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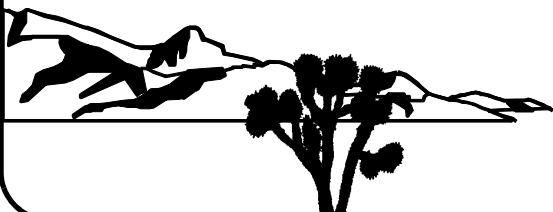
Corrective Action Investigation Plan for Corrective Action Unit 576: Miscellaneous Radiological Sites and Debris Nevada National Security Site, Nevada

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Revision No.: 0

December 2016

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**CORRECTIVE ACTION INVESTIGATION PLAN
FOR CORRECTIVE ACTION UNIT 576:
MISCELLANEOUS RADIOLOGICAL SITES
AND DEBRIS
NEVADA NATIONAL SECURITY SITE, NEVADA**

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

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FOR CORRECTIVE ACTION UNIT 576:
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NEVADA NATIONAL SECURITY SITE, NEVADA**

Approved by: /s/ Robert F. Boehlecke

Date: 12/13/2016

for Tiffany A. Lantow
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Date: 12/13/2016

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List of Acronyms and Abbreviations

General Acronyms and Abbreviations

ASTM	ASTM International
bgs	Below ground surface
BJY	Buster Jangle Y
CA	Contamination area
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	<i>Comprehensive Environmental Response, Compensation, and Liability Act</i>
CFR	<i>Code of Federal Regulations</i>
cm	Centimeter
COC	Contaminant of concern
COPC	Contaminant of potential concern
cpm	Counts per minute
CR	Closure report
CSM	Conceptual site model
day/yr	Days per year
DOE	U.S. Department of Energy
dpm/100cm ²	Disintegrations per minute per 100 square centimeters
DQA	Data quality assessment
DQI	Data quality indicator

List of Acronyms and Abbreviations (Continued)

DQO	Data quality objective
EPA	U.S. Environmental Protection Agency
FAL	Final action level
FFACO	<i>Federal Facility Agreement and Consent Order</i>
FIDLER	Field instrument for the detection of low-energy radiation
FSR	Field-screening result
ft	Foot
GPS	Global Positioning System
GZ	Ground zero
hr/day	Hours per day
hr/yr	Hours per year
HWAA	Hazardous waste accumulation area
IDW	Investigation-derived waste
in.	Inch
in./yr	Inches per year
ISOCS	In Situ Object Counting System
kt	Kiloton
m	Meter
m ²	Square meter
MDC	Minimum detectable concentration
MEI	Most exposed individual
mi	Mile
mrem/yr	Millirem per year
N/A	Not applicable
NAC	<i>Nevada Administrative Code</i>

List of Acronyms and Abbreviations (Continued)

NAD	North America Datum
NDEP	Nevada Division of Environmental Protection
NEPA	<i>National Environmental Policy Act</i>
NNSA/NFO	U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office
NNSS	Nevada National Security Site
PAL	Preliminary action level
PCB	Polychlorinated biphenyl
PET	Potential evapotranspiration
PPE	Personal protective equipment
PRG	Preliminary Remediation Goal
PSM	Potential source material
QA	Quality assurance
QAP	Quality Assurance Plan
QC	Quality control
r^2	Coefficient of determination
Rad	Radiological
Rad-chem	Radiochemistry
RBCA	Risk-based corrective action
RCRA	<i>Resource Conservation and Recovery Act</i>
REOP	Real Estate/Operations Permit
RMA	Radioactive material area
RRMG	Residual radioactive material guideline
RWMC	Radioactive waste management complex
RWMS	Radioactive waste management site

List of Acronyms and Abbreviations (Continued)

SG	Study Group
SGZ	Surface ground zero
SOW	Statement of work
SVOC	Semivolatile organic compound
TED	Total effective dose
TLD	Thermoluminescent dosimeter
TPH	Total petroleum hydrocarbons
TSCA	<i>Toxic Substances Control Act</i>
UCL	Upper confidence limit
UR	Use restriction
URMA	Underground radioactive material area
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
VOC	Volatile organic compound
W5B	Well 5B

Symbols for Elements and Compounds

Ac	Actinium
Ag	Silver
Al	Aluminum
Am	Americium
C	Carbon
Cm	Curium
Co	Cobalt
Cs	Cesium

List of Acronyms and Abbreviations (Continued)

Eu	Europium
I	Iodine
K	Potassium
Kr	Krypton
Nb	Niobium
Pa	Protactinium
Pb	Lead
Pu	Plutonium
Ru	Rubidium
Sb	Antimony
Sr	Strontium
Tc	Technetium
Th	Thorium
Tl	Thallium
U	Uranium
Xe	Xenon
Y	Yttrium
Zr	Zirconium

Executive Summary

Corrective Action Unit (CAU) 576 is located in Areas 2, 3, 5, 8, and 9 of the Nevada National Security Site, which is approximately 65 miles northwest of Las Vegas, Nevada. CAU 576 is a grouping of sites where there has been a suspected release of contamination associated with nuclear testing. This document describes the planned investigation of CAU 576, which comprises the following corrective action sites (CASs):

- 00-99-01, Potential Source Material
- 02-99-12, U-2af (Kennebec) Surface Rad-Chem Piping
- 03-99-20, Area 3 Subsurface Rad-Chem Piping
- 05-19-04, Frenchman Flat Rad Waste Dump
- 09-99-08, U-9x (Allegheny) Subsurface Rad-Chem Piping
- 09-99-09, U-9its u24 (Avens-Alkermes) Surface Contaminated Flex Line

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

The sites will be investigated based on the data quality objectives (DQOs) developed on June 14, 2016, by representatives of the Nevada Division of Environmental Protection and the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Field Office. The DQO process was used to identify and define the type, amount, and quality of data needed to develop and evaluate appropriate corrective actions for CAU 576. The site investigation process will also be conducted in accordance with the *Soils Activity Quality Assurance Plan*, which establishes requirements, technical planning, and general quality practices to be applied to this activity.

The potential contamination sources associated with CASs 00-99-01, 02-99-12, 03-99-20, 05-19-04, 09-99-08, and 09-99-09 are from testing activities conducted at the Nevada National Security Site within the associated CAS areas. The presence and nature of contamination at CAU 576 will be evaluated based on information collected from a field investigation. Radiological contamination will be evaluated based on a comparison of the total effective dose at sample locations to the dose-based

final action level. The total effective dose will be calculated as the sum of the total internal and external dose. Results from the analysis of soil samples and In Situ Object Counting System measurements will be used to calculate internal radiological dose. Thermoluminescent dosimeters placed at the center of each sample location will be used to measure external radiological dose.

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

1.0 Introduction

This Corrective Action Investigation Plan (CAIP) contains activity-specific information, including facility descriptions, environmental sample collection objectives, and criteria for conducting site investigation activities at Corrective Action Unit (CAU) 576: Miscellaneous Radiological Sites and Debris, Nevada National Security Site (NNSS), Nevada.

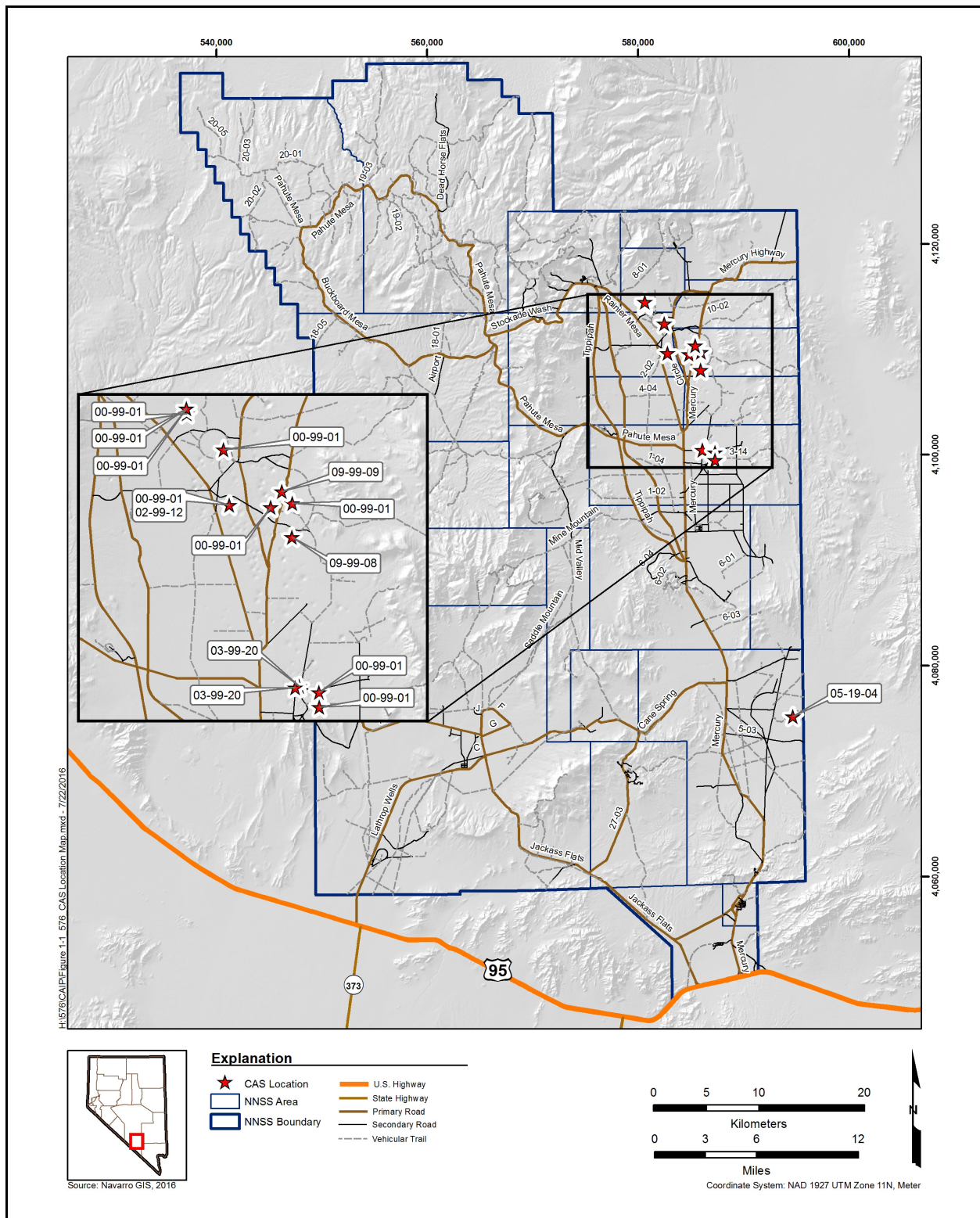
This CAIP has been developed in accordance with the *Federal Facility Agreement and Consent Order* (FFACO) (1996, as amended) that was agreed to by the State of Nevada; U.S. Department of Energy (DOE), Environmental Management; U.S. Department of Defense; and DOE, Legacy Management.

CAU 576 is located in Areas 2, 3, 5, 8, and 9 of the NNSS, which is approximately 65 miles (mi) northwest of Las Vegas, Nevada. CAU 576 comprises six corrective action sites (CASs) shown on [Figure 1-1](#) and listed in [Table 1-1](#).

The corrective action investigation (CAI) will include field inspections, radiological and geophysical surveys, In Situ Object Counting System (ISOCS) measurements, soil sampling, analysis of samples, and assessment of investigation results. Data will be obtained to support evaluations of corrective action alternatives (CAAs) and waste management decisions.

1.1 Purpose

The CASs in CAU 576 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.



**Table 1-1
CAU 576 CAS Information**

CAS Number	CAS Name ^a	Associated Tests	Location ^a
00-99-01	Potential Source Material	Various	Various
02-99-12	U-2af (Kennebec) Surface Rad-Chem Piping	Kennebec	U2af
03-99-20	Area 3 Subsurface Rad-Chem Piping	Chinchilla and Platypus	U3ag and U3ad
05-19-04	Frenchman Flat Rad Waste Dump	Unknown	N/A
09-99-08	U-9x (Allegheny) Subsurface Rad-Chem Piping	Allegheny	U9x
09-99-09	U-9its u24 (Avens-Alkermes) Surface Contaminated Flex Line	Avens-Alkermes	U9ITS U-24

^a Throughout this document, locations of tests and detonations will be referenced as cited in NNSA/NFO (2015b). CAS names will be referenced as cited in Appendix III of the FFACO (1996 as amended).

N/A = Not applicable
Rad = Radiological
Rad-chem = Radiochemistry

1.1.1 CAU 576 History and Description

CAU 576, Miscellaneous Radiological Sites and Debris, is composed of six CASs located in Areas 2, 3, 5, 8, and 9 of the NNSS. The CAU 576 sites consist of releases of contaminants to surface and shallow subsurface soil from nuclear testing activities at the NNSS. Operational histories for each CAU 576 site are detailed in [Section 2.2](#).

1.1.2 Data Quality Objectives 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 Field Office (NNSA/NFO). DQOs are used to identify and define the type, amount, and quality of data needed to develop and evaluate appropriate corrective actions for CAU 576. This CAIP describes the investigative approach developed to collect the necessary data identified in the DQO process. Discussions of the DQO methodology and the DQOs specific to CAU 576 are presented in [Appendix A](#). A summary of the DQO process is provided below.

The DQO problem statement for CAU 576 is as follows: “Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs in CAU 576.” To address this problem, resolution of the decision statements presented in [Section 3.4](#) is required. For judgmental sampling decisions, any contaminant associated with a CAS that is present at concentrations exceeding its corresponding final action level (FAL) will be defined as a contaminant of concern (COC). For probabilistic sampling decisions, any contaminant for which the 95 percent upper confidence limit (UCL) of the mean exceeds its corresponding FAL will be defined as a COC. A COC may also be defined as a contaminant that, in combination with other like contaminants, is determined to jointly pose an unacceptable risk based on a multiple constituent analysis (NNSA/NFO, 2014).

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 soil 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](#).

To facilitate site investigation and the evaluation of DQO decisions for different releases, the reporting of investigation results and the evaluation of DQO decisions for different releases were organized into study groups, as described below. The study groups, CASs associated with each study group, the NNSA area, and CAS-specific releases are described in [Table 1-2](#). Although the need for corrective action is evaluated separately for each release, CAAs are evaluated for each FFACO CAS.

- **SG1 (Surface Rad-Chem Piping).** This release category is specific to radionuclide waste contained within a gas-sampling flex line. The flex line is associated with gas-sampling activities conducted during a weapons-related test (Avens-Alkermes). This containment is expected to fail and release contaminants to the surrounding soil.
- **SG2 (Subsurface Rad-Chem Piping).** This release category is specific to radionuclide contamination from waste contained primarily within subsurface rad-chem piping at Kennebec, Chinchilla, Platypus, and Allegheny. This containment is expected to fail and release contaminants to the surrounding soil. In addition, releases may have occurred from gas-sampling components and venting of gases from the exhaust pipe at Kennebec and Allegheny.

- **SG3 (Rad Waste Dump).** This release category is specific to contained material that was stored on the surface and then removed or contaminated material that is currently buried at the site. Removable surface soil contamination was detected, and an area of approximately 30 by 30 feet (ft) was posted as a contamination area (CA).
- **SG4 (Debris).** This release category is specific to chemical and possibly radiological surface soil contamination from legacy debris associated with testing activities. The PSM consists of, but is not limited to, lead (bricks, sheets, shielding), battery with lead plates, tower debris (fragments), and radiologically elevated soil beneath two small drums. The debris is found within multiple areas of the NNSS. The debris has the potential to leach contaminants (chemical or radiological) into the environment (surface soil).

Table 1-2
CAU 576 Study Groups
(Page 1 of 2)

Potential Releases (Also see Section 2.4)	SG	Area	Associated FFACO CAS	Release Name
• Associated with a weapons-related nuclear test • Surface and/or shallow subsurface release of radionuclides from waste contained within the flex line	1	9	09-99-09	Avens-Alkermes
• Associated with a weapons-related nuclear test • Release of radionuclides from waste contained within the subsurface rad-chem piping • Surface and/or shallow subsurface release of radionuclides from surface gas-sampling components • Surface and/or shallow subsurface release of radionuclides from the venting of gases via the exhaust pipe	2	2	02-99-12	Kennebec
• Associated with Chinchilla weapons-related nuclear test • Release of radionuclides from waste contained within the subsurface rad-chem piping	2	3	03-99-20	Chinchilla
• Associated with Platypus weapons-related nuclear test • Release of radionuclides from waste contained within the subsurface rad-chem piping	2	3	03-99-20	Platypus
• Associated with a weapons-related nuclear test • Release of radionuclides from waste contained within the subsurface rad-chem piping • Surface and or shallow subsurface release of radionuclides from gas-sampling activities • Surface and shallow subsurface release of radionuclides from venting of gases via the exhaust pipe	2	9	09-99-08	Allegheny

Table 1-2
CAU 576 Study Groups
(Page 2 of 2)

Potential Releases (Also see Section 2.4)	SG	Area	Associated FFACO CAS	Release Name
Surface/subsurface releases of radionuclides and other COCs from a possible landfill	3	5	05-19-04	Rad Waste Dump
Surface and shallow subsurface chemical release from PSM	4	2	00-99-01	Lead Bricks
Surface and shallow subsurface chemical release from PSM	4	2	00-99-01	Lead Objects
Surface and shallow subsurface radiological release from PSM	4	3	00-99-01	Tower Debris
Surface and shallow subsurface chemical release from PSM	4	3	00-99-01	Lead Object
Surface and shallow subsurface chemical release from PSM	4	8	00-99-01	Battery
Surface and shallow subsurface chemical release from PSM	4	8	00-99-01	Lead Object
Surface and shallow subsurface chemical release from PSM	4	9	00-99-01	Lead Brick
Surface and shallow subsurface radiological release from PSM	4	9	00-99-01	Radiologically Elevated Soil

PSM = Potential source material
SG = Study Group

1.2 Scope

To generate information needed to resolve the decision statements identified in the DQO process, the scope of the CAI for CAU 576 includes the following activities:

- Conduct radiological surveys.
- Conduct geophysical surveys.
- Perform field screening.
- Measure internal contamination levels of rad-chem piping systems using ISOCS or equivalent measurement device.

- Measure in situ external dose rates using thermoluminescent dosimeters (TLDs) or other dose-measurement devices.
- Collect and submit environmental samples for laboratory analysis to determine whether any COC is present.
- Collect and submit environmental samples for laboratory analysis to determine the nature and extent of any COCs that are present.
- Collect samples of waste material, if needed, to determine the potential for soil contamination exceeding FALs.
- Collect samples of potential remediation wastes, if needed, to determine potential waste types.
- Collect quality control (QC) samples.

Soil contamination originating from activities not identified in the conceptual site model (CSM) 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 be identified as part of another CAS (either new or existing) in the Corrective Action Decision Document (CADD).

The surface features at Bernalillo (U3n) were addressed under CAU 547, and the surface features at Colfax (U3k) were addressed under CAU 568.

1.3 CAIP Contents

[Section 1.0](#) presents the purpose and scope of this CAIP, while [Section 2.0](#) provides background information about CAU 576. Objectives of the investigation, including the CSM, are presented in [Section 3.0](#). Field investigation and sampling activities are discussed in [Section 4.0](#), and waste management issues are discussed in [Section 5.0](#). General field and laboratory quality assurance (QA) (including collection of QA samples) is presented in [Section 6.0](#) and in the *Soils Activity Quality Assurance Plan* (QAP) (NNSA/NSO, 2012a). The activity schedule and records availability are discussed in [Section 7.0](#). [Section 8.0](#) provides a list of references.

[Appendix A](#) provides a detailed discussion of the DQO methodology and the DQOs specific to each CAS, while [Appendix B](#) contains information on the activity organization. [Appendix C](#) contains responses to NDEP comments on the draft version of this document.

2.0 Facility Description

CAU 576 comprises six CASs at the NNSS. The investigation will also address potential contamination associated with the releases identified in [Table 1-2](#). These releases were organized into study groups based on their type of release and investigation approach.

2.1 Physical Setting

The following subsections describe the general physical settings of Areas 2, 3, 5, 8, and 9 of the NNSS. General background information pertaining to topography, geology, hydrogeology, and climatology is provided for these specific areas of the NNSS region in the *Geologic Map of the Nevada Test Site, Southern Nevada* (Frizzell and Shulters, 1990); *CERCLA Preliminary Assessment of DOE's Nevada Operations Office Nuclear Weapons Testing Areas* (DRI, 1988); *Final Environmental Impact Statement, Nevada Test Site, Nye County, Nevada* (ERDA, 1977); and the *Final Site-Wide Environmental Impact Statement for the Continued Operation of the Department of Energy/National Nuclear Security Administration Nevada National Security Site and Off-Site Locations in the State of Nevada*, (NNSA/NSO, 2013).

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

2.1.1 Yucca Flat

All CAU 576 CASs except CAS 05-19-04, Frenchman Flat Rad Waste Dump, are located within the Yucca Flat Hydrographic Area of the NNSS. The release associated with the CASs are referenced in [Table 1-2](#). Yucca Flat is a closed basin, which is slowly being filled with alluvial deposits eroding from the surrounding mountains (Laczniak et al., 1996).

The local topography is relatively flat and is located within the Yucca Flat Tributary Flow System, a part of the regional carbonate aquifer flow system, and moves generally from northeast to southwest (Fenelon et al., 2010). Within the overlying alluvial and volcanic aquifers, lateral groundwater flow occurs from the margins to the center of the basin and downward into the carbonate aquifer (Laczniak et al., 1996).

Table 2-1 reflects the average annual potential evapotranspiration (PET) for the Areas 3 and 5 as well as the nearest rain gauge information (Buster Jangle Y [BJY]) in Area 1.

Table 2-1
Rainfall and PET Information for Yucca Flat

	Area 3 PET ^a (cm)	Area 5 PET ^a (cm)	BJY Precipitation ^b (cm)
Minimum	150.2	158.3	3.8
Maximum	160.8	164.6	37.4
Mean	156.7	161.4	16.1
95% UCL	159.6	164.3	18.2

^a Yucef, 2009

^b Soulé, 2006

cm = Centimeter

The nearest groundwater well to the majority of releases within CAU 576 is U.S. Geological Survey (USGS) Water Well ER-2-1 (main), an active well is located 875 m southeast of the Area 2 site (Kennebec). The most recent recorded depth to water table is approximately 1,725 ft below ground surface (bgs) (USGS/DOE, 2016). The thickness of the unsaturated zone extends to more than 600 ft bgs (Hevesi et al., 2003).

2.1.2 Frenchman Flat

CAS 05-19-04, Frenchman Flat Rad Waste Dump, lies within the southern portion of the Frenchman Flat Hydrographic Area, a broad-lined closed basin surrounded by low-lying mountains that separate this area from the Mercury Valley Hydrographic Area to the south and from the Yucca Flat Hydrographic Area to the north (Laczniak et al., 1996). Erosion of the surrounding mountains has resulted in the accumulation of more than 1,000 ft of alluvial deposits in some areas of Frenchman Flat (DOE/NV, 1996).

Groundwater flow beneath the Frenchman Flat area occurs primarily within the carbonate-rock aquifer. Groundwater flow in this region of the aquifer is generally from the northeast to southwest. Within the overlying alluvial and volcanic aquifers, lateral groundwater flow occurs from the margins to the center of the basin and downward into the carbonate-rock aquifer. The hydraulic gradient in

most areas of the alluvial aquifer in Frenchman Flat is relatively flat (less than 1 foot per mile) except near active water wells and/or test wells (Hevesi et al., 2003). The average annual precipitation at rain gauge Well 5B (W5B), which is located near Frenchman Flat, is 4.85 inches (in.) (USGS/DOE, 2016). The Frenchman Flat unsaturated zone extends to approximately 600 ft bgs (Hevesi et al., 2003). Additional rainfall and PET information is presented in [Table 2-1](#).

2.2 Operational History

The following subsections provide a description of the use and history of each potential release. The CAS specific summaries are designed to describe the releases associated with each site and document all significant, known activities.

2.2.1 SG1 (Surface Rad-Chem Piping)

2.2.1.1 CAS 09-99-09, U-9its u24 (Avens-Alkermes) Surface Contaminated Flex Line

[Figure 2-1](#) reflects the location of the release associated with CAS 09-99-09 within Area 9. More than 65 meters (m) of gas-sampling flex line has been identified outside the fenced surface ground zero (SGZ) ([Figure 2-2](#)). This CAS consists of possible surface and shallow subsurface soil contamination from releases associated with rad-chem sampling activities associated with an underground weapons-related test (Avens-Alkermes) conducted as part of the Emery Operation on December 16, 1970, and resulted in a yield less than 20 kt. The U9ITS U-24 emplacement hole was drilled between November 10 and November 20, 1970, with a depth of burial of -1,004 ft (NNSA/NFO, 2015b).

2.2.2 SG2 (Subsurface Rad-Chem Piping)

2.2.2.1 CAS 02-99-12, U-2af (Kennebec) Surface Rad-Chem Piping

[Figure 2-3](#) reflects the location of the release associated with CAS 02-99-12 within Area 2. This CAS consists of environmental surface and subsurface soil contamination from rad-chem sampling activities associated with a weapons-related test (Kennebec) conducted as part of Operation Storax in emplacement hole U2af on June 25, 1963. The emplacement hole was drilled between February 27 and March 25, 1963, with a depth of burial of -742 ft (NNSA/NFO, 2015b). The rad-chem system was designed to convey gas to sampling locations along the approximately 1,000-ft rad-chem pipe of

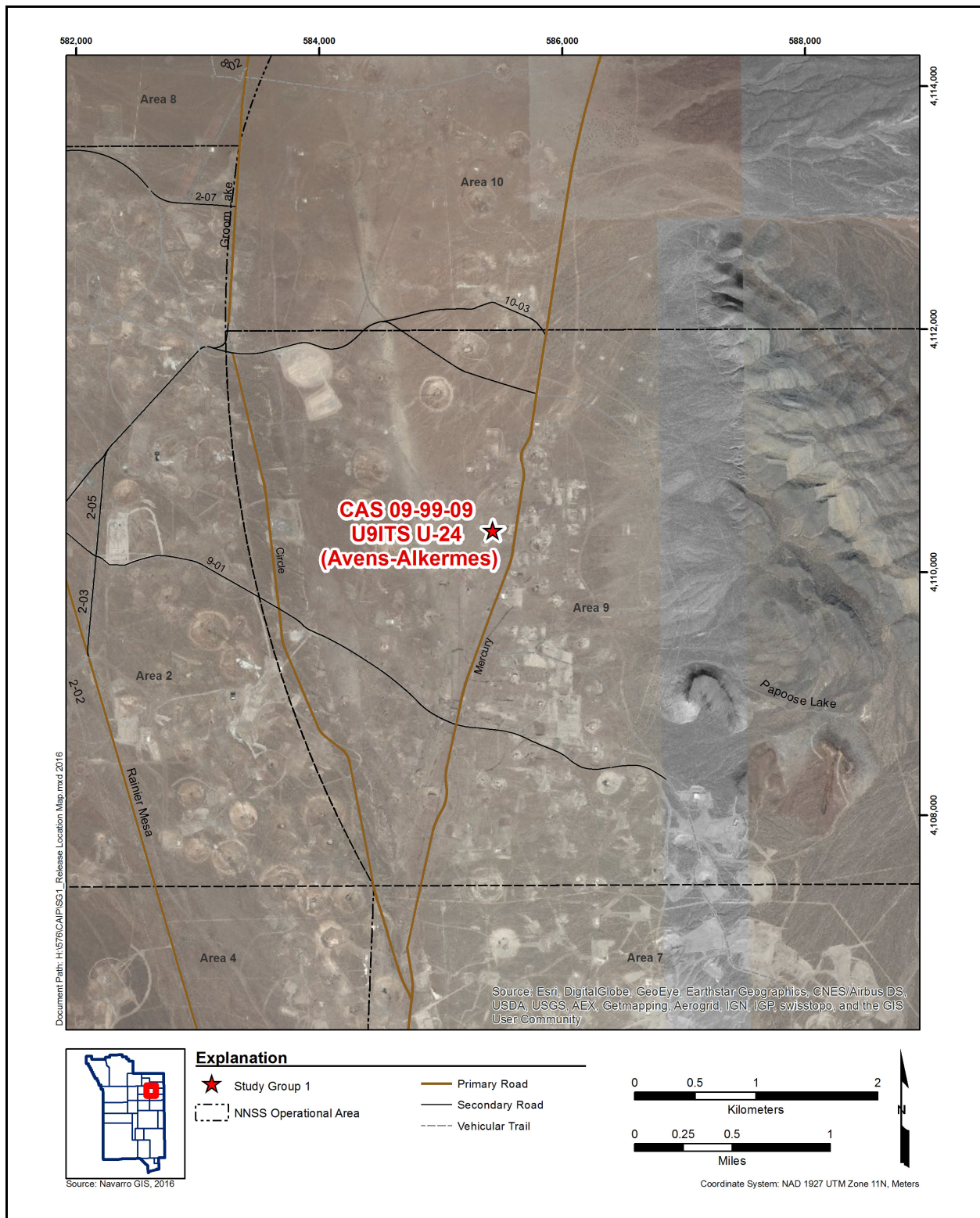


Figure 2-1
SG1: Release Location Map



Figure 2-2
SG1: CAS 09-99-09, U-9its u24 (Avens-Alkermes) Surface Contaminated Flex Line
Note: Photograph looking north.

U2af (surface and subsurface). [Figure 2-4](#) reflects the layout of the sampling system and the potential release points at the Kennebec site. [Figure 2-5](#) is the 1963 engineering drawing of the U2af “rad-chem piping,” and [Figure 2-6](#) is the key for the engineering drawing. According to the engineering drawing ([Figure 2-5](#)), and as reflected in the linear drawing of the Kennebec sampling system ([Figure 2-4](#)), the first sampling point is 600 ft west of the U2af emplacement hole ([Figure 2-7](#)); the second sampling point is 800 ft west ([Figure 2-8](#)); a possible third sampling point is located approximately 900 ft west of the U2af emplacement hole; and the piping continues west another 100 ft, where it terminates 1,000 ft west of the U2af emplacement hole.

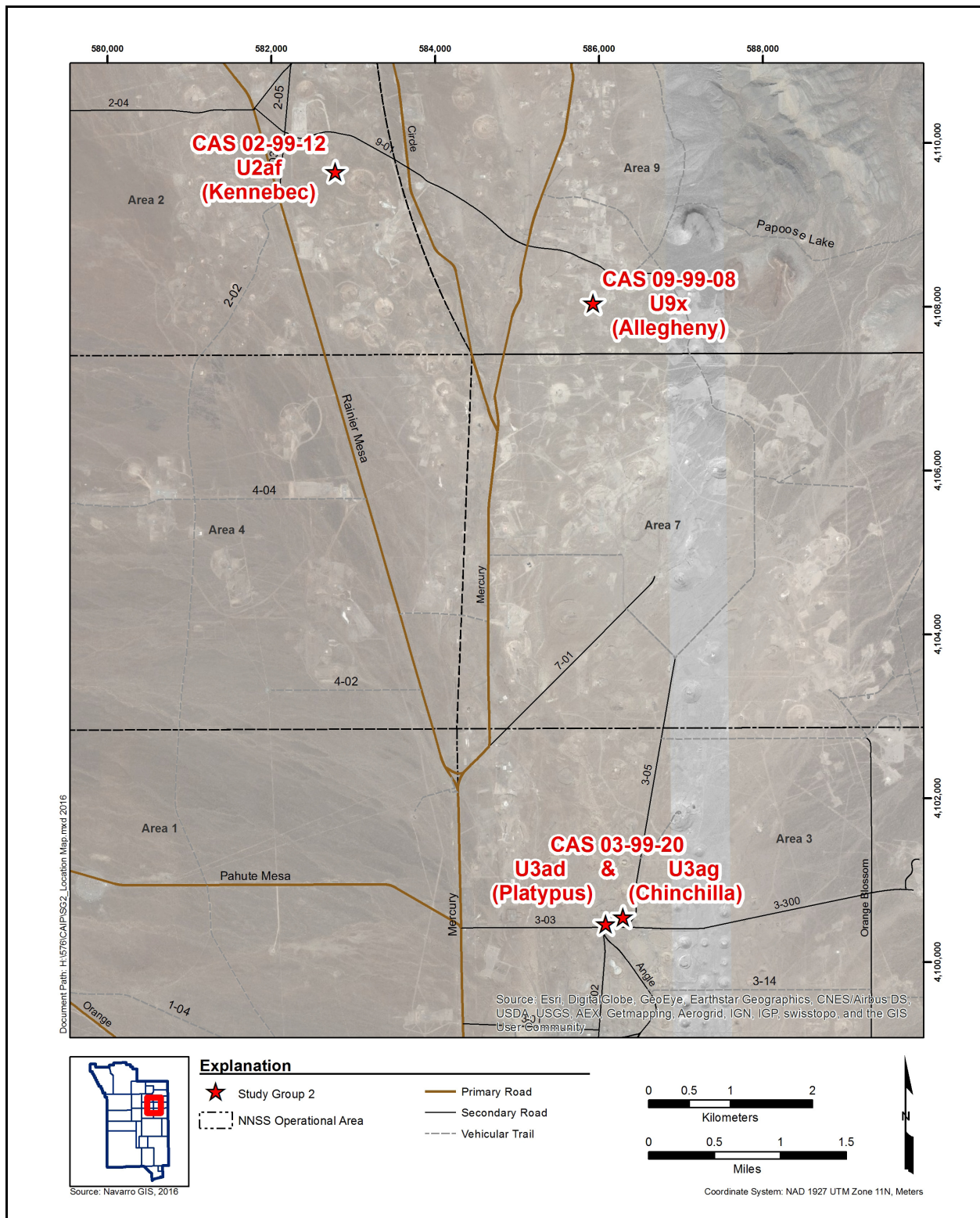


Figure 2-3
SG2: Release Location Map

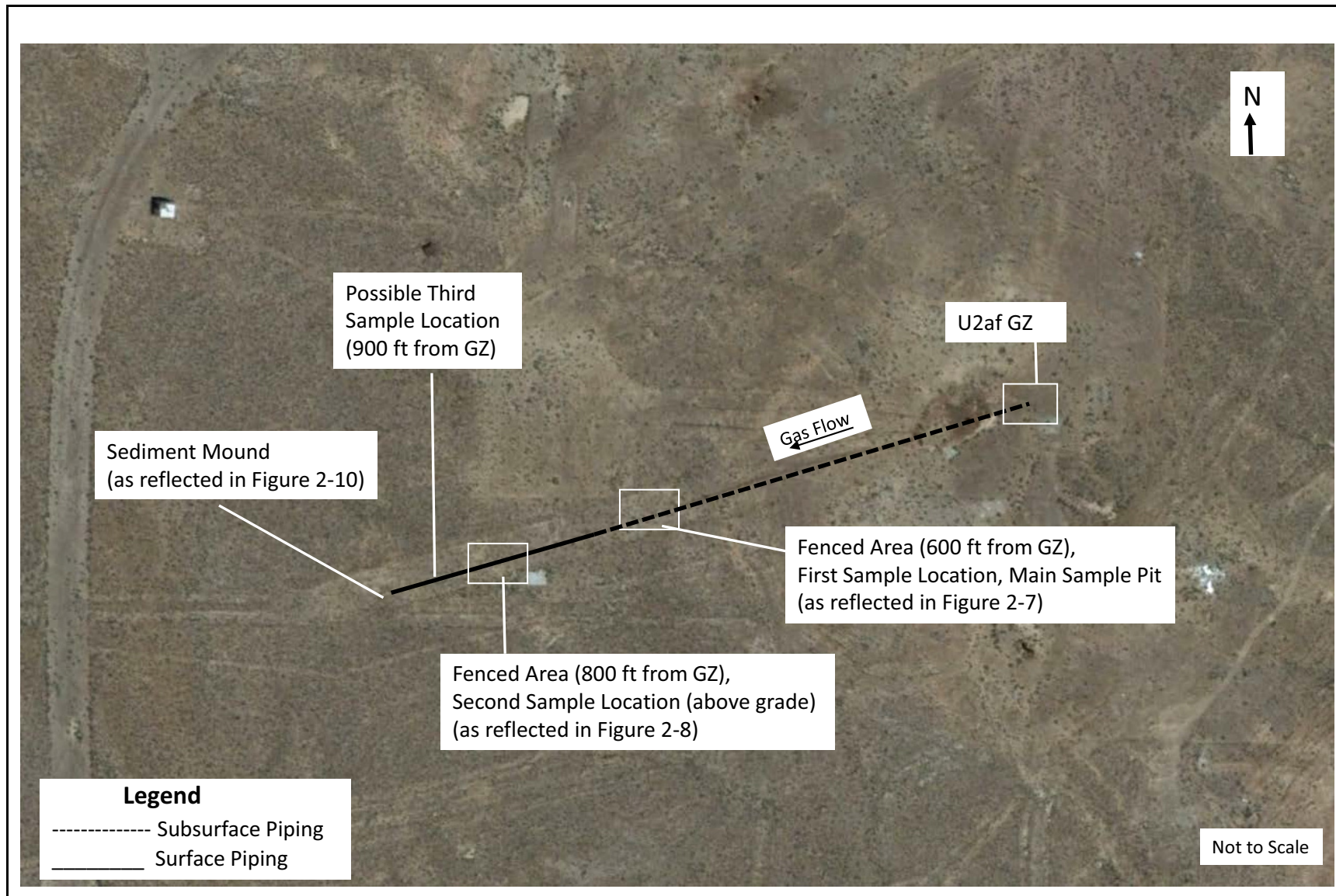


Figure 2-4
SG2: Layout at the U2af (Kennebec) Site

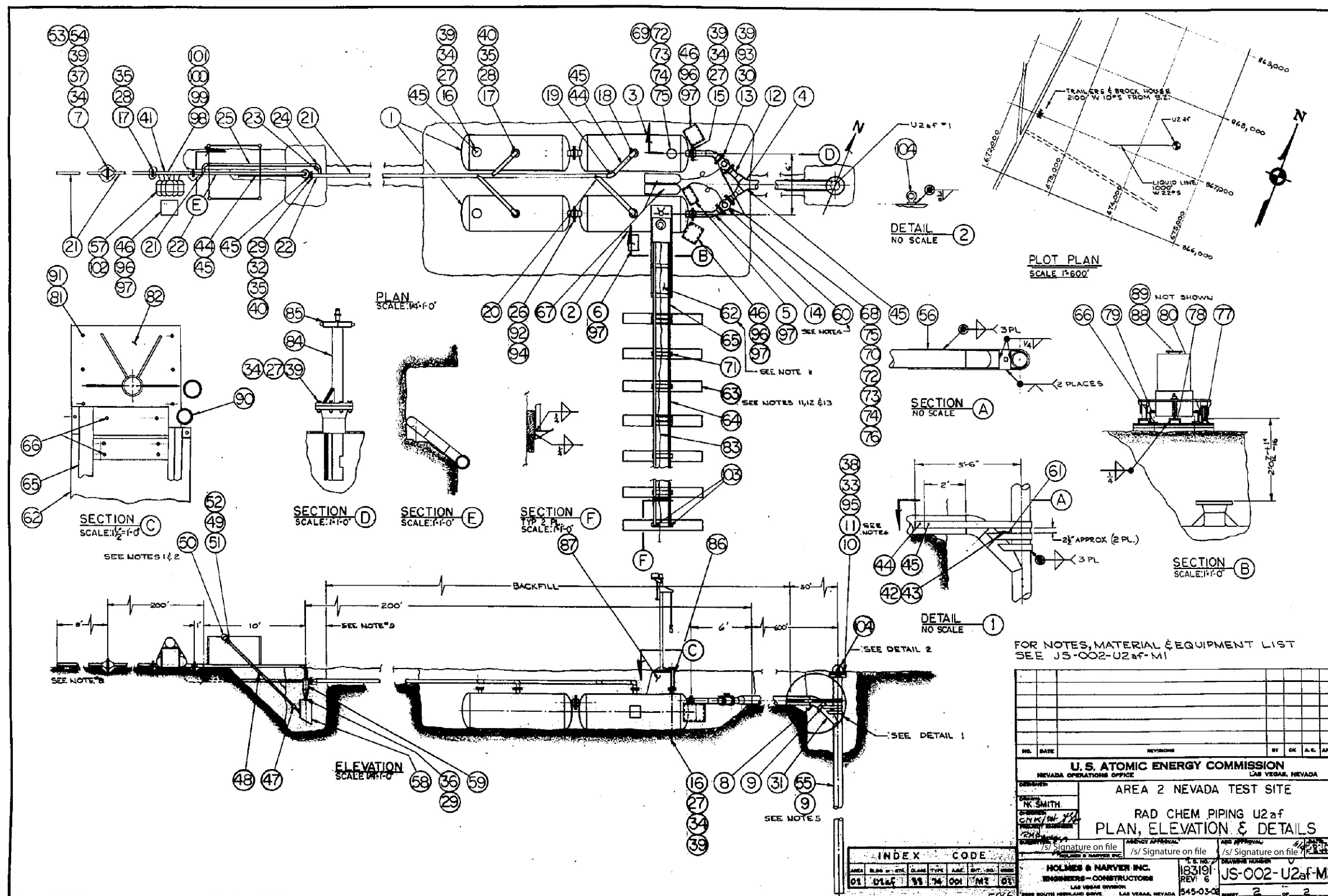


Figure 2-5
SG2: Engineering Drawing for U2af (Kennebec)
 Source: H&N, 1963a

EQUIPMENT & MATERIAL LIST						
ITEM	LRL PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.
1.	G3-112084-00	TANK TAB-C1	2			
2.	G3-112084-00	TANK TAB-C2	1			
3.	G3-112084-00	TANK TAB-C3	1			
4.	G2-124445-00	10" REDUCING "Y"	1			
5.		RAMS COUNTER	1			
6.		DTA EQUIPMENT	2			
7.		IODINE TRAP L12M4G34(MODIF)	1			
8.		ELBOW-10"x45" STD.WT.WELD SMLS	1	STL.	ASTM-A234	
9.		PIPE-10" SCH. 40 SMLS	AS REQ'D	STL.	ASTM-A53	
10.		FLANGE-WELDING NECK 10" 600"	1	STL.	ASTM-A105	
11.		FLANGE-BLIND 10" 600"	1	STL.	ASTM-A105	
12.		PIPE-6" SCH. 40 SMLS	AS REQ'D	STL.	ASTM-A53	
13.		FLANGE-WELDING NECK 6" ASA 300	4	STL.	ASTM-A181	
14.		ELBOW-STD.WT.WELD 6"x45" SMLS	2	STL.	ASTM-A234	
15.		FLANGE-WELDING NECK 6" 150"	2	STL.	ASTM-A181	
16.		FLANGE-BLIND-6" 150"	3	STL.	ASTM-A181	
17.		FLANGE-WELDING NECK 4" 150"	2	STL.	ASTM-A181	
18.		ELBOW-WELD STD.WT. 4"x90" SMLS	4	STL.	ASTM-A234	
19.		ELBOW-WELD STD.WT. 4"x45" SMLS	1	STL.	ASTM-A234	
20.		SHAPED NIPPLE-WELD STD.WT. 4"x45"	3	STL.	ASTM-A234	
21.		PIPE-4" SCH. 40 SMLS	AS REQ'D	STL.	ASTM-A53	
22.		REDUCER-4"x3" STD.WT.WELD SMLS	2	STL.	ASTM-A234	
23.		SHAPED NIPPLE-WELD STD.WT. 3"x30"	2	STL.	ASTM-A234	
24.		ELBOW-WELD STD.WT. 3"x90" SMLS	2	STL.	ASTM-A234	
25.		PIPE-3" SCH. 40 SMLS	AS REQ'D	STL.	ASTM-A53	
26.		GASKET-10" FLAT RING 150"x1/2 THK	2	ASBESTOS		
27.		GASKET-6" FLAT RING 150"x1/2 THK	7	ASBESTOS		
28.		GASKET-4" FLAT RING 150"x1/2 THK	6	ASBESTOS		
29.		GASKET-3" FLAT RING 150"x1/2 THK	2	ASBESTOS		
30.		GASKET-6" FLAT RING 300"x1/2 THK	4	ASBESTOS		
31.		SHAPED NIPPLE-WELD STD.WT. 10"x45"	1	STL.	ASTM-A234	
32.		FLANGE-WELDING NECK 3" 150"	1	STL.	ASTM-A181	
33.		CAP SCR. 1 1/4" 7/8" x 7" LG. HEX.	16	STL.		
34.		CAP SCR. 3/4" 1/2" x 3 1/2" LG. HEX.	64	STL.		
35.		CAP SCR. 3/8" 1/2" x 3" LG. HEX.	52	STL.		
36.		CAP SCR. 3/8" 1/2" x 1 1/4" LG. HEX.	8	STL.		
37.		GASKET-6" FLAT RING 150"x1/2 THK	16	ASBESTOS		
38.		NUT-1 1/4" 7/8" HEX	16	STL.		
39.		NUT-3/4" 1/2" HEX	112	STL.		
40.		NUT-3/8" 1/2" HEX	52	STL.		
41.	G2-107843-0A	SAMPLING PIPE SECTION	1			
42.	G2-108701-00	ACCELEROMETER BASE	2			
43.		ACCELEROMETER	2			
44.		THERMOCOUPLE	4			
45.		TRANSDUCER-PRESSURE	7			
46.	G2-115261-0A	FISSION COUNTER	2			
47.		COUPLING-2" NOM PIPS 150"	1	STL.		
48.		PIPE-2" SCH. 40.9 LG. THREADED ENDS SMLS	1	STL.	ASTM-A53	
49.	G2-108376-00	SPANNER REDUCER	1			
50.	G2-108407-0A	SAMPLER	1			
51.		BUSHING-1/4" x 1/2" NPT	1	STL.		
52.		GAUGE-0-1000 PSI PRESS. REC TYPE	1			
53.	L12M4G93-C	FILTER SCREEN	1			
54.		FILTER PAPER	2			
55.		STARCH-CORN	2 TON			
56.		PLATE-2"x4" LENGTH TO SUIT	3	STL.	ASTM A7-46	
57.	G2-107850-00	SAMPLE BOTTLE UNIT	1			
58.	G3-112676-00	COLLECTOR	1			
59.	G3-112091-00	MODIFIED SEPARATOR UNIT(SMALL)	1			
60.		VALVE 6" BALL MT. GANNASEAL CS 155	2			
61.		3/4" W/ROBOTARM ACTUATOR S22-SR	1			
62.		PLATE 1/2"	1	STL.	ASTM A7-46	
63.		PLYWOOD-1"x2"x8' EXT. GRADE C-C	2			
64.	G3-113676-00	LUMBER-2"x1"x8' LG. 2 COMMON GR EQ	15	DOUGLAS FIR		
65.	G2-113700-00	TRACK	4			
66.		TRACK	1			
67.		NUT-1/2" 1/2" NC HEX	6	STL.		
68.		BOTTLE AIR 200 CU. FT. CAP	2			
69.		STREET ELBOW-90° 3/4" NPT	2	STL.	WP-P-521	
70.		REGULATOR-AIR VICTOR "R250	2			
71.		TUBE-3/4" O.D. x .065 WALL	20'	COPPER		
72.		LAG BOLT 1/2" x 2" SQ. HD. WOOD	63	STL.		
73.		SCR. TYPE THDS.				
74.		UNION GASKET-3/8" TYPE III	4	(SEE LRL DWG "10A1021-4)		4730-1G194
75.		UNION NUT-3/8" TYPE V	4	(SEE LRL DWG "10A1041-4)		4730-1G184
76.		UNION NIPPLE TYPE VII	4	(SEE LRL DWG "10A1171-4)		4730-1G151
77.		UNION COUPLING W/MPF 3/8" TYPE I	4	(SEE LRL DWG "10A1011-4)		4730-1G171
78.	G3-118620-00	BUSHING PIPE 3/8" x 1/4"	2			4730-14747
79.	G3-118620-00	PIG CART SUB ASSY	1			
80.	G3-118620-00	STOP CHANNEL	1			
81.	G3-118608-00	HOLD DOWN	1			
82.		DIG	1			
83.	G3-118606-00	CAP SCR. 1-8 NC-2 LG. HEX. HD	8	STL.		
84.	G3-118606-00	SAMPLE RECOVERY MECHANISM	1			
85.	G3-118504-00	ROPE-MANILA 1/2" x 50' LG.	1			3980-305E2
86.	G3-118504-00	FLANGE ADAPTER SUBASSY TAB C2	1			
87.	G3-118504-00	SAMPLE RECOVERY-MANUAL	1			
88.	G3-118504-00	FLANGE ADAPTER SUB ASSY TAB C1	1			
89.	G3-118550-00	SUPPORT STAND	1			
90.	G3-118527-00	INSERT	1			
91.	G3-118570-00	HANDLE	1			
92.	G3-112658-00	SAMPLE COLLECTOR CONTAINER	1			
93.		NUT-1" 9/16" NC HEX.	8	STL.		
94.		CAP SCR. 7/8" 9/16" x 3 1/4" LG. HEX.	24	STL.		
95.		CAP SCR. 3/4" 1/2" x 4 1/4" LG. HEX.	48	STL.		
96.		NUT 7/8" 9/16" NC HEX	24	STL.		

EQUIPMENT & MATERIAL LIST (CONT'D)						
ITEM	LRL PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.
95.		GASKET-10" FLAT RING 300"x1/2 THK	1	ASBESTOS		
96.		BRICK 2"x4"x8"	275	LEAD	COMMON	
97.		PLYWOOD 3/4 THK.	AS REQ'D	FIR	DFPA-DD	
98.	G2-107844-00	CONNECTING TUBE TAB-C1	3			
99.	G2-107844-00	CONNECTING TUBE TAB-C2	2			
100.	G2-107844-00	CONNECTING TUBE TAB-C3	1			
101.		THREAD PIECE-UNION	6		10A-1011-4	4730-1G171
102.	G2-124485-00	MANIFOLD	1			
103.	G3-114270-00	WHEEL STOP	2			
104.		EYE BOLT	1	STL.		5302-42251

GENERAL NOTES:

1. SAMPLER (ITEM 50) TO BE PLACED AFTER TEST.
2. SAFETY BARRICADE TO BE CONSTRUCTED TO SUIT HAZARDS CONTROL REQUIREMENTS.
3. * INDICATES CONTRACTOR FURNISH. (ALL OTHER ITEMS BY LRL)
4. AIR OPERATED VALVES TO HAVE POWER ON SIGNAL TO C.P.-1 & OPERATOR AT C.P.-1.
5. THE BOTTOM 116' OF VERTICAL PIPE (ITEM 9) IS TO BE FILLED WITH 50% SOLUTION OF CORN STARCH (ITEM 55) (2.4 CU.YDS.) AFTER STARCH SOLUTION IS IN PIPE ADD 1782 GALS. OF WATER.
6. AFTER FILLING REPLACE 10" FLANGE (ITEM 11) WITH PRESCRIBED GASKET.
7. INSTRUMENTATION PER THIS DWG. WILL BE FURNISHED BY LRL PERSONNEL AND TO BE INSTALLED ACCORDING TO THEIR DIRECTION.
8. THERE SHALL BE NO OBSTRUCTIONS TO FREE FLOW FROM EXHAUST PIPE FOR A MINIMUM DISTANCE OF 30'.
9. CONTRACTOR TO PROVIDE SUITABLE COVER TO SHIELD SEPARATOR AREA FROM WEATHER.
10. STAKE TO GROUND.
11. MINE SHORING CAN BE USED IN PLACE OF ITEM G3.
12. TRACK TO BE LAYED & SHORED AS REQ'D FOR LEVEL RUN.

REFERENCE DRAWINGS:

RAD-CHEM PIPING DETAILS - JS-002-U2af-M2
RAD-CHEM EXCAVATION LAYOUT - JS-002-U2af-C2

INDEX		CODE	
AREA	BLDG	STA	CLAS
02	U2af	33	74 001 MI 02

U.S. ATOMIC ENERGY COMMISSION NEVADA OPERATIONS OFFICE LAS VEGAS, NEVADA	
AREA 2, NEVADA TEST SITE	
RAD-CHEM PIPING STA. U2af	
EQUIPMENT & MATERIAL LIST	
DRAWN BY: REIDENBACH	
CHECKED BY: [Signature]	
PROJECT ENGINEER: [Signature]	
SUPERVISOR: [Signature]	
HOLMES & NARVER INC. ENGINEERS & CONSTRUCTORS SPECIAL PROJECTS DIVISION 646 SOUTH BROADWAY LOS ANGELES 14, CALIF.	
185191 REV 6 445-0302	
DRAWING NUMBER JS-002-U2af-M1.1	
SHEET 1 OF 2	

Figure 2-6
SG2: Engineering Drawing Key for U2af (Kennebec)
Source: H&N, 1963b



Figure 2-7
SG2: CAS 02-99-12 U2af (Kennebec) Surface Rad-Chem Piping, Vault Area
Note: Photograph looking north.



Figure 2-8
SG2: CAS 02-99-12 U2af (Kennebec) Surface Rad-Chem Piping, Sampler at the Sampling Assembly
Note: Photograph looking north.

Figure 2-9 is a photograph of a surface section surrounded by debris; the location of this photograph is after the second sampling point but before pipe termination. Figure 2-10 depicts the pipe (called “exhaust pipe” at this point) terminating just before a soil mound. It is believed that the soil mound was created during post-test cleanup activities to cover contamination. Footnote 8 in the engineering drawing (Figure 2-5) states, “There shall be no obstructions to free flow from exhaust pipe for a minimum distance of 30-ft,” which implies the soil mound was created after the test.



Figure 2-9
SG2: CAS 02-99-12, U2af (Kennebec) Surface Rad-Chem Piping and Debris
Note: Photograph looking north

2.2.2.2 CAS 03-99-20, Area 3 Subsurface Rad-Chem Piping

Figure 2-3 reflects the location of the subsurface piping and potential release sites associated with CAS 03-99-20 within Area 3. The CAS is associated with only the subsurface piping at the Chinchilla and Platypus sites and consists of contained radioactive waste within the two rad-chem piping systems. The weapons-related tests were conducted in emplacement holes U3ag (Chinchilla) and U3ad (Platypus) on February 19 and February 24, 1962, respectively (NNSA/NFO, 2015b).

The Chinchilla (U3ag) emplacement hole was drilled between May 18 and June 1, 1959, with a depth of burial of -492 ft. The Platypus (U3ad) emplacement hole was drilled between November 10 and



Figure 2-10
SG2: CAS 02-99-12, U2af (Kennebec) Surface Rad-Chem Piping,
Pipe (exhaust) Terminating at Soil Mound

Note: Photograph looking west.

November 24, 1961, with a depth of burial of -190 ft. The Chinchilla and Platypus tests were both part of Operation Nougat. The nuclear detonations had yields of 1.9 kiloton (kt) for the Chinchilla experiment and a low-yield for the Platypus experiment (NNSA/NFO, 2015b). The systems were designed to use nearby holes as the sampling location, as reflected in [Figure 2-11](#).

The first subsurface rad-chem piping system runs from the Chinchilla (U3ag) emplacement hole to the Bernalillo (U3n) emplacement hole ([Figure 2-12](#)) and is within a posted underground radioactive material area (URMA). The U3n hole provided a convenient location to collect test gases from the Chinchilla test.

The second subsurface piping system lies within a CA and encompasses locations of several other underground tests. The Platypus rad-chem piping system extends from the Platypus (U3ad) emplacement hole to the Colfax (U3k) hole ([Figure 2-13](#)). The U3k hole provided a convenient location to collect gases from the Platypus test.

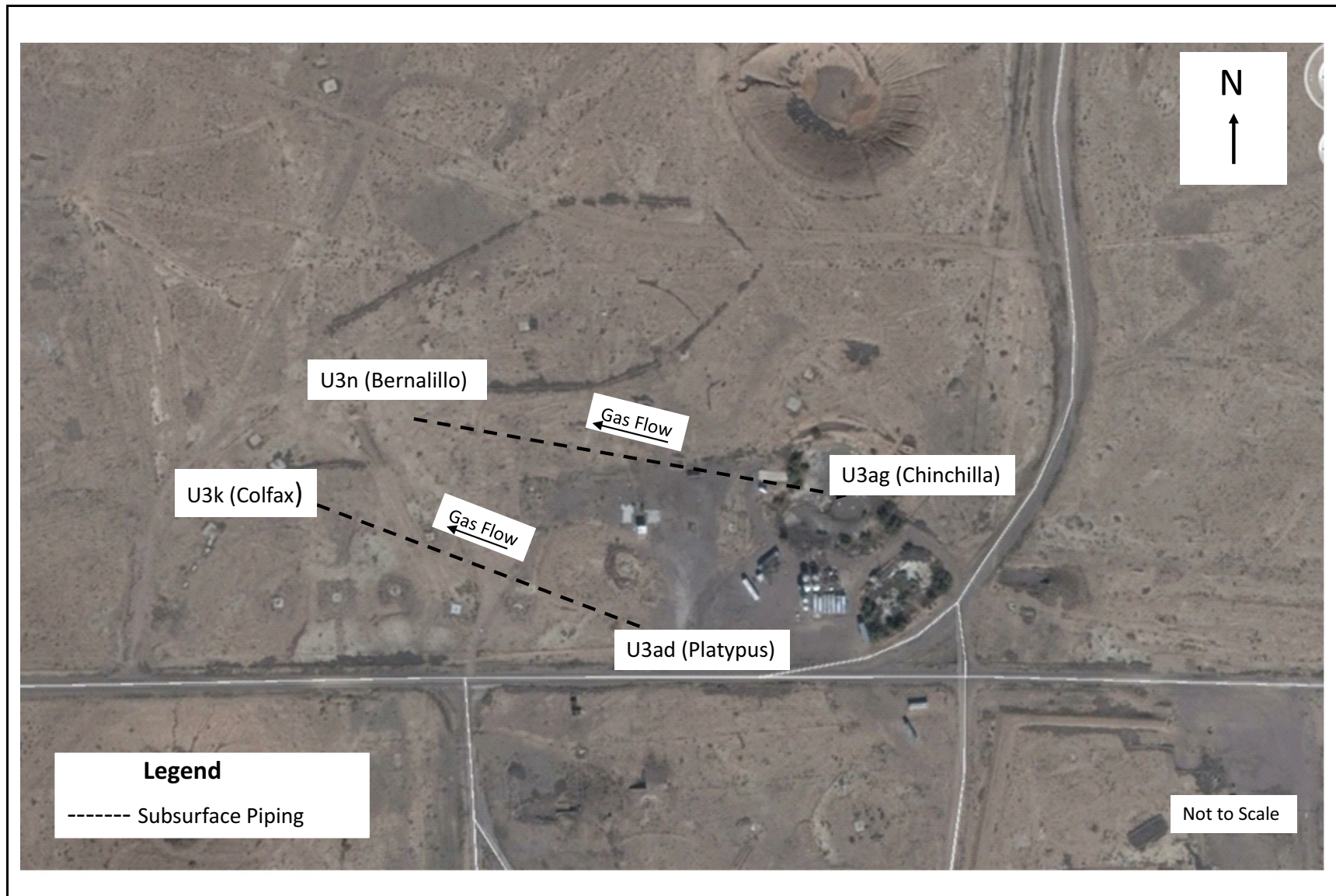


Figure 2-11
SG2: Overview of the Area 3 Subsurface Rad-Chem Piping

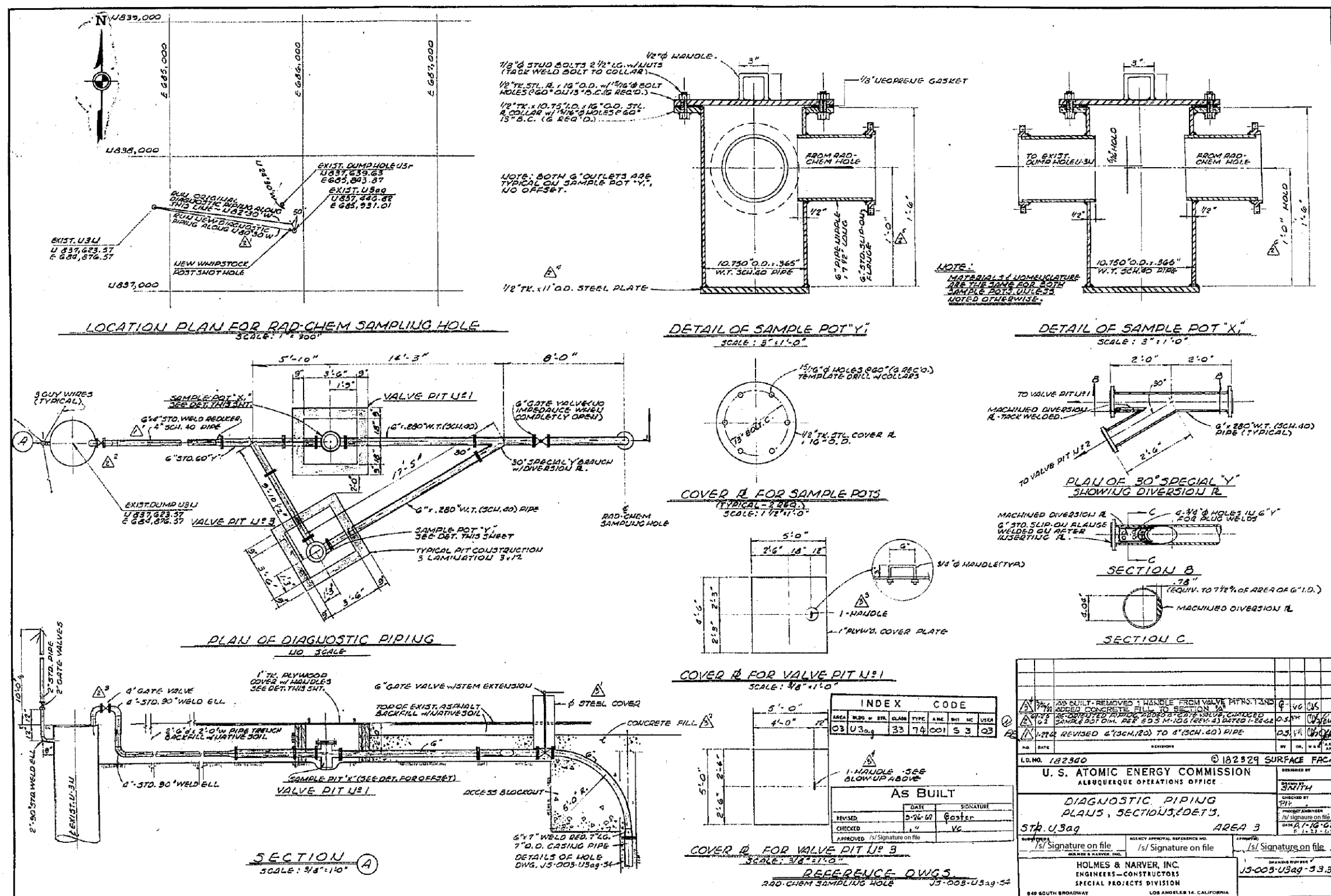


Figure 2-12
 SG2: Engineering Drawing for U2ag (Chinchilla)
 Source: H&N, 1962a

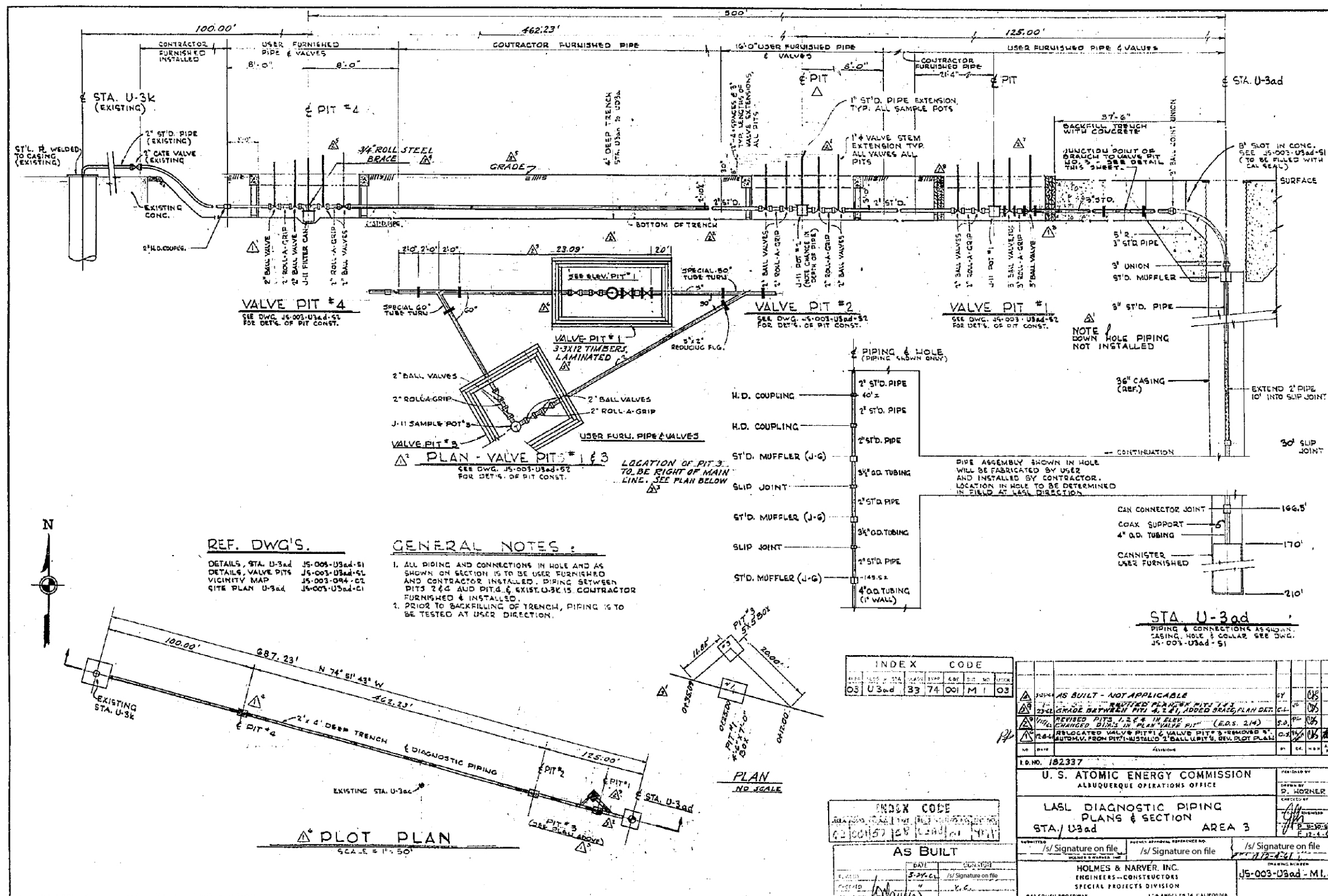


Figure 2-13
 SG2: Engineering Drawing for U3ad (Platypus)
 Source: H&N, 1961

2.2.2.3 CAS 09-99-08, U-9x (Allegheny) Subsurface Rad-Chem Piping

Figure 2-3 reflects the location of the release associated with CAS 09-99-08 within Area 8 of the NNSS. This CAS consists of consists of potential environmental surface and subsurface soil contamination from releases associated with the rad-chem sampling activities associated with the weapons-related test (Allegheny) conducted as part of Operation Storax in emplacement hole U9x on September 29, 1962. The emplacement hole was drilled between April 28 and September 6, 1962, with a depth of burial of -692 ft. U9x-1 was drilled between June 7 and September 9, 1962 (NNSA/NFO, 2015b). Figure 2-14 reflects the location of the emplacement hole (U9x) and the rad-chem hole (U9x-1).

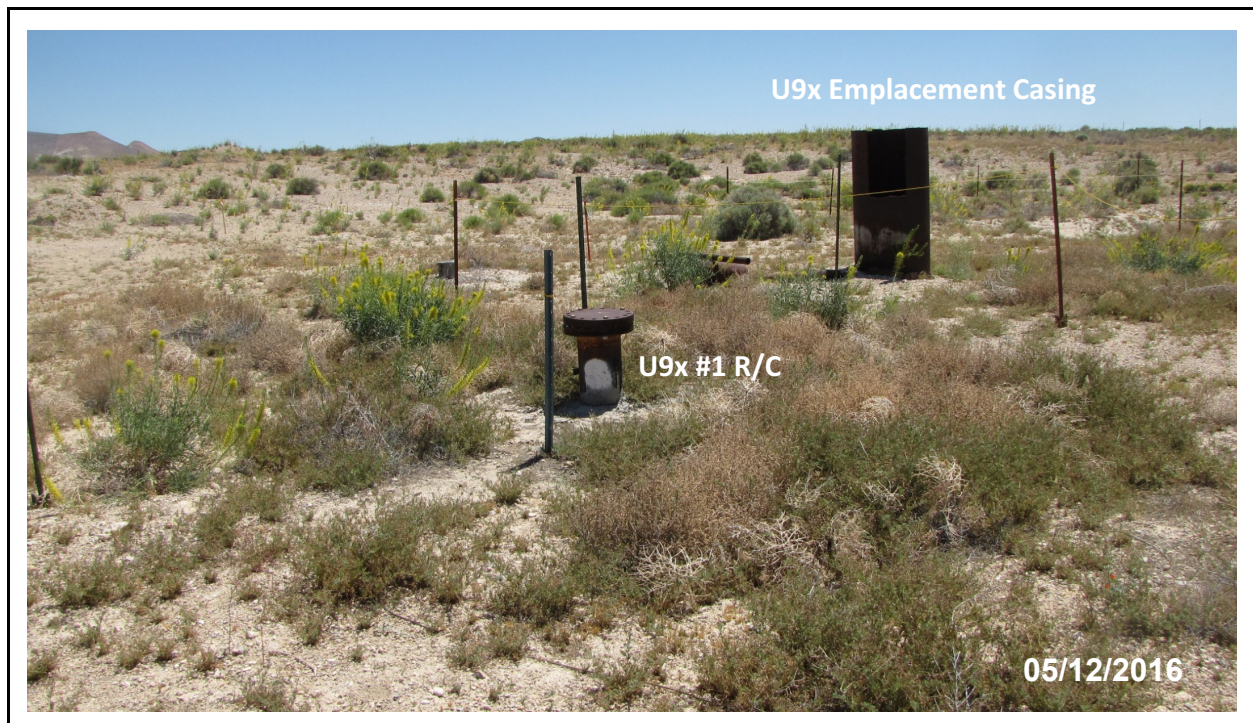


Figure 2-14
SG2: CAS 09-99-08, U9x (Allegheny) Subsurface Rad-Chem Piping,
Locations of U9x and U9x-1 Hole

Note: Photograph looking west.

Figure 2-15 generically reflects the layout of the Allegheny site and supplements the engineering drawing (Figure 2-16). According to the engineering drawing, "Prompt Sampler Rad-Chem Piping Layout," the subsurface piping extends 800 ft in a northeast direction from U9x-1 and, with the exception of the first 10 ft, the piping was placed in a 2-ft trench and covered with soil after

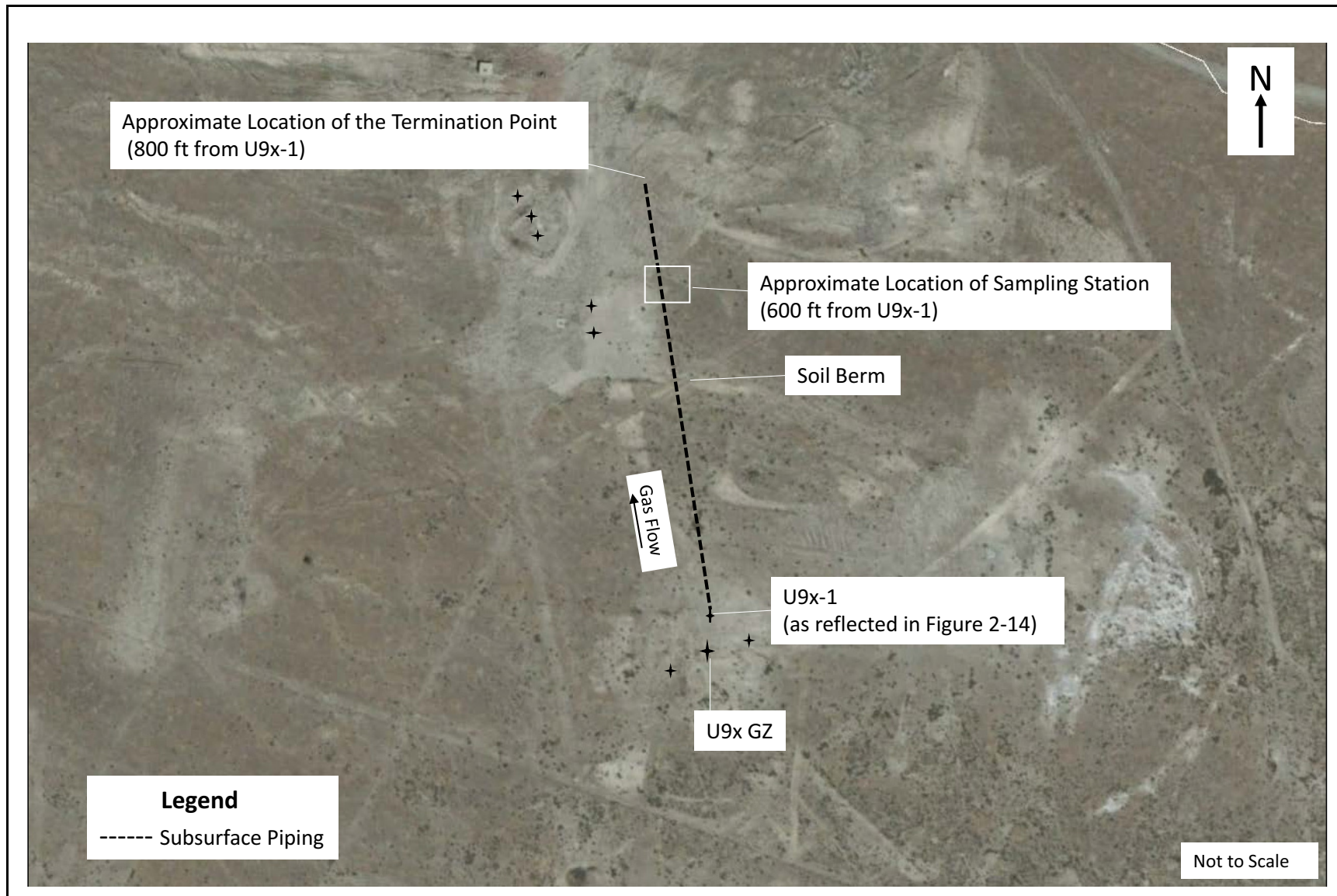


Figure 2-15
SG2: Layout of the U9x (Allegheny) Site

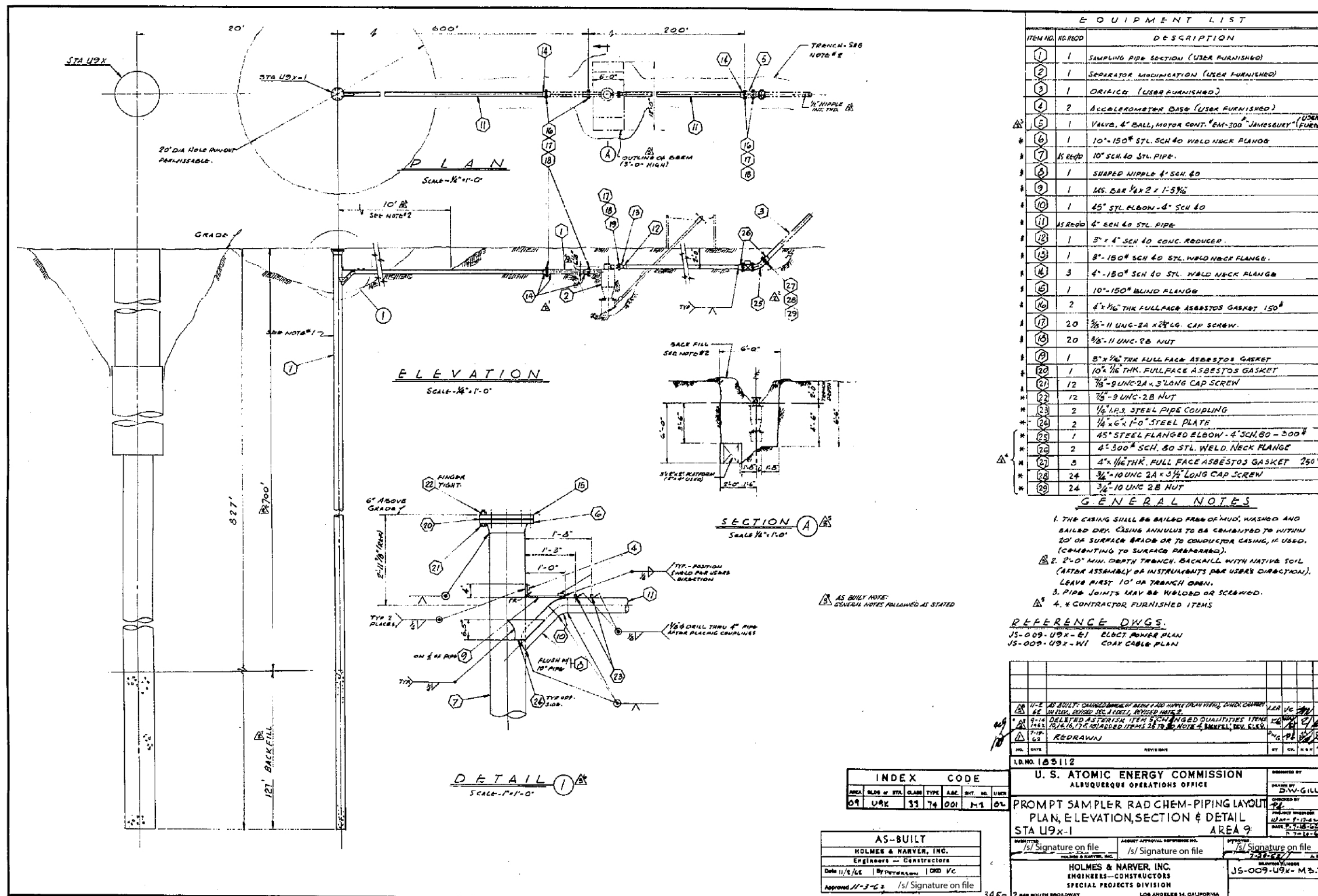


Figure 2-16
SG2: Engineering Drawing for U9x (Allegheny)
Source: H&N, 1962b

instrumentation was installed at a sampling station. The sampling station was located approximately 600 ft northeast from U9x-1 and was not identified during the site visit; however, after traversing a soil mound a clearing with a wooden structure and a corresponding depression was identified. From the sampling station, the piping extends approximately 200 ft northeast, where it terminates at the surface per the engineering drawing. The termination point of the U9x rad-chem pipe (exhaust pipe) was not identified during the site visit.

2.2.3 SG3 (Rad Waste Dump)

2.2.3.1 CAS 05-19-04, Frenchman Flat Rad Waste Dump

Figure 2-17 reflects the release location of the rad waste dump associated with CAS 05-19-04 within Area 5 of the NNSS. This CAS was identified during a review of a 1965 Frenchman Flat Quadrangle map, which noted a “radiological waste dump” (Poole, 1965). The “rad waste dump” is located on the northern edge of Frenchman Flat and was identified having surface soil contamination, scattered debris, and possible radiological waste. Radiological surveys and swipe samples identified removable contamination for an area approximately 30 by 30 ft (Figure 2-18). The area was posted as a CA, and there is currently no information available indicating the source of the release or whether anything is buried at the site.

2.2.4 SG4 (Debris)

2.2.4.1 CAS 00-99-01, Potential Source Material

CAS 00-99-01 consists of potential release of contaminants to the soil surface from legacy debris left behind from testing activities. The debris includes lead (bricks, sheets, shielding), lead-acid batteries, tower fragments, and radiologically elevated soil beneath two small drums. Debris with a potential to be PSM (indications of the presence of chemical or radiological contaminants) will be included in the scope of CAS 00-99-01. Currently identified debris is found within multiple areas of the NNSS that has the potential to leach contaminants into the environment (surface soil). It is believed that the debris is related to the testing in the area in which debris is located.

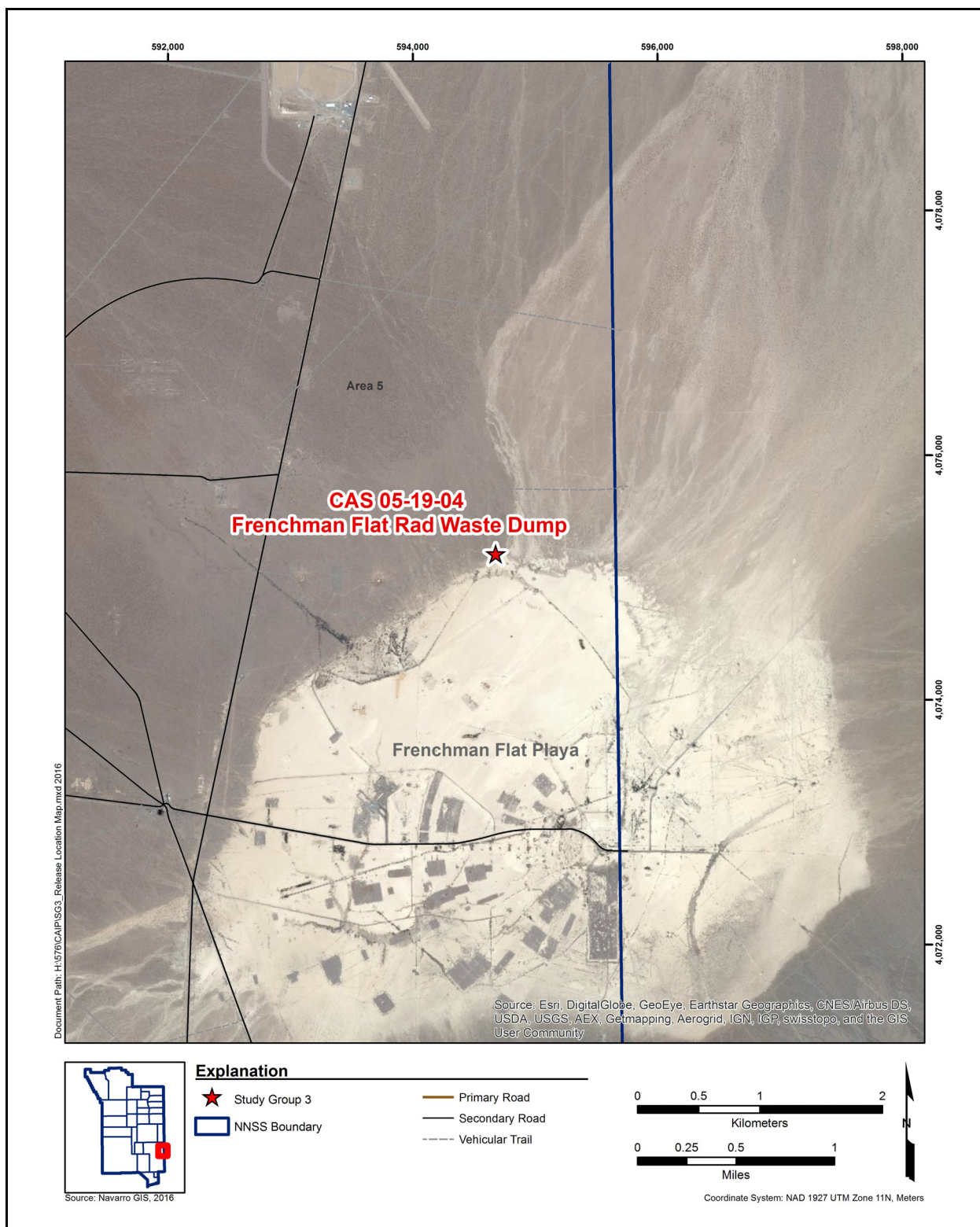


Figure 2-17
SG3: Release Location Map



Figure 2-18
SG3: CAS 05-19-04, Frenchman Flat Rad Waste Dump

Note: Photograph looking west.

Locations of debris (release locations) currently identified during the preliminary investigation of legacy piping are listed below and are shown on [Figure 2-19](#):

- Lead bricks around the U2af (Kennebec) site ([Figure 2-20](#); engineering drawing [[Figure 2-6](#)] reflects 275 lead bricks)
- Lead objects (bricks and lead sheet) near U2e (Cumberland) ([Figure 2-21](#))
- Tower debris near U3bk (Mataco) ([Figure 2-22](#))
- Lead object near U3bq (Anchovy) ([Figure 2-23](#))
- Battery with lead plates near U8b (Cyathus) ([Figure 2-24](#))
- Lead object near U8n (Kawich A-White) ([Figure 2-25](#))
- Lead brick near U9bb (Bunker) ([Figure 2-26](#))
- Radiologically elevated soil beneath two small drums near U9u (Raritan) (no photograph)

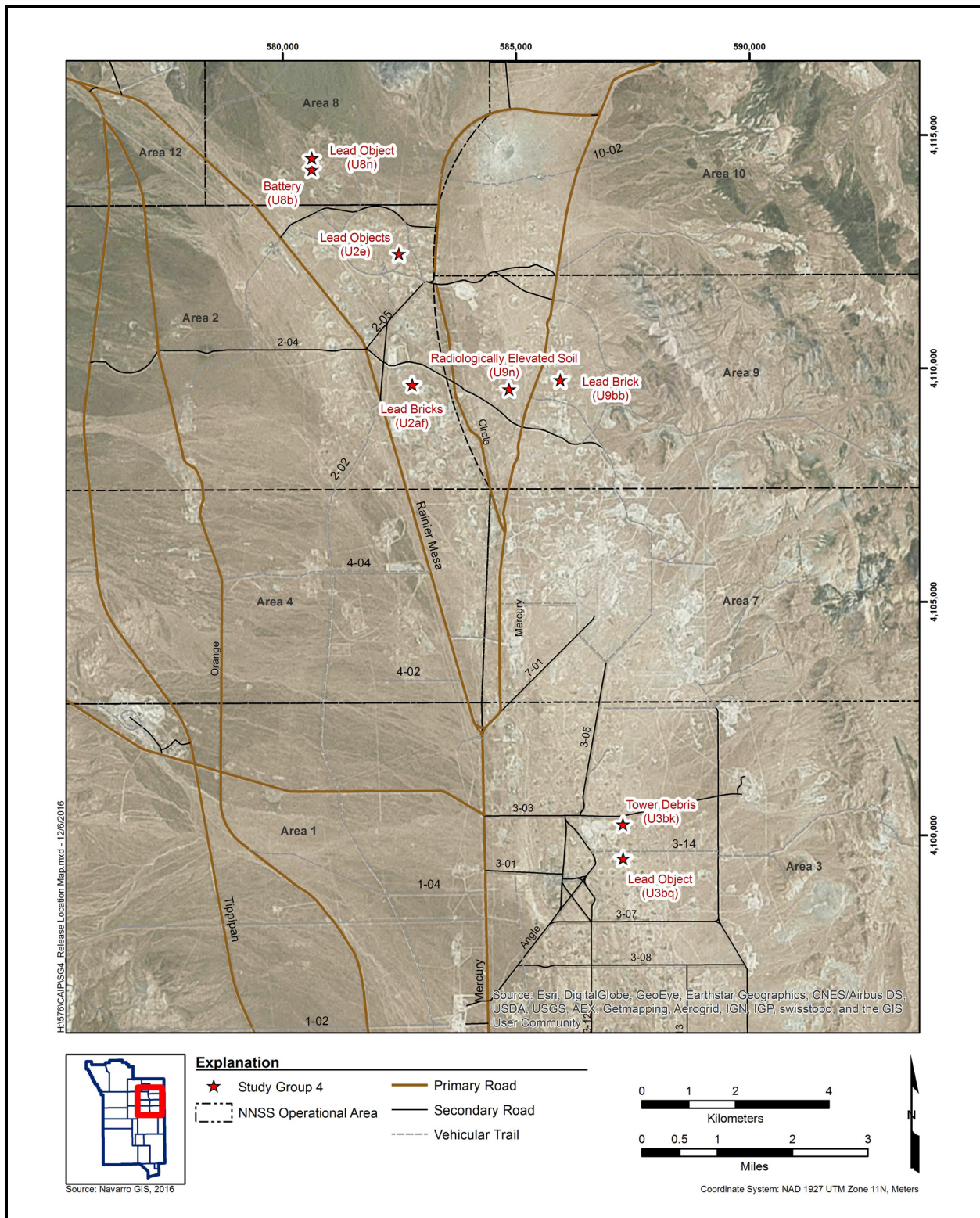


Figure 2-19
SG4: Release Location Map



Figure 2-20
SG4: CAS 00-99-01, Miscellaneous Potential Source Material Lead Bricks
around the U2af (Kennebec) Site



Figure 2-21
SG4: CAS 00-99-01, Miscellaneous Potential Source Material Lead Objects
(bricks and lead sheet) near the U2e (Cumberland) Site



Figure 2-22
SG4: CAS 00-99-01, Miscellaneous Potential Source Material Tower Debris
near the U3bk (Mataco) Site



Figure 2-23
SG4: CAS 00-99-01, Miscellaneous Potential Source Material Lead Object
near the U3bq (Anchovy) Site

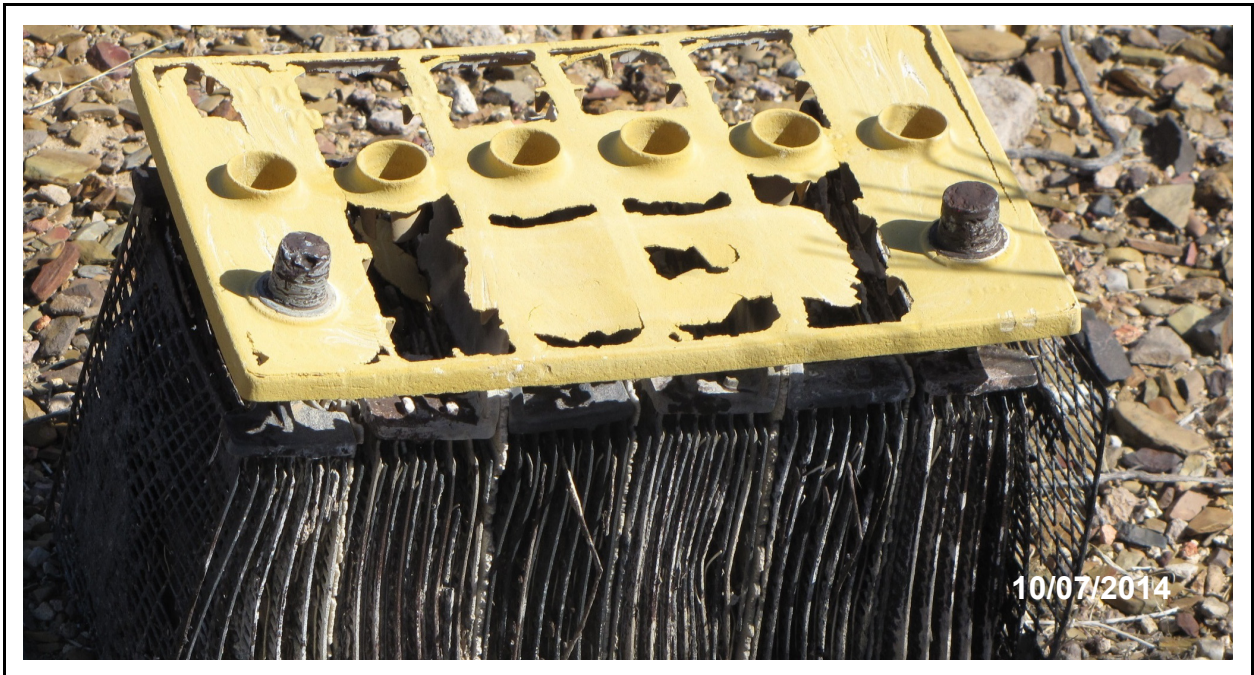


Figure 2-24
SG4: CAS 00-99-01, Miscellaneous Potential Source Material Battery with Lead Plates
near the U8b (Cyathus) Site



Figure 2-25
SG4: CAS 00-99-01, Miscellaneous Potential Source Material Lead Object
near the U8n (Kawich A-White) Site



Figure 2-26
SG4: CAS 00-99-01, Miscellaneous Potential Source Material Lead Brick
near the U9bb (Bunker) Site

2.3 Waste Inventory

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

2.3.1 SG1 (Surface Rad-Chem Piping)

2.3.1.1 CAS 09-99-09, U-9its u24 (Avens-Alkermes) Surface Contaminated Flex Line

Solid waste items identified at CAS 09-99-09 include the flex line and nozzles. Unknown volumes of fission products are potentially present within the flex line. Potential waste types include sanitary and radioactive wastes.

2.3.2 SG2 (Subsurface Rad-Chem Piping)

2.3.2.1 CAS 02-99-12, U-2af (Kennebec) Surface Rad-Chem Piping

Solid waste items identified at CAS 02-99-12 include piping and piping accessories (e.g., valves, hoses). Unknown volumes of fission products are potentially present within the surface components of the gas-sampling components (vault area, sampling assembly area and surface piping [joints]) as well as the soil surrounding the exhaust pipe. Potential waste types include sanitary and radioactive wastes. All waste types may be composed of debris and investigation-derived waste (IDW).

2.3.2.2 CAS 03-99-20, Area 3 Subsurface Rad-Chem Piping

Solid waste items identified at CAS 03-99-20 include rad-chem piping and piping accessories. Unknown volumes of fission products are potentially present within the rad-chem piping and sampling assembly, and in the underlying soil. Potential waste types include sanitary and radioactive wastes. All waste types may be composed of debris, IDW, decontamination liquids, and soil.

2.3.2.3 CAS 09-99-08, U-9x (Allegheny) Subsurface Rad-Chem Piping

Solid waste items identified at CAS 09-99-08 include rad-chem piping and piping accessories. Unknown volumes of fission products are potentially present within the subsurface piping, sampling assembly, and soil surrounding the exhaust pipe. Potential waste types include sanitary and radioactive wastes. All waste types may be composed of debris, IDW, decontamination liquids, and soil.

2.3.3 SG3 (Rad Waste Dump)

2.3.3.1 CAS 05-19-04, Frenchman Flat Rad Waste Dump

Solid waste items identified at CAS 05-19-04 include a small amount of scrap metal, and miscellaneous wood and wires. It is unknown whether any buried debris exists at this site. Waste types may include sanitary waste, *Resource Conservation and Recovery Act* (RCRA) hazardous waste, radioactive waste, and mixed waste.

2.3.4 SG4 (Debris)

2.3.4.1 CAS 00-99-01, Potential Source Material

Solid waste items identified at CAS 00-99-01 include lead objects (bricks, sheets, shielding), a battery with lead plates, tower debris, and radiologically elevated soil beneath two small drums. Additional wastes may include IDW, decontamination liquids, and contaminated soils. Potential waste types include industrial waste, RCRA hazardous waste, and low-level radioactive waste.

2.4 Release Information

Potential releases of contamination associated with CAU 576 are identified in [Table 1-2](#). They are directly or indirectly associated with underground nuclear tests conducted in the area and other NNSS operations. The investigation of specific releases at CAU 576 will depend upon the nature of these releases. Therefore, the releases at CAU 576 have been categorized into one of the study groups defined in [Section 1.1.2](#).

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

The following subsections contain study group-specific descriptions of known or suspected releases associated with CAU 576.

2.4.1 SG1 (Surface Rad-Chem Piping)

The release source specific to SG1 is currently contained within the surface flex line. The radioactive waste is associated with gas-sampling activities at Avens-Alkermes. It is believed the nozzle on the end of the flex line was connected to a trailer where gas-sampling data were collected. When the material comprising the flex line deteriorates, waste within the flex line will be released to the environment (surrounding soil). There is a potential for an external dose from the contaminants

within the line and for surface and/or shallow subsurface contamination from the radioactive waste if contaminants contained within the flex line are released.

2.4.2 SG2 (Subsurface Rad-Chem Piping)

The release source specific to SG2 is the potential release of radionuclides from the contained waste within subsurface piping at the Kennebec, Chinchilla, Platypus, and Allegheny sites. In addition, the Kennebec and Allegheny sites also include surface components from which radionuclides from testing activities may have been released to the underlying soil. There is potential for external dose from the contaminants within the piping when the subsurface piping fails. In addition, releases to the surrounding soil may have occurred from surface gas-sampling components and the venting of gases from the exhaust pipe during the weapons-related tests at the Kennebec and Allegheny sites.

2.4.3 SG3 (Rad Waste Dump)

The release source specific to SG3 is contaminated material that was released to the surface soil from wastes that were stored and/or disposed of at the site in the past, or contaminated material that is currently present on the surface or buried at the site.

2.4.4 SG4 (Debris)

The release source specific to SG4 is the release of contaminants to the soil from debris left behind from previous testing activities. There is the potential for chemical and radiological contamination of the surface soil from items such as lead (bricks, sheets, shielding), a battery with lead plates, tower debris (fragments), and radiologically elevated soil beneath two small drums.

2.5 Investigative Background

All previous investigation data are assessed in the planning phase to identify bias used in the selection of appropriate sampling locations. Results from the preliminary investigation radiation surveys are discussed in [Sections 2.5.1 through 2.5.8](#).

2.5.1 Legacy Piping Investigation

At NNSA/NFO request, a worksheet of more than 800 underground nuclear tests was compiled, and a comprehensive investigation for legacy (surface) piping (material left from underground nuclear weapons testing) ensued. The comprehensive search included a review of previous investigations, interviews, and historical engineering searches in OPTIX.

2.5.2 CAS 00-99-01, Potential Source Material

The debris sites of CAS 00-99-01 are located in various areas of the NNSS. No previous investigative results have been identified for the debris locations except for what was identified during the preliminary investigation activities, such as a lead brick in the northeast vault at the Kennebec site (Figure 2-6 reflects 275 lead bricks were used) and the radiologically elevated soil beneath two small rusted drums near Raritan (U9u) site. The results of the radiation surveys conducted at these two sites are as follows:

- *Lead brick in northeast vault at Kennebec (U2af) site:* approximately 17 times background using the field instrument for the detection of low-energy radiation (FIDLER) (background is 19,447 counts per minute [cpm])
- *Soil beneath two small rusted drums, near Raritan (U9u) site:* 0-alpha and 9,000-beta disintegrations per minute per 100 square centimeters (dpm/100cm²) using the NE Electra

2.5.3 CAS 09-99-08, U-9x (Allegheny) Subsurface Rad-Chem Piping

2.5.3.1 Surface Piping Preliminary Investigation

In 2014, a preliminary investigation was conducted at the Allegheny site. This effort included photographic documentation, visual inspections, and radiological surveys. Handheld radiological surveys (Bicron and Ludlum 44-10) identified above background readings (both alpha and beta radiation) around a drill hole casing. The RCT posted area around U9x-1 as a radioactive material area (RMA) (Figure 2-14). Cesium (Cs)-137 was identified as the primary isotope using the Canberra Inspector 1000.

2.5.4 CAS 09-99-09, U-9its u24 (Avens-Alkermes) Surface Contaminated Flex Line

2.5.4.1 Surface Piping Preliminary Investigation

In 2016, a preliminary investigation was conducted at the Area 9 “ITS” series of tests. Twenty-two sites were identified in Area 9 and investigated for surface piping. Surface piping (flex line, similar to hydraulic hose) was identified at the U9ITS U-24 (Avens-Alkermes) site. The flex line was observed coming up from the bulkhead and extending outside the fenced area for approximately 65 ft (Figure 2-2). The test at U9ITS U-24 was part of the Avens series, which was a simultaneous test at four separate holes: Avens-Alkermes (U9ITS U-24), Avens-Andorre (U9ITS T-28), Avens-Asmalte (U9ITS W-21), and Avens-Cream (U9ITS X-29) conducted on December 16, 1970. The U9ITS U-24 (Avens-Alkermes) site was the only location where surface piping (flex line) was identified.

The Avens-Alkermes site is located within a posted RMA just north of the Area 9 balloon pad (most notable: Hood and Charleston tests).

In 2016, a preliminary investigation was conducted at the Avens-Alkermes site, and hand-held radiological surveys (Ludlum 44-10, Electra, and Canberra Inspector 1000) identified readings above background. There were no alpha emitters, but beta was detected and the Canberra Inspector 1000 identified Cs-137 as the primary isotope.

2.5.5 CAS 02-99-12, U2af (Kennebec) Surface Rad-Chem Piping

2.5.5.1 Surface Piping Preliminary Investigation

In 2014, a preliminary field investigation was conducted at the Kennebec site. This effort included photographic documentation, visual inspections, and radiological surveys (various instruments Electra, Ludlum 44-10, Bicon, Inspector 1000). Elevated radiological readings were detected, using a FIDLER, around the surface gas-sampling components (vault area, sampling assembly area, surface pipe [joints]) and a soil mound at the end of the surface pipe (exhaust pipe section).

2.5.6 CAS 03-99-20, Area 3 Subsurface Rad-Chem Piping

During the investigation of CAU 547 and 568, two Area 3 subsurface rad-chem piping systems were identified in engineering drawings running from and Chinchilla to Bernalillo and Platypus to Colfax (Figures 2-12 and 2-13). Unlike Chinchilla and Platypus (weapons-related tests), Bernalillo and Colfax were safety experiments, and the surface features at Bernalillo and Colfax have been addressed under CAU 547 and CAU 568, respectively.

2.5.6.1 CAU 547 Investigation

The rad-chem sampling system for the Chinchilla test used hole U3n (Bernalillo) as the location to collect test gases. Surface features at Bernalillo were addressed under CAU 547. Per the CAU 547 Closure Report (CR) (NNSA/NSO, 2012b), loose piping, a collar, and a vertical vent pipe near Bernalillo (U3n) were removed and packaged as low-level radioactive waste. The exposed portion of the 4-in. pipe that entered the site from the east was also cut at the ground surface and capped.

2.5.6.2 CAU 568 Investigation

The rad-chem sampling system for the Platypus test used hole U3k (Colfax) as the location to collect test gases. Surface features at Colfax were addressed under CAU 568. According to the CAU 568 Corrective Action Plan (NNSA/NFO, 2016), a physical barrier (steel well head cover) will be installed over the Colfax safety experiment ground zero (GZ) to cover contamination. A FFACO use restriction (UR) with UR warning signs will be implemented and presented in the CAU 568 CR. The CAU 568 CR estimated completion date is June 17, 2017.

2.5.7 CAS 05-19-04, Frenchman Flat Rad Waste Dump

2.5.7.1 CAU 576 Investigation

Radiological (FIDLER) drive-over surveys were performed in August 2015, and the locations of elevated radiological readings were flagged. Subsequent removable contamination surveys identified removable contamination exceeding 20 dpm/100 cm². An area approximately 30 by 30 ft was posted as a CA.

2.5.8 National Environmental Policy Act

The *Final Site-Wide Environmental Impact Statement for the Continued Operation of the Department of Energy/National Nuclear Security Administration Nevada National Security Site and Off-Site Locations in the State of Nevada* (NNSA/NSO, 2013) includes site investigation activities such as those proposed for CAU 576.

In accordance with the NNSA/NFO *National Environmental Policy Act* (NEPA) Compliance Program, a NEPA checklist will be completed before beginning site investigation activities at CAU 576. This checklist requires NNSA/NFO activity personnel to evaluate their proposed activities against a list of potential impacts that include, but are not limited to, air quality, chemical use, waste generation, noise level, and land use. Completion of the checklist results in a determination of the appropriate level of NEPA documentation by the NNSA/NFO NEPA Compliance Officer. This will be accomplished before mobilization for the field investigation.

3.0 Objectives

This section presents an overview of the DQOs for CAU 576 and formulation of the CSM. Also presented is a summary listing of the contaminants of potential concern (COPCs), the preliminary action levels (PALs), and the process used to establish FALs. Additional details and figures depicting the CSM are located in [Appendix A](#).

3.1 Conceptual Site Model

The CSM describes the most probable scenario for current conditions at each site and defines the assumptions that are the basis for identifying the future land use, contaminant sources, release mechanisms, migration pathways, exposure points, and exposure routes. The CSM was used to develop appropriate sampling strategies and data collection methods. The CSM was developed for CAU 576 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 soil and COPCs. [Figure A.2-1](#) depicts a representation of the conceptual pathways to receptors from CAU 576 sources. [Figure A.2-2](#) 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 field conditions may be reviewed; the CSM may be revised; the DQOs may be reassessed; and a recommendation may be made as to how best to proceed. In such cases, decision makers listed in [Section A.2.1](#) will be notified and given the opportunity to comment on and/or concur with the recommendation.

The following subsections discuss future land use and the identification of exposure pathways (i.e., combination of source, release, migration, exposure point, and receptor exposure route) for CAU 576.

3.1.1 *Land-Use and Exposure Scenarios*

Land-use zones where the CAU 576 sites are located dictate future land use, and restrict current and future land use to nonresidential (i.e., industrial) activities. Exposure scenarios for the CAU 576 sites have been categorized into the following three types based on current and projected future land uses:

- **Industrial Area.** This scenario is based on industrial workers at established work facilities where the worker has a permanent assigned work area. This scenario assumes the worker will be on the site for an entire career (8 hours per day [hr/day], 250 days per year [day/yr], for 25 years). The industrial worker is assumed to spend 1/3 of the workday outdoors exposed to contaminated soil. The annual exposure time using this exposure scenario is 2,000 hours.
- **Remote Work Area.** This exposure scenario has the same basis as the Industrial Area scenario except that the industrial worker is not present at the work site for the entire year. This scenario assumes that the Remote Work Area has established work facilities where the worker regularly visits but is not a permanent assigned work area. A site worker under this scenario is assumed to be at the site for an equivalent of 8 hr/day, 42 day/yr, for 25 years. The industrial worker is assumed to spend 1/3 of the workday outdoors exposed to contaminated soil. The annual exposure time using this exposure scenario is 336 hours.
- **Occasional Use Area.** This scenario is based on industrial workers at locations where there are no established work facilities in an area where the worker does not regularly visit but may occasionally use for short-term activities. This scenario assumes the worker will be on the site for an equivalent of 80 hours per year (hr/yr) (or 10 day/yr) for 5 years. The industrial worker is assumed to spend the entire workday outdoors exposed to contaminated soil. The annual exposure time using this exposure scenario is 80 hours.

The Avens-Alkermes release site (SG1); Kennebec, Chinchilla, Platypus, and Allegheny release sites (SG2); and PSM release sites (SG 4) are located in the “Nuclear and High Explosives Test Zone” within the NNSS. This area is designated for additional underground nuclear weapons tests and outdoor high-explosive tests. This zone includes compatible defense and nondefense research, development, and testing activities; and is reserved for dynamic experiments, hydrodynamic tests, and underground nuclear weapons and weapons-effects tests (NNSA/NSO, 2013).

The Rad Waste Dump release site (SG3) is located in the land-use zone described as the “Research, Test, and Experiment Zone.” This area is designated for small-scale research and development projects and demonstrations; pilot projects; outdoor tests; and experiments for the development, QA, or reliability of material and equipment under controlled conditions. This zone includes compatible research, development, and testing activities (NNSA/NSO, 2013).

The CAU 576 land-use zones and exposure scenarios are based on current and potential future land uses at the NNSS. CAU 576 is a remote location without any site improvements and where no regular work is performed. There is still the possibility, however, that site workers could occupy these locations on an occasional and temporary basis such as a military exercise. Therefore, this site is classified as an Occasional Use Area.

3.1.2 Contaminant Sources

Contaminant sources for most of the CAU 576 CASs are the releases identified in [Section 2.4](#) as radiological and chemical contamination to the soil as a result of rad-chem sampling activities and PSM. However, the source of contamination for the Area 5 Rad Waste Dump is unknown.

3.1.3 Release Mechanisms

The release mechanisms are discussed in the following subsections by study group.

3.1.3.1 SG1 (Surface Rad-Chem Piping)

The release mechanism for SG1, Avens-Alkermes, is associated with a gas-sampling flex line used to carry the gases and particulates for radiochemical analysis. Approximately 65 m of the flex line is currently lying on the ground surface outside the fenced SGZ, and waste contained within the flex line will be released to the environment (surface soil) upon degradation (deterioration) of the line. There is also a potential of a surface release from the connection nozzles from the end of the line.

3.1.3.2 SG2 (Subsurface Rad-Chem Piping)

The release mechanism for SG2 is associated with gas-sampling activities. There is radioactive waste contained within subsurface piping at the Kennebec, Chinchilla, Platypus, and Allegheny release sites. In addition, radionuclide releases may have occurred from surface gas-sampling components and the venting of gases from the exhaust pipe during the weapons-related tests at the Kennebec and Allegheny sites.

- The release mechanism for Kennebec consists of the release of radionuclides from subsurface rad-chem piping and surface gas-sampling components, and the exhaust pipe where gases vented to the surrounding soil. Kennebec was a weapons-related test, and it is expected that

when containment fails, the waste within subsurface piping will be released to the environment (surrounding soil). In addition, elevated radiological activity has been identified at the surface gas-sampling components such as the vaults, sampling assembly, surface piping (joints), and the soil where the exhaust pipe vented (Figures 2-4 through 2-6).

- The release mechanism for Chinchilla and Platypus sites consist of the release of radionuclides from subsurface rad-chem sampling activities. Two subsurface rad-chem sampling systems have been identified in Area 3. The first system is Platypus (U3ad), which vented into Colfax (U3k); and the second system is Chinchilla (U3ag), which vented into Bernalillo (U3n). Both tests were weapons-related tests, and it is expected that the when containment fails, the waste within the subsurface piping will be released to the environment (surrounding soil [Figures 2-11 through 2-13]).
- The release mechanism for Allegheny consists of the release of radionuclides from subsurface rad-chem piping and surface components such as the sampling assembly and exhaust pipe. Allegheny was a weapons-related test, and it is expected that when containment fails, the waste within subsurface piping will be released to the environment (surrounding soil), as well as to the soils surrounding the sampling assembly area and the soils surrounding where the exhaust pipe vented (Figures 2-15 and 2-16).

3.1.3.3 SG3 (Rad Waste Dump)

The release mechanism for SG3, Rad Waste Dump, is either from the release of contaminants into adjacent soil from waste that was stored on the surface and then removed, or the release of contaminants into adjacent soil from waste that is currently buried at the site. The site was identified as a “rad waste dump,” and elevated radioactivity as well as removable contamination has been identified.

3.1.3.4 SG4 (Debris)

The release mechanism for SG4, PSM, consists of potential releases of chemical or radiological contaminants to the soil beneath or surrounding the debris.

3.1.4 Migration Pathways

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

Surface migration pathways for CAU 576 include lateral migration of potential contaminants across surface soils since original deposition. CASs are located in Yucca Flat and Frenchman Flat playa (dry) lake bed. No major washes were identified at CAU 576; however, minor drainage channels were identified around the Area 2 site (U2af, Kennebec). Additional visual surveys will be conducted during the CAI to identify any other drainages. For Yucca Flat, drainage flows toward and into the Yucca Flat dry lake. Drainages entering Frenchman Flat playa are generally dry but are subject to infrequent precipitation events; however, when Frenchman Flat playa is inundated, contamination on the typically dry surface may become submerged, allowing water-soil interactions that could provide a mechanism for transport away from the known area of contamination (Hershey et al., 2013). Other migration pathways for contamination are wind-borne material and material displaced during road construction and maintenance activities.

Migration is influenced by physical and chemical characteristics of the contaminants and soil. Contaminant characteristics include, but are not limited to, solubility, density, and adsorption potential. Soil characteristics include permeability, porosity, water-holding capacity, sorting, chemical composition, and organic content. In general, contaminants with low solubility, high affinity for soil, and high density can be expected to be found relatively close to release points. Contaminants with high solubility, low affinity for soil, and low density can be expected to be found farther from release points. These factors affect the migration pathways and potential exposure points for the contaminants in the various soil 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 Radioactive Waste Management Site (RWMS) and Area 5 Radioactive Waste Management Complex (RWMC) has been estimated at 62 and 66 in., respectively (Yucel, 2009; BN, 2001); and limited precipitation for these regions at 6.3 and 4.9 inches per year (in./yr), respectively (Soulé, 2006; USGS/DOE, 2016)—percolation of infiltrated precipitation at the NNSS does not provide a significant mechanism for vertical migration of contaminants to groundwater (DOE/NV, 1992).

Subsurface migration pathways at CAU 576 are expected to be predominately vertical, although spills or leaks at the ground surface may also have limited lateral migration before infiltration. The depth of infiltration (shape of the subsurface contaminant plume) will be dependent upon the type, volume,

and duration of the discharge as well as the presence of relatively impermeable layers that could modify vertical or lateral transport pathways, both on the ground surface (e.g., concrete) and in the subsurface (e.g., calcrete or other indurated layers). For surface contamination to reach the water table, the contaminants would have to be dissolved in infiltrating precipitation and then be transported through the vadose zone alluvium, which extends the entire unsaturated thickness of approximately 1,600 ft at Well ER-3-2 (Yucca Flat [USGS/DOE, 2016]) and 600 ft at the Frenchman Flat playa (Hevesi et al., 2003).

3.1.4.1 SG1 (Surface Rad-Chem Piping)

Surface migration pathways at this study group may include lateral migration of potential contaminants across surface soils and vertical migration of potential contaminants into the subsurface soils. No major washes were identified in Area 9; however, runoff from a major storm event can cause a drainage channel to incise. Additional visual inspections will be conducted during the CAI to identify any potential (current or past) drainage channels at the U9ITS U-24 (Avens-Alkermes) site. Other migration pathways for contamination are wind-borne material, and material displaced during road construction and maintenance activities.

3.1.4.2 SG2 (Subsurface Rad-Chem Piping)

Surface migration pathways at this study group may include lateral migration of potential contaminants across surface soils and vertical migration of potential contaminants into the subsurface soils. No major washes were identified in Areas 2, 3, and 9; runoff from a major storm event can cause a drainage channel to incise. Additional visual inspections will be conducted during the CAI to identify any potential (current or past) drainage channels at the SG2 sites. Other migration pathways for contamination are wind-borne material, and material displaced during road construction and maintenance activities.

3.1.4.3 SG3 (Rad Waste Dump)

At the Frenchman Flat Rad Waste Dump, surface migration pathways include the lateral migration of potential contaminants across surface soils into ephemeral drainages transecting the site. The ephemeral drainages entering and leaving this area are generally dry, but are subject to infrequent flows in response to storm events. These storm events may provide an intermittent mechanism for

both vertical (infiltration) and lateral transport of contaminants. Contaminants may be transported into the vadose zone by infiltration. Contaminated sediments entrained by the runoff events would be carried by the streamflow to and be deposited on the surface of the Frenchman Flat playa.

3.1.4.4 SG4 (Debris)

Surface migration pathways at this study group may include lateral migration of potential contaminants across surface soils and vertical migration of potential contaminants into the subsurface soils. Runoff from a major storm event could cause a drainage channel to incise, and flows may transport contaminated material away from the site or contaminants may be transported into the vadose zone by infiltration within the channel. Additional visual inspections will be conducted during the CAI.

3.1.5 Exposure Points

Exposure points for the CSM are expected to be areas of surface contamination where visitors and site workers may come in contact with contaminated surface soil. Subsurface exposure points may exist if construction workers come in contact with contaminated soil 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 soil. 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, and infrastructure at the CAU 576 sites is presented in [Section 2.0](#) 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 drainage channels may be identified based on a

comparison of historical photographs and visual inspections where erosion and deposition have occurred within the washes.

3.2 Contaminants of Potential Concern

The COPCs for CAU 576 are defined as the contaminants reasonably expected at the site that could contribute to a dose or risk exceeding FALs. Based on the nature of the releases identified in [Section 2.4](#) and previous investigation results presented in [Section 2.5](#), the COPCs at CAU 576 are as follows:

- *SG1 and SG2, weapons-related test releases (Avens-Alkermes, Kennebec, Chinchilla, Platypus, and Allegheny):* Cs-137
- *SG3, Frenchman Flat Rad Waste Dump:* Cs-137, europium (Eu)-152, -154, and -155; uranium (U)-234, -238, and -235; plutonium (Pu)-238, -239/240, and -241; and americium (Am)-241.
- *SG4, PSM:* metallic lead and the radionuclides Cs-137; Eu-152, -154, and -155; U-234, -235, and -238; Pu-238, -239/240, and -241; and Am-241, if radiological activity is detected above background.

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

The COPC for SG1 and SG2 (the sample groups associated with gas sampling systems from underground nuclear tests) is Cs-137. This was determined based on process knowledge and the evaluation of analytical data. Finnegan et al. (2016) and Bowen et al. (2001) address the distribution of radionuclides in an underground test, as follows:

“Immediately after a nuclear explosion, all of the radioactive species exist as a plasma. As the cavity ceases to expand, heat is transferred to the wall rock and the cavity temperature and pressure begin to drop. The melt that flows to the floor of the cavity entrains the refractory radionuclides with higher boiling points (rare earth elements, alkaline earths, Zr, and Pu). Most of these refractory species are trapped in the cooling melt; a small proportion is incorporated with the collapsed chimney rubble as splash or

fine droplets entrained with escaping cavity gases. Volatile species with lower boiling points (tritium, alkalis, Ru, U, Sb, Cl, I) circulate up cracks in the rubble chimney. Activation products are concentrated around the working point and will be largely incorporated in the melt or debris that borders the cavity. Volatile species, particularly Kr-90 and Xe-137, are transported as gases through the rubble and will be concentrated higher in the cavity and in the chimney relative to the refractory radionuclides.”

Therefore, the expected radionuclides in the gas sampling system are Cs-137 and strontium (Sr)-90 (the daughter products of krypton [Kr]-90 and xenon [Xe]-137). While it is possible that Sr/yttrium (Y)-90 could be present in activities equivalent to Cs-137, Cs-137 provides approximately 100 times more dose than Sr/Y-90 and is the predominant dose contributor based on the modeled exposure scenario. This is shown in the evaluation of analytical results from 14 nuclear test sites as shown in [Figure 3-1](#).

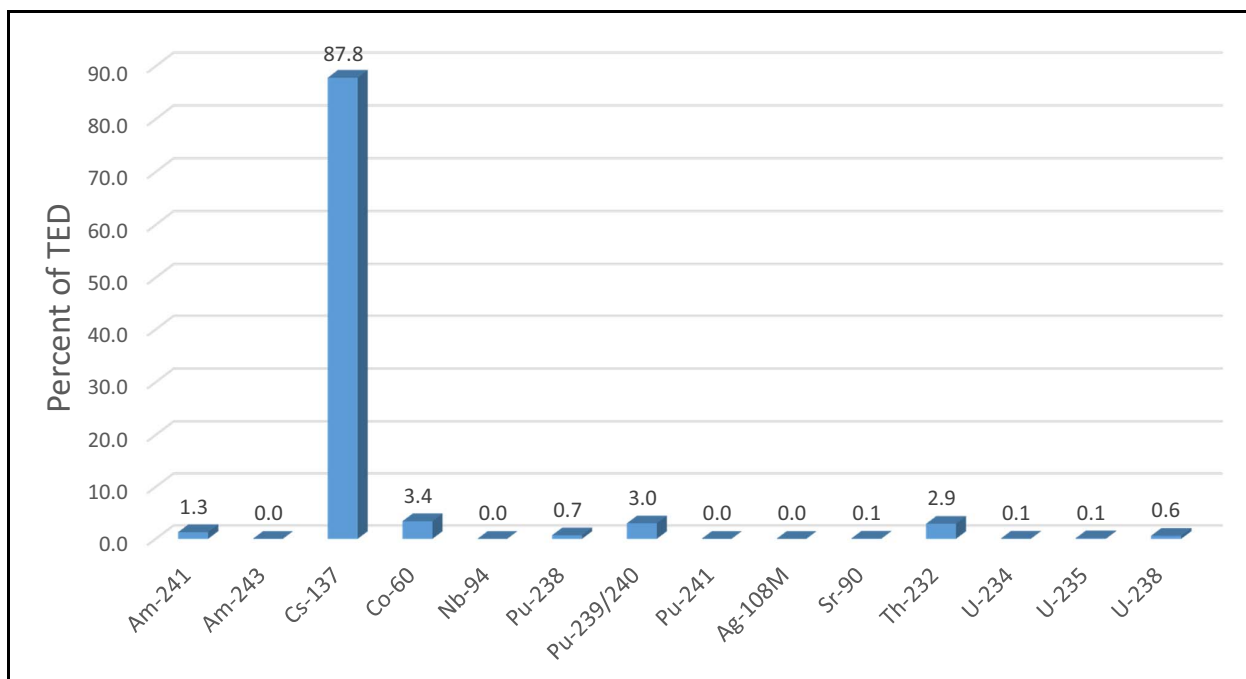


Figure 3-1
Contribution to Dose from 14 Fission Releases
Note: Excluding soil activation products.

Also evaluated were the analytical results from two underground nuclear tests that vented gases to the surface as shown in [Figure 3-2](#). This shows that Cs-137, as presented in the CAU 576 DQOs, is the only significant dose contributor expected in the underground test gas sampling systems.

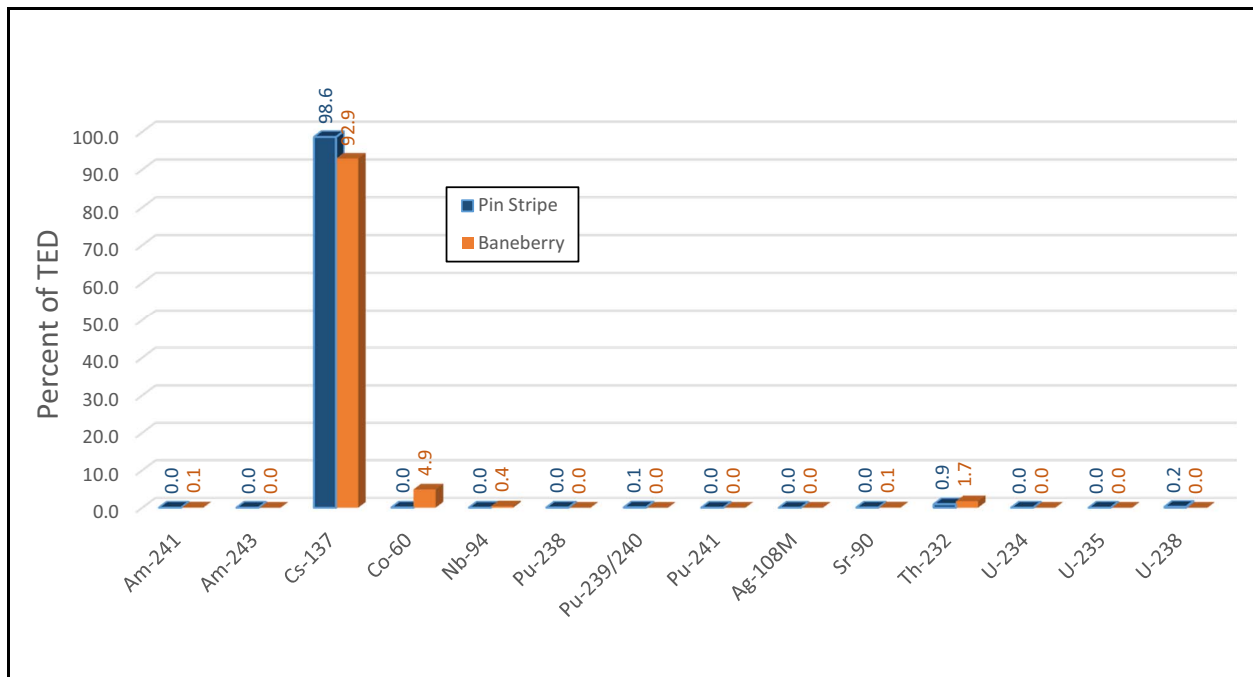


Figure 3-2
Contribution to Dose from 2 Venting Releases

Note: Excluding soil activation products.

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

3.3 Preliminary Action Levels

The PALs presented in this section are to be used for site screening purposes and are not necessarily intended to be used as cleanup action levels or FALs. However, the PALs are useful in screening out contaminants that are not present in sufficient concentrations to warrant further evaluation, thereby streamlining the consideration of remedial alternatives. The RBCA process used to establish FALs is described in the Soils RBCA document (NNSA/NFO, 2014). This process conforms with *Nevada Administrative Code* (NAC) 445A.227, which lists the requirements for sites with soil contamination (NAC, 2015a). For the evaluation of corrective actions, NAC 445A.22705 (NAC, 2015b) requires the use of ASTM International (ASTM) Method E1739 (ASTM, 1995) to “conduct an evaluation of the site, based on the risk it poses to public health and the environment, to determine the necessary

remediation standards or to establish that corrective action is not necessary.” For the evaluation of corrective actions, the FALs are established as the necessary remedial standard.

This RBCA process, summarized in [Figure 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.
- **Tier 2 evaluation.** Conducted by calculating Tier 2 action levels using site-specific information as inputs to the same or similar methodology used to calculate Tier 1 action levels. The Tier 2 action levels are then compared to individual sample results from reasonable points of exposure (as opposed to the source areas as is done in Tier 1) on a point-by-point basis. Results from total petroleum hydrocarbons (TPH) analyses will not be used for risk-based decisions under Tier 2 or Tier 3. Rather, the individual chemical constituents of petroleum products reported from volatile organic compound (VOC) and semivolatile organic compound (SVOC) analyses will be compared to the action levels.
- **Tier 3 evaluation.** Conducted by calculating Tier 3 action levels on the basis of more sophisticated risk analyses using methodologies described in Method E1739 that consider site-, pathway-, and receptor-specific parameters.

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

If, after implementation of corrective actions, contamination remains in place that is less than the site-specific exposure scenario based FAL but exceeds 25 millirem per year (mrem/yr) based on the Industrial Area exposure scenario, an administrative UR 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 PALs and site-specific exposure scenario based FALs. The FALs (along with the basis for their selection) will be proposed in the CADD, as well as be compared to laboratory results in the evaluation of potential corrective actions.

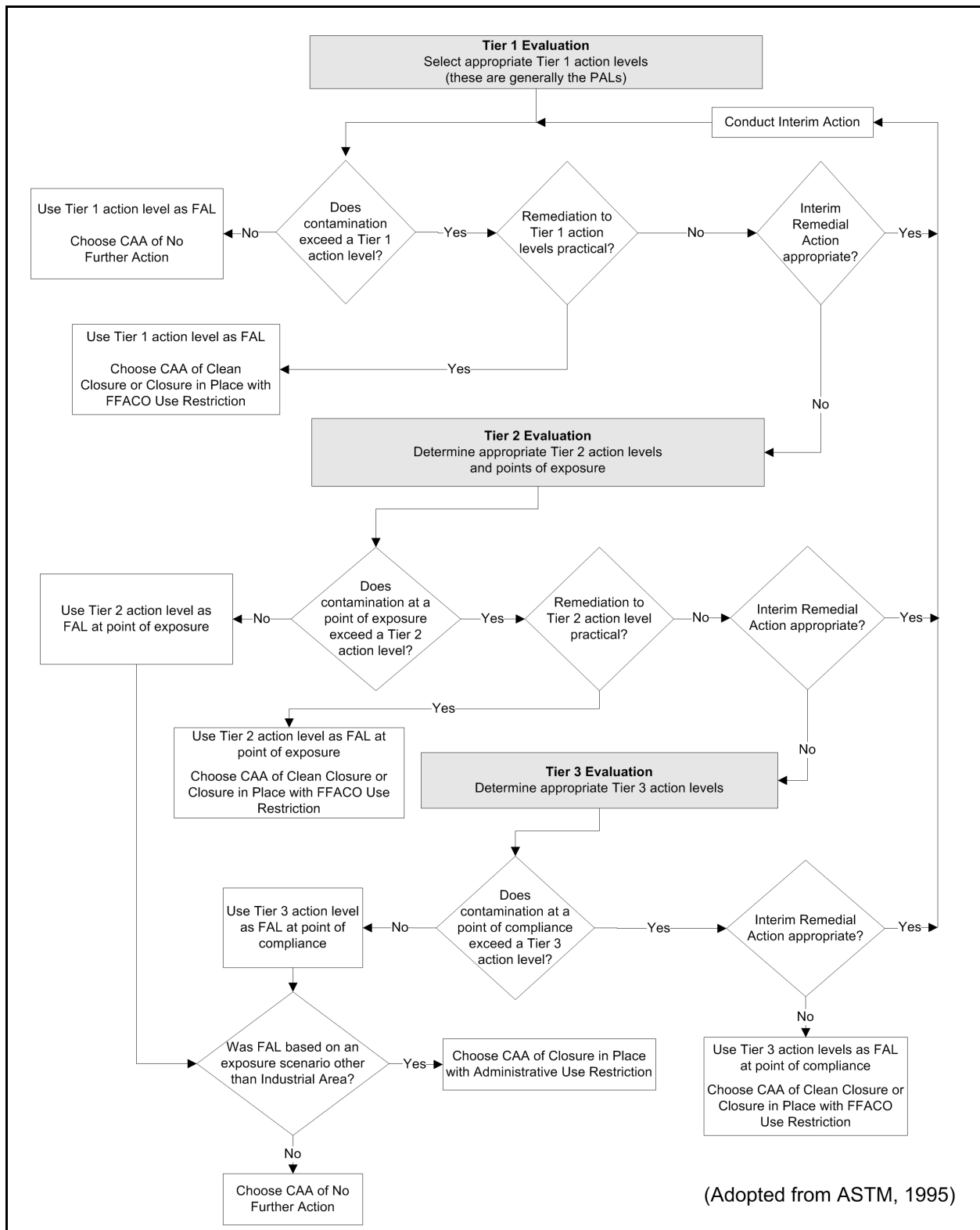


Figure 3-3
RBCA Decision Process

3.3.1 Chemical PALs

Except as noted herein, the chemical PALs are defined as the U.S. Environmental Protection Agency (EPA) Region 9 Regional Screening Levels for chemical contaminants in industrial soils (EPA, 2016). Background concentrations for RCRA metals will be used instead of screening levels when natural background concentrations exceed the screening level, as is often the case with arsenic on the NNSS. Background is considered the mean plus two standard deviations of the mean for sediment samples collected by the Nevada Bureau of Mines and Geology throughout the 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 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 a total effective dose (TED) of 25 mrem/yr, based upon the Industrial Area exposure scenario. The Industrial Area exposure scenario is described in Soils RBCA document (NNSA/NFO, 2014). The TED is calculated as the sum of external dose and internal dose. External dose is determined directly from TLD measurements. Internal dose is determined by comparing analytical results from soil samples to residual radioactive material guidelines (RRMGs) that were established using the RESRAD computer code (Yu et al., 2001). RRMGs are radionuclide-specific values for radioactivity in surface soils. The RRMG is the value, in picocuries per gram of surface soil, for a particular radionuclide that would result in an internal dose of 25 mrem/yr to a receptor (under the appropriate exposure scenario) independent of any other radionuclide (assuming that no other radionuclides contribute dose). The RRMGs are presented in the Soils RBCA document (NNSA/NFO, 2014).

In the RESRAD calculation, several input parameters are not specified so that site-specific information can be used. The default and site-specific input parameters used in the RESRAD calculation of RRMGs for each exposure scenario are listed in the Soils RBCA document.

3.4 DQO Process Discussion

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

As presented in [Section 1.1.2](#), the DQOs address two types of potential contaminant release types. SG3 will be investigated through a combination of probabilistic and judgmental sampling; SG1, SG2, and SG4 will be investigated through judgmental sampling.

The DQO strategy for CAU 576 was developed at a meeting on June 14, 2016. DQOs were developed to identify data needs, to 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 576 is as follows: “Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs in CAU 576.” To address this problem statement, resolution of the following decision statements is required:

- **Decision I.** “Is any COC present in environmental soil 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 following:
 - The lateral and vertical extent of COC contamination
 - The information needed to determine potential remediation waste types
 - The information needed to evaluate the feasibility of remediation alternatives

A corrective action will be determined for any release site containing a COC. The evaluation of the need for a corrective action will include the potential for wastes that are present at the site to contain contaminants that, if released, could cause the surrounding environmental soil to contain COCs. Such a waste will be evaluated using the PSM criteria listed in the Soils RBCA document (NNSA/NFO, 2014) to determine the need for corrective action.

The informational inputs and data required to resolve the problem and decision statements were generated as part of the DQO process for this CAU and are documented in [Appendix A](#). The information necessary to resolve the DQO decisions will be generated for each CAU 576 CAS by collecting and analyzing samples generated during a field investigation. The presence of a COC will be determined by collecting and analyzing samples from locations determined most likely to contain a COC (based on the presence of a biasing factor).

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

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

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

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

For the laboratory data, the data quality indicators (DQIs) of precision, accuracy, representativeness, comparability, completeness, and sensitivity needed to satisfy DQO requirements are discussed in the Soils QAP, see [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. Proposed actions to resolve DQO decisions are presented in [Section A.8.0](#).

4.0 Field Investigation

This section contains a description of the activities to be conducted to gather and document information from the CAU 576 field investigation.

4.1 Technical Approach

The information necessary to satisfy the DQO data needs will be generated for CAU 576 by collecting and analyzing samples collected during a field investigation. The presence and nature of COCs (Decision I) will be a judgmental decision determined using sample results from biased locations. Although sample plot locations will be selected judgmentally, each Decision I sample plot will generate a probabilistic value that represents the population of doses within the 100-square-meter (m²) area of the sample plot. This representative value will be determined using probabilistic sampling design to generate a 95 percent UCL of the average TED within the plot area as described in the Soils RBCA document (NNSA/NFO, 2014). For grab samples, DQO decisions will be based on a direct comparison of sample results to the FAL.

The extent of COC contamination portion of the Decision II will be resolved using one of the methods listed in [Section A.4.1](#).

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

4.2 Field Activities

Field activities at CAU 576 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 (HWAAs) and site exclusion zones; providing sanitary facilities; constructing decontamination facilities; and moving staged equipment.

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

- Perform radiological surveys to identify bias used in selecting sample locations.
- Install activity-specific environmental monitoring TLDs (see [Section 4.2.3](#) for additional information).
- Perform visual inspections at all sites within CAU 576 to identify any staining, discoloration, disturbance of native soils, or any other indication of potential contamination.

4.2.2 Sample Collection

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

The sampling strategy and the estimated locations of biased samples are presented in [Appendix A](#).

Biasing factors will be used to select the most appropriate sample locations, and as they are identified and used for selection of sampling locations, they will be documented.

The number, location, and spacing of step-outs may be modified as warranted by site conditions to achieve DQO criteria stipulated in [Appendix A](#). Where sampling locations are modified beyond the criteria specified in the DQOs, the justification for these modifications will be documented in the CADD.

The CAU 576 sampling program will consist of the following activities:

- Collect soil samples from locations as described in [Sections 4.2.2.1 to 4.2.2.4](#).
- Collect required QC samples.
- Collect waste management samples as necessary.
- Collect external dose measurements by hanging TLDs at the sample plots or extent locations.
- Record Global Positioning System (GPS) coordinates for each environmental sample location.

4.2.2.1 SG1 (Surface Rad-Chem Piping)

Three Decision I bias ISOCS sampling locations will be determined by the highest radiation survey values from along the length of the flex line. ISOCS results will be used to estimate the presence and activity of radionuclides within the piping and to determine whether dose could exceed FAL at the time when the containment afforded by the piping fails. A single TLD will be placed in the area of the highest radiation survey measurement (using the NE Electra) to determine whether external dose exceeds the FAL.

For Decision I, a grab soil sample will be collected at the end of the piping (nozzle) and submitted for gamma spectroscopy; and isotopic U, Pu, and Am analyses (to verify the CSM). Decision II will be resolved as the physical extent of the piping, and results from the ISOCS will also be used to determine potential corrective action waste types.

4.2.2.2 SG2 (Subsurface Rad-Chem Piping)

It is assumed that the waste contained within the subsurface piping exceeds FALs, and corrective action is required. Therefore, Decision I is resolved, and no sampling is planned for the waste contained within the subsurface piping. A single TLD will be placed in the area of highest radiation survey value at each CAS to measure external dose.

Decision II will be resolved as the physical extent of the piping system and will be determined using engineering drawings, geophysics, or direct measurements. Soil sampling will be conducted at the terminal end of the exhaust piping for both the Kennebec and Allegheny sites to determine whether

contamination is present beyond the extent of the piping. Additional samples may be collected (including ISOCS), if needed, to determine potential waste types.

4.2.2.3 SG3 (Rad Waste Dump)

Decision I sampling for subsurface contamination will consist of a geophysical survey to determine the presence or absence of buried wastes. The geophysical survey will be performed within the current posted CA. If buried waste exists, Decision II for subsurface contamination will be resolved as the entire volume of buried wastes.

Decision I sampling for surface contamination will consist of two probabilistic sample plots within the CA and will be selected at the locations of the highest radiation survey values using the NE Electra. Samples will be submitted for gamma spectroscopy; and isotopic U, Pu, and Am analyses. TLDs will be placed in the center of each sample plot to measure external dose.

Decision II for surface contamination will be resolved as the lateral extent of COC(s) and the definition of potential corrective action waste types. If additional samples are needed to define the extent of COC contamination, a radiation survey may be performed outside the CA to select step-out sample locations.

4.2.2.4 SG4 (Debris)

Decision I will be resolved using the criteria for the presence of PSM as defined in the Soils RBCA document (NNSA/NFO, 2014). Locations of debris currently identified during the preliminary investigation of legacy piping are listed below as well as shown on [Figure 2-19](#).

- Lead bricks around the U2af (Kennebec) site ([Figure 2-20](#); engineering drawing [[Figure 2-6](#)] reflects 275 lead bricks)
- Lead objects (bricks and lead sheet) near U2e (Cumberland) ([Figure 2-21](#))
- Tower debris stored near U3bk (Mataco) ([Figure 2-22](#))
- Lead object near U3bq (Anchovy) ([Figure 2-23](#))
- Battery with lead plates near U8b (Cyathus) ([Figure 2-24](#))

- Lead object near U8n (Kawich A-White) (Figure 2-25)
- Lead brick near U9bb (Bunker) (Figure 2-26)
- Radiologically elevated soil beneath two small drums near U9u (Raritan) (no photograph)

All debris items that are identified as metallic lead are defined as PSM. Decision I will be resolved using the criteria for the presence of PSM as defined in the Soils RBCA document (NNSA/NFO, 2014). One judgmental surface grab sample will be collected beneath the lead debris items and submitted for RCRA metals analysis. A single TLD will be placed in the area of highest radiation survey value at the tower debris site and the drum site to measure external dose, and a grab sample will be taken for gamma spectroscopy analysis.

If during the course of the investigation other biasing factors are identified (e.g., non-lead item-stain or spills) that represent a potential release, samples will be collected from beneath the material that represents the greatest degree of environmental concern and analyzed based on potential release (e.g., hydrocarbon stain).

Decision II sampling, if needed, will be conducted to define the extent of soil contamination and potential corrective action waste types. Additional items may be identified during the CAI. If additional items are identified, they will be investigated according to the criteria specified in this study group.

4.2.3 Sample Management

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

4.3 *Site Restoration*

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

- All equipment, wastes, debris, and materials associated with the CAI will be removed from the site.
- Site will be restored (to the extent practical) to pre-CAI conditions.

5.0 Waste Management

Waste generated during the CAU 576 field investigation will be managed in accordance with all applicable DOE orders, federal and state regulations, and agreements and permits between DOE and NDEP. Wastes will be characterized based on these regulations using process knowledge, field-screening results (FSRs), and analytical results from investigation and waste samples. Waste types that may be generated during the CAI include industrial, hazardous, hydrocarbon, *Toxic Substances Control Act* (TSCA) regulated (e.g., polychlorinated biphenyls [PCBs], asbestos), low-level radioactive, or mixed wastes.

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

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

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

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

5.1 Waste Minimization

The CAI will be conducted in a manner that will minimize the generation of wastes using process knowledge, segregation, visual examination, and/or field screening (e.g., radiological survey and swipe results) to avoid cross-contaminating uncontaminated soil or uncontaminated IDW that would otherwise be characterized and disposed as industrial waste. As appropriate, soil and debris will be

returned to their original location. To limit unnecessary generation of hazardous or mixed waste, hazardous materials will not be used during the CAI unless required and approved by Environmental Compliance and Health and Safety. Other waste minimization practices will include, as appropriate, avoiding contact with contaminated materials, performing dry decontamination or wet decontamination over source locations, and carefully segregating waste streams.

5.2 Potential Waste Streams

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

- Disposable sampling equipment and field screening waste
- PPE
- Soil
- Surface debris (e.g., discarded chemicals, batteries, scrap metal)
- 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., industrial, low-level), or the combination of waste types. A determination of the waste type will be guided by several factors including, but not limited to, the analytical results of samples either directly or indirectly associated with the waste, historical site knowledge, knowledge of the waste generation process, field observations, field-monitoring/screening results, and/or radiological survey/swipe results. The following subsections describe how specific waste types will be managed.

5.3.1 Industrial Waste

Industrial solid waste, if generated, will be collected, managed, and disposed in accordance with the solid waste regulations and the permits for operation of the NNSS Solid Waste Disposal Sites. The most commonly generated industrial solid waste includes disposable sampling equipment and PPE that will be collected in plastic bags, and marked in accordance with requirements. This waste, and other waste generated such as debris or soil that is characterized as industrial waste, may be placed in

the roll-off box located adjacent to Building 23-310 in Mercury or in another approved container (e.g., drum).

5.3.2 Hazardous Waste

Suspected or known hazardous waste, if generated, will be containerized and managed in waste accumulation areas in accordance with 40 *Code of Federal Regulations* (CFR) 262.34 (CFR, 2016a).

5.3.3 Hydrocarbon Waste

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

5.3.4 Polychlorinated Biphenyls

The management of PCBs is governed by TSCA and its implementing regulations at 40 CFR 761 (CFR, 2016b), and agreements between EPA and NDEP. PCB contamination may be found as a sole contaminant or in combination with any of the types of waste discussed in this document. For example, PCBs may be a co-contaminant in soil that contains a RCRA “characteristic” waste (PCB/hazardous waste), or in soil that contains radioactive wastes (PCB/radioactive waste), or even in mixed waste (PCB/radioactive/hazardous waste). IDW initially will be evaluated using analytical results for soil samples from the CAI. If any type of PCB waste is generated, it will be managed in accordance with 40 CFR 761 (CFR, 2016b) as well as State of Nevada requirements (NAC, 2014b), guidance, and agreements with NNSA/NFO.

5.3.5 Low-Level Waste

Low-level radioactive waste, if generated, will be managed in accordance with the contractor-specific waste certification program plan, DOE orders, and the requirements of the current version of the *Nevada National Security Site Waste Acceptance Criteria* (NNSA/NSO, 2015a). Potential radioactive waste containers will be staged and managed at a designated RMA.

5.3.6 *Mixed Low-Level Waste*

Mixed waste, if generated, will be managed in accordance with the RCRA requirements (CFR, 2016b), agreements between NNSA/NFO and the State of Nevada, and DOE requirements for radioactive waste. Waste characterized as mixed will not be stored for a period of time that exceeds the RCRA requirements unless subject to agreements between NNSA/NFO and the State of Nevada. The mixed waste must be transported via an approved hazardous waste/radioactive waste transporter to the NNSS transuranic waste storage pad for storage pending treatment or disposal.

6.0 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 CASs in CAU 576. All characterization activities, including those related to TLD measurements, will be conducted in accordance with the Soils QAP (NNSA/NSO, 2012a) and the Soils RBCA document (NNSA/NFO, 2014), which define rigorous data quality requirements. [Sections 6.1](#) and [6.2](#) discuss the collection of required QC samples in the field and QA requirements for soil samples.

6.1 QC Sampling Activities

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

- **Radiological samples**
 - Field duplicates for ISOCS and grab samples (1 per 20 environmental samples)
- **Chemical samples (if collected)**
 - Field duplicates for grab samples (1 per 20 environmental samples)
 - Trip blanks (1 per sample cooler containing VOC environmental samples)

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

6.2 Laboratory/Analytical Quality Assurance

As stated in the Soils QAP, data used for making DQO decisions will be evaluated for data quality. The Soils QAP (NNSA/NSO, 2012a) defines and establishes data quality criteria that are evaluated in three defined steps:

1. Data Verification
2. Data Validation
3. Data Quality Assessment

Data verification will include an evaluation of all chemical and radiological laboratory data for data quality in accordance with company-specific procedures. The data will be reviewed to evaluate the completeness, correctness, and conformance of each dataset. This verification will include a review of sample collection, handling and transfer, and documentation associated with sampling activities.

Data validation must be performed on a portion of the environmental sample results to determine the analytical quality of a dataset. Data validation criteria must be based upon the DQOs and the intended use of the data. Validation should include an evaluation of method and contract compliance, data calculations, QC and calibration verifications, raw data, and data generation methods. Validation can include qualifying data that may restrict or limit data use. The data validation includes an evaluation of the DQIs, which are qualitative and quantitative descriptors used in interpreting the degree of acceptability or utility of data. DQIs include the following:

1. Precision
2. Accuracy/bias
3. Representativeness
4. Comparability
5. Completeness
6. Sensitivity

Data that do not meet the DQI criteria must be evaluated for usability in the CADD.

A data quality assessment (DQA) must be performed to determine whether the data meet the DQO requirements of the investigation and the performance criteria for the DQIs. The DQA considers how the data relate to decisions to be made, the intended use of the data, and whether data are suitable for making those decisions. 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).

7.0 Duration and Records Availability

7.1 Duration

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

7.2 Records Availability

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

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Appendix A

Data Quality Objectives

A.1.0 Introduction

The DQO process described in this appendix is a seven-step strategic systematic planning method used to plan data collection activities and define performance criteria for the CAU 576, Miscellaneous Radiological Sites and Debris, field investigation. DQOs are designed to ensure that the data collected will provide sufficient and reliable information to identify, evaluate, and technically defend recommended corrective actions (i.e., no further action, closure in place, or clean closure). Existing information about the nature and extent of contamination at the CASs in CAU 576 is insufficient to evaluate and select preferred corrective actions; therefore, a CAI will be conducted.

The CAU 576 CAI will be based upon the DQOs presented in this appendix as developed by NDEP and NNSA/NFO representatives. The seven steps of the DQO process presented in [Sections A.2.0 through A.8.0](#) were developed in accordance with *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA, 2006).

In general, the procedures used in the DQO process provide the following:

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

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

A.2.0 Step 1 - State the Problem

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

The problem statement for CAU 576 is as follows: “Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs in CAU 576.”

A.2.1 Planning Team Members

The DQO planning team consists of representatives from NDEP and NNSA/NFO. The DQO planning team met on June 14, 2016, 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 576 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 soil and COPCs.

The CSM consists of the following:

- Potential contaminant releases, including soil 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.

The applicability of the CSM to each release source is summarized in [Table A.2-1](#) and discussed in the following subsections. [Table A.2-1](#) provides information on CSM elements that will be used throughout the remaining steps of the DQO process. [Figure A.2-1](#) depicts a representation of the conceptual pathways to receptors from CAU 576 sources. [Figure A.2-2](#) depicts a graphical representation of the CSM. To facilitate site investigation and the evaluation of the DQO decisions for different CSM components, the releases at each CAS were classified into one of the study groups defined in [Section 1.1.2](#).

A.2.2.1 Release Sources

The release sources specific to CAU 576 CASs are presented by study group in the following subsections.

A.2.2.1.1 SG1 (Surface Rad-Chem Piping)

The release source specific to SG1, Avens-Alkermes, is the release of radionuclides from the gas-sampling flex line used to carry the gases and particulates for radiochemical analysis. Approximately 65 m of the flex line is currently lying on ground surface outside the fenced GZ ([Figure 2-2](#)), and although contamination is currently contained within the flex line, this containment

Table A.2-1
CSM Description of Elements for Each SG in CAU 576

SG Identifier	1	2	3	4
SG Description	Surface Rad-Chem Piping	Subsurface Rad-Chem Piping	Rad Waste Dump	PSM
Site Status	Sites are inactive and/or abandoned			
Exposure Scenario	Occasional Use			
Sources of Potential Soil Contamination	Radioactive waste within the rad-chem piping and venting from exhaust pipe to surface soil	Disposal of wastes in landfill and release of contaminants to the surface soil from wastes that were previously stored at the site	Release of contaminants to soil from contaminated debris	
Location of Contamination/ Release Point	Beneath piping system and at end of pipes or where pipes were breached	Beneath surface waste and/or surrounding buried waste	Beneath debris items	
Amount Released	Unknown			
Affected Media	Surface and shallow subsurface soil			
Potential Contaminants	See Table A.2-2 .			
Transport Mechanisms	Infiltration and percolation of precipitation through soil serves as the major driving force for migration of contaminants. Surface water runoff may provide for the transportation of some contaminants within or outside the footprints of the releases.			
Migration Pathways	Vertical (down) transport expected to dominate over lateral transport due to small gradients and lack of surface drainage features. The large depth to the uppermost aquifer precludes groundwater as a significant pathway.			
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. Lateral and vertical extent of contamination exceeding FALs is assumed to be within the spatial boundaries.			
Exposure Pathways	The land use is limited to the occasional use by workers and military personnel conducting training. These human receptors may be exposed to COPCs through oral ingestion or inhalation of, or dermal contact (absorption) with, soil and/or debris due to inadvertent disturbance of these materials, or irradiation by radioactive materials.			

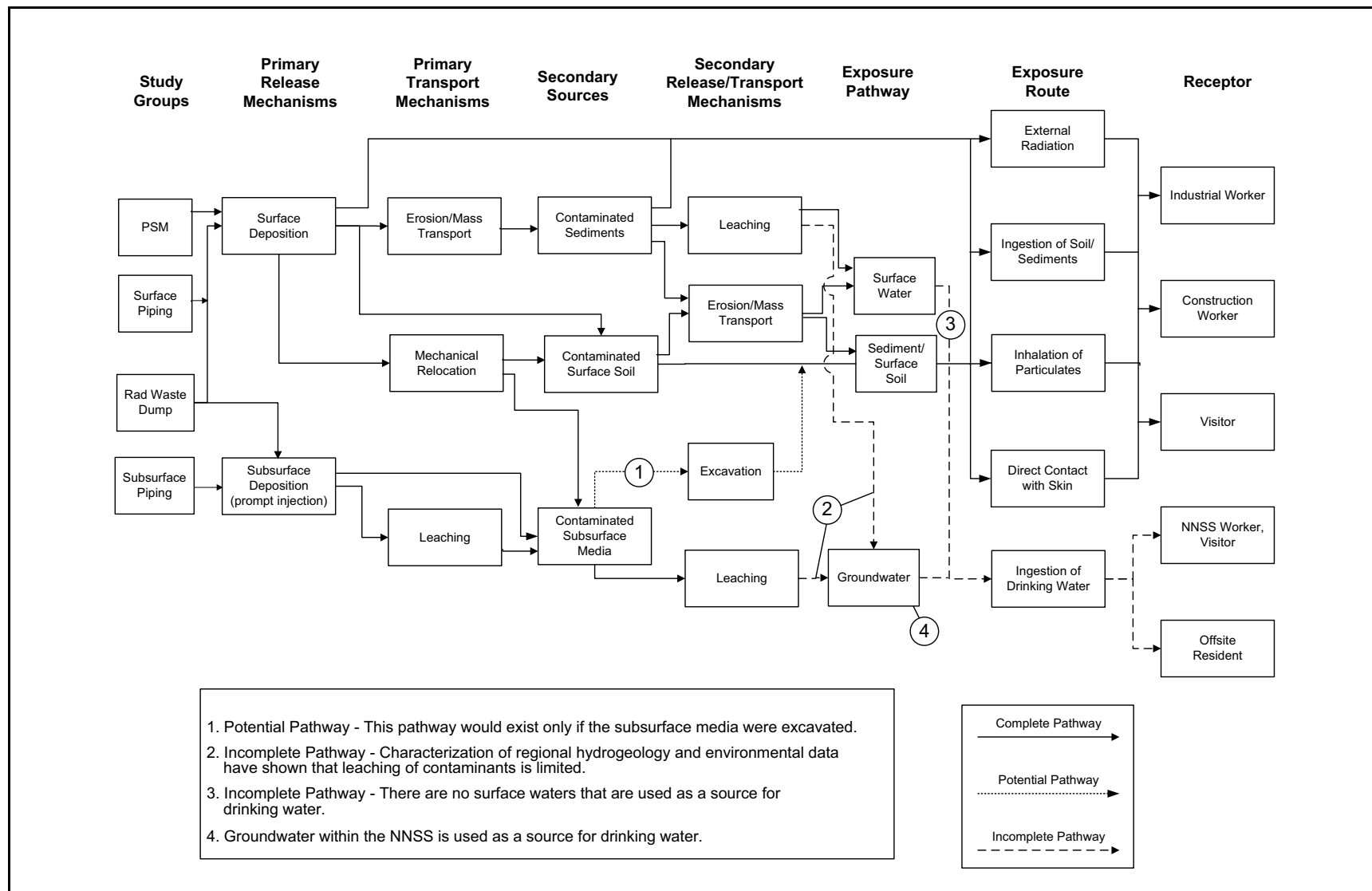


Figure A.2-1
CAU 576 CSM Pathways to Receptors

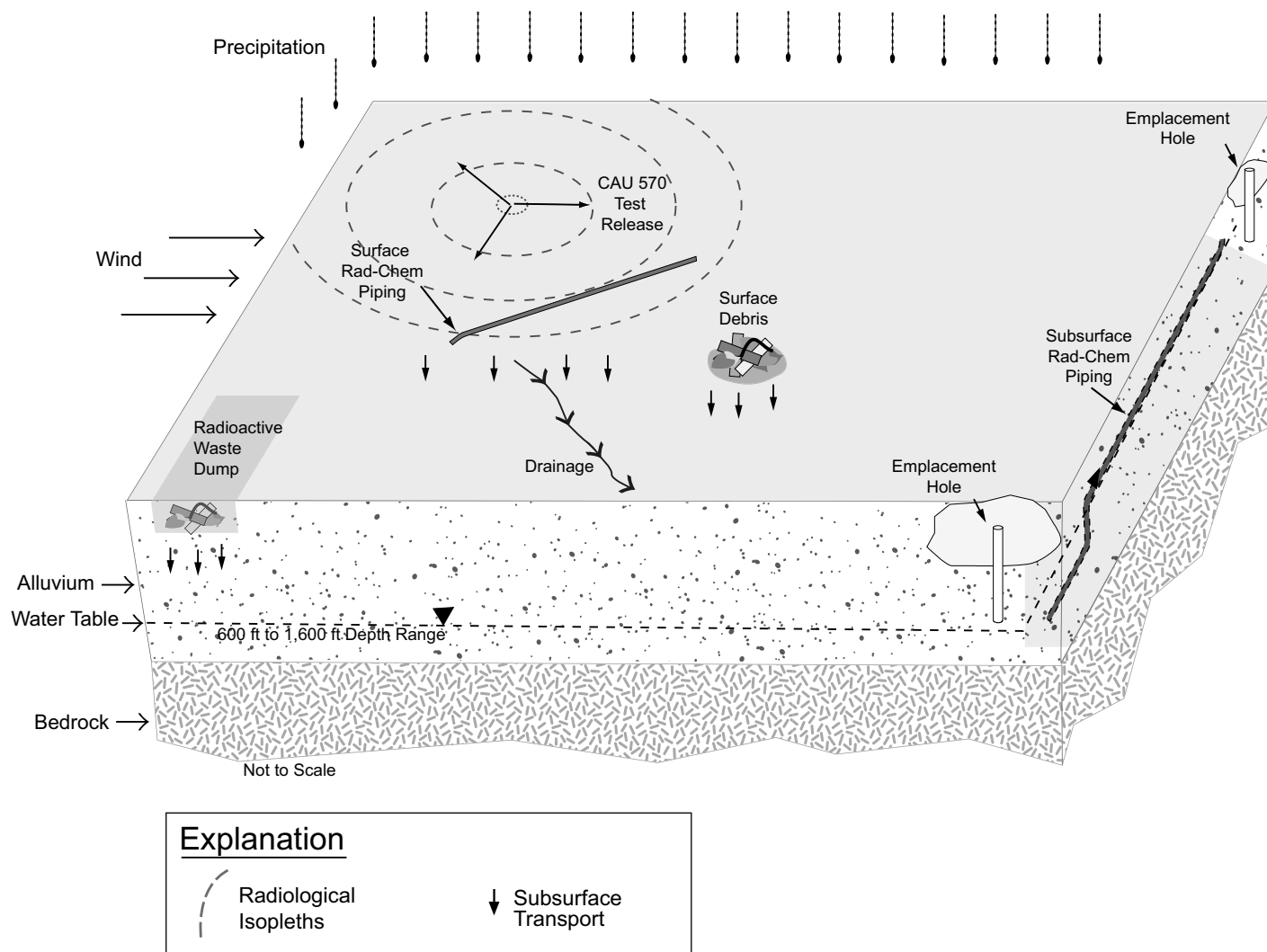


Figure A.2-2
CSM for CAU 576

**Table A.2-2
Contaminants of Potential Concern**

COPCs	SG1	SG2	SG3	SG4
Inorganic COPCs				
Lead	--	--	X	X
Radionuclide COPCs				
U-234	--	--	X	--
U-235/236	--	--	X	--
U-238	--	--	X	--
Pu-238	--	--	X	--
Pu-239/240	--	--	X	--
Cs-137	X	X	X	--
Am-241	--	--	X	--

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

is expected to fail in the future and release contaminants to the surrounding soil. Avens-Alkermes, a less-than-20-kt test, was conducted on December 16, 1970, as part of Operation Emery (NNSA/NFO, 2015).

A.2.2.1.2 SG2 (Subsurface Rad-Chem Piping)

The release source specific to SG2 is the release of radionuclides from the rad-chem piping systems at the Kennebec, Chinchilla, Platypus, and Allegheny sites. In addition, releases may have occurred from gas-sampling components and the venting of gases from the exhaust pipe during the weapons-related tests at the Kennebec and Allegheny sites.

- **CAS 02-99-12, U2af (Kennebec) Surface Rad-Chem Piping**, was a low-yield weapons-related test, conducted on June 25, 1963, as part of Operation Storax (NNSA/NFO, 2015). According to an engineering drawing (Figure 2-5), the rad-chem system was designed to convey gas to sampling locations along the approximately 1,100-ft rad-chem pipe of U2af (surface and subsurface). The rad-chem system conveyed gas west from U2af via subsurface piping to a sample recovery mechanism (U2af#1), past a vault area (four underground pits that provided access to diagnostic equipment and tanks [Figure 2-7]) to the sampling assembly (sampler at surface and assembly subsurface [Figure 2-8]). The piping continued west another approximately 250 ft, where it terminated at the surface

(Figure 2-10). Figure 2-10 depicts the pipe (called “exhaust pipe” at this point) terminating just before a soil mound. It is expected that when the containment fails, the waste within subsurface piping will be released to the environment (surrounding soil). In addition, elevated radiological activity has been identified at the surface gas-sampling components such as the vaults, sampling assembly, surface piping (joints) and the soil where the exhaust pipe vented. Releases to the surrounding soil may have occurred at these surface components as well.

- **CAS 03-99-20, Area 3 Surface Rad-Chem Piping**, consists of two subsurface rad-chem piping systems. The first subsurface rad-chem piping system runs from hole U3ag (Chinchilla) to hole U3n (Bernalillo), where the post-test gases were collected (Figure 2-12). The Chinchilla experiment was a weapons-related test; had a yield of 1.9 kt; and was conducted on February 19, 1962, as part of Operation Nougat (NNSA/NFO, 2015). The second subsurface rad-chem piping system runs from hole U3ad (Platypus) to hole U3k (Colfax), where post-test gases were collected (Figure 2-13). The Platypus experiment was a weapons-related test; had a low yield; and was conducted on February 24, 1962, as part of Operation Nougat (NNSA/NFO, 2015). It is expected that the subsurface rad-chem piping will fail, and radioactive contaminants will be released to the surrounding soil.
- **CAS 09-99-08, U9x (Allegheny) Subsurface Rad-Chem Piping**, was a weapons-related, low-yield test conducted on September 29, 1962, as part of Operation Storax (NNSA/NFO, 2015). According to an engineering drawing (Figure 2-16), the subsurface piping extends 800 ft in a northeast direction from U9x-1 and, with the exception of the first 10 ft, the piping was placed in a 2-ft trench and covered with soil after instrumentation was installed at a sampling station. The sampling station was located approximately 600 ft northeast from U9x-1 and was not identified during the site visit; however, a clearing with a wooden structure and a corresponding depression was identified. From the sampling station, the piping extends approximately 200 ft northeast, where it terminates at the surface (this portion of the pipe is called the “exhaust pipe” section). It is expected that when containment fails, the waste within subsurface piping will be released to the surrounding soil. In addition, releases to the surrounding soil may have occurred around the sampling station and where the exhaust pipe vented.

A.2.2.1.3 SG3 (Rad Waste Dump)

The release source specific to SG3 is contaminated material that was either stored on the surface and then removed and/or is currently buried at the site. CAS 05-19-04, Frenchman Flat Rad Waste Dump, is located on the north edge of Frenchman Flat and was identified as a “rad waste dump” from a 1965 Quadrangle Map (Poole, 1965). Removable surface soil contamination was detected, and an area of approximately 30 by 30 ft was posted as a CA. It is unknown whether any buried material/debris (landfill) exists at this site. Terrestrial radiological surveys detected elevated radiological readings.

A.2.2.1.4 SG4 (Debris)

The release source specific to SG4 is the release of contaminants to the soil from debris items. CAS 00-99-01, Potential Source Material, consists of chemical and possibly radiologically contaminated debris from testing activities on the NNSS. The debris consists of, but is not limited to, lead (bricks, sheets, shielding), a battery with lead plates, tower debris (fragments), and radiologically elevated soil beneath two small drums. The debris is found within multiple areas of the NNSS. The current locations are identified in [Figure 2-19](#).

A.2.2.2 Potential Contaminants

The release-specific COPCs are defined as the contaminants reasonably expected at the site that could contribute to a dose or risk exceeding FALs. Based on the nature of the releases identified in [Section 2.4](#) and previous investigation results presented in [Section 2.5](#), the following contaminants could reasonably be suspected to be present at CAU 576. These COPCs were identified during the planning process through the review of site history, process knowledge, personal interviews, past investigation efforts (where available), and inferred activities associated with the study groups (including those that may be discovered during the investigation; see [Section 3.2](#)). Additional potential releases may be discovered during the investigation. COPCs will be determined for newly discovered releases based on the nature of the release (e.g., lead bricks, staining). If a radionuclide is identified that is not expected, such as Am-241 or U-235, isotopic analyses would be requested for those samples (such as isotopic Pu or isotopic U). COPCs will be reported by the analytical methods identified in [Table A.2-3](#) for environmental samples taken at each of the sites. The analytes reported for each analytical method are listed in [Table A.2-4](#).

Table A.2-3
Analyses Required by Group ^a
(Page 1 of 2)

Analyses	Group 1	Group 2	Group 3	Group 4
Inorganic COPCs				
RCRA Metals	--	--	X ^b	X ^b
ISOCS	X	X	--	--

Table A.2-3
Analyses Required by Group ^a
(Page 2 of 2)

Analyses	Group 1	Group 2	Group 3	Group 4
Organic COPCs				
VOCs	--	--	--	--
SVOCs	--	--	--	--
Radionuclide COPCs				
Gamma Spectroscopy	X	X	X	X
Isotopic U	--	--	X	--
Isotopic Pu	--	--	X	--
Isotopic Am	--	--	X	--

^a The analytical method has been determined based on the site-specific COPCs.

^b Analyses for VOCs, or SVOCs will only be run based on indicators of their presence (e.g., stains).

X = Required analytical method

-- = Not required

A.2.2.3 Contaminant Characteristics

Contaminant characteristics include, but are not limited to, solubility, density, and adsorption potential. In general, contaminants with larger particle sizes, low solubility, high affinity for soil, and high density can be expected to be found relatively close to release points. Contaminants with smaller particle size, high solubility, low density, and/or low affinity for soil are found farther from release points or in low areas where evaporation of ponding will concentrate dissolved contaminants.

An example of the migration potential of radionuclides released from a nuclear detonation was demonstrated in a long-term radionuclide migration study of an underground nuclear test. A well installed into the groundwater 91 m away from the Cambric test GZ (and much closer to the nearest extent of the test cavity) was continuously pumped from 1975 to 1991 in order to draw radionuclides from the detonation cavity. The May 1965 Cambric test released a yield of 750 tons at a depth of burial of -967 ft (NNSA/NFO, 2015; Hoffman and Daniels, 1984). No radionuclides associated with nuclear fission tests (including the major contributing radionuclides plutonium, uranium, cesium, europium, strontium, or cobalt) other than tritium and krypton (which are considered to be conservative tracers in groundwater, as they do not interact with the geologic soil through which the

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

Organic COPCs				Inorganic COPCs	Radionuclide COPCs		
Method 8260 ^a		Method 8270 ^a		Method 8082 ^a	Method 6010 ^a	Method Ga-01 ^b	Method U-02 ^b
VOCs		SVOCs		PCBs	RCRA Metals	Gamma Spec	Isotopic U
1,1,1,2-Tetrachloroethane	Carbon tetrachloride	1,4-Dioxane	Bis(2-ethylhexyl)phthalate	Aroclor 1016	Arsenic	Ac-228	U-234
1,1,1-Trichloroethane	Chlorobenzene	2,3,4,6-Tetrachlorophenol	Butyl benzyl phthalate	Aroclor 1221	Barium	Ag-108m	U-235
1,1,2,2-Tetrachloroethane	Chloroethane	2,4,5-Trichlorophenol	Carbazole	Aroclor 1232	Beryllium	Al-26	U-238
1,1,2-Trichloroethane	Chloroform	2,4,6-Trichlorophenol	Chrysene	Aroclor 1242	Cadmium	Am-241	Method Sr-02 ^b
1,1-Dichloroethane	Chloromethane	2,4-Dimethylphenol	Di-n-butyl phthalate	Aroclor 1248	Chromium	Cm-243	
1,1-Dichloroethene	Chloroprene	2,4-Dinitrotoluene	Di-n-octyl phthalate	Aroclor 1254	Lead	Co-60	Isotopic Sr
1,2,4-Trichlorobenzene	cis-1,2-Dichloroethene	2-Chlorophenol	Dibenzo(a,h)anthracene	Aroclor 1260	Selenium	Cs-137	Sr-90
1,2,4-Trimethylbenzene	Dibromochloromethane	2-Methylnaphthalene	Dibenzofuran	Aroclor 1268	Silver	Eu-152	Method Pu-02 ^b
1,2-Dibromo-3-chloropropane	Dichlorodifluoromethane	2-Methylphenol	Dimethyl phthalate			Eu-154	
1,2-Dichlorobenzene	Ethyl methacrylate	2-Nitrophenol	Fluoranthene		Method 7196 ^a Chromium VI	Eu-155	Isotopic Pu
1,2-Dichloroethane	Ethylbenzene	3-Methylphenol ^c (m-cresol)	Fluorene			K-40	Pu-238
1,2-Dichloropropane	Isobutyl alcohol	4-Methylphenol ^c (p-cresol)	Hexachlorobenzene			Nb-94	Pu-239/240
1,3,5-Trimethylbenzene	Isopropylbenzene	4-Chloroaniline	Hexachlorobutadiene			Pa-233	Method Am-01 ^b
1,3-Dichlorobenzene	Methacrylonitrile	4-Nitrophenol	Hexachloroethane			Pb-212	
1,4-Dichlorobenzene	Methyl methacrylate	Acenaphthene	Indeno(1,2,3-cd)pyrene			Pb-214	Isotopic Am
2-Butanone	Methylene chloride	Acenaphthylene	n-Nitroso-di-n-propylamine			Th-229	Am-241
2-Chlorotoluene	n-Butylbenzene	Aniline	Naphthalene			Th-234	Am-243
2-Hexanone	n-Propylbenzene	Anthracene	Nitrobenzene			Tl-208	
4-Isopropyltoluene	sec-Butylbenzene	Benzo(a)anthracene	Pentachlorophenol			U-235	
4-Methyl-2-pentanone	Styrene	Benzo(a)pyrene	Phenanthrene				
Acetone	tert-Butylbenzene	Benzo(b)fluoranthene	Phenol				
Acetonitrile	Tetrachloroethene	Benzo(g,h,i)perylene	Pyrene				
Allyl chloride	Toluene	Benzo(k)fluoranthene	Pyridine				
Benzene	Total xylenes	Benzoic acid	Diethyl phthalate				
Bromodichloromethane	Trichloroethene	Benzyl alcohol					
Bromoform	Trichlorofluoromethane						
Bromomethane	Vinyl acetate						
Carbon disulfide	Vinyl chloride						
						</	

^a Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (EPA, 2016a)

^b The Procedures Manual of the Environmental Measurements Laboratory, which includes HASL-300 Methods (DOE, 1997)

^c May be reported as 3,4-Methylphenol or m,p-cresol.

^d The most current EPA, DOE, or equivalent accepted analytical method may be used including; Laboratory Standard Operating Procedures approved by the contractor in accordance with industry standards and the contractor's SOW requirements.

HASL = Health and Safety Laboratory
SOW = Statement of work

Ac = Actinium
Ag = Silver
Al = Aluminum

Cm = Curium
Co = Cobalt
K = Potassium

Nb = Niobium
Pa = Protactinium
Pb = Lead

Tc = Technetium
Th = Thorium
Tl = Thallium

water moves) were detected in the pumped groundwater during 29 years of pumping (Bryant, 1992; Hoffman and Daniels, 1984). This test demonstrated the relative immobility of the fission radionuclides under conditions of very high mass flow (more than 1.5 billion gallons of water pumped) in a saturated matrix. Unsaturated conditions (such as surface soil with atmospheric deposition from nuclear test releases), water percolating through the vadose zone provides a small fraction of the migration potential (mass flow is less than 5 millimeters of recharge per year [Hevesi et al., 2003]). Therefore, it can be assumed that although the major fission radionuclides are relatively immobile in saturated conditions with an artificial gradient (i.e., under pumping conditions), they will be even less mobile under unsaturated conditions with limited net infiltration of precipitation.

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

A.2.2.4 Site Characteristics

Site characteristics are defined by the interaction of physical, topographic, and meteorologic attributes and properties. Topographic and meteorologic attributes and properties include slope stability, precipitation frequency and amounts, precipitation runoff pathways, ephemeral drainage channels, and evapotranspiration potential. Meteorological data are presented in [Section 2.1](#).

All CASs except CAS 05-19-04 are located in Yucca Flat. The area is relatively flat, gently sloping to the southwest. The area is sparsely vegetated with native plants. The soil at the CAU 576 sites consists mostly of sand to gravel-sized alluvium with some cobble and relic boulders of various lithologies, and includes area of disturbed soil (from site grading and underground testing). No perennial streamflow exists in this region.

CAS 05-19-04, Frenchman Flat Rad Waste Dump, is located within the Frenchman Flat playa. This area is nearly flat with no discernible slope direction. The area is sparsely vegetated with native plants. The soil consists of sandy-textured alluvial deposits. No perennial drainage channel flow exists in the region; however, water has been observed to pool in this area in wet conditions.

[Sections 2.1.1](#) and [2.1.2](#) and provides further details about the Yucca and Frenchman Flat geological and hydrological setting.

A.2.2.5 Migration Pathways and Transport Mechanisms

Migration pathways include 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 intermittent mechanism for both vertical and lateral transport of contaminants. Contaminated sediments entrained by these stormwater events would be carried by the drainage channel flow to locations where the flowing water loses energy and the sediments drop out. These locations are visually identifiable as sedimentation areas.

No significant ephemeral washes are observed at the CAU 576 sites. Slightly depressed areas are observed near the Kennebec and Allegheny sites.

Other migration pathways for contamination from the sites include wind-borne material and materials displaced from maintenance activities (e.g., moved during road maintenance). Contaminants may also be moved through mechanical disturbances due to maintenance or construction activities at the site. Specifically, this can include activities such as decontamination and demolition of facilities, investigation and resolution of CASs, and disassembly and removal of equipment and support structures.

Migration is influenced by chemical characteristics of the contaminants (presented in [Section A.2.2.3](#)) and physical characteristics of the vadose zone material (presented in [Section A.2.2.4](#)). In general, the contaminants that are reasonably expected to be present at CAU 576 (i.e., Cs-137) have low solubilities and high affinity for soil. The physical characteristics of the vadose zone material generally include medium and high adsorptive capacities, low moisture contents (i.e., available water-holding capacity), and relatively long distances to groundwater (approximately 1,600 ft bgs [USGS/DOE, 2016]). Based on these physical and chemical factors, contamination is expected to be found relatively close to release points.

Infiltration and percolation of precipitation serve as driving forces for downward migration of contaminants. However, due to high PET—annual PET at the Area 3 RWMS and Area 5 RWMC has been estimated at 62 and 66 in., respectively (Yucel, 2009; BN, 2001); and limited precipitation for these regions at 6.3 and 4.9 in./yr, respectively (Soulé, 2006; USGS/DOE, 2016)—percolation of infiltrated precipitation at the NNSS does not provide a significant mechanism for vertical migration of contaminants to groundwater (DOE/NV, 1992).

Underground test craters have associated chimneys of disturbed geologic material that may provide a preferential pathway. Collection of stormwater into these craters also provides additional localized infiltration that will enhance contaminant migration rates.

For the subsurface piping where contaminants are currently contained, migration and transport is limited. However, in general, 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 may be subject to higher fluvial transport rates than contaminants present on other surface areas. Ephemeral washes are generally dry but are subject to infrequent flows in response to storm events. These runoff flow events provide an intermittent mechanism for both vertical and lateral transport of contaminants. Contaminated sediments entrained by these runoff flow events would be carried by the channelized flow to locations where the flowing water loses energy and the sediments drop out. These locations are readily identifiable as depositional areas. For surface contamination to reach the water table, the contaminants would have to be dissolved in infiltrating precipitation and then be transported through the vadose zone alluvium, which extends the entire unsaturated thickness of approximately 1,600 ft at Well ER-3-2 (Yucca Flat [USGS/DOE, 2016]) and 600 ft at the Frenchman Flat playa (Hevesi et al., 2003).

A.2.2.6 Exposure Scenarios

Human receptors may be exposed to COPCs through oral ingestion or inhalation of, or dermal contact (absorption) with, soil or debris due to inadvertent disturbance of these materials, or external irradiation by radioactive materials. The land-use and exposure scenarios for the CAU 576 CASs are listed in [Table A.2-5](#). This is based on current and future land use at the NNSS (NNSA/NSO, 2013). Release locations in CAU 576 are remote locations without any site improvements and where no

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

CAS	Record of Decision Land-Use Zone	Exposure Scenario
05-19-04	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 hr/yr for 5 years). Site structures are not present for shelter and comfort of the worker.
00-99-01, 02-99-12, 03-99-20, 09-99-08, 09-99-09	Nuclear and High Explosives Test This area is designated within the Nuclear Test Zone for additional underground nuclear weapons tests and outdoor high-explosive tests. This zone includes compatible defense and nondefense research, development, and testing activities.	Occasional Use Area Worker will be exposed to the site occasionally (up to 80 hr/yr for 5 years). Site structures are not present for shelter and comfort of the worker.

regular work is performed. The most exposed individual (MEI) is defined as a worker who could occupy these locations on an occasional and temporary basis, such as a military exercise. Therefore, the potential exposure to the MEI who uses locations within CASs in CAU 576 is conservatively represented by the Occasional Use Area exposure scenario.

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

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

A.3.1 Decision Statements

The Decision I statement is as follows:

- “Is any COC present in environmental soil within the study group?” For judgmental sampling design, any analytical result for a COPC above the FAL will result in the a COPC being designated as a COC.”

For the probabilistic (unbiased) sampling design, any COPC that has a 95 percent UCL of the average concentration above the FAL will result in that COPC being designated as a COC. A COC also may be defined as the identification of PSM as defined in the Soils RCBA document (NNSA/NFO, 2014) or a contaminant that, in combination with other like contaminants, is determined to jointly pose an unacceptable risk based on a multiple contaminant analysis (NNSA/NFO, 2014). If a COC is detected, then Decision II must be resolved.

The Decision II statement is as follows:

- “If corrective action is required, is sufficient information available to evaluate potential CAAs?” Sufficient information is defined to include the following:
 - The lateral and vertical extent of COC contamination
 - The information needed to predict potential remediation waste types and volumes
 - The information needed to evaluate the feasibility of remediation alternatives

For radiological contaminants, the presence of a COC is defined as the condition where the MEI has the potential to receive a TED exceeding 25 mrem/yr.

For SG1, resolution of Decision I will be determined by the estimation of the radionuclide activities within the piping using ISOCS measurements to estimate the presence and activity of radionuclides within the flex line to determine whether dose could exceed FAL at the time when the containment

would fail. Decision II will be resolved as the physical extent of the piping, and results from the ISOCS will be used to determine potential corrective action waste types.

For SG2, Decision I has been resolved by assuming that the waste contained within the subsurface piping exceeds FALs, and corrective action is required. Decision II will be resolved as the entire physical extent of the piping system, with additional samples to be collected at the exhaust piping for both Kennebec and Allegheny sites.

For SG3, Decision I sampling for the subsurface contamination will be resolved by determining whether the site contains buried waste via a geophysical survey within the current posted CA. If buried waste exists, Decision II for subsurface contamination will be resolved as the entire volume of buried wastes. Decision I for surface contamination will consist of two probabilistic sample plots within the CA. The locations will be selected using the highest radiation survey values from the NE Electra, and a TLD will be placed in the center of each sample plot to measure external dose.

Decision II for surface contamination will be resolved as the lateral extent of COC(s) and potential corrective action waste types. If needed, a radiation survey may be performed outside the CA, and a judgmental sampling design will be employed.

For SG4, Decision I will be resolved by using the PSM criteria defined in the Soils RBCA document (NNSA/NFO, 2014). A judgmental surface grab sample will be collected beneath the lead debris items and submitted for analysis (RCRA metals-lead). A single TLD will be placed in the area of highest radiation survey value at the tower debris site and the contaminated soil site to measure external dose.

If during the course of the investigation other biasing factors are identified (e.g., non-lead item-stain or spills) that represent a potential release, samples will be collected from beneath the material that represents the greatest degree of environmental concern and analyzed based on potential release (e.g., hydrocarbon stain).

Decision II sampling, if needed, will be conducted to define the extent of soil contamination and waste types. The locations of the debris items are shown in [Figure 2-19](#). If additional items are identified, they will be included within the scope of this study group.

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

A.3.2 Alternative Actions to the Decisions

This section identifies actions that may be taken to resolve the decision statements depending on the possible outcomes of the investigation.

A.3.2.1 Alternative Actions to Decision I

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

A.3.2.2 Alternative Actions to Decision II

If the lateral and vertical extent of COC contamination have not been defined for radiological contamination, then additional samples may be collected until a coefficient of determination (r^2) greater than 0.8 can be established between TED values and radiation survey values. If a valid correlation cannot be established using this criterion, the lateral and vertical extent of COC contamination will be defined by bounding locations consistent with the CSM where the TED is less than the FAL.

If the lateral and vertical extent of COC contamination have not been defined for chemical COCs, then additional bounding samples will be collected.

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

A.4.0 Step 3 - Identify Information Inputs

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

A.4.1 Information Needs

To resolve Decision I (determine whether contamination from the release is present at levels exceeding a FAL) for the areas outside the default contamination boundaries, 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 release site (probabilistic sampling).
- The analytical suite selected must be sufficient to identify any COC present in the samples.

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

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

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

- Samples of the waste or soil must provide sufficient information to determine potential remediation waste types.
- Samples of the waste must provide sufficient information to determine whether the waste is PSM.

A.4.2 Sources of Information

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

A.4.2.1 Sample Locations

Design of the sampling approaches for the CAU 576 releases must ensure that the data collected are sufficient for selection of the CAAs (EPA, 2002). To meet this objective, the samples collected from each site should either be from locations that most likely contain a COC, if present (judgmental), or from locations that properly represent overall contamination at the release (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. The implementation of a judgmental approach for sample location selection, and of a probabilistic sampling approach, for CAU 576 are discussed in [Section A.8.0](#).

A.4.2.2 Analytical Methods

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

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

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

A.5.1 Target Populations of Interest

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

- The extent of COC contamination using one of the methods described in [Section A.4.1](#)
- Investigation waste and potential remediation waste characteristics

A.5.2 Spatial Boundaries

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

- **Vertical (below current ground surface)**
 - For SG1 and SG2, 2 in. below any release point
 - For SG3, 15 ft bgs
 - For SG4, 1 ft bgs
- **Lateral (horizontally)**
 - For SG3, 50 ft from release point

Contamination found beyond these boundaries may indicate a flaw in the CSM and may require reevaluation of the CSM before the investigation can continue. Each release is considered geographically independent, and intrusive activities are not intended to extend into the boundaries of neighboring CASs.

A.5.3 Practical Constraints

Practical constraints (e.g., activities by other organizations at the NNSS, utilities, threatened or endangered animals and plants, unstable or steep terrain, and/or access restrictions) may affect the ability to investigate this site. Practical constraints that have been identified specific to CAU 576 include the presence of subsidence craters or potential crater areas from underground testing that was conducted in the area.

A.5.4 Define the Sampling Units

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

A.6.0 Step 5 - Develop the Analytic Approach

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

A.6.1 Population Parameters

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

A.6.1.1 Judgmental Sampling Design

The judgmental design will be implemented as described in the Soils RBCA document (NNSA/NFO, 2014). For chemical contaminants, the population parameter is the observed concentration of each contaminant from each individual analytical sample. For radiological contaminants, the population parameter is the calculated TED from each location. Each sample result will be compared to the FALs to determine the appropriate resolution to Decision I and Decision II. A single sample result for any contaminant exceeding a FAL would cause a determination that a corrective action is required (for Decision I), or that the extent of COC contamination is not bounded (for Decision II). If good prior information about the target site is available, then the sampling may be designed to collect samples only from areas known to have the highest concentration levels on the target site. If the observed concentrations from these samples are below the action level, then a decision can be made that the site contains safe levels of the contaminant without the samples being truly representative of the entire area (EPA, 2006).

A.6.1.2 Probabilistic Sampling Design

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

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

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

A.6.2 Action Levels

The PALs presented in this section are to be used for site screening purposes and are not necessarily intended for use as cleanup action levels or FALs. However, the PALs 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 FALs will be established using the RBCA process described in the Soils RBCA document (NNSA/NFO, 2014). This process conforms with NAC 445A.227, which lists the requirements for sites with soil contamination (NAC, 2015a). For the evaluation of corrective actions, NAC 445A.22705 (NAC, 2015b) requires the use of ASTM Method E1739 (ASTM, 1995) to “conduct an evaluation of the site, based on the risk it poses to public health and the environment, to determine the necessary remediation standards or to establish that corrective action is not necessary.” For the evaluation of corrective actions, the FALs are established as the necessary remedial standard. The RBCA process as described in the Soils RBCA document (NNSA/NFO, 2014) defines three tiers (or levels) of evaluation involving increasingly sophisticated analyses.

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

A.6.2.1 Chemical PALs

Except as noted herein, the chemical PALs are defined as the Region 9 Regional Screening Levels for chemical contaminants in industrial soils (EPA, 2016b). Chemical background concentrations for RCRA metals will be used instead of screening levels when natural background concentrations exceed the screening level (e.g., arsenic on the NNSS). Background is considered the average concentration plus two standard deviations of the average concentration for sediment samples collected by the Nevada Bureau of Mines and Geology throughout the 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 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.

A.6.2.2 Radionuclide PALs

The PAL for radioactive contaminants is a TED of 25 mrem/yr, based upon the Industrial Area exposure scenario. The Industrial Area exposure scenario is described in Soils RBCA document (NNSA/NFO, 2014).

A.6.3 Decision Rules

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

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

The decision rules for Decision I are as follows:

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

The decision rules for Decision II are as follows:

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

A.7.0 Step 6 - Specify Performance or Acceptance Criteria

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

A.7.1 Decision Hypotheses

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

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

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

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

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

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

A.7.2 False-Negative Decision Error

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

A.7.2.1 False-Negative Decision Error for Judgmental Sampling

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

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

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

To satisfy the first criterion, Decision I samples must be collected in areas most likely to be contaminated by a COC (supplemented by unbiased samples where appropriate). A biased sampling strategy will be used to target areas with the highest potential to contain COC, if it is present anywhere in the release. Sample locations will be determined based on process knowledge, previously acquired data, or field-screening and biasing factors listed in [Section A.4.2.1](#). Decision II samples must be collected in areas that represent the lateral and vertical extent of COCs. 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. The CADD will present an assessment on the DQI of representativeness that samples were collected from those locations that best represent the populations of interest as defined in [Section A.5.1](#).

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

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

To provide information for the assessment of the DQIs of precision and accuracy, the following QC samples will be collected:

- Field duplicates (minimum of 1 per 20 environmental grab samples)
- Laboratory QC samples (1 per 20 samples).

A.7.2.2 False-Negative Decision Error for Probabilistic Sampling

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

- Sample size
- Actual variability
- Measurement error

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

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

A.7.3 False-Positive Decision Error

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

False-positive results are typically attributed to laboratory and/or sampling/handling errors that could cause cross contamination. To control against cross contamination, decontamination of sampling equipment will be conducted in accordance with established and approved procedures, and only clean sample containers will be used. To determine whether a false-positive analytical result may have occurred, the following QC samples will be collected (as established in the CAU 576 DQOs):

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

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

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

Step 7 of the DQO process selects and documents a design that will produce data that exceeds performance or acceptance criteria.

Judgmental sampling schemes will be implemented to select sample plot and grab sample locations. Probabilistic sampling schemes will be implemented to select locations. Probabilistic sampling schemes will be implemented to select sample locations within sample plots. Investigation results will be compared to FALs to determine the need for corrective action. Debris sample results will be evaluated against the PSM criteria listed in [Section A.3.1](#) to determine the need for corrective action. All samples will be submitted for the analyses listed in [Table A.2-3](#).

If sufficient sample material cannot be collected at a specific surface soil location (e.g., rock, calcrete, or buried material), it will be collected from the nearest place that a surface sample can be obtained.

Sample locations for releases identified will be determined based upon the likelihood of a contaminant release at each location.

These locations will be selected based on the identification of biasing factors during the investigation. These biasing factors may include the following:

- *Stains.* Any spot or area on the soil surface that may indicate the presence of a potentially hazardous liquid. Typically, stains indicate an organic liquid, such as an oil, has reached the soil and may have spread out vertically and laterally.
- *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.

- *Pre-selected areas based on process knowledge of the site.* Locations for which evidence such as historical photographs, experience from previous investigations, or input from interviewee(s) exists that a release of hazardous or radioactive substances may have occurred.
- Visual indicators such as discoloration, textural discontinuities, disturbance of native soils, or any other indication of potential contamination.

A.8.1 SG1 (Surface Rad-Chem Piping)

SG1, Avens-Alkermes, consists of potential release of radionuclides from gas-sampling activities. The waste is contained within a flex line, which is currently lying on ground surface. However, the waste within the flex line will be released to the surrounding soil as the containment of the flex line fails.

A.8.1.1 Decision I Sampling Selection

Decision I sampling will consist of three ISCOS sampling locations determined by the highest radiation survey values from the length of the flex line. ISOCS results will be used to estimate the presence and activity of radionuclides within the piping to determine whether dose could exceed FAL at the time when the containment afforded by the piping fails. A single TLD will be placed in the area of the highest radiation survey measurement using the NE Electra to determine whether external dose exceeds the FAL. In addition, a grab soil sample will be collected at the end of the piping and submitted for gamma spectroscopy; and isotopic U, Pu, and Am analyses.

A.8.1.2 Decision II Sampling Selection

Decision II is expected to be resolved as the physical extent of the piping, and results from the ISOCS will also be used to determine potential corrective action waste types.

A.8.2 SG2 (Subsurface Rad-Chem Piping)

SG2 consists of potential release of radionuclides from the rad-chem piping systems at Kennebec, Chinchilla, Platypus, and Allegheny sites. In addition, radionuclides may have been released from surface gas-sampling components and from venting of the exhaust pipe at the Kennebec and Allegheny sites.

A.8.2.1 Decision I Sampling Selection

The DQO process resulted in an assumption that the radioactive waste contained within the subsurface piping exceeds FALs. Therefore, Decision I is resolved, and no sampling is planned for the waste contained within the subsurface piping. A single TLD will be placed in the area of highest radiation survey value at each CAS to measure external dose.

A.8.2.2 Decision II Sampling Selection

Decision II is expected to be resolved as the physical extent of the piping, with additional samples to be collected at the exhaust pipe for both Kennebec and Allegheny sites to determine whether the COC contamination is present beyond the extent of the piping. Additional samples may be collected (including ISOCS), if needed, to determine potential waste types.

A.8.3 SG3 (Rad Waste Dump)

SG3, CAS 05-19-04, Frenchman Flat Rad Waste Dump, consists of soil contamination from wastes stored on the surface and then removed and/or currently buried at the site.

A.8.3.1 Decision I Sampling Selection

Decision I sampling for subsurface contamination will consist of a geophysical survey to determine the presence or absence of buried wastes. The geophysical survey will be performed within the current posted CA.

Decision I sampling for surface contamination will consist of two probabilistic sample plots within the CA and will be selected at the locations of the highest radiation survey values using the NE Electra. Samples will be submitted for gamma spectroscopy; and isotopic U, Pu, and Am analyses. A TLD will be placed in the center of each sample plot to measure external dose.

A.8.3.2 Decision II Sample Selection

If buried waste is present, the physical extent of the buried waste will be resolved as the entire volume of buried waste. Decision II for surface contamination will be resolved as the lateral extent of COC(s) and the definition of potential corrective action waste types. If additional samples are needed to

define the extent of COC contamination, a radiation survey may be performed outside the CA to select step-out sample locations.

A.8.4 SG4 (Debris)

SG4, PSM, consists of the potential release of chemical and radiological contaminants to the surface soil. PSM debris items consist of lead bricks, lead sheets, lead shielding, and lead-acid batteries. Elevated soil radiological readings have been identified near a pile of tower debris and radiologically elevated soil beneath two small drums.

A.8.4.1 Decision I Sample Selection

Decision I will be resolved using the criteria for the presence of PSM as defined in the Soils RBCA document (NNSA/NFO, 2014). If the debris is a lead item, one judgmental surface grab sample will be collected beneath the debris items and submitted for RCRA metals analysis. A single TLD will be placed in the area of highest radiation survey value at the tower debris and the radiologically elevated soil beneath two drums to measure external dose, and a grab sample will be taken for gamma spectroscopy analysis.

If during the course of the investigation other biasing factors are identified (e.g., non-lead item-stain or spills) that represent a potential release, samples will be collected from beneath the material that represents the greatest degree of environmental concern and analyzed based on potential release (e.g., hydrocarbon stain).

A.8.4.2 Decision II Sample Selection

Decision II sampling, if needed, will be conducted to define the extent of soil contamination and potential corrective action waste types. Additional items may be identified during the CAI. If additional items are identified, they will be investigated according to the criteria specified in this study group.

A.9.0 References

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Appendix B

Activity Organization

B.1.0 Activity Organization

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

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

Appendix C

Nevada Division of Environmental Protection Comments

(11 Pages)

NEVADA ENVIRONMENTAL MANAGEMENT OPERATIONS ACTIVITY DOCUMENT REVIEW SHEET

1. Document Title/Number: Corrective Action Investigation Plan for Corrective Action Unit 576: Miscellaneous Radiological Sites and Debris, Nevada National Security Site, Draft			2. Document Date: July 2016		
3. Revision Number: 0			4. Originator/Organization: Nevada Division of Environmental Protection		
5. Responsible DOE NNSA/NFO Activity Lead: T. Lantow			6. Date Comments Due: September 10, 2016		
7. Review Criteria:					
8. Reviewer/Organization Phone No.: NDEP			9. Reviewer's Signature:		
10. Comment Number/Location	11. Type ^a	12. Comment	13. Comment Response		
1.	ES-2, Executive Summary	Suggest adding regulatory citation, e.g., "The total effective dose (TED) means the sum of the effective dose (for external exposures) and the committed effective dose (10 CFR 835)."	Executive summaries are considered stand-alone documents. Therefore, reference citations are not included therein, as this would require an accompanying reference list. Sentence was revised to the following: "The total effective dose will be calculated as the sum of the total internal and external dose."		
2.	1.1.2, Table 1-2	a. Table introduces study groups 3 & 4 although these have not been discussed yet. Suggest the table be moved to the end of the bulleted study group section. b. "Potential Releases" column: suggest adding the word "underground" to the 1-2 phrase "weapons-related nuclear test" because all the named releases were underground tests according to DOE/NV-209. Should the reader assume the rest of the releases are from above-ground tests? Clarify.	Relocated Table 1-2. Added note within the column to reference Section 2.4 for release information. Additionally, text was revised in the last 8 rows as follows: "Surface and shallow subsurface radiological release from PSM."		

^aComment Types: M = Mandatory, S = Suggested.

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10/10/2013

N-014

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7. Review Criteria:			
8. Reviewer/Organization Phone No.: NDEP			9. Reviewer's Signature:
10. Comment Number/Location	11. Type ^a	12. Comment	13. Comment Response
3.	2.2.1.1, page 10, paragraph 1	a. 3rd sentence: insert the word "underground" before the phrase "weapons- related." b. Second to last sentence: state the detection method/instrument and its rationale with respect to expected long-lived fission/activation products and unspent weapon material as COPCs c. Move the last sentence to just before the sentence beginning with "The Avens series..."	The sentence was revised as suggested. Deleted the 2nd to the last sentence from this section as it is more appropriate in Section 2.5 (Investigative Background). New Section 2.5.4.1 was added: "In 2016, a preliminary investigation was conducted at the Area 9 "ITS" series of tests. Twenty-two sites were identified in Area 9 and investigated for surface piping. Surface piping (flex line, similar to hydraulic hose) was identified at the U9ITS U-24 (Avens-Alkermes) site. The flex line was observed coming up from the bulkhead and extending outside the fenced area for approximately 65 ft (Figure 2-2). The test at U9ITS U-24 was part of the Avens series, which was a simultaneous test at four separate holes: Avens-Alkermes (U9ITS U-24), Avens-Andorre (U9ITS T-28), Avens-Asmalte (U9ITS W-21), and Avens-Cream (U9ITS X-29) conducted on December 16, 1970. The U9ITS U-24 (Avens-Alkermes) site was the only location where surface piping (flex line) was identified. The Avens-Alkermes site is located within a posted RMA just north of the Area 9 balloon pad (most notable: Hood and Charleston tests). In 2016, a preliminary investigation was conducted at the Avens-Alkermes site, and hand-held radiological surveys (Ludlum 44-10, Electra, and Canberra Inspector 1000) identified readings above background. There were no alpha emitters, but beta was detected and the Canberra Inspector 1000 identified Cs-137 as the primary isotope." Sentence was moved to suggested location.
4.	2.2.2.1, Page 12, Paragraph 1	Last sentence beginning with, "As reflected...": because of layout and reproduction, it's difficult to understand the significance of Figs. 2-4 & 2-5 in light of corrective action investigation planning; see comment 5a.	Figures 2-4 and 2-5 are engineering drawings with the intent of providing additional detail and historical content. To graphically show the location of the emplacement hole, the pipe run, and other key attributes of the pipe system, an additional figure was added, and figures were renumbered in the document, as appropriate. A reference to the new figure was added in Section 2.2.2.1 following, "The rad-chem system was designed...U2af (surface and subsurface)." The revised text states "Figure 2-4 reflects the layout of the sampling system and the potential release points at the Kennebec site."

^aComment Types: M = Mandatory, S = Suggested.

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10. Comment Number/Location	11. Type ^a	12. Comment	13. Comment Response		
5.	2.2.2.1, Page 14/15, Figs. 2-4, 2-5	a. Usefulness could be greatly improved by editing drawing with a few explanatory graphic notes identifying the most relevant features and process flows that gave rise to the release; e.g., it would helpful to emphasize the contaminated surface flex line and other features described in Sec. 2.2.2.1. b. Assess how much material and equipment shown in Figure remains, e.g., 4 subsurface tanks (although sheet 1 of 2 lists only 3). What was the depth of burial for subsurface equipment?	See Comment Response #4. In accordance with the DQOs, lateral and vertical extent of contamination will be determined during the investigation. To clarify, the 2nd paragraph in Section 4.2.2.2 was revised as follows: "Decision II will be resolved as the physical extent of the piping system and will be determined using engineering drawings, geophysics, or direct measurements. Soil sampling will be conducted at the terminal end of the exhaust piping for both the Kennebec and Allegheny sites to determine whether contamination is present beyond the extent of the piping. Additional samples may be collected (including ISOCs), if needed, to determine potential waste types."		
6.	2.2.2.2, Page 19/20, Figs. 2-10, 2-11	See comment 5a.	Figures 2-10 and 2-11 are engineering drawings with the intent of providing additional detail and historical content. To graphically show the location of the emplacement hole, the pipe run, and other key attributes of the pipe system, an additional figure was added, and figures were renumbered in the document, as appropriate. A reference to the new figure was added to the end of the 2nd paragraph in Section 2.2.2.2 as follows: "The systems were designed to use nearby holes as the sampling location, as reflected in Figure 2-11."		
7.	2.2.2.3, Page 22, Fig. 2-13	See comment 5a.	See Comment Response #6.		

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10. Comment Number/Location	11. Type ^a	12. Comment	13. Comment Response		
8.	2.2.3.1, Page 23, Paragraph 1	a. Release source may be "unknown," but it's reasonable to discuss it in relation to atmospheric tests (CAU 541: CASs 05-23-04, 05-4S-03) on Frenchman Playa since activities associated with those tests could have given rise to CAS 05-19-04. b. Describe the range of the "elevated rad readings" and the method / instrument used.	There is presently no basis for speculating the source of the release or where the waste may have originated. To clarify, the last sentence of Section 2.2.3.1 was revised as follows: "The area was posted as a CA, and there is currently no information available indicating the source of the release or whether anything is buried at the site." Added Section 2.5.7.1 (CAU 576 Investigation): "Radiological (FIDLER) drive-over surveys were performed in August 2015, and the locations of elevated radiological readings were flagged. Subsequent removable contamination surveys identified removable contamination exceeding 20 dpm/100 cm². An area approximately 30 by 30 ft was posted as a CA."		
9.	2.2.3.1, Page 24, Fig 2-14	a. Retitle the CAS shown on the Figure as "Frenchman Flat Rad Waste Dump" in agreement with (IAW) nomenclature used throughout the rest of the document. b. Modify title as "Frenchman Flat Rad Waste Dump" IAW Fig. 2-15 title. c. Move the title off the "Study Group 3" to make the symbol visible. d. Identify in legend the NNSS/NTTR Boundary line; suggest also placing these callouts within Figure. e. Identify in Figure the physical feature: "Frenchman Dry Lake (or Flat or Playa)." f. Desirable for clarity: add GZs for BFa and Small Boy for reference.	Figure corrected. The figure title is consistent with other Study Group figures throughout the document. No change. Corrected. Boundary identified in the figure, as suggested. Frenchman Flat Playa will be labeled on the document. The CASs at CAU 541 are not relevant to CAU 576. No change to figure.		
10.	2.2.3.1, Page 25, Fig 2-15	Figure appears to be misplaced next to content from Sec. 2.2.4.1; suggest moving it adjacent to content in 2.2.3.1.	Figure 2-15 appears directly after Figure 2-14 in the document. Formatting restrictions prevent it from being moved closer to Section 2.2.3.1.		
11.	2.2.4.1, Page 25, Paragraph 1	Photos of previously discussed CASs have been presented; if available, similar photos of SG4 legacy debris should also be presented for continuity.	Inserted photos for Study Group 4, as available.		

^aComment Types: M = Mandatory, S = Suggested.

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10. Comment Number/Location	11. Type ^a	12. Comment	13. Comment Response		
12.	2.3.2.1, Page 27, Paragraph 1	2nd sentence: clarify that in addition to unknown volumes, unknown types of fission products may also be present: see comment 18.	Refer to Comment Response #18.		
13.	2.3.2.2, Page 27, Paragraph 1	2nd sentence: see comment 18	Refer to Comment Response #18.		
14.	2.3.2.3, Page 27, Paragraph 1	2nd sentence: see comment 18	Refer to Comment Response #18.		
15.	2.4.1, Page 29, Paragraph 1	4th sentence: "containment" implies barrier other than the flex line itself is preventing release. Suggest rewording to clarify that as the material comprising the flex line deteriorates, waste release becomes likely.	Replaced the 4 th sentence of Section 2.4.1 with the following: "When the material comprising the flex line deteriorates, waste within the flex line will be released to the environment (surrounding soil)."		
16.	2.4.2, Page 29, Paragraph 1	3rd sentence: without appropriate sampling and measurements, how can it be claimed that radioactive waste from the cited subsurface piping is "currently contained"?	Revised the 3 rd sentence of Section 2.4.2 with the following: "There is potential for external dose from the contaminants within the piping when the subsurface piping fails "		
17.	2.4.3, Page 29, Paragraph 1	Suggest modifying first sentence as follows: "...were stored and/or disposed of at the site". The second sentence seems redundant.	Revised the 1 st sentence and deleted the last sentence of Section 2.4.3, as follows: "The release source specific to SG3 is contaminated material that was released to the surface soil from wastes that were stored and/or disposed of at the site in the past, or contaminated material that is currently present on the surface or buried at the site."		

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3. Revision Number: 0			4. Originator/Organization: Nevada Division of Environmental Protection		
5. Responsible DOE NNSA/NFO Activity Lead: T. Lantow			6. Date Comments Due: September 10, 2016		
7. Review Criteria:					
8. Reviewer/Organization Phone No.: NDEP			9. Reviewer's Signature:		
10. Comment Number/Location	11. Type ^a	12. Comment	13. Comment Response		
18.	3.2, Page 40, Bullet 1	Provide rationale for listing Cs-137 as the only COPC for SG1 and SG2. There is no consistency between the radionuclide source term for CAU 97 and CAU 576, although they should be similar. Differences might be attributable to attenuation in release pathways. NOTE: CAU 97 External Peer Review Team Report, Rev. 0, January 2015, and the CAU 97 CAIP, Rev. 1, February 2013, show that radionuclides (long-lived fission/activation products and unspent weapon material) are not restricted to Cs-137.	The following text was inserted into Section 3.2 following the 2nd full paragraph: The COPC for SG1 and SG2 (the sample groups associated with gas sampling systems from underground nuclear tests) is Cs-137. This was determined based on process knowledge and the evaluation of analytical data. Finnegan et al. (2016) and Bowen et al. (2001) address the distribution of radionuclides in an underground test, as follows: <i>"Immediately after a nuclear explosion, all of the radioactive species exist as a plasma. As the cavity ceases to expand, heat is transferred to the wall rock and the cavity temperature and pressure begin to drop. The melt that flows to the floor of the cavity entrains the refractory radionuclides with higher boiling points (rare earth elements, alkaline earths, Zr, and Pu). Most of these refractory species are trapped in the cooling melt; a small proportion is incorporated with the collapsed chimney rubble as splash or fine droplets entrained with escaping cavity gases. Volatile species with lower boiling points (tritium, alkalis, Ru, U, Sb, Cl, I) circulate up cracks in the rubble chimney. Activation products are concentrated around the working point and will be largely incorporated in the melt or debris that borders the cavity. Volatile species, particularly Kr-90 and Xe-137, are transported as gases through the rubble and will be concentrated higher in the cavity and in the chimney relative to the refractory radionuclides."</i> Therefore, the expected radionuclides in the gas sampling system are Cs-137 and strontium (Sr)-90 (the daughter products of krypton [Kr]-90 and xenon [Xe]-137). While it is possible that Sr/yttrium (Y)-90 could be present in activities equivalent to Cs-137, Cs-137 provides approximately 100 times more dose than Sr/Y-90 and is the predominant dose contributor based on the modeled exposure scenario. This is shown in the evaluation of analytical results from 14 nuclear test sites as shown in Figure 3-1.		

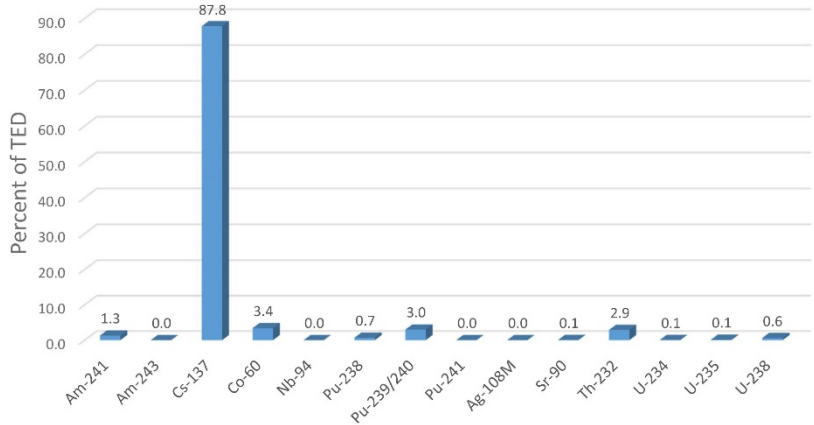
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			 Figure 3-1 Contribution to Dose from 14 Fission Releases Note: Excluding soil activation products. Also evaluated were the analytical results from two underground nuclear tests that vented gases to the surface as shown in Figure 3-2. This shows that Cs-137, as presented in the CAU 576 DQOs, is the only significant dose contributor expected in the underground test gas sampling systems.		

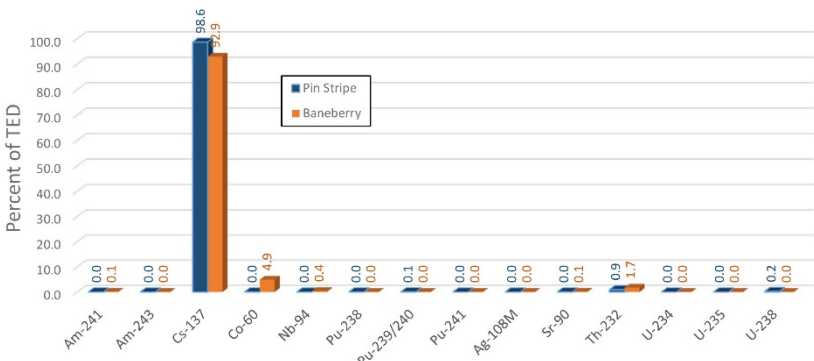
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			 Figure 3-2 Contribution to Dose from 2 Venting Releases Note: Excluding soil activation products. The following references were inserted at the end of the main document. Finnegan, D.L., S.M. Bowen, J.L. Thompson, C.M. Miller, P.L. Baca, L.F. Olivas, C.G. Geoffrion, D.K. Smith, W. Goishi, B.K. Esser, J.W. Meadows, N. Namboodiri, and J.F. Wild. 2016. <i>Nevada National Security Site Radionuclide Inventory, 1951–1992: Accounting for Radionuclide Decay through September 30, 2012</i>, LA-UR-16-21749. Los Alamos, NM: Los Alamos National Laboratory. Bowen, S.M., D.L. Finnegan, J.L. Thompson, C.M. Miller, P.L. Baca, L.F. Olivas, C.G. Geoffrion, D.K. Smith, W. Goishi, B.K. Esser, J.W. Meadows, N. Namboodiri, and J.F. Wild. 2001. <i>Nevada Test Site Radionuclide Inventory, 1951–1992</i>, LA-13859-MS. Los Alamos, NM: Los Alamos National Laboratory.
19.	3.2, Page 40, Bullet 2	Sections 2.4 and 2.5 do not provide sufficient information to identify the list of COPCs. A review of the CAU 98 COPC list identifies additional radionuclide contaminants not listed. Justify the COPC list for SG3; specifically, explain why Sr/Y-90 is not listed since its production is nearly identical to that of Cs-137 from weapon detonation.	Refer to Comment Response #18.

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20.	3.2, Page 40, Bullet 3		Clarify "low-level radiological". The previous bullets have listed radionuclides.		
21.	3.2, Page 40, Paragraph 3		a. Verify that Section A.2.2.1 clearly discusses the incomplete history of site testing operations as referenced in Section 3.2. As written, Sections. 4.2.2.1-4.2.2.4 do not appear to effectively convey "incomplete history". b. List the other COPCs that will be analyzed for even though they are not suspected of being present.		
22.	3.2, Page 40, Paragraph 4		Table A.2-3 does not list isotopic Sr as a radionuclide COPC yet it is listed in Table A.2-4. Align table contents. Paragraph confusing and unnecessary. Deleted paragraph. Refer to Comment Response #18. Paragraph deleted.		
23.	4.2.2.1, Page 49, Paragraph 1		2nd sentence: ISOCS identifies only gamma-emitting radionuclides and is not adequate to detect the presence of beta or alpha emitting nuclides (e.g., Sr/Y-90, Pu-239) that may also be present within the pipe, leading to inaccurate characterization and underestimating dose. Clarify how the internal contents of the Surface Rad-Chem Piping will be characterized to account for the presence of non- gamma emitting radionuclides. If only external dose is evaluated, how will TED be accomplished? Refer to Comment Response #18.		
24.	4.2.2.1, Page 49, Paragraph 2		Explain why the sample would be analyzed for additional radiological constituents (e.g., gamma spectroscopy, and isotopic U, Pu, and Am) other than the stated COPC of Cs-137. Inserted "to verify the CSM" at the end of the 1st sentence.		

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25.	4.2.2.2, Page 49, Paragraph 1	A single TLD placed at the highest surface radiation survey location only provides the external dose of the TED component. How will the internal dose component be determined for the subsurface pipes and how will extent be determined if the piping has been breached? Please clarify how data will be collected to determine the internal dose so TED can be estimated for the subsurface piping. Additionally, this section limits extent to the physical piping. How will lateral extent beyond the physical piping be determined? This will be crucial information prior to any corrective action to ensure ALARA.	No change to document; refer to Comment Response #18. Although the subsurface contamination is the focus of the release, there is a potential that some surface release has occurred. To address this potential, a radiological survey of the site will be conducted, and the location of the highest readings will be sampled for external dose with a TLD as a precaution. The TLD measurement was included in the CAU 576 DQOs as sufficient to demonstrate the absence of Cs-137 in the surface soil at levels of potential concern. Dose estimates for the subsurface piping is not necessary because (per the DQOs) it is assumed that the entire extent of the subsurface piping exceeds 25 mrem/yr. Geophysics will determine lateral extent of subsurface piping. Based on the accepted CSM in the DQOs, the subsurface piping is located in vadose zone material where the only migration pathway for the potential contamination is the vertical percolation of storm water. There exists no mechanism for lateral flow other than diffusion occurring during vertical percolation, which will have minimal effect on lateral migration (especially due to the low solubility and high adsorptive properties of Cs-137). The UR boundary that will be defined in the CADD or CR will include a buffer that will more than compensate for any minimal diffusion.		
26.	4.2.2.3, Page 50, Paragraph 1	How would Decision II be resolved if geophysical survey does not identify buried wastes? Geophysics favors subsurface electromagnetic (EM) variations, but contamination could exist without measurable EM variations such as from metal.	Per the DQOs, if no geophysical anomalies, then it is assumed no landfill. If landfill exists, then determine lateral and physical extent using geophysics. To clarify, new Section 2.5.7.1 was added, and subsection text was added as follows: "Radiological (FIDLER) drive-over surveys were performed in August 2015, and the locations of elevated radiological readings were flagged. Subsequent removable contamination surveys identified removable contamination exceeding 20 dpm/100 cm². An area approximately 30 by 30 ft was posted as a CA."		
27.	4.2.2.3, Page 50, Paragraph 2	Should the samples also be submitted for isotopic Sr?	See Comment Response #18.		

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28.	6.1, Page 57, 1 st bullet	What are the QC and data acceptance requirements for ISOCS measurements, i.e., is ISOCS being deployed as M&TE to collect decision-supporting data?	This will be reported in the DQA section of the CADD. To clarify, revised the 1st sub-bullet as follows: "Field duplicates for ISOCS and grab samples..." No change to document. It is not anticipated that the ISOCS data will be used as decisional data. However, in accordance with the Soils QAP, the data quality for the ISOCS data will be assessed in the DQA section of the CADD depending upon the final use of the data in resolving DQO decisions.		
29.	A.2.2.1.1, Page A-6, Fig A.2-1	The Figure is missing the singular source for each of the 4 study groups. Include the source of contamination for each of the four study groups, i.e., "weapons-related testing."	Replaced "Source" with "Study Groups."		
30.	A.2.2.1.1, Page A-8, Table A.2-2	Footnote 'a': There is insufficient data presented to substantiate the statement.	Refer to Comment Response #18. Deleted footnote (a) in Table A.2-2.		
31.	A.2.2.2, Page A-10, Paragraph 1	Last sentence: clarify the sentence by clearly stating that radiation surveys could isotopically detect Cs-137 and specify the survey method and instrumentation used.	The last sentence of the 1st paragraph and the following bullets in Section A.2.2.2 were deleted. A reference to Section 3.2 was provided to refer the reader to the appropriate section. The 3rd sentence in the 1st paragraph was revised as follows: "These COPCs were identified during the planning process through the review of site history, process knowledge, personal interviews, past investigation efforts (where available), and inferred activities associated with the study groups (including those that may be discovered during the investigation; see Section 3.2)."		
32.	A.2.2.2, Page A-11, Table A.2-3	Footnote 'c': clarify how gamma analysis will be used to determine "whether further isotopic analysis is warranted."	Removed footnote "c" from Table A.2-3. Inserted the following before the last sentence in A.2.2.2: "If a radionuclide is identified that is not expected, such as Am-241 or U-235, isotopic analyses would be requested for those samples (such as isotopic Pu or isotopic U)."		
33.	A.2.2.3, Page A-11, Paragraph 2	Last sentence beginning with, "No radionuclides ...": the source term of contamination is from fission weapon detonation; listed COPCs do not include major contributing radionuclides referenced in this section contributed by CAUs 97 and 98; the purpose of this reference is unclear.	No change to document. As stated, the purpose is to provide an example of the migration potential of radionuclides from nuclear testing and show that, other than tritium and krypton, these radionuclides do not migrate significant distances from the source. See Comment Response #18.		
34.	Throughout the document		Several other minor editorial corrections were made.		

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