factors to be used for selection of sampling locations are listed in Section A.4.2.1. As biasing factors are identified and used for selection of sampling locations, they will be documented in the appropriate field documents.

The following factors will also be considered in selecting locations for analytical samples at CAU 375:

- Documented process knowledge on source and location of release (e.g., volume of release).
- Stains: Any spot or area on the soil surface that may indicate the presence of a potentially hazardous liquid. Typically, stains indicate an organic liquid such as an oil has reached the soil and may have spread out vertically and horizontally.
- Pre-selected areas based on process knowledge of the site: Locations for which evidence such as the 1994 aerial radiological survey provides a basis upon which sample plots can be designated (e.g., man-made gross counts).
- Radiological survey anomalies: Radiological survey results that are significantly higher than the surrounding area.
- Geophysical anomalies: Geophysical survey results that are not consistent with the surrounding area (e.g., results indicating buried concrete or metal, surface metallic objects).
- Drums, containers, equipment, or debris: Materials that contain or may have contained hazardous or radioactive substances.
- Lithology: Locations where variations in lithology (soil or rock) indicate that different conditions or materials exist.
- Preselected areas based on process knowledge of the site: Locations for which evidence such as historical photographs, experience from previous investigations, or interviewee’s input 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.
- Previous sample results: Locations that may reasonably have been contaminated based upon the results of previous field investigations.
- Experience and data from investigations of similar sites.
- Visual indicators such as discoloration, textural discontinuities, disturbance of native soils, or any other indication of potential contamination.
- Presence of debris, waste, or equipment.
- Odor.
- Physical and chemical characteristics of contaminants.
- Other biasing factors: Factors not previously defined for the CAI that become evident once the investigation of the site is under way.

A.8.3.1 Decision I

A judgmental sampling design will be implemented for the non-test releases for establishing sample locations and evaluating sample results. For the non-test releases, 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 to developing a sampling design. If good prior information is available on the target site of interest, 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).

All non-test release sample locations will be selected to satisfy the DQI of representativeness in that samples collected from selected locations will best represent the populations of interest as defined in Section A.5.1. To meet this criterion for non-test releases, a biased sampling strategy will be used to target areas with the highest potential for contamination, if it is present anywhere in the CAS. Sample locations will be determined based on process knowledge, previously acquired data, or the field-screening and biasing factors listed in Section A.4.2.1. 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 this DQO.

A.8.3.1.1 CAS 25-23-22

The area inside the fence at TCA will only be sampled for Decision I non-test releases. Decision I soil samples from inside and outside the fenced industrial area at TCA will be collected based on the presence of biasing factors. Decision I soil samples will be collected from the immediate area around the test pad, soils located inside the earthen bunker, soil where runoff from the test pad drains onto, and the soil piles present in the area. Additional Decision I samples may be collected from the railroad tracks within the fence, asphalted areas, or any other locations where biasing factors are present. The fenced area is currently posted as an RMA.

The nearest identifiable drainage to CAS 25-23-22 located outside the fenced area is to the south of TCA and flows into the Jackass Flats area. This drainage will be visually surveyed to a distance of up to 3 mi from TCA for the presence of sediment accumulation areas to identify all sediment collection areas. A sampling location will be established at the center of the nearest two sediment accumulation areas outside the initial corrective action boundary (established using gamma survey data). At each location, a sample will be collected from each 5-cm depth interval until native material is encountered. Each sample will be screened with an alpha/beta contamination meter. If any sample exceeds the FSL, the sample with the highest screening value will be submitted for analysis. If no sample exceeds the FSL, the surface sample will be submitted for analysis (Figure A.8-4).

A.8.3.1.2 CAS 30-45-01

The nearest identifiable drainage to CAS 30-45-01 is located to the east of the Buggy crater and flows into Fortymile Wash and into Fortymile Canyon. This drainage will be visually surveyed to a distance of up to 1 mi downgradient of GZ for the presence of sediment accumulation areas.

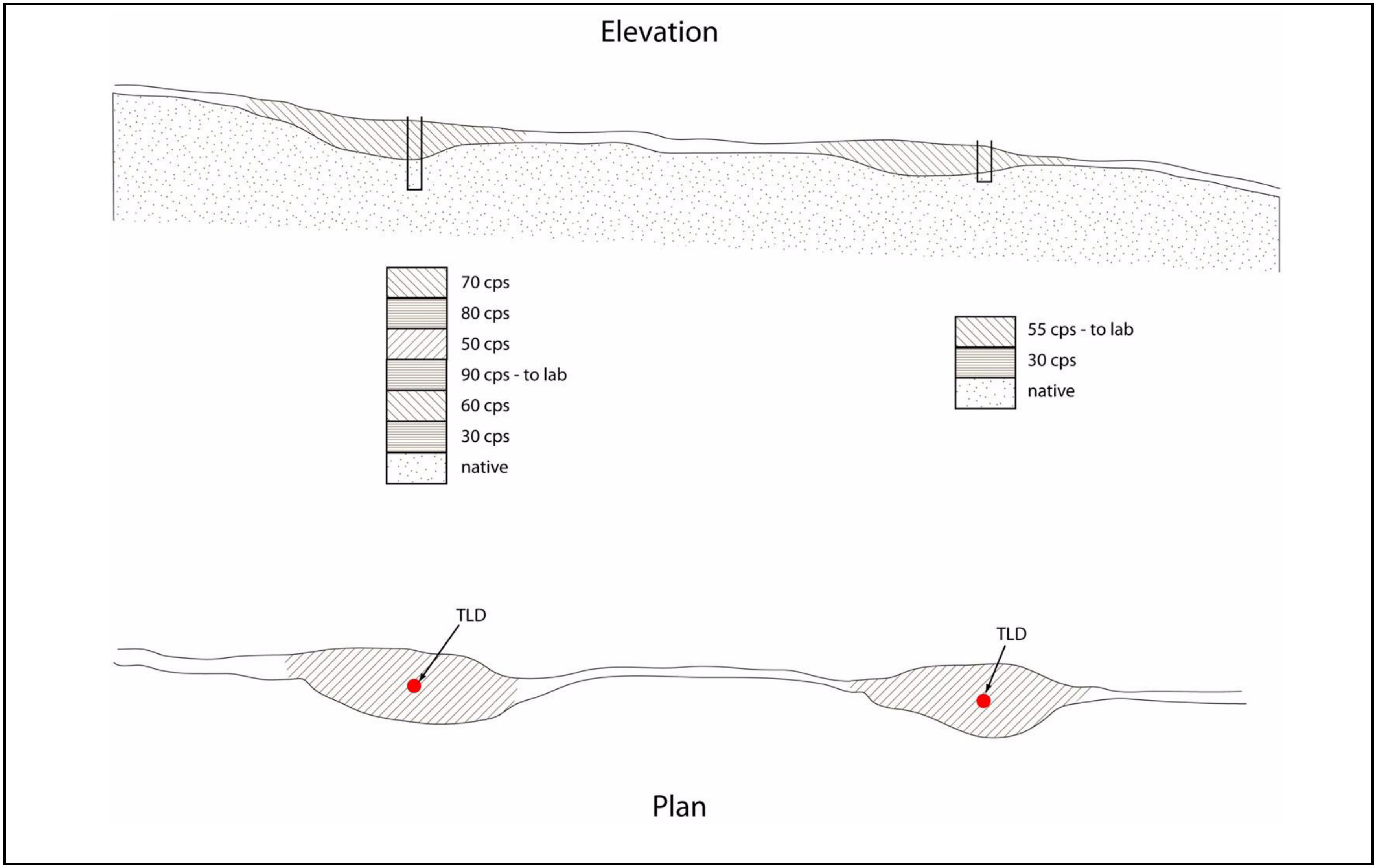


Figure A.8-4
Displaying Sedimentation Sampling

A sampling location will be established at the center of the nearest two sediment accumulation areas outside the initial corrective action boundary (established using gamma survey data). At each location, a sample will be collected from each 5-cm depth interval until native material is encountered. Each sample will be screened with an alpha/beta contamination meter. If any sample exceeds the FSL, the sample with the highest screening value will be submitted for analysis. If no sample exceeds the FSL, the surface sample will be submitted for analysis (Figure A.8-4).

Samples will be collected for other non-test releases sites based on the type and nature of the release (based on the biasing factors present). Other locations where non-test soil samples will be collected are from within the retention basin, beneath the battery, and the area surrounding the lead box. Other samples will be collected from the material that presents the greatest degree of the biasing factor (surface or subsurface as discussed above).

A.8.3.1.3 Other Potential Releases

During the course of the CAU 375 investigation, the identification of any biasing factors will be used to determine whether a potential release is present (e.g., stains, spills, debris). Samples will be collected from the material that presents the greatest degree of the biasing factor (surface or subsurface as discussed above). Specific analyses requested for these samples will be determined based on the nature of the potential release (e.g., hydrocarbon stain, lead bricks).

A.8.3.2 Decision II

A.8.3.2.1 Drainages

If a COC is present at a sediment collection area sampling location, additional sedimentation areas will be sampled until at least two consecutive sedimentation areas are found that do not contain COCs. All apparent drainages downgradient from each CAS will be assessed for the potential to have sediment collection areas that contain a COC. Decision II will be resolved by the assumption that the entire volume of sediment in each sediment collection area where a COC was identified contains the COC.

A.8.3.2.2 Other Non-test Releases

Decision II samples for non-test releases other than drainage areas will be collected from judgmental sampling locations selected based on locations where COCs were detected, the CSM, and other field-screening and biasing factors listed in Section A.4.2. In general, sample locations will be arranged in a triangular pattern around the area containing COCs at distances based on site conditions, process knowledge, and biasing factors. If COCs extend 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 all locations. A clean sample (i.e., COCs less than FALs) collected from each step-out direction (lateral or vertical) will define extent of contamination in that direction. The Task Manager or Site Supervisor may modify the number, location, and spacing of step-outs as warranted by site conditions.

For the area inside the TCA fence line, Decision I soil samples and results will satisfy Decision II requirements inasmuch as the entire fenced area will be considered the extent.

A.8.4 Establishment of Final Corrective Action Boundary

The final corrective action boundary will be established to include the default contamination boundary, the initial corrective action boundary, any additional areas that exceed the FAL based on plutonium contamination (sample plots based on the Am-241 survey), and any COCs identified from the non-test releases (e.g., from spills, waste, or the migration of contamination in drainages).

A.9.0 References

ARL/SORD, see Air Resources Laboratory/Special Operations and Research Division

ASTM, see American Society for Testing and Materials.

Air Resources Laboratory/Special Operations and Research Division. 2009. *NTS Climatological Rain Gauge Data*. As accessed at http://www.word.nv.doe.gov/home_climate_rain.htm on 23 November.

American Society for Testing and Materials. 1995 (reapproved 2002). *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*, ASTM E1739 - 95(2002). Philadelphia, PA.

BN, see Bechtel Nevada.

Bechtel Nevada. 1999. *An Aerial Radiological Survey of the Nevada Test Site,* DOE/NV/11718--324. Prepared for the U.S. Department of Energy, Nevada Operations Office. Las Vegas, NV: Remote Sensing Laboratory.

Bechtel Nevada. 2002. *A Hydrostratigraphic Model and Alternatives for the Groundwater Flow and Contaminant Transport Model of Corrective Action Units 101 and 102: Central and Western Pahute Mesa, Nye County, Nevada*, DOE/NV/11718--706. Prepared for the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. Las Vegas, NV.

DOE/NV, see U.S. Department of Energy, Nevada Operations Office.

EPA, see U.S. Environmental Protection Agency.

LRL, see Lawrence Radiation Laboratory.

Lawrence Radiation Laboratory. Date unknown. *Description of Craters Nevada Test Site*, 173664. Prepared by the U.S. Army Engineer Nuclear Cratering Group. Livermore, CA.

Moore, J., Science Applications International Corporation. 1999. Memorandum to M Todd (SAIC) entitled, “Background Concentrations for NTS and TTR Soil Samples,” 3 February. Las Vegas, NV: IT Corporation.

Murphy, T., Bureau of Federal Facilities. 2004. Letter to R. Bangerter (NNSA/NSO) entitled, “Review of Industrial Sites Project Document Guidance for Calculating Industrial Sites Project Remediation Goals for Radionuclides in Soil Using the Residual Radiation (RESRAD) Computer Code,” 19 November. Las Vegas, NV.

NAC, see *Nevada Administrative Code*.

NBMG, see Nevada Bureau of Mines and Geology.

NNES GIS, see Navarro Nevada Environmental Services Geographic Information Systems.

NNSA/NSO, see U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office.

NNSA/NV, see U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office.

Navarro Nevada Environmental Services Geographic Information Systems. 2010. ESRI ArcGIS Software.

Nevada Administrative Code. 2009a. NAC 445A.227, "Contamination of Soil: Order by Director for Corrective Action; Factors To Be Considered in Determining Whether Corrective Action Required." Carson City, NV. As accessed at http://www.leg.state.nv.us/nac on 29 October.

Nevada Administrative Code. 2009b. NAC 445A.22705, "Contamination of Soil: Evaluation of Site by Owner or Operator; Review of Evaluation by Division." Carson City, NV. As accessed at http://www.leg.state.nv.us/nac on 29 October.

Nevada Bureau of Mines and Geology. 1998. *Mineral and Energy Resource Assessment of the Nellis Air Force Range*, Open-File Report 98-1. Reno, NV.

PNNL, see Pacific Northwest National Laboratory.

Pacific Northwest National Laboratory. 2005. *Visual Sample Plan, Version 4.0 User's Guide*, PNNL-15247. Richland, WA.

Shott, G.J., V. Yucel, M.J. Sully, L.E. Barker, S.E. Rawlinson, and B.A. Moore. 1997. *Performance Assessment/Composite Analysis for the Area 3 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada*, Rev. 2.0. Las Vegas, NV.

Thompson, J.L., M.A. Guell, and J.R. Hunt. 1997. *Subsurface Nobel Gas Transport at the Nevada Test Site*, LA-UR-97-3255. Los Alamos, NM: Los Alamos National Laboratory.

USGS, see U.S. Geological Survey.

U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office. 2002. *Industrial Sites Quality Assurance Project Plan, Nevada Test Site, Nevada,* Rev. 3, DOE/NV--372. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2003. *Nevada Test Site Routine Radiological Environmental Monitoring Plan*, DOE/NV/11718--804. Prepared by Bechtel Nevada. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2006. *Industrial Sites Project Establishment of Final Action Levels*, Rev. 0, DOE/NV--1107. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2007. *Nevada Test Site Environmental Report 2006*, DOE/NV 25946--259. Prepared by National Security Technologies, LLC. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1992. *Remedial Investigation and Feasibility Study for the Plutonium Contaminated Soils at Nevada Test Site, Nellis Air Force Range and Tonopah Test Range*. April. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 2000. *United States Nuclear Tests, July 1945 through September 1992*, DOE/NV--209-Rev 15. Las Vegas, NV.

U.S. Environmental Protection Agency. 2002a. *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*, OSWER 9285.6-10. December. Washington, DC: Office of Emergency and Remedial Response.

U.S. Environmental Protection Agency. 2002b. *Guidance for Quality Assurance Project Plans*, EPA QA/G5. Washington, DC.

U.S. Environmental Protection Agency. 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA QA/G-4. Washington, DC.

U.S. Environmental Protection Agency. 2009. *Region 9: Superfund, Preliminary Remediation Goals, Screening Levels for Chemical Contaminants*. As accessed at http://www.epa.gov/region09/waste/sfund/prg/index.html on 28 October. Prepared by EPA Office of Superfund and Oak Ridge National Laboratory.

U.S. Geological Survey. 1982. *Timber Mountain Quadrangle, Nevada - Nye County, 7.5 Minute Series (Topographic)*, U.S. Geological Survey Geologic Quadrangle Map, scale 1:24,000.

Appendix B

Project Organization

B.1.0 Project Organization

The NNSA/NSO Federal Sub-Project Director is Kevin Cabble. He can be contacted at (702) 295-5000.

The identification of the project 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/NSO Federal Sub-Project Director be contacted for further information. The Task Manager will be identified in the FFACO Monthly Activity Report before the start of field activities.

Appendix C

Nevada Division of Environmental Protection Comment Responses

(8 Pages)

NEVADA ENVIRONMENTAL RESTORATION PROJECT
DOCUMENT REVIEW SHEET

1. Document Title/Number:	Draft Corrective Action Investigation Plan for Corrective Action Unit 375: Area 30 Buggy Unit Craters, Nevada Test Site, Nevada	**2. Document Date:**	1/25/2010
3. Revision Number:	0	**4. Originator/Organization:**	Navarro-INTERA
5. Responsible NNSA/NSO Federal Sub-Project Director:	Kevin J. Cabble	**6. Date Comments Due:**	2/25/2010
7. Review Criteria:	Full		
8. Reviewer/Organization/Phone No:	Jeff MacDougall, NDEP, 486-2850	**9. Reviewer's Signature:**	

10. Comment Number/Location	11. Type*	12. Comment	13. Comment Response	14. Accept
1.) Section 2.2.1	Mandatory	Can the cleanup effort be better explained? It appears to this reader that, in the description of the process of cleaning the paved road, workers possibly dispersed contamination with pressurized water. Please provide more detailed information regarding this process.	Further description of the cleanup effort will be incorporated into the document. The entire section explaining the cleanup will be added as follows: The following description of the cleanup is taken from the Kiwi B4A Reactor Operation (REECo, 1962) “Fractured fuel material was ejected from the reactor during the operation of the KIWI B4A and resulted in contaminating approximately 18 acres of land around the test stand. The contamination existed as an uneven deposit of ejected material. The size ranged from large, identifiable to microscopic pieces. Radiation levels greater than 500 R/hr were measured at near contact with the larger pieces one day after the reactor operation… The road was decontaminated first to permit entry of survey and recovery vehicles into the test cell area. Fire hoses were connected to the hydrants near the Dewar vessel area. High-pressure streams of water removed the contamination from the pavement. Approximately 2,600 feet of hard-surface roads were decontaminated in this manner… The decontamination effort required locating, recovering, and transporting identifiable pieces to the disassembly bay in the R-MAD Building. A portion of the ejected material was located visually. However, the majority was located by using radiation-survey instruments because most of the pieces were obscured by vegetation. Many pieces were so small that they were not visually detectable. High-range gamma detectors were used for surveying and for locating the larger pieces of material. G-	

UNCONTROLLED when Printed

NEVADA ENVIRONMENTAL RESTORATION PROJECT
DOCUMENT REVIEW SHEET

1. Document Title/Number:	Draft Corrective Action Investigation Plan for Corrective Action Unit 375: Area 30 Buggy Unit Craters, Nevada Test Site, Nevada	**2. Document Date:**	1/25/2010
3. Revision Number:	0	**4. Originator/Organization:**	Navarro-INTERA
5. Responsible NNSA/NSO Federal Sub-Project Director:	Kevin J. Cabble	**6. Date Comments Due:**	2/25/2010
7. Review Criteria:	Full		
8. Reviewer/Organization/Phone No:	Jeff MacDougall, NDEP, 486-2850	**9. Reviewer's Signature:**	

10. Comment Number/Location	11. Type*	12. Comment	13. Comment Response	14. Accept
	Mandatory		M instruments, with the detector probes on long handles, were used to search for the smaller pieces of radioactive material. A variety of tongs, several long handle shovels, a dozen 20-quart pails, and 26 small lead lined boxes were used for handling and storing the collected radioactive material."	

1. Document Title/Number:	Draft Corrective Action Investigation Plan for Corrective Action Unit 375: Area 30 Buggy Unit Craters, Nevada Test Site, Nevada	**2. Document Date:**	1/25/2010
3. Revision Number:	0	**4. Originator/Organization:**	Navarro-INTERA
5. Responsible NNSA/NSO Federal Sub-Project Director:	Kevin J. Cabble	**6. Date Comments Due:**	2/25/2010
7. Review Criteria:	Full		
8. Reviewer/Organization/Phone No:	Jeff MacDougall, NDEP, 486-2850	**9. Reviewer's Signature:**	

10. Comment Number/Location	11. Type*	12. Comment	13. Comment Response	14. Accept
2.) General Comment		In descriptions of the Buggy site found throughout the document, the explanations of risk regarding downward contaminant migration seem to be very similar to those given for other sites which exhibit many feet of alluvial soils. These explanations may not apply to the Buggy site which exhibits a different geology and therefore should be explained differently to more accurately reflect this. If the risks are indeed comparable, then the reasons for this should be more fully developed and presented in the document.	The discussion that will be incorporated into Sections 2.1.2 and A.2.2.4 is as follows: Corrective Action Site 30-45-01 is located in Area 30, atop a mesa above Fortymile Canyon identified as Chukar Mesa. The geology of Chukar Mesa is fractured volcanic basalt (LRL, date unknown) with the surface being composed of uncompacted clay with small- to medium-size volcanic gravel and rocks with sparse vegetation. The nearest water well is ER-30-1, where the depth to the uppermost aquifer is 450 ft bgs (NNES GIS, 2010). The well is located 4.28 mi northeast of the crater at an elevation approximately 500 ft lower than the Buggy site. Therefore, depth to groundwater at the Buggy site is estimated to be approximately 950 ft. The average elevation of the site is approximately 5,200 ft amsl (NNES GIS, 2010). The direction of precipitation runoff flow is into gullies and washes that generally drain to the south. Drainage channels are generally dry but are subject to infrequent, potentially intense, stormwater flows. Sedimentation entrained by these stormwater events would be carried by the streamflow to locations where the flowing water loses energy and the sediments drop out. These locations are readily identifiable as sedimentation areas. The document A Hydrostratigraphic Model and Alternatives for the Groundwater Flow and Contaminant Transport Model of Corrective Action Units 101 and 102: Central and Western Pahute Mesa, Nye County, Nevada (BN, 2002)	

NEVADA ENVIRONMENTAL RESTORATION PROJECT
DOCUMENT REVIEW SHEET

1. Document Title/Number:	Draft Corrective Action Investigation Plan for Corrective Action Unit 375: Area 30 Buggy Unit Craters, Nevada Test Site, Nevada	**2. Document Date:**	1/25/2010
3. Revision Number:	0	**4. Originator/Organization:**	Navarro-INTERA
5. Responsible NNSA/NSO Federal Sub-Project Director:	Kevin J. Cabble	**6. Date Comments Due:**	2/25/2010
7. Review Criteria:	Full		
8. Reviewer/Organization/Phone No:	Jeff MacDougall, NDEP, 486-2850	**9. Reviewer's Signature:**	

10. Comment Number/Location	11. Type*	12. Comment	13. Comment Response	14. Accept
			points out that although the interstitial porosity in such formations may be high, the interconnectivity of the pore space is poor, and these relatively incompetent rocks tend not to support open fractures. Secondary alteration ultimately yields a very impermeable unit. Additionally, these formations tend to have very low hydraulic conductivity. Though these rocks can be moderately fractured, the fractures are typically sealed by secondary mineralization. That same document further states: "Of particular importance are the type and distribution in the rock, of alteration minerals such as clays, zeolites, and iron oxides. Not only do these minerals reduce the interstitial porosity of rocks, many of them have a capacity to sorb radionuclides, depending on their chemical nature, and they show markedly different sorptive capacities. Work in Frenchman Flat has identified the importance of zeolites and clays in retarding the movement of radionuclides via sorption and ion exchange. Various types of alteration minerals can make up a large percentage of the rocks that compose most of the volcanic HSUs defined as confining units. Zeolites and clay minerals may be present in the matrix of tuffs as a result of alteration of the glass in the original vitric tuff, or can be components of the mineral coatings on fracture surfaces. The presence of coatings or fillings in fractures not only reduces hydraulic conductivity by reducing the volume of fracture openings, but specific fracture-filling minerals may	

NEVADA ENVIRONMENTAL RESTORATION PROJECT

DOCUMENT REVIEW SHEET

1. Document Title/Number:	Draft Corrective Action Investigation Plan for Corrective Action Unit 375: Area 30 Buggy Unit Craters, Nevada Test Site, Nevada	**2. Document Date:**	1/25/2010
3. Revision Number:	0	**4. Originator/Organization:**	Navarro-INTERA
5. Responsible NNSA/NSO Federal Sub-Project Director:	Kevin J. Cabble	**6. Date Comments Due:**	2/25/2010
7. Review Criteria:	Full		
8. Reviewer/Organization/Phone No:	Jeff MacDougall, NDEP, 486-2850	**9. Reviewer's Signature:**	

10. Comment Number/Location	**11. Type***	**12. Comment**	**13. Comment Response**	**14. Accept**
			act to sorb radionuclides to various degrees. A few data are available for NTS rocks from studies conducted to investigate the nature and mineralogy of fracture fillings. The sorption of radionuclides by zeolites, clays, and iron oxides in fracture coatings may impede the diffusion of nuclides out of the fracture into the matrix. Thus, though the presence of sorptive minerals in the rock matrix can slow diffusion by trapping radionuclides, the presence of these minerals in fracture coatings may increase transport by preventing the diffusion of radionuclides from the fracture into the rock matrix. Matrix diffusion can slow the movement of any radionuclide, reactive or not, and thus is another very important process to consider in the modeling of radionuclide migration.” A discussion to be incorporated in Section A.2.2.3 is as follows: Contaminant characteristics include, but are not limited to, solubility and adsorption potential. In general, contaminants with low solubility and high affinity for media can be expected to be found relatively close to release points. Contaminants with high solubility and low affinity for media are found further from release points or in low areas where evaporation of ponding will concentrate dissolved contaminants. As stated in the document Subsurface Nobel Gas Transport at the Nevada Test Site (Thompson et al., 1997), the Cambric test at the NTS was used to study long-term radionuclide migration from the underground detonation of	

NEVADA ENVIRONMENTAL RESTORATION PROJECT
DOCUMENT REVIEW SHEET

1. Document Title/Number:	Draft Corrective Action Investigation Plan for Corrective Action Unit 375: Area 30 Buggy Unit Craters, Nevada Test Site, Nevada	**2. Document Date:**	1/25/2010
3. Revision Number:	0	**4. Originator/Organization:**	Navarro-INTERA
5. Responsible NNSA/NSO Federal Sub-Project Director:	Kevin J. Cabble	**6. Date Comments Due:**	2/25/2010
7. Review Criteria:	Full		
8. Reviewer/Organization/Phone No:	Jeff MacDougall, NDEP, 486-2850	**9. Reviewer's Signature:**	

10. Comment Number/Location	**11. Type***	**12. Comment**	**13. Comment Response**	**14. Accept**
			a nuclear device. The Cambric test (with a yield of 750 tons) was conducted below the water table in Frenchman Flat in 1965. A well installed into the groundwater 91 m away from GZ was continuously pumped for 16 years (from 1975 to 1991) in order to draw radionuclides from the detonation cavity. The extracted water was tested for radionuclides. None of the adsorbing radionuclides (Am-241, Ca-41, Cs-137, Eu-154, Pu-241, samarium [Sm]-151, neptunium [Np]-237, or Sr-90) were detected in the pumped groundwater (attesting to their low solubility and affinity to adsorb to media). The radionuclides tritium and krypton detected in the pumped groundwater are considered to be conservative tracers in groundwater (i.e., they do not interact with the geologic media through which the water moves). The evaluation of the characteristics of the radionuclide contaminants associated with TCA and the Buggy site are based on the results of the Cambric test. This test conservatively demonstrated the potential for migration of the targeted contaminants in media similar to that of TCA and the Buggy site (i.e., similar pH and mineralogy), and under conditions more likely to cause migration than that of TCA and the Buggy site (i.e., saturated versus unsaturated conditions). This test demonstrated the relative immobility of the adsorbing radionuclides under saturated conditions where an artificial hydraulic gradient (pumping) was imposed. The contaminants at TCA and the Buggy site are located in unsaturated media (i.e., vadose) hundreds of feet above the shallowest aquifer. The contaminants generated by the Cambric test include the contaminants reasonably expected to be present at the TCA and the Buggy site (i.e.,	

UNCONTROLLED when Printed

NEVADA ENVIRONMENTAL RESTORATION PROJECT
DOCUMENT REVIEW SHEET

1. Document Title/Number:	Draft Corrective Action Investigation Plan for Corrective Action Unit 375: Area 30 Buggy Unit Craters, Nevada Test Site, Nevada	**2. Document Date:**	1/25/2010
3. Revision Number:	0	**4. Originator/Organization:**	Navarro-INTERA
5. Responsible NNSA/NSO Federal Sub-Project Director:	Kevin J. Cabble	**6. Date Comments Due:**	2/25/2010
7. Review Criteria:	Full		
8. Reviewer/Organization/Phone No:	Jeff MacDougall, NDEP, 486-2850	**9. Reviewer's Signature:**	

10. Comment Number/Location	11. Type*	12. Comment	13. Comment Response	14. Accept
			americium, cesium, plutonium, and uranium). Because these contaminants did not migrate from the Cambric cavity in pumped groundwater into to the adjacent test well during a period of 16 years, this demonstrates that the CAU 375 radionuclide contaminants are relatively immobile even under conditions of saturated flow with an imposed gradient. A discussion to be incorporated in Section A.2.2.5 is as follows: Migration is influenced by the chemical characteristics of the contaminants (presented in Section A.2.2.3) and the physical characteristics of the vadose media (presented in Section A.2.2.4). As shown in these sections, the contaminants reasonably expected to be present at CAU 375 (i.e., americium, cesium, plutonium, and uranium) are relatively immobile even under conditions of saturated flow with an imposed gradient. However, the only driver for contaminant migration in the vadose zone at TCA and the Buggy site is the percolation of infiltrated stormwater through the media. As shown in Section 2.1, percolation through the vadose is expected to be very limited due to high evapotranspiration potentials and low precipitation rates typical of the NTS. Therefore, the CAU 375 radionuclide contaminants are expected to be even less mobile in the vadose zone as water movement through the vadose zone is much less than in the saturated conditions of the aquifer. The physical characteristics of the vadose media generally include medium to high adsorptive capacities, low moisture contents (i.e., available water-holding capacity), and relatively long distances to	

UNCONTROLLED when Printed

NEVADA ENVIRONMENTAL RESTORATION PROJECT
DOCUMENT REVIEW SHEET

1. Document Title/Number:	Draft Corrective Action Investigation Plan for Corrective Action Unit 375: Area 30 Buggy Unit Craters, Nevada Test Site, Nevada	**2. Document Date:**	1/25/2010
3. Revision Number:	0	**4. Originator/Organization:**	Navarro-INTERA
5. Responsible NNSA/NSO Federal Sub-Project Director:	Kevin J. Cabble	**6. Date Comments Due:**	2/25/2010
7. Review Criteria:	Full		
8. Reviewer/Organization/Phone No:	Jeff MacDougall, NDEP, 486-2850	**9. Reviewer's Signature:**	

10. Comment Number/Location	11. Type*	12. Comment	13. Comment Response	14. Accept
			groundwater (e.g., approximately 950 to 1,000 ft bgs). Based on these physical and chemical factors, contamination is expected to be found relatively close to release points.	

Library Distribution List

	Copies
U.S. Department of Energy National Nuclear Security Administration Nevada Site Office Technical Library P.O. Box 98518, M/S 505 Las Vegas, NV 89193-8518	1 (Uncontrolled, electronic copy)
U.S. Department of Energy Office of Scientific and Technical Information P.O. Box 62 Oak Ridge, TN 37831-0062	1 (Uncontrolled, electronic copy)
Southern Nevada Public Reading Facility c/o Nuclear Testing Archive P.O. Box 98521, M/S 400 Las Vegas, NV 89193-8521	2 (Uncontrolled, electronic copies)
Manager, Northern Nevada FFACO Public Reading Facility c/o Nevada State Library & Archives 100 N Stewart Street Carson City, NV 89701-4285	1 (Uncontrolled, electronic copy)