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# CORRECTIVE ACTION DECISION DOCUMENT/ CLOSURE REPORT FOR CORRECTIVE ACTION UNIT 527: HORN SILVER MINE NEVADA TEST SITE, NEVADA

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

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**CORRECTIVE ACTION DECISION DOCUMENT/CLOSURE REPORT FOR CORRECTIVE ACTION UNIT 527: HORN SILVER MINE NEVADA TEST SITE, NEVADA**

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# List of Acronyms and Abbreviations

| | |
|---|---|
| ASTM | American Society for Testing and Materials |
| bgs | Below ground surface |
| CADD | Corrective Action Decision Document |
| CAI | Corrective Action Investigation |
| CAIP | Corrective Action Investigation Plan |
| CAS | Corrective Action Site |
| CAU | Corrective Action Unit |
| CFR | *Code of Federal Regulations* |
| CLP | Contract Laboratory Program |
| COC | Contaminants of concern |
| COPC | Contaminants of potential concern |
| CRDL | Contract required detection limit |
| CSM | Conceptual site model |
| DOE | U.S. Department of Energy |
| DQI | Data quality indicator |
| DQO | Data quality objective |
| DRO | Diesel-range organics |
| EPA | U.S. Environmental Protection Agency |
| FADL | Field activity daily log |
| FD | Field duplicate |
| FFACO | *Federal Facility Agreement and Consent Order* |
| FSL | Field-screening level |
| FSR | Field-screening results |
| ft | Foot |
| gal | Gallon |
| GPS | Global positioning system |

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

| | |
|---|---|
| GRO | Gasoline-range organics |
| HPGe | High-purity germanium |
| HSM | Horn Silver Mine |
| HWAA | Hazardous Waste Accumulation Area |
| ICP | Inductively coupled plasma |
| IDW | Investigation-derived waste |
| in. | Inch(es) |
| LCS | Laboratory control sample |
| LCSD | Laboratory control sample duplicate |
| LD | Laboratory duplicate |
| M&O | Management and Operating |
| MDC | Minimum detectable concentration |
| mg/kg | Milligrams per kilogram |
| mg/L | Milligrams per liter |
| mg/m$^3$ | Milligrams per cubic meter |
| mi | Mile |
| mrem/yr | Millirems per year |
| MRL | Minimum reporting limit |
| MS/MSD | Matrix spike/matrix spike duplicate |
| NAC | *Nevada Administrative Code* |
| NCRP | National Council on Radiation Protection and Measurements |
| ND | Normalized difference |
| NDEP | Nevada Division of Environmental Protection |
| NIST | National Institute for Standards and Technology |
| NNSA/NSO | U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office |
| NRS | *Nevada Revised Statutes* |

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

| | |
|---|---|
| NTTR | Nevada Test and Training Range |
| NTS | Nevada Test Site |
| NURE | National Uranium Resource Evaluation |
| PAL | Preliminary action level |
| PB | Preparation blank |
| PCB | Polychlorinated biphenyls |
| pCi/g | Picocuries per gram |
| pCi/L | Picocuries per liter |
| POC | Performance Objective for Certification |
| ppb | Parts per billion |
| PPBV | Parts per billion volume |
| ppm | Parts per million |
| PRG | Preliminary remediation goal |
| PVC | Polyvinyl chloride |
| QA | Quality assurance |
| QAPP | Quality Assurance Project Plan |
| QC | Quality control |
| RadCon | Radiological control |
| RCP | Reactor Control Point |
| RCRA | *Resource Conservation and Recovery Act* |
| RCT | Radiation Control Technician |
| ROTC | Record of Technical Change |
| RPD | Relative percent difference |
| SAL | Screening action level |
| SDG | Sample delivery group |
| SEA | Science and Engineering Associates, Inc. |

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

| | |
|---|---|
| SNJV | Stoller-Navarro Joint Venture |
| SOP | Standard Operating Procedure |
| Sr | Stronium |
| SSHASP | Site-specific health and safety plan |
| SVOC | Semivolatile organic compound |
| TPH | Total petroleum hydrocarbons |
| USGS | U.S. Geological Survey |
| VOC | Volatile organic compound |
| µg/kg | Micrograms per kilogram |
| µg/L | Micrograms per liter |
| $\mu g/m^3$ | Micrograms per cubic meter |
| %R | Percent recovery |

# Executive Summary

This Corrective Action Decision Document/Closure Report (CADD/CR) has been prepared for Corrective Action Unit (CAU) 527: Horn Silver Mine, Nevada Test Site (NTS), Nevada, in accordance with the *Federal Facility Agreement and Consent Order* (1996). Corrective Action Unit 527 is located within Area 26 of the NTS and consists of CAS 26-20-01, Contaminated Waste Dump #1. This CADD/CR refers to the site as CAU 527 or the Horn Silver Mine (HSM).

This CADD/CR provides or references the specific information necessary to support the closure of this CAU. Corrective action investigation activities were performed from November 12, 2003 through January 21, 2004. Additional sampling of liquid obtained from HSM-3 was conducted on May 3, 2004. Corrective action investigation activities were performed as set forth in the Corrective Action Investigation Plan for Corrective Action Unit 527 (NNSA/NV, 2002a).

Assessment of the data generated from investigation activities identified the explosive nitrobenzene as a contaminant of concern (COC) on the floor of the 500-foot drift (HSM #2). No other COCs were identified in the rock samples collected during the investigation activities. The air samples collected from borings HSM-1, HSM-2, and HSM-3 showed volatile organic compounds (primarily gasoline-related contaminants) to be present above the acceptable residential exposure criteria in the boreholes. A conservative modeling effort demonstrated that these concentrations would not migrate to the surface at concentrations that will present an unacceptable risk to future land users. However, other COCs are assumed to exist based on historical documentation on the types of waste placed in the shaft; therefore, the mine including the 300- and 500-foot drifts is considered to be contaminated above action levels.

Current results of the field investigation show there are no active transport mechanisms or exposure routes for the contaminants identified in the 500-foot drift. The analytical data did not show the migration of COCs beyond the floor of the 500-foot drift or from the air within the drift. On a conservative basis, the subsurface volume of the zone of contamination is limited to a depth from 150 ft to a maximum of 670 feet below ground surface extending to a radius of 300 feet from the mineshaft. Based on these data, a use restriction will be established for this volume of soil. In addition, the security of the mineshaft is maintained and does not allow unauthorized personnel to enter the vicinity of the mineshaft. Since the removal of the contaminants is not feasible, the close in place with administrative controls corrective action alternative is appropriate because it will prevent inadvertent contact with the subsurface COCs and meets all applicable state and federal regulations for closure of the site.

Post-closure monitoring will be conducted for one year. This monitoring will include using the lysimeter at HSM-3 and the data logger to measure precipitation-induced vadose zone moisture flow through the rock beneath the waste shaft at the Horn Silver Mine. Results of the monitoring will be documented in a letter report at the end of one year, anticipated in June 2005. A copy of this report will be submitted to the Nevada Division of Environmental Protection. After one year of monitoring, a determination will be made by the Nevada Division of Environmental Protection and U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office if future monitoring is needed or if use restriction boundaries need to be adjusted. If a large enough pulse of water moves into the lysimeter, a sample will be collected for laboratory analysis. If there is not sufficient volume of liquid collected for a sample or if no COCs are detected in collected samples at the end of this time period, it is recommended that the monitoring wells at the HSM be sealed in accordance with the State of Nevada regulations.

# 1.0 Introduction

This Corrective Action Decision Document/Closure Report (CADD/CR) has been prepared for Corrective Action Unit (CAU) 527: Horn Silver Mine, Nevada Test Site (NTS), Nevada, in accordance with the *Federal Facility Agreement and Consent Order* (FFACO) that was agreed to by the State of Nevada, U.S. Department of Energy (DOE), and the U.S. Department of Defense (FFACO, 1996). The NTS is approximately 65 miles (mi) northwest of Las Vegas, in Nye County, Nevada. The Corrective Action Site (CAS) 26-20-01, Contaminated Waste Dump #1, is the only CAS in CAU 527 and is located in Area 26 (Figure 1-1). This CADD/CR refers to the site as CAU 527 or the Horn Silver Mine (HSM). This CADD and CR have been combined into one report because the only viable corrective action alternative is close in place with administrative controls. This CADD/CR provides or references the specific information necessary to support the closure of this CAU.

## 1.1 Purpose

The HSM shaft is narrow and deep, and is approximately 8- by 8-feet (ft) square and 500 ft deep. Drifts were developed at 60, 160, 300, and 500 ft below ground surface (bgs) (Lawry, 1929a). Mining operations at the HSM were started in 1928 when a high-grade, silver-gold ore was discovered, but ore production was limited and the mine was abandoned in 1929 (Lawry, 1929a and b). The mine entrance sits on a leveled area of sloping terrain.

Historical documentation indicates that between 1959 and the 1970s, nonliquid classified material and unclassified waste was placed in the Horn Silver Mine's shaft. Some of this waste is known to be radioactive; however, it is unknown if hazardous wastes were disposed of in the mine. Documentation indicates that waste is present from 150 feet ft bgs to the bottom of the mine, which is 500 ft bgs. The shaft from 150 ft to the surface is filled with clean fill and sealed at the surface with a 20 ft by 20 ft concrete pad and locking cover. Additional information about the history, planning, and scope of the investigation are provided in the *Corrective Action Investigation Plan (CAIP) for Corrective Action Unit 527: Horn Silver Mine, Nevada Test Site, Nevada* (NNSA/NV, 2002a) and the four Record of Technical Changes (ROTCs).

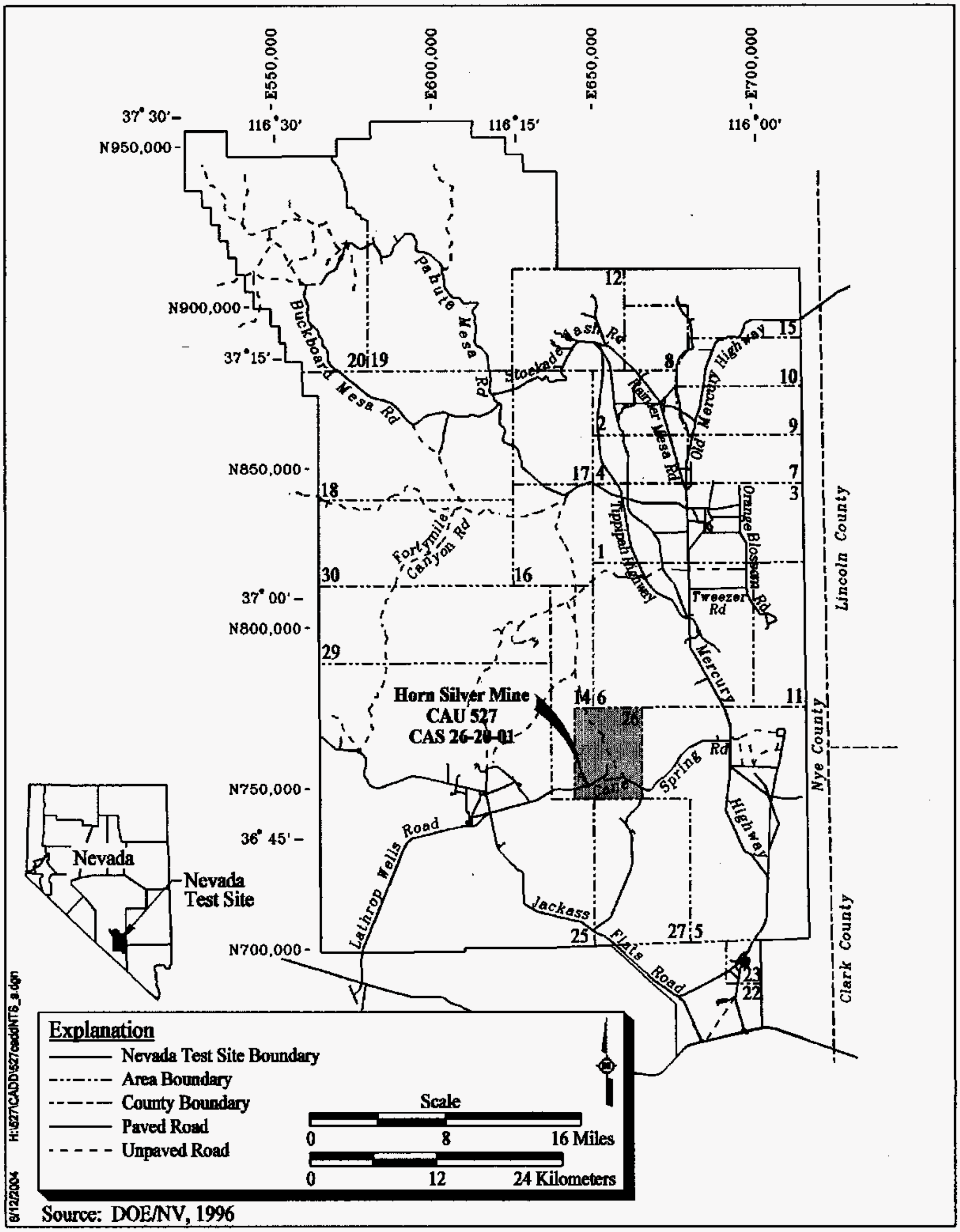


**Figure 1-1**
**Nevada Test Site and CAU 527 Location Map**

This CADD/CR provides the supporting documentation and rationale for the selection of the close in place corrective action. The rationale is based on process knowledge and the results of investigative activities conducted in accordance with the CAIP. The corrective action alternative of no further action was not evaluated because historical documentation shows that the material in the mineshaft contains radioactive constituents to be present at concentrations that are expected to exceed the regulatory action levels. Security restriction precluded the collection of environmental samples within a 50-ft radius of the mineshaft. The clean closure corrective action alternative was not evaluated because of the security restrictions associated with the waste and safety concerns associated with excavation of the waste. Close in place is appropriate because the contaminants that are present at concentrations exceeding action levels are between 150 and 500 ft bgs and do not pose an unacceptable risk to human health and the environment. The results of the field investigation show that contaminants of concern (COCs) were not detected in samples, except nitrobenzene, suggesting that contaminants have not migrated away from the HSM shaft. Nitrobenzene, the only COC identified in the rock samples, was detected in the floor of the drift at HSM-2 and showed no indication of migration. Therefore, a risk assessment was not required nor conducted. The volatile organic compounds (VOCs) detected in the air from the drifts, although present at concentrations exceeding residential criteria in the drift, are not migrating to the surface at concentrations that pose an unacceptable risk to human health.

Use-restriction signs will be placed on the existing fence around the HSM. The future use of the CAU would be restricted from any activity that would alter or modify the containment control unless appropriate concurrence was obtained from Nevada Division of Environmental Protection (NDEP). The combination of these measures will effectively prevent inadvertent contact with contaminants by humans.

## 1.2 Scope

The scope of this CADD/CR is to support the recommended close in place corrective action alternative for CAU 527, Horn Silver Mine. To achieve this scope, the following actions were implemented:

- Conducted video mole survey of surrounding mineshafts to determine if there were any drifts that may provide migration pathways for suspected contaminants.

- Drilled and sampled 2 vertical borings to the depths of the 300-ft and 500-ft drifts.
- Drilled an angle boring to a depth and location directly beneath the mineshaft without infringing on the 50-ft restricted radius.
- Collected rock-cutting samples at specified intervals throughout the borings to identify contamination, if present.
- Collected 20 ft of rock core from the bottom of the angle boring for geotechnical and chemical analyses.
- Installed monitoring systems in the vertical borings to determine if groundwater is migrating through the overlying rock and transporting contaminants away from the shaft or drifts.
- Installed a lysimeter water-collection system in the angled boring to allow for the collection of water moving as unsaturated flow.
- Collected air samples from the borings to determine if contaminants are migrating from the drift through the fractures or pores of the overlying rock.
- Conducted the field activities in accordance with the CAIP (NNSA/NV, 2002a) and ROTCs #1 through 4.
- Evaluated the close in place remedial alternative.
- Installed the appropriate signage on the existing fence around the main shaft of the mine that identifies the recommended use restrictions.
- Conducted well monitoring and sampling after the well installation as detailed in the CAIP. The monitoring of the angle boring is planned for at least a year on a quarterly basis.

## *1.3 CADD/CR Contents*

This CADD/CR is divided into the following sections:

Section 1.0 - Introduction: summarizes the purpose, scope, and contents of this CADD/CR.

Section 2.0 - Corrective Action Investigation Summary: summarizes the investigation field activities, the results of the investigation, and the justification for close in place.

Section 3.0 - Recommendation: recommends close in place as the appropriate corrective action for CAU 527.

Section 4.0 - References: provides a list of all referenced documents.

Appendix A - *Corrective Action Investigation Results for CAU 527*: provides a description of the project objectives, field investigation and sampling activities, investigation results, waste management, and quality assurance.

Appendix B - *Data Assessment for CAU 527*: summarizes the investigation results as they meet the requirements set forth during the data quality assessment process.

Appendix C - *DQO Summary*: provides a summary of the DQOs used for the CAU 527 investigation.

Appendix D - *Use Restrictions*: provides the use restrictions for CAU 527.

Appendix E - *Air-Flow Measurements in NTS Boreholes HSM-1 and HSM-3* prepared by Science Engineering Associates, Inc. (SEA).

Appendix F - Evaluation of Total Petroleum Hydrocarbon (TPH) Contamination in Drill Cuttings

Appendix G - Provides the responses to the Nevada Division of Environmental Protection (NDEP) comments.

### 1.3.1 Supporting Documentation

All work was performed in accordance with the following documents:

- *Corrective Action Investigation Plan for Corrective Action Unit 527: Horn Silver Mine, Nevada Test Site, Nevada* (NNSA/NV, 2002a)
- *Industrial Sites Quality Assurance Project Plan* (QAPP) (NNSA/NV, 2002b)
- *Federal Facility Agreement and Consent Order* (1996)
- *Project Management Plan* (DOE/NV, 1994)

### 1.3.2 Data Quality Objectives

The Data Quality Objectives (DQOs) identified in the CAIP are as follows:

- Determine if a significant contaminant transport pathway and mechanism (i.e., groundwater and vapor transport) is present.
- Determine if significant contamination migration has occurred within open fractures or drifts.
- Determine the extent of contamination if migration has occurred.

The results of the field investigation show no significant contaminant transport mechanism exists. Data from HSM-3 show that COCs have not migrated vertically and data from HSM-1 show COCs have not migrated laterally from the HSM shaft or associated drifts; therefore, a risk assessment is not required. The Data Quality Indicators (DQIs) as discussed in Appendix B, were achieved and the DQOs established in the CAIP as discussed in Appendix C, were met.

# 2.0 Corrective Action Investigation Summary

The following sections summarize the CAU 527 investigation activities and results, and the justification for the close in place remedial alternative. Detailed investigation activities and results for CAU 527 and modifications to the CAIP and field activities are presented in Appendix A of this document.

## 2.1 Investigation Activities

Three boreholes were drilled during the corrective action investigation (CAI). The nomenclature for each boring is:

- HSM-1 (307-ft boring)
- HSM-2 (485-ft boring)
- HSM-3 (724-ft angle boring)

The CAI activities were performed as set forth in the CAIP (NNSA/NV, 2002a) from November 12, 2003 through January 21, 2004. Additional sampling of liquid identified at 214 ft bgs in HSM-3 was conducted on May 3, 2004.

The purpose and scope of the CAI for CAU 527 was to determine if a significant contaminant transport mechanism (e.g., saturated and unsaturated flow, or vapor) and pathways (e.g., fractures, drifts, porous media) exist to allow unacceptable concentrations of suspected contaminants to migrate from the mineshaft. Contamination cannot migrate or pose an unacceptable risk to human health or the environment without a viable transport mechanism. To address these issues, a CAI was developed using the DQO process. Table 2-1 provides a cross-reference between the CAI activities and the conceptual site model (CSM) presented in the CAIP. This table shows how each activity was used to address the problem statement and support the decisions and recommendations for the closure of this CAU.

The observations made and data collected from the field investigation were consistent with the CSM developed for CAU 527; therefore, no revisions to the CSM were necessary. Appendix B provides additional discussion on the representativeness of the CSM.

**Table 2-1**
**Correlation Between CAI Activities and the CSM for CAU 527, Horn Silver Mine**

| CAI Activity | CSM Component | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Contamination | | Migration Pathway | | | Transport Mechanism | | |
| | Nature | Extent | Fractures | Drifts | Porous Media | Vapor | Unsat. Flow | Sat. Flow |
| Video survey of surrounding mineshafts | | | | X | | X | | X |
| Vertical borings | X | X | X | X | X | X | X | X |
| Angle boring | X | X | X | | X | | X | X |
| Rock cutting samples | X | X | X | X | X | | X | X |
| Rock core samples | X | X | X | | X | | X | X |
| Borehole permeability testing | | | X | X | X | X | X | X |
| Geotechnical analysis of rock core | | | | | | X | X | |
| Chemical and radiological analysis of rock samples | X | X | | | | | X | X |
| Chemical and radiological analysis of vapor samples | X | X | X | X | X | X | | |
| Installation of monitoring wells | X | X | | X | | | | X |
| Installation of lysimeter/tensiometer | X | X | X | | X | | X | |
| Quarterly monitoring | X | X | X | X | X | | X | X |
| Weather station | | | X | | X | | X | X |
| Radiological monitoring (air and rock) | X | X | X | X | X | | X | |
| Vapor modeling | | X | X | | X | X | | |
| Geophysical logging | | | X | X | X | | X | X |
| Data logging | | | X | X | X | | X | X |

The CAI included the following general activities. An explanation of how these activities provided information needed to validate the CSM and satisfy DQO data needs is also provided:

- Conducted a video survey of three adjacent mineshafts to determine if a migration pathway exists from the main shaft or drifts for vapor or liquids.
- Drilled two vertical borings to the depths of the 300- and 500-ft drifts to provide information on lithology, presence of faults, determine if perched groundwater is present in the formation, and to access sample locations within and near the drifts.
- Drilled an angle boring to a depth and location directly beneath the mineshaft to collect data on lithology, faults, the presence of formation water, and to collect samples directly below the mineshaft and to access sample locations beneath the mineshaft.

- Field screened and radiological monitored rock samples and drilling activities to collect information on the presence of potential radioactive contamination in the drifts or formation surrounding the mineshaft.

- Collected rock-cutting samples to determine if contamination has migrated from the mineshaft either laterally or vertically into the surrounding formation.

- Collected groundwater samples using a tensiometer in the vadose zone at a depth of 214 ft near the mineshaft on May 3, 2004, to determine if contaminants are migrating away from the mineshaft via unsaturated flow at concentrations that exceed the PALs.

- Collected air samples (summa canisters) from the drifts to determine the presence of gas-phase contaminants. These data allowed for the identification of contaminants that may be migrating from the drift through the fractures or pores into the surrounding formation.

- Conducted air permeability testing of the formation near the mine drifts. This was done to determine how the formation permeability, either natural or mining induced, is impacting the potential vertical or lateral migration of contamination.

- Collected 20 ft of rock core from the bottom of the angle boring for geotechnical and chemical analyses. These samples provided data on the physical properties of the rock surrounding the mineshaft and identified if contamination has migrated from the base of the mineshaft and to support the modeling of the vapor in the drifts and rock to the surface. Geophysical logging provided information on the fracture density and spacing, lithology of the formation surrounding the shaft and drifts, and presence of faults. The geophysical logging information from HSM-1 was also used to identify potential sampling intervals in HSM-2.

- Permeability testing of the formations was conducted to determine the impact of the formation porosity and permeability on the transport of contaminants vertically by either water or vapor. Permeability testing of the formation provided information that HSM-1 was drilled in close proximity to the drift and information on physical properties of the formation for modeling, if needed.

- Established water collection systems (monitoring wells and lysimeter) to determine if pulses of groundwater are moving contaminants via unsaturated flow vertically from the shaft or drifts.

- Installed a weather station to provide site-specific precipitation data and support the further evaluation of potential infiltration and contaminant migration, if necessary.

- Installed data logging equipment to continuously monitor the three wells and notify the project personnel of the presence of water or other changes in the system that may suggest contamination migration.

- Geophysical logging of the formation. This activity provided information on the presence and nature of fractures, saturated or wet zones, and faults.
- Characterization of waste streams to be compliant with disposal requirement.
- Surveyed sample locations using global positioning system (GPS) equipment to document sample results.
- Planned additional sample collection and monitoring of the wells and lysimeter for up to one year. This activity may provide additional information and notification if conditions change (e.g., if pulses of moisture move through the formation during the year following the investigation.

During investigation activities, 24 cuttings samples, 7 air samples, and associated quality control (QC) samples were collected from within the three borings (HSM-1 through HSM-3). Additionally, at HSM-3 one liquid sample and two geotechnical samples were collected and analyzed. Soil samples were field screened for volatile organic compound (VOCs) and alpha and beta/gamma radiation and then shipped to an off-site laboratory for analyses. Investigation activities and results are discussed in detail in Appendix A.

## *2.2 Results*

Environmental data from the corrective action investigation is summarized in Section 2.2.1. This information illustrates the degree of characterization accomplished through the field effort and identifies those contaminants of potential concern (COPCs) that exceeded preliminary action levels (PALs) and are identified as COCs. Section 2.2.2 summarizes the data quality assessment detailed in Appendix B. This information demonstrates that the investigation results met the DQO requirements.

### *2.2.1 Summary of Investigation Results*

Chemical and radiological results for samples exceeding PALs are presented in this section. The PALs for the CAU 527 investigation were identified during the DQO process. For chemical COPCs, PALs are based on U.S. Environmental Protection Agency (EPA) *Region 9 Industrial Preliminary Remediation Goals* (PRGs) (EPA, 2002), background concentrations for metals, and 100 milligrams per kilogram (mg/kg) for TPH.

The PALs for radiological contaminants are taken from the recommended screening limits for the construction, commercial, and industrial land-use scenario in Table 2.1 of the National Council on Radiation Protection and Measurements (NCRP), Report No. 129, *Recommended Screening Limits for Contaminated Surface Soil and Review of Factors Relevant to Site-Specific Studies* (1999), scaled from 25- to 15-millirems per year (mrem/yr) dose, and, the generic guidelines for residual concentration of radionuclides in DOE Order 5400.5, "Radiation Protection of the Public and the Environment" (DOE, 1993). The specific radiological PALs for CAU 527 are listed in the radiological specific tables in Appendix A.

Details about the methods used during the investigation and a comparison of environmental sample results to the PALs are presented in Appendix A. Sample locations selected to determine the presence and/or extent of contamination are shown in Appendix A figures. Based on these results, the nature and extent of COCs at CAU 527 have been identified and results support the recommendation for a close in place corrective action.

The CAI identified nitrobenzene as a COC at a concentration of 2,100 mg/kg in a sample collected from the floor of the drift in HSM-2 (sample 527B0121) at a depth between 478 and 481 ft bgs. Nitrobenzene was not detected in samples taken from intervals above the 500-ft drift, at the depth equivalent to the 300-ft drift in HSM-1. Because nitrobenzene was only detected on the floor of the 500-ft drift and not in any of the other samples from any of the three borings, the nitrobenzene is considered not to be mobile. Nitrobenzene is an explosive compound used in the manufacturing of chemicals including explosives and is suspected to be a residual of the explosives of the mining operations and not associated with material in the shaft. No other COCs were identified in the samples collected at CAU 527.

Although TPH-diesel-range organics (DRO) exceeded the PAL of 100 mg/kg in all three boreholes, the contaminant most likely has been introduced into the borings by the air compressor and vacuum circulation system used to remove the cuttings from the borings. Therefore, TPH will not be considered a COC (see Section A.3.4.3 and Appendix F). Arsenic exceeded the PAL of 23 mg/kg in most of the samples collected in the three boreholes with concentrations ranging from 13 to over 300 mg/kg. Arsenic is found in naturally occurring high concentrations (>500 mg/kg) in sulfide deposits (NAP, 1977) such as the silver ore veins within the Horn Silver Mine; therefore, it will not be considered a COC (see Section A.3.4.4).

A zone of moisture was identified during logging at a shallow depth (approximately 214 ft) in HSM-3. This zone is above any waste in the HSM. A sample of the liquid was collected on May 3, 2004, and was analyzed for VOCs and tritium. No COCs were identified from this liquid sample. Additional information regarding this sample can be found in Section A.2.3.5 and Section A.3.4.15.

### 2.2.2 DQO Assessment

An assessment of CAU 527 corrective action investigation results was performed to determine whether the data collected met the DQOs as discussed in Appendix C and could support their intended use in the decision-making process. The data assessment provided in Appendix B includes an evaluation of the DQIs to determine the degree of acceptability and usability of the reported data in the decision-making process. Additionally, a reconciliation of the data with the CSM established for this project was conducted. Conclusions were validated based on the results of the quality assurance (QA)/QC measurements provided in Appendix B and discussed in Section A.5.0.

The overall results of the assessment indicate that the DQI goals for precision, accuracy, completeness, representativeness, and comparability have been achieved. Precision and accuracy of the datasets were demonstrated to be high. Rejected data were not used; however, an evaluation of completeness indicates that sufficient information was collected to support DQO decisions and to meet the DQI of completeness. Representativeness of site characteristics was demonstrated with the CAU 527 data. An evaluation of comparability provides a high confidence that the datasets for the project are comparable to other datasets generated by accepted industry standard practices (e.g., EPA SW-846). Meeting DQI goals supports acceptance of the CAU 527 dataset for meeting the DQOs established for this project and the subsequent use of this data in the decision-making process.

The CSM presented in the CAU 527 CAIP and the four ROTCs were the basis for the sample collection designs used for the site investigation. The reconciliation of CAU 527 corrective action investigation results to the established CSM supports the assumptions documented in the CSM.

### 2.3 Justification for No Further Action

Close in place with administrative controls is appropriate because it will prevent inadvertent contact with COCs. Results of the field investigation show no significant contaminant transport mechanisms were identified and COCs were not detected in samples, except for nitrobenzene, suggesting that contaminants have not migrated away from the HSM shaft. Nitrobenzene, the only COC identified in the rock samples, was detected in the floor of the drift at HSM-2 and showed no indication of migration. Because COCs have not been shown to have migrated from the shaft or associated drifts and the identified contamination in HSM is located between 150 ft and 500 ft bgs, a risk assessment is not required.

The following evaluation of *Nevada Administrative Code* (NAC) 445A.227 (2) (a-k) (NAC, 2003) supports the conclusion that COCs at CAU 527 do not pose a significant risk to groundwater:

a. Perched groundwater exists sporadically ranging from 77 to 182 ft in some, but not all, of the Pluto wells drilled approximately 3 mi to the east of the Horn Silver Mine (Johnson and Ege, 1964). Perched water was not detected during mining or drilling operations at HSM within or beneath the strata where wastes were disposed. Depth to groundwater at the nearest well (J-11 WW, which is 7 mi to the southwest of the Horn Silver Mine) is approximately 1,037 ft bgs and completed in volcanic rock (USGS, 2002; Walker et al., 1961). Groundwater flow is generally to the southwest and may discharge at Ash Meadows (USGS, 1996).

b. The distance to the nearest active water-supply well (Well 4a) is approximately 10 mi northeast of HSM (DOE/NV, 1998). Well 4a is primarily used to provide potable water for Area 6 and is located upgradient of HSM.

c. Soil at this site is shallow (less than a few inches), generally a light brown, silty gravel that is poorly sorted, and made up of alluvial, colluvial, and volcanic rocks. The surface immediately surrounding HSM is covered with mine tailings ranging in thickness from a few inches to several feet.

d. Average annual precipitation for valleys in the South-Central Great Basin ranges from 3 to 6 inches (in). (Winograd and Thordarson, 1975). Annual evaporation is roughly 5 to 25 times the annual precipitation (Winograd and Thordarson, 1975). The high evaporation and low precipitation rates limit the amount of infiltration that could percolate into and through the deep subsurface. Therefore, very limited precipitation is available to drive migration of COCs.

e. Nitrobenzene was identified in the subsurface rock at the base of the drift at location HSM-2. This compound is considered to be a residual contaminant from the mining operations and not from the waste in the mineshaft. Downward migration of COCs is slowed by the following parameters.

- Volume of release - It is assumed that most of the nitrobenzene was consumed during the mining activities (expended as an explosive) and any remaining volume was released over a short period of time.

- Soil saturation - The rock is unsaturated, including the base of the drift where the nitrobenzene was detected.

- Soil particle adsorption/desorption - Nitrobenzene tends to adsorb to the soil particles with little desorption, as suggested by the limited vertical migration of COCs.

f. The lateral extent of the contamination is defined by analytical data indicating the lack of contamination found in HSM-1 drilled in close proximity to the drift, thereby demonstrating minimal lateral mobility. There were no COCs identified in the rock samples collected from the angle boring (HSM-3), which is below the depth of where nitrobenzene was detected, demonstrating minimal vertical migration. The vertical extent of the contamination is confined from 150 to 500 ft bgs (the extent of the waste in the mineshaft and drifts).

g. Presently, CAU 527 is located on a government-controlled facility. The NTS is a restricted area that is guarded on a 24-hour, 365-day per year basis; unauthorized personnel are not admitted to the facility. Corrective Action Unit 527 is contained within a restricted-use zone classified as a "Research Test and Experiment Zone" (i.e., nonresidential) (DOE/NV, 1998). The entry to the mineshaft and fencing is also inspected daily for security reasons.

h. Preferential routes of vertical and lateral migration exist but do not transmit unacceptable concentrations of contaminants to the surface.

i. See Section 2.2.1 for site-specific considerations.

j. The potential for a hazard related to fire, vapor, or explosion is nonexistent for the COCs at the site.

k. No other site-specific factors are known at this site.

Based on this evaluation, impacts to groundwater are not expected. Therefore, groundwater monitoring is not proposed for this site other than what is currently taking place.

# 3.0 Recommendations

The HSM and the associated drifts are considered to be contaminated above action levels based on the results of the CAI activities discussed in the previous sections and detailed in Appendix A. The constraint of not being able to penetrate within a 50-ft radius of the HSM shaft prevented sampling of the mine contents and limited the identification of contaminants originating from the mineshaft. Close in place with administrative controls will prevent inadvertent contact with COCs. These controls would consist of a use restriction to restrict access and prevent unauthorized intrusive activities. Use-restriction signs will be placed on the existing fence around the HSM.

On a conservative basis, the subsurface volume of the zone of contamination is limited to a depth from 150 ft to a maximum of 670 ft bgs extending to a maximum radius of 300 ft from the mineshaft. Based on these data, a use restriction will be established for this volume of rock. In addition, the security of the mineshaft is maintained and does not allow unauthorized personnel to enter the vicinity of the mineshaft. The future use of the CAU would be restricted from any activity that would alter or modify the containment control unless appropriate concurrence was obtained from NDEP. Since the removal of the contaminants is infeasible, the close in place with administrative controls corrective action alternative is appropriate because it will prevent inadvertent contact with the subsurface COCs and meets all applicable state and federal regulations for closure of the site.

The U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) provides the following recommendations:

- The corrective action of close in place with administrative controls at CAU 527.
- A subsurface volume (from 150 ft to 670 ft bgs) to a radius of 300 ft around the HSM will have a use restriction.
- A Notice of Completion to NNSA/NSO is requested from the NDEP for closure of CAU 527.
- CAU 527 should be moved from Appendix III to Appendix IV of the FFACO.

Post-closure monitoring will be conducted at CAU 527. The ROTC#1 to the CAIP requires the measurement of precipitation-induced vadose zone moisture flow through the subsurface native rock beneath the waste shaft at the Horn Silver Mine. If a large enough pulse of water moves into the lysimeter, a sample will be collected for laboratory analysis. Since the current system (using the lysimeter as a tensiometer) may be less responsive to changes in moisture than the advanced tensiometer system, an attempt to collect a lysimeter water sample will be performed at a minimum interval of once per quarter. Since the current lysimeter system was initiated on May 12, 2004, the quarterly due dates for sampling the lysimeter will be August 11, 2004; November 10, 2004; February 9, 2005; and May 11, 2005. Results of the monitoring will be documented in a letter report at the end of one year. A copy of this report will be submitted to NDEP and a determination will be made by NDEP and NNSA/NSO if future monitoring is needed. If there is not sufficient volume of liquid collected for a sample or if no COCs are detected in collected samples at the end of this time period, it is recommended that the monitoring wells at the HSM be sealed in accordance with the State of Nevada regulations.

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# Appendix A

## Corrective Action Investigation Results for Corrective Action Unit 527

# A.1.0 Introduction

This appendix details corrective action investigation (CAI) activities and analytical results for CAU 527, Horn Silver Mine. This CAU is located in Area 26 of the NTS and is comprised of CAS 26-20-01, Contaminated Waste Dump #1 (see Figure 1-1 of main document).

The HSM is located in the Wahmonie mining district, which lies in the southwestern quadrant of Area 26. The Wahmonie mining district was prospected for minerals in the 1850s and again in the late 1920s. The Wahmonie mine workings cover an area about three square miles (Tonopah Daily Times, 1928) and consists of the HSM and at least six shallow shafts (Quade and Tingley, 1983). Ore production occurred at the HSM in 1928 when a high-grade, silver-gold ore was discovered, but that ore production was limited and the mine was abandoned in 1929. The HSM shaft is narrow and deep, and is approximately 8- by 8-ft square and 500 ft deep. Drifts were developed at 60, 160, 300, and 500 ft bgs (Lawry, 1929a and b).

Wastes and fill were deposited in the mineshaft by the NNSA/NSO (and its predecessor) beginning in approximately 1959 through 1972 from 500 to 150 ft bgs. Specific information about the material disposed of in the mineshaft is classified and can not be described in this report. Previously published, unclassified documents state that radioactive debris was buried at the bottom of the shaft during the Pluto Program, which was conducted from 1959 to 1964. Between 1960 and 1964, the mineshaft was used for the disposal of wastes and materials from the Tory Reactor Facility, which was associated with the Pluto Program (DOE, 1988; Penwell, 2002). Unclassified waste disposal records are discussed in Section 2.3 of the CAIP (NNSA/NV, 2002a). The mine was listed in the April 1988 *Environmental Survey Preliminary Report* as an inactive underground classified material burial site that was used to accumulate radioactive waste from the local area. Additional information regarding the physical setting, climate, geology, history of the site, planning, and the scope of the investigation is presented in the CAIP (NNSA/NV, 2002a).

Currently, the surface of the HSM consists of a 20- by 20-ft concrete pad with a locked steel cover on the shaft to limit surface water infiltration and to control access. The concrete pad surrounding the cover is fenced and locked. For security reasons, the NNSA/NSO has established a 50-ft perimeter around the classified material and unclassified waste that could not be penetrated during any subsurface investigations.

Investigation of CAU 527 was performed because process knowledge indicated that waste may be present without appropriate controls and hazardous and/or radioactive constituents may be present or migrating and may pose a threat to human health and the environment. The CAI was conducted in accordance with the CAIP for CAU 527 as developed under the FFACO (1996).

### *A.1.1 Objectives*

The primary objective of the investigation was to provide sufficient information and data to support the selection of a close in place corrective action in the CADD/CR. The no further action corrective action alternative was not evaluated because the waste is known to contain radioactive constituents exceeding action levels. The clean closure corrective action alternative was not evaluated because of security restrictions associated with the waste and safety concerns associated with excavating the waste.

To support the close in place corrective action, the following secondary objectives were established:

- Determine if a significant contaminant transport mechanism (i.e., groundwater and vapor transport) is present.
- Determine if significant contamination migration has occurred within open fractures or drifts.
- Determine the extent of contamination if migration has occurred.

The selection of borehole locations and sample depths were based on site conditions and the strategy developed during the DQO process as outlined in the CAIP. Changes to the sampling strategy based on site-specific conditions are documented in project records and discussed in Section A.2.1.

### *A.1.2 Report Content*

This appendix contains information and data describing the field investigation, documenting the completion of CAIP requirements, and reporting the analytical results. The report is arranged as follows:

- Section A.1.0 describes the investigation background, objectives, and report contents.
- Section A.2.0 provides a description of the investigation with drillhole-specific information regarding field activities and sampling methods.
- Section A.3.0 provides laboratory analytical results from investigation samples.
- Section A.4.0 summarizes waste management activities.
- Section A.5.0 discusses QA and QC procedures followed during the CAI and results of the supporting QA/QC activities.
- Section A.6.0 lists cited references.

The complete field documentation and laboratory data, including field activity daily logs (FADLs), sample collection logs, analysis request/chain-of-custody forms, cuttings sample descriptions, laboratory certificates of analyses, analytical results, and surveillance results are retained in project files as hard copy files or in electronic format.

## A.2.0 Investigation Overview

The CAI was accomplished by collecting rock cuttings and core and air samples during the drilling of boreholes drilled at 3 locations (Figure A.2-1). The field investigation was conducted from November 12, 2003 through January 21, 2004. To further evaluate a moist zone identified in HSM-3, a water sample from the moist zone at ~ 214 ft bgs was collected from HSM-3 on May 3, 2004.

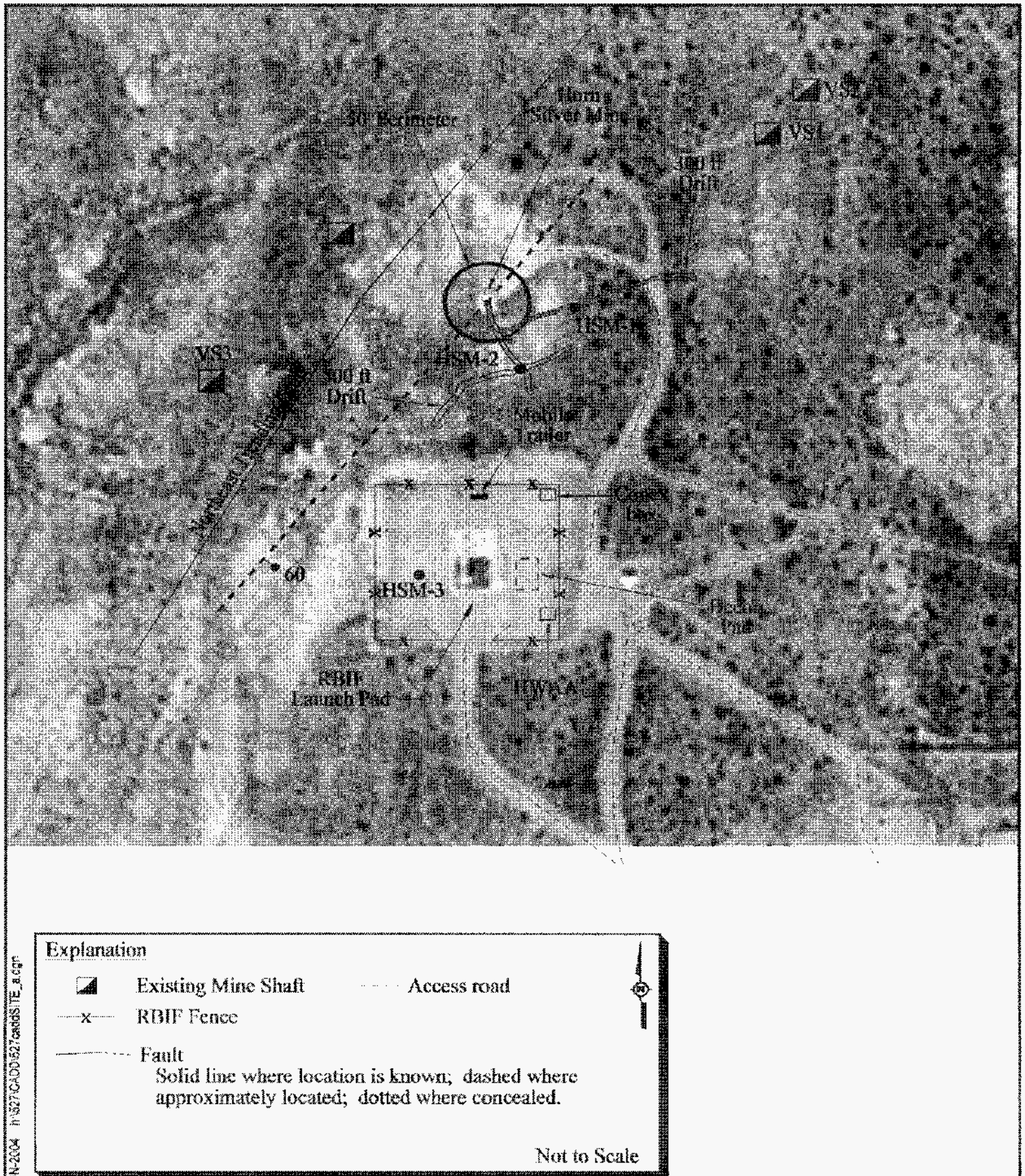
The CAI was managed in accordance with the requirements and approach set forth in the CAIP: Field activities were performed following the approved site-specific health and safety plan (SSHASP) (IT, 2002), which was consistent with the DOE Integrated Safety Management System. Samples were collected and documented following approved protocols and procedures specified in the CAIP. Quality control samples (e.g., field blanks, equipment rinsate blanks, trip blanks, and field duplicates) were collected as required by the Industrial Sites QAPP (NNSA/NV, 2002b) and approved procedures. During the CAI, waste minimization practices were followed according to approved procedures, including segregation of waste by waste stream.

Weather conditions at the site varied including rain, snow, low to moderate temperatures, intermittent cloudiness, and light to strong winds. High winds and snow occasionally delayed site operations; otherwise, weather conditions were generally acceptable.

Site data were generated through the laboratory analysis of subsurface rock cuttings and core samples. Samples were collected using reverse-circulation rotary drilling and coring. Investigation intervals and cuttings samples were field screened for VOCs and alpha and beta/gamma radiation. The results were compared against field-screening levels (FSLs) to guide the investigation. Selected samples were shipped to an off-site laboratory to be analyzed for the chemical and radiological parameters specified in the CAIP.

Three boreholes were drilled during the CAI. The nomenclature for each boring is:

- HSM-1 (307-ft boring)
- HSM-2 (485-ft boring)
- HSM-3 (724-ft angle boring)




Source: USGS, 1997; Slate et al., 1999; Lawry, 1929a

**Figure A.2-1**
**Horn Silver Mine Site Layout**

Section A.2.1 through Section A.2.3.11 provide the investigation methodology and activities. The borehole-specific investigation analytical results are provided in Section A.3.0.

### A.2.1 Deviations to the CAIP

There were four deviations to the CAIP, which were each documented in an ROTC. These deviations did not adversely impact the completeness of the investigation or the completion of the CAIP requirements. These deviations are:

- ROTC #1 involved installing a tensiometer and data logger at HSM-3 capable of detecting water entering the borehole and pulses of unsaturated moisture flow beneath the HSM waste. When sufficient moisture is available, a sample will be collected and analyzed. After one year of monitoring, a determination will be made by NDEP and NNSA/NSO if future monitoring is needed. In addition, a monitoring well was installed to collect any saturated moisture flow and a rain gauge was installed to record rainfall at the site.
- ROTC #2 addresses the issue that the borehole locations were different than those planned in the CAIP. The angle borehole (HSM-3) was drilled at the launch pad at the RBIFF facility, south of the mineshaft. This allowed the angle boring to intercept the fault and other parallel fractures and be completed closer to the base of the mineshaft and penetrate the same lithology as the mineshaft. The two vertical boring (HSM-1 and HSM-2) locations were also moved further from the mineshaft. Moving the locations of all three boreholes allowed for the construction of the drilling pads without extensive damage to the wash and did not require excessive volumes of soil to be moved. These locations were not restricted by buildings, storage areas, active operations, or aboveground and underground utilities. The CAI spatial boundaries were expanded to include the potential area of investigation.
- ROTC #3 involved pressure/injection testing to be conducted in the angle borehole to help assess permeability of the formation. This data was collected to support modeling if volatile migration of contaminants was detected.
- ROTC #4 involved changing the radiological PALs to dose-based action levels.

### A.2.2 Borehole Locations

The two vertical boring locations were selected to try and intercept or drill as near as possible to the two mine drifts that are adjacent to the waste mass. The HSM-1 targeted the 300-ft drift and HSM-2 targeted the 500-ft drift. The drifts above these two do not intercept the waste mass and were not considered potential migration pathways. The location of HSM-3 was selected to allow the angle drilling to terminate as close to the base of the mineshaft as possible without infringing on the 50-ft security radius or intercepting the 500-ft drift. Actual borehole locations are shown in map view on Figure A.2-1 and in cross-section on Figure A.2-2. The locations of all three boreholes were moved as discussed in Section 2.1. The three borehole locations were staked in the field, labeled appropriately, and surveyed.

### *A.2.3 Investigation Activities*

The investigation activities performed at CAU 527 were based on the field investigation activities discussed in the CAIP (NNSA/NV, 2002a). The technical approach consisted of the following activities:

- Running a video camera in three open mineshafts in the vicinity of the HSM shaft to determine if drifts are present that could provide a pathway from the HSM to the surface.
- Drilling of two vertical and one angle borehole
- Field screening and radiological monitoring
- Rock core and cuttings, liquid, and air sampling
- Geophysical logging of the formation
- Permeability testing of the formation
- Characterization of waste streams
- Surveying drilling locations using GPS equipment
- Installation and monitoring in the two vertical borings
- Installation and monitoring of tensiometer and lysimeter in the angle boring
- Installation of a data logger and weather station
- Additional sample collection and monitoring of the three monitoring wells for up to a year.

The following sections describe the specific investigation activities conducted at CAU 527.

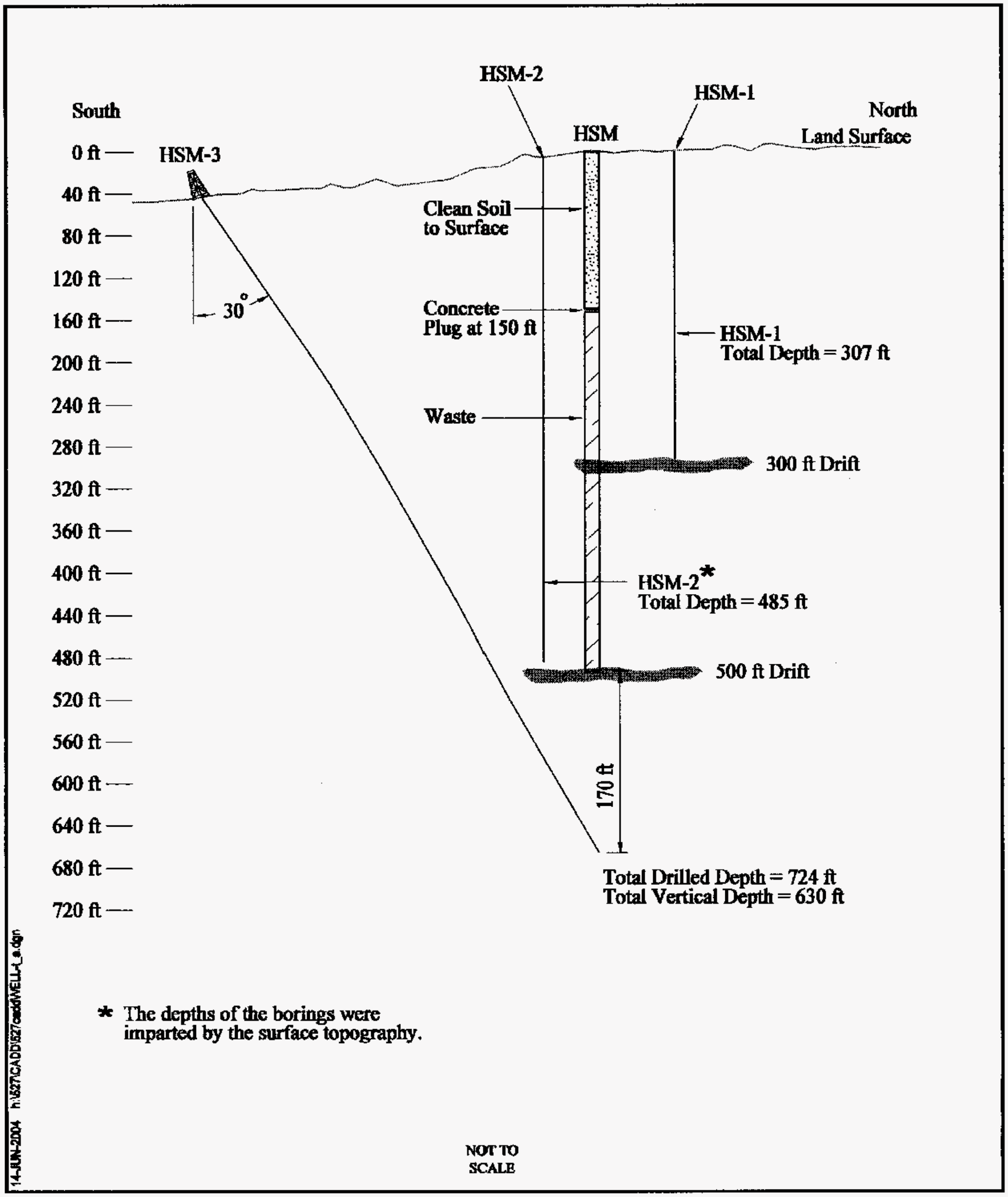



**Figure A.2-2**
**HSM South-North Schematic Cross Section**

### *A.2.3.1 Video Mole of Nearby Mineshafts*

Video-mole surveys were run on three open mineshafts (VS1, VS2, and VS3) in the vicinity of the HSM (Figure A.2-1). The video-mole surveys were performed to determine if unmapped drifts are present that could provide a pathway for HSM contaminant migration. The video-survey equipment was lowered through the shaft entrance being careful not to damage the camera and avoid any obstructions. Notes were made on the FADL of what was shown on the screen. Personnel operating the video mole were not allowed to advance closer than 6 ft to the open shaft. The video camera was pushed through a section of polyvinyl chloride (PVC) pipe and directed into the shafts to allow the operator to remain at least 6 ft from the mineshaft. A cable distance scale was used to determine the depths of the shafts. A radiological control technician (RCT) was present to monitor the video mole and cable for radiological contamination upon extraction from the mineshafts.

Observations made during the video surveys of nearby mines verified that no drifts are present in these mineshafts. The unnamed shaft shown in Figure A.2-1 between VS1 and VS3 was observed to be a surface excavation less than 2 ft deep so no video survey was performed. The video surveys measured the shafts to be ~40 ft deep at VS1, ~70 ft deep at VS2, and 5 ft deep at VS3. Both of the deeper shafts had solid wooden planks on all four sides of the shaft in the upper 10 ft. Ladders and cross beams were observed below this. The lower sections of these two shafts were open and no drifts were observed in the shaft walls. The base of each shaft terminated abruptly and appeared to be level. Additional information about the video surveys can be found in the FADL located in project files. The CAIP requirements to determine if nearby shafts contained drifts that could contact the HSM were achieved.

### *A.2.3.2 Field-Screening Methodology*

Field-screening activities for VOC and alpha and beta/gamma radiation were performed in accordance with the CAIP. The FSLs for VOC headspace was established at 20 parts per million (ppm) or 2.5 times background, whichever was greater. Field screening was conducted using a photoionization detector for VOCs.

Radiological FSLs were established for each borehole using the drill cuttings from the first 150 ft bgs drilling interval. This method calculated a running FSL over the upper 150 ft bgs background interval and was more representative than calculating FSLs based on surface soil. The RCTs collected samples of drill cuttings and placed them in appropriate containers, homogenized the sample and took 10 static one-minute measurements with a handheld radiological survey instrument (e.g., NE Electra or E-600). The RCT documented the alpha and beta/gamma results for the 10 static measurements. The RCT then calculated the mean and the standard deviation of the population for this dataset and computed the FSL as the mean plus two times the standard deviation of the population (i.e., 95$^{th}$ percent confidence interval). The radiation FSLs are instrument-specific and were established for each instrument prior to use. Field screening was conducted using a handheld alpha and beta/gamma radiological survey instrument achieving the CAIP requirements to field screen samples.

#### *A.2.3.3 Radiological Monitoring*

A combination of air sampling and radiological monitoring/screening was used to demonstrate compliance with regulations in 10 *Code of Federal Regulations* (CFR) 835, document radiological conditions, and to protect workers from potential internal and external exposures to radiation. To determine if an airborne radiological hazard was present, the filter media from the vacuum truck exhaust air-sampler, the cyclone separator air-sampler, the drill deck air-sampler, and the support zone air-sampler was collected and analyzed using a high-purity germanium (HPGe) detector. If a radiological contaminant was identified on the filter media, the settled soil cuttings from the cyclone separator were analyzed using the HPGe detector to confirm the filter media findings. If the findings were confirmed, the work was suspended and the situation evaluated. Work was suspended at HSM-2 when the drift was penetrated due to elevated radioactivity. The elevated activity was confirmed by the HPGe detector as radon due to detection and identification of the long-lived gamma-emitting progeny. As a result of this quick detection and identification, drilling activities were able to resume with no impact on the schedule of the project. The results of all radiological monitoring were documented and no other elevated radiological readings were identified.

Smear surveys were conducted around the drill rig and work location, cyclone separator, and radiation control (RadCon) laboratory trailer. Radiological monitoring also occurred during opening and removal of settled cuttings from within cyclone separator. The CAIP requirement to provide radiological monitoring was achieved.

#### *A.2.3.4 Rotary Drilling and Cuttings/Core Sampling*

Samples were collected at all three boreholes using a reverse circulation rotary drill rig (Table A.2-1) operated by Dynatek, Inc. The drilling method involved using air-rotary, dual-tube, reverse circulation with vacuum assist. No fluids were added to the borings during drilling so not to obscure the identification of the presence (or absence) of groundwater. Periodically (at 20 to 60 ft intervals) throughout the drilling of the three borings, gyroscopic surveys (a directional tool) were conducted to ensure that the boring maintained the intended direction. The drilling rate was slowed approximately 10 to 15 ft above the targeted drifts to reduce the possibility of damaging the drill string and influencing the air quality in the drift.

Samples of the drill cuttings were collected throughout the drilling of all three borings for lithologic description and a visual classification log was prepared for each boring, which is retained in the project files.

Cuttings samples were collected for laboratory chemical and radiological analysis at 50-ft intervals beginning at approximately 150 ft bgs (depth of the top of the waste in the mineshaft) for borings HSM-1 and HSM-2. At HSM-3 cuttings were collected in the lower 50 ft of the borehole. Drilling was stopped and the hole cleared of cuttings prior to sampling. The selected sample interval was then drilled and the cuttings collected in a stainless-steel container from the discharge point of the cyclone.

Core samples were collected in the lower 50 ft of the HSM-3 borehole. Each core sample was collected using a split core barrel. A section of the core was sent to the laboratory for chemical and radiological analysis. A geotechnical core sample was also collected from HSM-3. The geotechnical sample was placed in lexan tubing, capped, taped, labeled, and shipped to the geotechnical laboratory. The remaining core is stored in the U.S. Geological Survey (USGS) core library in Mercury, Nevada.

During cuttings collection, the total VOCs and GRO sample containers were filled first, followed by collection of cuttings for VOC field screening using headspace analysis. Additional cuttings were transferred into a stainless-steel bowl, homogenized, and screened for alpha and beta/gamma radiation prior to filling the remaining sample containers. The FSLs were not exceeded during drilling so excess cuttings from sampling and drilling were placed in a pile and spread out on the ground surface at the completion of drilling at each borehole.

**Table A.2-1**
**Samples Collected at Horn Silver Mine**
(Page 1 of 3)

| Sample Location | Sample Number | Depth (ft bgs) | Sample Matrix | Purpose | Analyses |
|---|---|---|---|---|---|
| **Horn Silver Mine 1** | | | | | |
| HSM-1 | 527A0011 | 150 - 152 | Rock Cuttings | SC, MS/MSD | Set 1 |
| | 527A0021 | 200 - 202 | Rock Cuttings | SC | Set 1 |
| | 527A0031 | 250 - 252 | Rock Cuttings | SC | Set 1 |
| | 527A0041 | 280 - 282 | Rock Cuttings | SC | Set 1 |
| | 527A0051 | 305 - 307 | Rock Cuttings | SC | Set 1 |
| | 527A0061 | 305 - 307 | Rock Cuttings | Field Duplicate of #527A0051 | Set 1 |
| | 527A00622 | 300 | Air | SC | Total VOCs |
| | 527A00632 | 300 | Air | Field Duplicate of #527A00622 | Total VOCs |
| | 527A00642 | 280 | Air | SC | Total VOCs |
| | 527A00652 | 280 | Air | Field Duplicate of #527A00642 | Total VOCs |
| | 527A00662 | 287 - 289 | Air | SC | Total VOCs |
| NA | 527A3013 | NA | Water | Trip Blank | Total VOCs |
| Approximately 50 ft Away from Drilling Operations | 527A3023 | NA | Water | Field Blank | Set 1 |
| NA | 527A3033 | NA | Water | Trip Blank | Total VOCs |
| | 527A3053 | NA | Water | Trip Blank | Total VOCs |
| Area 1 Decon Pad | 527A3063 | NA | Water | Source Blank | Set 1 |
| HSM-1 Decon Area | 527A3073 | NA | Water | Equipment Rinsate Blank | Set 1 |

**Table A.2-1**
**Samples Collected at Horn Silver Mine**
(Page 2 of 3)

| Sample Location | Sample Number | Depth (ft bgs) | Sample Matrix | Purpose | Analyses |
|---|---|---|---|---|---|
| **Horn Silver Mine 2** | | | | | |
| HSM-2 | 527B0011 | 149 - 151 | Rock Cuttings | SC, MS/MSD | Set 1 |
| | 527B0021 | 199 - 201 | Rock Cuttings | SC | Set 1 |
| | 527B0031 | 249 - 251 | Rock Cuttings | SC | Set 1 |
| | 527B0041 | 299 - 301 | Rock Cuttings | SC | Set 1 |
| | 527B0051 | 349 - 351 | Rock Cuttings | SC | Set 1 |
| | 527B0061 | 399 - 401 | Rock Cuttings | SC | Set 1 |
| | 527B0071 | 449 - 451 | Rock Cuttings | SC | Set 1 |
| | 527B0081 | 469 - 471 | Rock Cuttings | SC | Set 1 |
| | 527B0092 | 476 | Air | SC | Total VOCs |
| | 527B0102 | 476 | Air | Field Duplicate of #527B0092 | Total VOCs |
| | 527B0111 | 478 - 481 | Rock Cuttings | SC | Set 1 |
| | 527B0121 | 478 - 481 | Rock Cuttings | Field Duplicate of #527B0111 | Set 1 |
| | 527B0132 | Within Drill Pipe | Air | SC | Total VOCs |
| NA | 527B3013 | NA | Water | Trip Blank | Total VOCs |
| Prepared By Lab | 527B3023 | NA | Water | Trip Blank | Total VOCs |

**Table A.2-1**
**Samples Collected at Horn Silver Mine**
(Page 3 of 3)

| Sample Location | Sample Number | Depth (ft bgs) | Sample Matrix | Purpose | Analyses |
|---|---|---|---|---|---|
| **Horn Silver Mine 3** | | | | | |
| HSM-3 | 527C0011 | 681 - 683 | Drill Cutting | SC | Set 1 |
| | 527C0022 | NA | Air | Source Blank | Total VOCs |
| | 527C0031 | 724 | Drill Cutting | SC | Set 1 |
| | 527C0041 | 717.6 - 719.4 | Drill Core | SC | Set 1 |
| | 527C0052 | 622 - 624 | Air | SC | Total VOCs |
| | 527C0062 | 335 - 337 | Air | SC | Total VOCs |
| | 527GT01 | 706.5 - 707.2 | Drill Core | SC/Geotechnical | Set 2 |
| | 527GT02 | 719.6 - 720.2 | Drill Core | SC/Geotechnical | Set 2 |
| | 527C3013 | NA | Water | Trip Blank | Total VOCs |
| | 527C0013 | 214 | Water | SC | Total VOCs, Tritium |
| | 527C3013 | NA | Water | Trip Blank | Total VOCs |

Set 1 = Total VOCs, TPH DRO-gasoline-range organics (GRO), Total semivolatile organic compounds (SVOCs), Explosives, polychlorinated biphenyls (PCBs), Antimony, Beryllium, Nickel, Zinc, Total Resource Conservation and Recovery Act (RCRA) Metals, Gamma Spectroscopy, Gross Alpha/Beta, Isotopic Uranium, Isotopic Plutonium, Isotopic Technetium-99, Strontium-90, and Tritium
Set 2 = Moisture Content, Bulk Density, Calculate Porosity, Helium Porosity, Formation Factor

ft bgs = Feet below ground surface
NA = Not applicable
SC = Site Characterization
MS/MSD = Matrix spike/matrix spike duplicate

### *A.2.3.5 Groundwater Samples*

Historical records indicate that groundwater or moisture was not encountered during mineshaft or drift development in the 1920s. Additionally, there was no indication of groundwater or perched water at depths equal to the drifts or directly below the mineshaft. However, a zone of moisture was identified during logging at a shallow depth in the angle boring. During the monitoring of HSM-3, a sample of the liquid was collected from the shallow string #3 at a depth of approximately 214 ft and sent for analyses for VOCs and tritium. Analytical results for the water samples are discussed in Section A.3.4.15.

### *A.2.3.6 Air Samples*

Air samples were also collected for laboratory analyses from all three boreholes (Table A.2-1). A sample was collected in close proximity to the drift in HSM-1 and within the drift in HSM-2. Although the HSM-1 drift was not penetrated, permeability tests (Section A.2.3.8) conducted by SEA indicated a significant increase in permeability at the depth interval where the drift was expected. This indicates that the fractures in this interval of the borehole are in direct linkage to the HSM-1 drift and that the air sample taken from this interval is representative of the air in the HSM-1 drift. A dual packer system was used to collect air samples from this interval.

At HSM-2, when the expected depth of the drift was reached, the rotary drilling was slowed and advancement was monitored to allow for the identification of the drift. When the drift was penetrated at HSM-2, the supply air was turned off and vacuum assist allowed to purge the drill string and drift of drilling induced air. A sample of the air in the drift was collected by lowering a single packer assembly into the inner drill pipe to a depth approximately 5 ft above the bit.

Air samples were collected from HSM-3 using a dual packer system from two of the three intervals identified by SEA as having increased permeability. Air samples were collected in summa canisters and sent to the laboratory for VOC analysis. Analytical results for air samples are shown in Section A.3.4.16.

### *A.2.3.7 Laboratory Analytical Information*

Radiological analyses were performed by Paragon Analytics, Inc., Fort Collins, Colorado. Chemical analyses were performed by EMAX Laboratories, Inc. in Torrance, California. The analytical parameters and laboratory analytical methods used to analyze CAU 527 investigation samples are listed in Table A.2-2. Organic and inorganic analytical results are compared to the minimum reporting limits (MRLs) established in Table A.1-4 in the CAIP (NNSA/NV, 2002a). The analytical results for gamma-emitting radionuclides, isotopic uranium, isotopic plutonium, strontium (Sr)-90, and tritium are compared to the MRLs presented in Table A.1-5 of the CAIP.

## Table A.2-2
## Laboratory Analytical Parameters and Methods, CAU 527 Investigation Samples

| Analytical Parameter | Analytical Method |
|---|---|
| Total volatile organic compounds | SW-846 8260B [a] |
| Total semivolatile organic compounds | SW-846 8270C [a] |
| Total petroleum hydrocarbons - gasoline-range organics | SW-846 8015B (modified) [a] |
| Total petroleum hydrocarbons - diesel-range organics | SW-846 8015B (modified) [a] |
| Polychlorinated biphenyls | SW-846 8082 [a] |
| Total RCRA metals[b] | Water - SW-846 6010B/7470A [a,]<br>Soil - SW-846 6010B/7471A [a,] |
| Total antimony, beryllium, nickel, and zinc | |
| Total Explosives | SW-846-8330[a] |
| Gamma-emitting radionuclides | Water - EPA 901.1 [c, d]<br>Soil - HASL-300 [c, e] |
| Isotopic uranium | Water - ASTM D3972-02 [c, f]<br>Soil ASTM C1000-02 [c, g] |
| Isotopic plutonium | Water - ASTM D3865-02 [c, h]<br>Soil - ASTMC1001-00 [c, i] |
| Strontium-90 | Water -ASTM D5811-00 [c, j]<br>Soil - HASL-300 [c, e] |
| Tritium | Water - EPA 906.0 [d]<br>Soil - PAI 754/704 [k] |
| Isotopic Technetium | Water - PAI 755/704 [k]<br>Soil - PAI 756/704 [k] |
| Gross Alpha/Beta | Water - EPA 900.0 [d]<br>Soil - PAI 763/724 [k] |
| Volatiles in Air | T014A |

[a]U.S. Environmental Protection Agency (EPA), *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* 3rd Edition, Parts 1-4, SW-846 (EPA, 1996)
[b]Arsenic, barium, cadmium, lead, mercury, selenium, silver, and chromium
[c]Or equivalent laboratory method
[d]*Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (EPA, 1980)
[e]*The Procedures Manual of the Environmental Measurements Laboratory,* HASL-300 (DOE, 1997)
[f]*Standard Test Method for Isotopic Uranium in Water by Radiochemistry* (ASTM, 2003a)
[g]*Standard Test Method for Radiochemical Determination of Uranium Isotopes in Soil by Alpha Spectroscopy* (ASTM, 2003d)
[h]*Standard Test Method for Plutonium in Water* (ASTM, 2003b)
[i]*Standard Test Method for Radiochemical Determination of Plutonium in Soil by Alpha Spectroscopy* (ASTM, 2003c)
[j]*Standard Test Method for Strontium-90 in Water* (ASTM, 2003e)
[k]Paragon Analytics, Inc.

The validated analytical results for samples collected from the CAU 527 investigation have been compiled and evaluated to determine the presence and/or extent of COCs in Section A.3.0. The complete laboratory data packages are available in the project files.

The analytical parameters were selected through the application of site process knowledge according to the EPA's *Guidance for the Data Quality Objectives Process* (EPA, 2000).

Bioassessment samples were not collected because field-screening results and observations did not indicate the need to assess biodegradation of contaminants. Geotechnical samples were collected in the deepest interval of HSM-3. Geotechnical analyses were performed by D.B. Stevens and Associates of Albuquerque, New Mexico. The geotechnical methods used to analyze CAU 527 geotechnical samples are listed in Table A.3-1.

The analytical results for the cuttings, air, core, and geotechnical samples are provided in Section A.3.0 of this appendix.

#### *A.2.3.8 Permeability Tests*

Science Engineering and Associates, Inc. performed a series of *in situ* gas permeability measurements in HSM-1 and HSM-3 to support data needs developed during the DQO meeting. Permeability testing was conducted following a review of the geophysical logs and drill cuttings to determine the capacity of the fracture systems to transmit vapor and to supply information necessary to support a modeling effort, if needed, to define the extent of migrating contamination. Measurements were made using a straddle packer system, allowing permeability data to be obtained within the boreholes from discrete intervals as determined by the Site Supervisor.

Results from HSM-1 revealed a significant increase in permeability from ~1.0 darcies to over 3 darcies in the depth interval of the HSM-1 drift (285 - 300 ft bgs). This data helps support the DQO needs that HSM-1 was in close proximity to the drift and allowed for air-gas and cuttings samples to be collected from this interval. Permeabilities in HSM-3 ranged from less than 1 darcy to over 47 darcies in an interval at 622 ft. The upper part of the borehole had the lowest permeabilities, while an increase was seen at 224 ft, 335 ft, and 622 ft.

The complete SEA report is provided in Appendix F.

#### A.2.3.9 Geophysical Logging

The boreholes were logged using geophysical tools to determine the physical and radiological conditions in the borings. The following geophysical tools were run on the borings after the completion of each borehole.

- Caliper
- Spectral Gamma ("KUT" - potassium, uranium, and thorium)
- Optical Borehole Imager (OBI)
- Downhole video camera

Haliburton ran the caliper and spectral gamma logs and Baker Hughes Intec ran the OBI log and deviation surveys. Geophysical logs are available in project files.

#### A.2.3.10 Monitoring Well Instrumentation and Data Logging

Horn Silver Mine-1 and HSM-2 were completed as monitoring wells using 2-in. ID PVC riser and slotted pipe. The riser pipe was installed at the bottom with a 5-ft section of slotted screen above a 5 ft sump and an end cap. Above this the riser pipe extended to ~3 ft above the land surface. The screened intervals were positioned in the drift at HSM-2 to collect any water flowing along the floor of the drift and at a depth estimated to be the floor of the drift in HSM-1. The lower portion of each hole was filled with grout and the slotted pipe inserted into the wet grout. The grout extended from the bottom of the hole up to the base of the slotted pipe. This will allow water to enter the sump that may flow along the floor of the drifts. At HSM-2, a grout basket was set on the PVC riser at a position above the top of the drift to prevent grout from entering the drift. At HSM-1, gravel was used around the screened interval. Above the screened interval in both HSM-1 and HSM-2, sand and bentonite pellets were emplaced to within 30 ft of land surface. The remaining hole was grouted to the land surface using a cement bentonite grout mixture. A protective casing and cement pad were installed at the surface to prevent surface run-off from entering the well and unauthorized entry. A pressure transducer was installed at the bottom of both wells. The transducer is connected to a data logging device at the surface. The data logger is set to continuously monitor the borehole for the presence of water in the sumps. The data logger will provide notification if water enters the borehole. Figure A.2-3 and Figure A.2-4 show as-built schematics of the well installations.

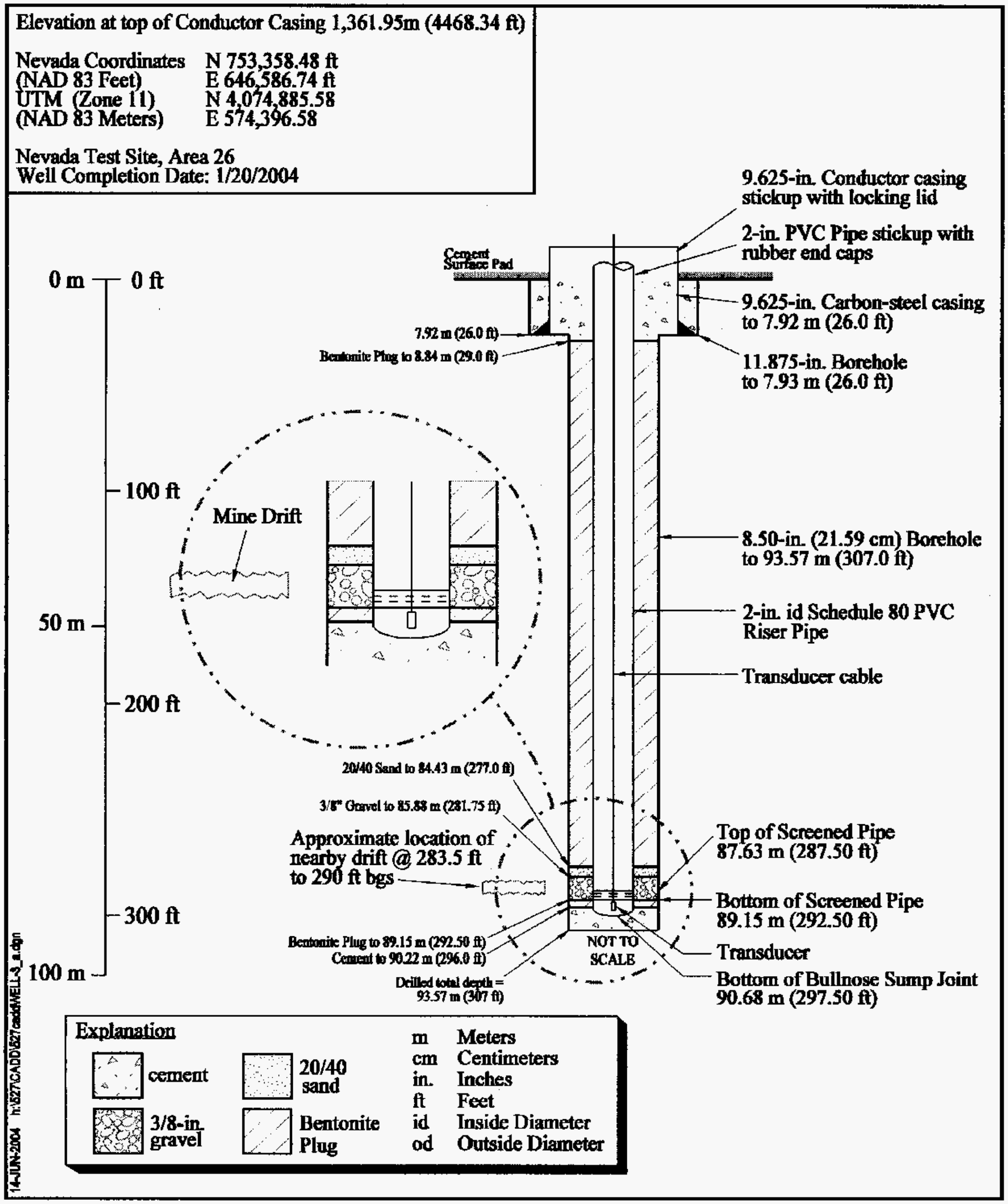



**Figure A.2-3**
**CAU 527, Well Completion Diagram for HSM-1**

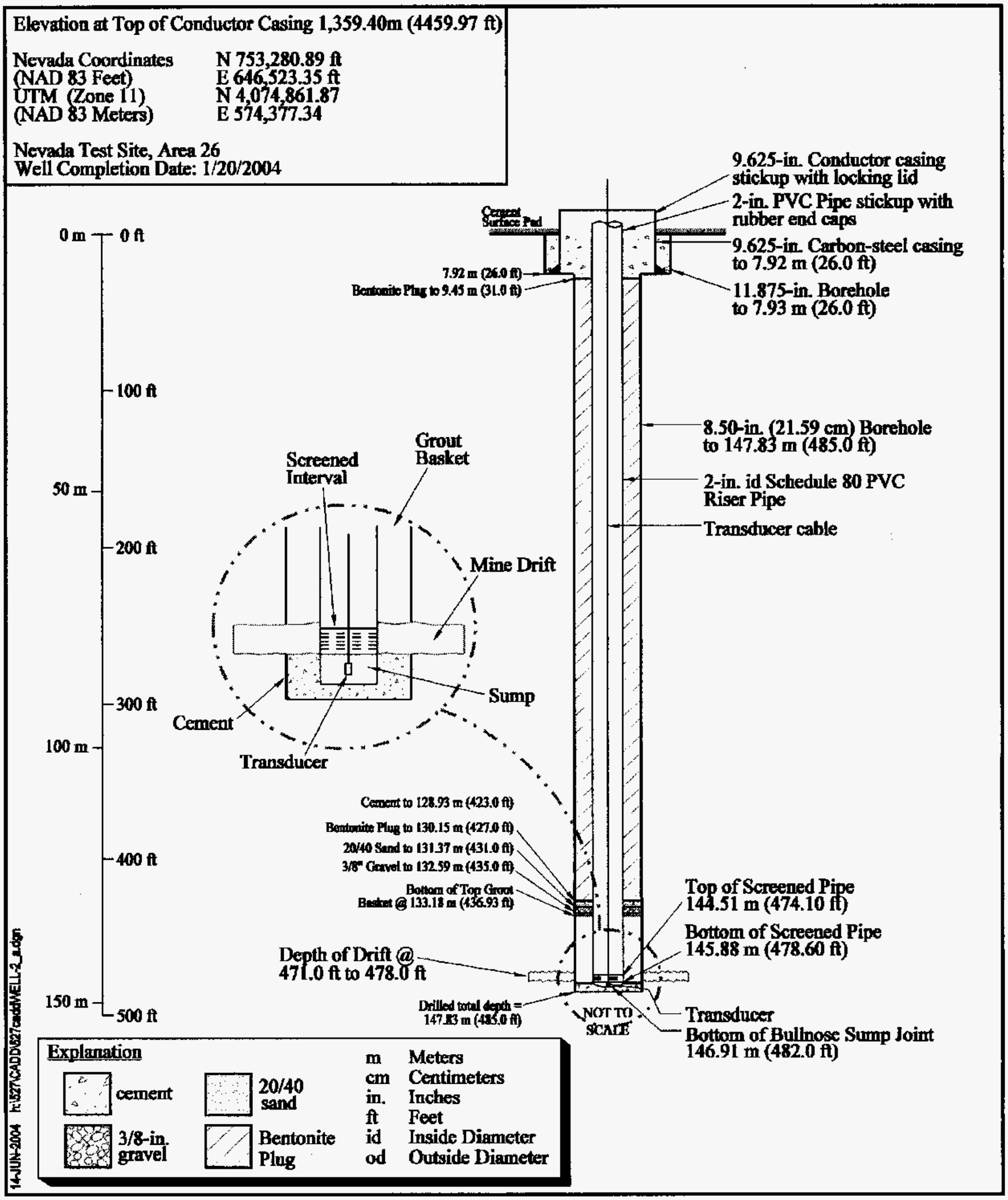



**Figure A.2-4**
**CAU 527, Well Completion Diagram for HSM-2**

Figure A.2-5 shows a schematic of the moisture sensing and sampling system for HSM-3. A tensiometer (not functional) and a lysimeter (see Figure A.2-6) was installed to measure and sample unsaturated moisture. The instruments were installed in the bottom of HSM-3 approximately 150 ft below the base of the mineshaft (~650 ft bgs). The instruments are connected to a data logger at the surface. The data logger provides notification if water enters the sump or if a moisture pulse is detected by the tensiometer, however the tensiometer is not functioning. The function of the tensiometer, to detect moisture pulses, was achieved by using the lysimeter.

The original design called for the installation of an advanced tensiometer and a lysimeter in HSM-3. Both the tensiometer and monitoring well were to be connected to the surface (and lowered into position) by 2-in. diameter, schedule-80 PVC riser pipes. Because of concerns of the tremie pipe crushing the PVC riser in a slightly "corkscrewed" drill hole, steel riser was installed instead of the designed PVC. After installation, it was discovered that both riser pipes were plugged with debris (mainly steel machine turnings) that prevented the use of either the tensiometer or the monitoring well. The debris was cleared from the monitoring well casing sufficiently to allow for sampling of the well; however, the debris could not be sufficiently cleared from the tensiometer. To alleviate this problem a PVC liner pipe was installed inside the steel riser pipe. During installation, the first 170 ft of pipe broke at one of the joints. The installed 170-ft section of liner pipe slid to the bottom of the riser pipe. The liner pipe hit the bottom with sufficient force to shatter the pipe. It is not known if this event damaged the tensiometer. Attempts to retrieve the liner pipe were unsuccessful.

As of June 2004, the monitoring well and the lysimeter are fully functional. Although the advanced tensiometer is not functional, its function (detection of percolating moisture pulses) was replaced through modified use of the lysimeter that will generate information on moisture content in the formation below the HSM waste. The surface at HSM-3 is protected from water infiltrations, unauthorized entry, and vandalism by a protective casing and concrete pad.

### *A.2.3.11 Weather Station*

Next to HSM-3, a solar-powered weather station rests on a tripod with a tipping rain gauge (Figure A.2-7) connected to a data logger. A data logger and cell phone/modem are located inside a weatherproof enclosure. The precipitation data will be used in the interpretation of the subsurface monitoring data.

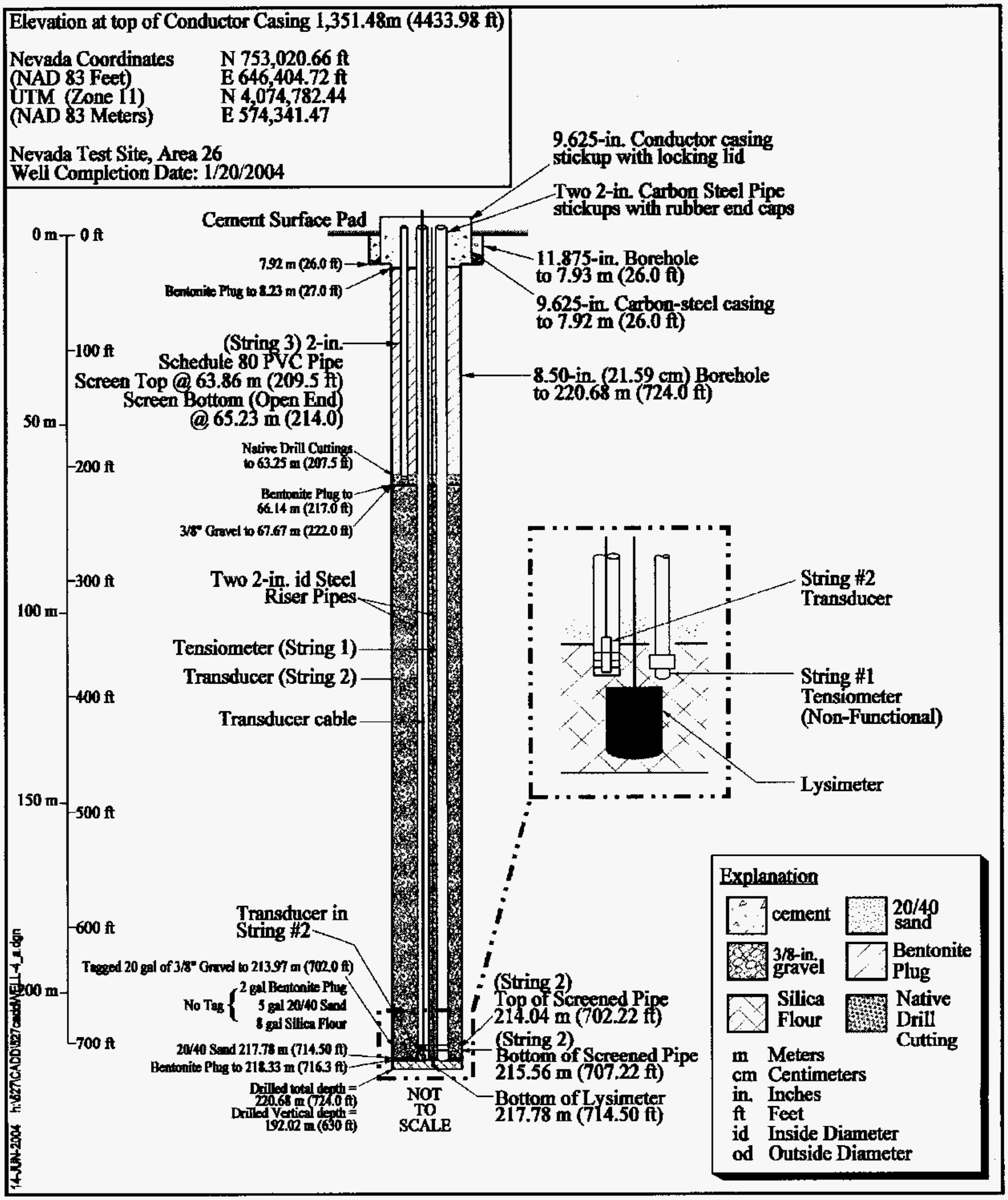



**Figure A.2-5**
**CAU 527, Well Completion Diagram for HSM-3**

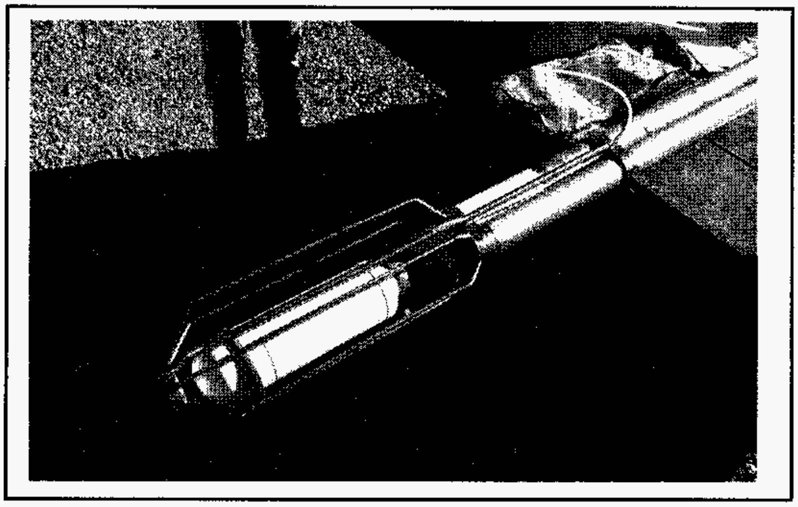


**Figure A.2-6**
**Photograph of Tensiometer and Lysimeter**

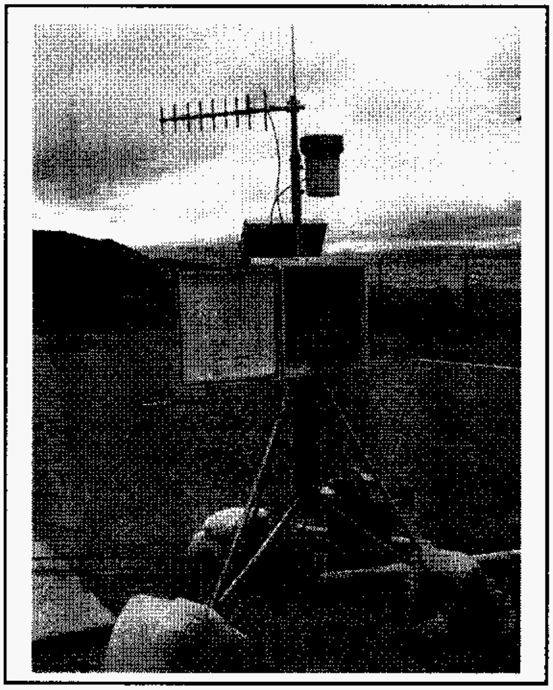


**Figure A.2-7**
**Photograph of Weather Station and Data Logger**

# A.3.0 Analytical Results

Twenty-four cuttings samples, seven air samples, and associated QC samples were collected from the three locations (HSM-1 through HSM-3) during investigation activities. In addition, at HSM-3 one liquid sample and two geotechnical core samples were collected and analyzed (Table A.2-1).

## A.3.1 Geotechnical Samples

Geotechnical samples (527GT01 and 527GT02) were collected from HSM-3 at a drilled depth of ~707 ft and 720 ft using a diamond core barrel and stainless-steel sleeves. This core was collected from the interval below the base of the mineshaft. The samples were wrapped in plastic wrap and aluminum foil prior to being place in lexan tubing with end caps and shipped to the geotechnical laboratory. The results are summarized in Table A.3-1 and a complete report is maintained in project files.

## A.3.2 Field-Screening Results

Cuttings samples were field screened for VOCs and alpha and beta/gamma radiation. The field-screening results (FSRs) were compared to FSLs to assist in sampling decisions. No VOC headspace or alpha and beta/gamma radiation FSLs were exceeded during sampling at any of the boreholes. Radiological monitoring was performed continuously throughout the drilling activities on cuttings and air for personnel protection. A discussion is in Section A.2.3.3.

## A.3.3 Preliminary Action Levels

Chemicals and radionuclides detected in samples at concentrations greater than PALs are identified as COCs. Based on an FFACO agreement, a corrective action must be considered for the CAS if COCs are detected. The PALs for the CAU 527 investigation were determined during the DQO process. For chemical COPCs, PALs are EPA PRGs (EPA, 2002b). The PAL for TPH is 100 mg/kg per the NAC 445A.2272 (NAC, 2003).

In ROTC #4 to the CAIP, the radiological PALs based on background concentrations were changed. The PALs for radiological contaminants are taken from the recommended screening limits for the construction, commercial, and industrial land-use scenario in Table 2.1 of the NCRP, Report No. 129,

**Table A.3-1**
**Geotechnical Data and Laboratory Analytical Methods for HSM-3**

| Geotechnical Parameter | Actual Method(s) | Parameter/Units | 527GT01 Results | 527GT02 Results |
|---|---|---|---|---|
| Initial moisture content | ASTM[a] D 2216-92 | Gravimetric (%, g/g) | 1.0 | 1.7 |
| | | Volumetric (%, $cm^3/cm^3$) | 2.5 | 4.1 |
| Dry bulk density | ASTM[a] D 4531-91 | Dry Bulk Density ($g/cm^3$) | 2.53 | 2.44 |
| | | Wet Bulk Density ($g/cm^3$) | 2.56 | 2.48 |
| Calculated porosity | MOSA[b] Chp. 18 | Calculated Porosity (%) | 4.5 | 8.1 |
| Helium porosity | API[c] 5.3.2.1.1 | Helium Porosity (%) | 4.6 | 6.1 |
| Formation Factor | Archie[d] | Fa | 741.06 | 534.93 |
| | | Ro, Ohm-m | 52.08 | 37.6 |
| | | m | 2.15 | 2.25 |

[a] *Annual Book of American Society for Testing and Materials* (ASTM) *Standards*, Section 4, "Construction," Volume 04.08, "Soil and Rock (I)," and Volume 04.09, "Soil and Rock (II)," 2004
[b] Methods of Soil Analysis, 2nd Edition, Part 1, Soil Science Society of America, 1986
[c] API-American Petroleum Institute
[d] Archie, G.E. 1942. *The Electrical Resistivity Log as an Aid In Determining Some Reservoir Characteristics.* Transactions of the American Institute of Mining and Metallurigical Engineers, Vol. 146, No. 1, pp. 54-62.

Geotechnical samples collected from 707 and 720 ft bgs in angled borehole HSM-3

mm = Millimeter(s)
% = Percent
g/g = Gram per gram
$cm^3$ = Cubic centimeter
$g/cm^3$ = Gram(s) per cubic centimeter
cm/s = Centimeter(s) per second
$cm^{-1}$ = Unit(s) per centimeter
Fa = Formation factor (calculated)
Ro, ohm-m = Resistivity in ohm-meters
m = Cementation exponent

*Recommended Screening Limits for Contaminated Surface Soil and Review of Factors Relevant to Site-Specific Studies* (1999), scaled from 25- to 15-mrem/yr dose, and, the generic guidelines for residual concentration of radionuclides in DOE Order 5400.5, "Radiation Protection of the Public and the Environment," (DOE, 1993). The specific radiological PALs for CAU 527 are listed in the radionuclide-specific tables in this section.

Sample data that exceed MRLs are tabulated in this section. Results that are greater than PALs (a subset of those that exceed MRLs) are identified by bold text in the corresponding tables and are discussed. Nondetected results and those below MRLs have been excluded to reduce the size of the document. A complete dataset is retained in electronic format in the project files.

### A.3.4 Analytes Detected Above Minimum Reporting Limits

The parameters detected at concentrations exceeding the MRLs are summarized in the following sections. These results were compared to PALs that are a subset of those that exceed MRLs. A portion of the analytical results were rejected; however, the rejected data did not impact closure decisions as discussed in Appendix B, Section B.1.1.4.

#### A.3.4.1 Total Volatile Organic Compound Analytical Results for Samples

Total VOCs detected in samples at concentrations exceeding MRLs are listed in Table A.3-2. None of the eight VOCs detected at concentrations exceeding the MRLs exceed the PALs.

#### A.3.4.2 Total Semivolatile Organic Compound Analytical Results for Samples

The semivolatile organic compound (SVOC) bis(2-Ethylhexyl)phthalate was detected throughout the two vertical borings (HSM-1 and -2) and in one sample interval of HSM-3 at concentration ranging from 350 micrograms per kilogram (μg/kg) in sample 527B0061 to 64,000 μg/kg in sample 537A0011DL. Although the reported concentrations exceed the MRL none exceeded the PAL as shown in Table A.3-3.

#### A.3.4.3 Total Petroleum Hydrocarbon Analytical Results for Samples

The TPH analytical results detected in samples above MRLs are shown in Table A.3-4. The results that exceeded the PAL are listed in bold text. The TPH-DRO exceeded the PAL of 100 mg/kg in all three boreholes. These concentrations of TPH-DRO most likely have been introduced into the borings by the air circulation system. Compressors use light machine oil to lubricate the air pumps and typically leak a small amount into the drill string. This is attributed as the source of the TPH in the cutting samples. The concentrations of TPH-DRO were the highest in HSM-1 in the interval above the level of the drift. This was the first boring drilled and the compressor was used to supply air continually throughout this interval. As the drilling progressed it was determined that the drilling was faster if the compressor was used sparingly, allowing the vacuum system to remove the cuttings.

# Table A.3-2
## Sample Results for Total VOCs Detected Above Minimum Reporting Limits at Horn Silver

| Sample Number | Depth (ft bgs) | Contaminants of Potential Concern (µg/kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1,2,4-Trimethylbenzene | 2-Butanone | 2-Hexanone | 4-Methyl-2-Pentanone | Acetone | Carbon Disulfide | Napthalane | Trichlorofluoromethane |
| Preliminary Action Levels[a] | | 170,000 | NI | NI | NI | 6,000,000 | 720,000 | 190,000 | 2,000,000 |
| Horn Silver Mine 1 | | | | | | | | | |
| 527A0011 | 150 - 152 | -- | 72 (J)[b] | -- | 13 (J)[b] | 130 (J)[b] | -- | -- | 9 (J)[b] |
| 527A0021 | 200 - 202 | -- | 16 | -- | -- | 83 | -- | -- | 6.2 |
| 527A0031 | 250 - 252 | -- | 25 | -- | -- | 50 | -- | -- | 9.2 |
| 527A0041 | 280 - 282 | -- | 94 (J)[c] | 17 (J)[b] | 25 (J)[b] | 170 (J)[c] | -- | -- | -- |
| 527A0051 | 305 - 307 | -- | 14 | -- | -- | 31 | -- | -- | -- |
| 527A0061 | 305 - 307 | -- | 23 | -- | -- | 51 | -- | -- | 18 |
| Horn Silver Mine 2 | | | | | | | | | |
| 527B0011 | 149 - 151 | -- | -- | -- | -- | 23 | -- | -- | -- |
| 527B0031 | 249 - 251 | -- | -- | -- | -- | 32 | -- | -- | -- |
| 527B0041 | 299 - 301 | -- | -- | -- | -- | 34 | -- | -- | -- |
| 527B0051 | 349 - 351 | -- | -- | -- | -- | 33 | -- | -- | -- |
| 527B0061 | 399 - 401 | -- | -- | -- | -- | 32 | -- | -- | -- |
| 527B0071 | 449 - 451 | -- | 32 | -- | 70 | 87 | -- | 9.5 | -- |
| 527B0081RE | 469 - 471 | 13 (J)[d] | 110 (J)[d] | 22 (J)[d] | 210 (J)[d] | 240 (J)[d] | -- | 21 (J)[d] | -- |
| 527B0111RE | 478 - 481 | 7.8 (J)[d] | 110 | 23 (J)[d] | 340 (J)[d] | 220 | 7 | 15 (J)[d] | -- |
| 527B0121 | 478 - 481 | 6.9 (J)[d] | 99 | 20 (J)[d] | 310 (J)[d] | 200 | 6.8 | 14 (J)[d] | -- |
| Horn Silver Mine 3 | | | | | | | | | |
| 527C0011 | 681 - 683 | -- | 30 | -- | 11 (J)[d] | 110 (J)[e] | -- | 68 (J)[d] | -- |
| 527C0031 | 724 | -- | -- | -- | -- | 25 (J)[e] | -- | -- | -- |

[a]Based on EPA *Region 9 Preliminary Remediation Goals* (PRGs) (EPA, 2002b)
[b]Qualifier added to laboratory data; record accepted. Matrix effects may exist. Internal standard area count outside control limits. Surrogate recovery exceeded the upper limits.
[c]Qualifier added to laboratory data; record accepted. Surrogate recovery exceeded the upper limits.
[d]Qualifier added to laboratory data; record accepted. Matrix effects may exist. Internal standard area count outside control limits.
[e]Qualifier added to laboratory data; record accepted. Average relative response factor < 0.05. Relative response factor < 0.05.

ft bgs = Feet below ground surface
µg/kg = Micrograms per kilogram
J = Estimated value.
NI = Not identified
-- = Not detected above minimum reporting limits

**Table A.3-3**
**Sample Results for Total SVOCs Detected Above Minimum Reporting Limits at Horn Silver Mine**

| Sample Number | Depth (ft bgs) | Contaminants of Potential Concern (µg/kg) |
|---|---|---|
| | | **Bis(2-Ethylhexyl)Phthalate** |
| **Preliminary Action Levels[a]** | | **120,000** |
| **Horn Silver Mine 1** | | |
| 527A0011DL | 150 - 152 | 64,000 (J) |
| 527A0021 | 200 - 202 | 790 |
| 527A0031 | 250 - 252 | 1,100 |
| 527A0041 | 280 - 282 | 3,000 |
| 527A0051 | 305 - 307 | 1,100 |
| 527A0061 | 305 - 307 | 850 |
| **Horn Silver Mine 2** | | |
| 527B0061 | 399 - 401 | 350 |
| 527B0071 | 449 - 451 | 830 |
| 527B0081 | 469 - 471 | 1,100 |
| 527B0111 | 478 - 481 | 2,000 |
| 527B0121 | 478 - 481 | 1,500 |
| **Horn Silver Mine 3** | | |
| 527C0011 | 681 - 683 | 580 |

[a]Based on EPA *Region 9 Preliminary Remediation Goals* (PRGs) (EPA, 2002b)

ft bgs = Feet below ground surface
µg/kg = Micrograms per kilogram
J = Estimated value. Qualifier added to laboratory data; record accepted. Surrogates diluted out.

The highest concentrations of the TPH-DRO were detected above the level of the drift (150 to 282 ft bgs). The DRO in these intervals is not expected to have originated in the drift although may have migrated from the shaft. However, the highest concentration of TPH-DRO was detected at 150 ft bgs, which is an elevation equivalent to the top of the waste in the mineshaft. Based on the permeability data collected from the formations, it is unlikely that the TPH-DRO migrated laterally to this extent. The same trend is evident in HSM-2 where the drilling was initiated without the use of the compressor. However, the compressor was used to supply air during the collection of samples

## Table A.3-4
## Sample Results for TPH (DRO-GRO) Detected Above Minimum Reporting Limits at Horn Silver Mine

| Sample Number | Depth (ft bgs) | Contaminants of Potential Concern (mg/kg) | |
|---|---|---|---|
| | | Diesel-Range Organics | Gasoline-Range Organics |
| **Preliminary Action Levels[a]** | | **100** | **100** |
| **Horn Silver Mine 1** | | | |
| 527A0011 | 150 - 152 | **40,000** (J)[b] | -- |
| 527A0021 | 200 - 202 | **730** (J)[c] | -- |
| 527A0031 | 250 - 252 | **720** | -- |
| 527A0041 | 280 - 282 | **1,500** (J)[c] | -- |
| 527A0051 | 305 - 307 | **480** | -- |
| 527A0061 | 305 - 307 | **470** (J)[c] | -- |
| **Horn Silver Mine 2** | | | |
| 527B0011 | 149 - 151 | 83 | -- |
| 527B0031 | 249 - 251 | 71 | -- |
| 527B0041 | 299 - 301 | 62 | -- |
| 527B0051 | 349 - 351 | 41 | -- |
| 527B0061 | 399 - 401 | 51 | -- |
| 527B0071 | 449 - 451 | 44 | 0.53 |
| 527B0081 | 469 - 471 | **260** | 0.62 |
| 527B0111 | 478 - 481 | **200** | 0.72 |
| 527B0121 | 478 - 481 | **180** | 1.1 |
| **Horn Silver Mine 3** | | | |
| 527C0011 | 681 - 683 | **230** | -- |
| 527C0031 | 724 | **160** | 1.6 |

[a]Based on NAC 445A, "Water Controls" (NAC, 2003)
[b]Qualifier added to laboratory data; record accepted. Surrogates diluted out.
[c]Qualifier added to laboratory data; record accepted. Surrogate recovery exceeded the upper limits

ft bgs = Feet below ground surface
mg/kg = Milligrams per kilogram
J = Estimated value.
-- = Not detected above minimum reporting limits

from the three intervals near the top of the 500-ft drift. As with the samples from HSM-1 the highest concentrations of TPH were in the samples collected using the compressor to remove the cuttings. The core collected from HSM-3 did not use this air circulation system and there was no hydrocarbon detected in any of the core (Table A.3-9). According to the waste records, no hydrocarbons were placed in the mineshaft by DOE (Friedrichs, 2004). A comparison between the cuttings samples and the compressor oil shows a very similar pattern and suggests the source of the TPH is the compressor oil; therefore, TPH-DRO is not considered a COC. A more detailed discussion of the TPH contamination in drill cuttings is included in Appendix F.

#### *A.3.4.4 Total RCRA Metals Analytical Results for Samples*

Total *Resource Conservation and Recovery Act* (RCRA) metals detected in samples above MRLs are shown in Table A.3-5. The arsenic results were the only results that exceeded the PAL and are shown in bold text in Table A.3-5.

Arsenic exceeded the PAL of 23 mg/kg in most of the samples collected in the three boreholes with concentrations ranging from 13 to over 300 mg/kg. Native arsenic is found in high concentrations >500 mg/kg in sulfide deposits (NAP, 1977) such as the silver ore veins within the Horn Silver Mine. Although no sample data were available in the area of HSM in a recent publication (LANL, 2003), the values detected at CAU 527 are not uncommon for the hydrothermally-altered volcanic rock of the Wahmonie Formation (Warren, 2004).

The National Uranium Resource Evaluation (NURE) Program contains a database of analytical sample results for metals. Values for arsenic from the Tonopah Quadrangle show values similar to and much higher (600 mg/kg) than what was found at CAU 527 (Smith, 2001). In addition, a DOE report on a mineral inventory of the NTS also shows arsenic values within this range (DOE/NV, 1983); therefore, arsenic is not being considered a COC at CAU 527.

#### *A.3.4.5 Explosives*

Nitrobenzene collected from the floor of the drift at HSM-2 (sample 527B0121) at a depth of 478 to 481 ft bgs was the only explosive reported that exceeded the MRL. The reported concentration (2,100 mg/kg) exceeded the PAL of 100 mg/kg; therefore, it is considered a COC. Nitrobenzene was

# Table A.3-5
## Sample Results for Metals Detected Above Minimum Reporting Limits at Horn Silver Mine
(Page 1 of 2)

| Sample Number | Depth (ft bgs) | Contaminants of Potential Concern (mg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Arsenic | Barium | Beryllium | Cadmium | Chromium | Lead | Mercury | Nickel | Selenium | Silver | Zinc |
| Preliminary Action Levels | | 23[a] | 67,000[a] | 1,900[a] | 450[a] | 450[a] | 750[a] | 310[a] | 20,000[a] | 5,100[a] | 51,000[a] | 100,000[a] |
| Horn Silver Mine 1 | | | | | | | | | | | | |
| 527A0011 | 150 - 152 | **85.3** | 110 | -- | 1.18 | 9.45 | 14 | 0.233 | 7.06 | -- | -- | 98.2 |
| 527A0021 | 200 - 202 | **32.6** | 238 | -- | -- | 2.62 | 19.1 | -- | 7.86 | 11.1 (J) | -- | 96.3 |
| 527A0031 | 250 - 252 | **312** | 99.5 | 1.21 | -- | 10.9 | 15.8 | -- | 11.9 | -- | -- | 148 |
| 527A0041 | 280 - 282 | **100** | 128 | -- | -- | 13.7 | 19.4 | -- | 7.47 | -- | 6.79 | 99 |
| 527A0051 | 305 - 307 | **31.8** | 52.3 | -- | -- | 9.09 | 11.9 | -- | 14.5 | -- | 17.1 | 124 |
| 527A0061 | 305 - 307 | **30.2** | 55.3 | -- | -- | 9.4 | 11.9 | -- | 16.5 | -- | 16 | 121 |
| Horn Silver Mine 2 | | | | | | | | | | | | |
| 527B0011 | 149 - 151 | -- | 192 | -- | -- | 3.23 | -- | -- | 2.27 | -- | -- | 23.9 |
| 527B0021 | 199 - 201 | -- | 125 | -- | -- | 6.44 | 13.1 | -- | 5.05 | -- | -- | 38.4 |
| 527B0031 | 249 - 251 | 13.1 | 272 | -- | -- | 7.67 | 19.8 | -- | 3.46 | -- | -- | 82.3 |
| 527B0041 | 299 - 301 | **27.2** | 438 | -- | -- | 7.05 | 20 | -- | -- | -- | -- | 27.5 |
| 527B0051 | 349 - 351 | **92** | 107 | -- | -- | 8.6 | 15.1 | -- | 3.21 | -- | -- | 39.5 |
| 527B0061 | 399 - 401 | **76.1** | 155 | -- | -- | 10.8 | 17.8 | 0.207 | 12.2 | -- | -- | 95.1 |
| 527B0071 | 449 - 451 | **185** | 147 | -- | -- | 10.9 | 12.5 | -- | 8.33 | -- | -- | 71.4 |
| 527B0081 | 469 - 471 | **134** | 207 | -- | -- | 17 | 14.5 | 0.243 | 9.84 | -- | -- | 88.2 |
| 527B0111 | 478 - 481 | **197** | 237 | -- | -- | 17 | 24.1 | 0.359 | 9.88 | 14.3 (J) | -- | 125 |
| 527B0121 | 478 - 481 | **168** | 211 | -- | -- | 14.9 | 20.2 | 0.365 | 12.2 | -- | -- | -- |

## Table A.3-5
## Sample Results for Metals Detected Above Minimum Reporting Limits at Horn Silver Mine
(Page 2 of 2)

| Sample Number | Depth (ft bgs) | Contaminants of Potential Concern (mg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Arsenic | Barium | Beryllium | Cadmium | Chromium | Lead | Mercury | Nickel | Selenium | Silver | Zinc |
| Preliminary Action Levels | | 23[a] | 67,000[a] | 1,900[a] | 450[a] | 450[a] | 750[a] | 310[a] | 20,000[a] | 5,100[a] | 51,000[a] | 100,000[a] |
| Horn Silver Mine 3 | | | | | | | | | | | | |
| 527C0011 | 681 - 683 | 34.5 | 103 | -- | -- | 26.2 | 14.5 | 0.172 | 12.9 | 15.8 | -- | 72.1 |
| 527C0031 | 724 | 17.5 | 246 | -- | -- | 54.6 | 11.1 | 0.424 | 28.6 | 24.4 | -- | 55 |

[a]Based on the background concentrations for metals. Background is considered the mean plus two times the standard deviation for sediment samples collected by the Nevada Bureau of Mines and Geology throughout the Nevada Test and Training Range (NBMG, 1998; Moore, 1999).
[b]Based on EPA, *Region 9 Preliminary Remediation Goals* (PRGs) (EPA, 2002b)

ft bgs = Feet below ground surface
mg/kg = Milligrams per kilogram
-- = Not detected above minimum reporting limits.
J = Estimated value. Qualifier added to laboratory data; record accepted. Negative bias found in continuing calibration/method blank

not detected in any other sample collected for laboratory analysis. Nitrobenzene is an aromatic hydrocarbon that is used primarily for the manufacture of aniline (a component of many explosives, dies, and lubricating oils) and may be a residue from the mining operations.

### A.3.4.6 Polychlorinated Biphenyls

Polychlorinated biphenyls (PCB) were not detected in cuttings or core samples at concentrations above MRLs.

### A.3.4.7 Gamma Spectroscopy Results for Cuttings Samples

Gamma spectroscopy analytical results for samples that exceed the MRLs are shown in Table A.3-6. The reported concentrations did not exceed the PALs.

### A.3.4.8 Isotopic Uranium Analytical Results for Samples

Concentrations for isotopic uranium detected above MRLs are shown in Table A.3-7. The results did not exceed the PALs.

### A.3.4.9 Isotopic Plutonium Analytical Results

Isotopic plutonium was not detected in cuttings samples above MRLs.

### A.3.4.10 Isotopic Technetium Analytical Results

Isotopic technetium was not detected in cuttings samples above MRLs.

### A.3.4.11 Strontium-90 Analytical Results

Strontium-90 was not detected in cuttings samples above MRLs.

### A.3.4.12 Tritium

Tritium was not detected in cuttings samples above MRLs.

## Table A.3-6
## Sample Results for Gamma-Emitting Radionuclides Detected Above Minimum Reporting Limits at Horn Silver Mine
(Page 1 of 2)

| Sample Number | Depth (ft bgs) | Contaminants of Potential Concern | | | | |
|---|---|---|---|---|---|---|
| | | Actinium-228 | Bismuth-214 | Lead-212 | Lead-214 | Thallium-208 |
| Preliminary Action Levels[a] | | 15 | 15 | 15 | 15 | 15 |
| Horn Silver Mine 1 | | | | | | |
| 527A0011 | 150 - 152 | 1.04 ± 0.33 | 0.91 ± 0.24 | 0.91 ± 0.19 | 0.93 ± 0.19 | 0.39 ± 0.11 |
| 527A0021 | 200 - 202 | 1.32 ± 0.34 | 1.03 ± 0.24 | 1.72 ± 0.28 | 1.06 ± 0.21 | 0.49 ± 0.13 |
| 527A0031 | 250 - 252 | 1.5 ± 0.31 | 0.75 ± 0.19 | 1.15 ± 0.2 | 0.81 ± 0.17 | 0.4 ± 0.096 |
| 527A0041 | 280 - 282 | 1.04 ± 0.22 | 0.51 ± 0.14 | 0.95 ± 0.16 | 0.58 ± 0.12 | 0.284 ± 0.07 |
| 527A0051 | 305 - 307 | -- | -- | 0.31 ± 0.1 | 0.257 ± 0.098 | -- |
| 527A0061 | 305 - 307 | -- | -- | 0.35 ± 0.11 | 0.256 ± 0.094 | 0.148 ± 0.064 |
| Horn Silver Mine 2 | | | | | | |
| 527B0011 | 149 - 151 | 1.43 ± 0.36 | 0.88 ± 0.22 | 1.43 ± 0.26 | 1.02 ± 0.21 | 0.48 ± 0.13 |
| 527B0021 | 199 - 201 | 1.51 ± 0.35 | 1.51 ± 0.35 | 1.92 ± 0.3 | 1.01 ± 0.21 | 0.47 ± 0.12 |
| 527B0031 | 249 - 251 | 1.68 ± 0.44 | 0.99 ± 0.28 | 1.6 ± 0.29 | 1.3 ± 0.25 | 0.6 ± 0.15 |
| 527B0041 | 299 - 301 | 1.66 ± 0.38 | 1.19 ± 0.27 | 1.57 ± 0.27 | 0.98 ± 0.21 | 0.7 ± 0.15 |
| 527B0051 | 349 - 351 | 1.42 ± 0.39 | 0.88 ± 0.28 | 1.5 ± 0.26 | 0.97 ± 0.22 | 0.51 ± 0.15 |
| 527B0061 | 399 - 401 | 1.31 ± 0.32 | 0.73 ± 0.2 | 1.49 ± 0.25 | 1.25 ± 0.23 | 0.48 ± 0.12 |
| 527B0071 | 449 - 451 | 1.19 ± 0.33 | 0.86 ± 0.26 | 1.49 ± 0.26 | 1.02 ± 0.22 | 0.49 ± 0.13 |
| 527B0081 | 469 - 471 | 1.18 ± 0.42 | 0.97 ± 0.29 | 1.34 ± 0.28 | 0.83 ± 0.26 | -- |
| 527B0111 | 478 - 481 | -- | 1.22 ± 0.39 | 1.23 ± 0.31 | 0.81 ± 0.24 | 0.52 ± 0.17 |

## Table A.3-6
## Sample Results for Gamma-Emitting Radionuclides Detected Above Minimum Reporting Limits at Horn Silver Mine
(Page 2 of 2)

| Sample Number | Depth (ft bgs) | Contaminants of Potential Concern | | | | |
|---|---|---|---|---|---|---|
| | | Actinium-228 | Bismuth-214 | Lead-212 | Lead-214 | Thallium-208 |
| **Preliminary Action Levels[a]** | | **15** | **15** | **15** | **15** | **15** |
| 527B0121 | 478 - 481 | 1.19 ± 0.4 | 0.88 ± 0.3 | 1.17 ± 0.29 | 0.94 ± 0.26 | 0.43 ± 0.14 |
| **Horn Silver Mine 3** | | | | | | |
| 527C0011 | 681 - 683 | -- | 1.25 ± 0.41 | 1.73 ± 0.35 | 1.36 ± 0.31 | 0.59 ± 0.19 |
| 527C0031 | 724 | 1.09 ± 0.33 | 0.86 ± 0.26 | 1.41 ± 0.26 | 0.99 ± 0.23 | 0.44 ± 0.12 |

[a]Based on the generic guidelines for residual concentrations of Ra-226, Ra-228, Th-230, and Th-232 as found in Chapter IV of DOE order 5400.5, Change 2, "Radiation Protection of the Public and Environment" (DOE, 1993). The PAL for these isotopes is specified as 5 pCi/g averaged over the first 15 centimeters of soil and 15 pCi/g for deeper soils.

ft bgs = Feet below ground surface
pCi/g = Picocuries per gram
-- = Not detected above minimum reporting limits
NA = Not applicable

## Table A.3-7
## Sample Results for Isotopic Uranium Detected Above Minimum Reporting Limits at Horn Silver Mine

| Sample Number | Depth (ft bgs) | Contaminants of Potential Concern (pCi/g) | | |
|---|---|---|---|---|
| | | Uranium-234 | Uranium-235 | Uranium-238 |
| Preliminary Action Levels[a] | | 85.9 | 10.5 | 63.2 |
| **Horn Silver Mine 1** | | | | |
| 527A0011 | 150 - 152 | 0.63 ± 0.14 | -- | 0.53 ± 0.13 |
| 527A0021 | 200 - 202 | 0.46 ± 0.12 | -- | 0.6 ± 0.14 |
| 527A0031 | 250 - 252 | 0.42 ± 0.1 | -- | 0.401 ± 0.096 |
| 527A0041 | 280 - 282 | 0.297 ± 0.085 | -- | 0.29 ± 0.083 |
| 527A0051 | 305 - 307 | 0.278 ± 0.08 | -- | 0.195 ± 0.064 |
| 527A0061 | 305 - 307 | 0.291 ± 0.08 | -- | 0.265 ± 0.076 |
| **Horn Silver Mine 2** | | | | |
| 527B0011 | 149 - 151 | 0.84 ± 0.17 | -- | 0.67 ± 0.14 |
| 527B0021 | 199 - 201 | 0.82 ± 0.17 | -- | 0.74 ± 0.16 |
| 527B0031 | 249 - 251 | 0.92 ± 0.19 | -- | 0.75 ± 0.16 |
| 527B0041 | 299 - 301 | 0.79 ± 0.17 | 0.046 ± 0.03 (LT) | 0.74 ± 0.16 |
| 527B0051 | 349 - 351 | 0.81 ± 0.17 | 0.068 ± 0.036 | 0.91 ± 0.18 |
| 527B0061 | 399 - 401 | 0.85 ± 0.18 | 0.056 ± 0.034 | 0.67 ± 0.15 |
| 527B0071 | 449 - 451 | 0.73 ± 0.16 | -- | 0.71 ± 0.16 |
| 527B0081 | 469 - 471 | 0.69 ± 0.15 | -- | 0.62 ± 0.14 |
| 527B0111 | 478 - 481 | 0.68 ± 0.15 | -- | 0.74 ± 0.16 |
| 527B0121 | 478 - 481 | 0.75 ± 0.16 | -- | 0.67 ± 0.15 |
| **Horn Silver Mine 3** | | | | |
| 527C0011 | 681 - 683 | -- | 0.78 ± 0.19 | 0.82 ± 0.19 |
| 527C0031 | 724 | -- | 0.62 ± 0.14 | 0.54 ± 0.12 |

[a]Based on the construction, commercial, industrial land use scenario in Table 2.1 of the NCRP Report No. 129, *Recommended Screening Limits for Contaminated Surface Soil and Review Factors Relevant to Site-Specific Studies* (NCRP, 1999). The values provided in this source document were scaled to a 15 mrem per year dose.

ft bgs = Feet below ground surface
pCi/g = Picocuries per gram
LT = Result is less than the required minimum detectable concentration, but greater than the specific minimum detectable concentration.
-- = Not detected above minimum reporting limits

### *A.3.4.13 Gross Alpha/Beta*

Gross alpha/beta analytical results for samples detected above MRLs are shown in Table A.3-8. The results were indicative of background.

### *A.3.4.14 Analytical Results for Core Samples*

A core sample (572C0041) was collected from near the bottom of HSM-3 and sent for laboratory analysis. Analytical results for all the parameters detected above MRLs are shown in Table A.3-9. The only result that exceeded a PAL for any of the parameters was arsenic. Arsenic is not considered a COC as discussed in Section A.3.4.4. The concentrations of the radioisotopes and metals are consistent with the result reported for the cutting samples suggesting that these concentrations are within the background ranges and are not attributable to contamination originating from the material in the mineshaft. There were no organic compounds (e.g., VOCs SVOCs, or TPH) reported in the core samples collected below the mineshaft. These data further suggest that the organic compounds detected in the cutting samples are a result of the drilling method (as discussed in Section A.3.4.3) rather than material migrating from the mineshaft.

### *A.3.4.15 Analytical Results for the HSM-3 Water Sample*

A zone of moisture was identified during logging at a shallow depth (approximately 214 ft) in HSM-3. This zone is above any waste in the HSM. A sample of the liquid was analyzed for VOCs and tritium. Analytical results for this water sample indicate the only VOCs above MDLs were for methel ethyl ketone and acetone. Methel ethyl ketone was detected at a concentration of 3,800 micrograms per liter (μg/L). This concentration is above the PRG of 1,900 μg/L. Acetone was detected at a concentration of 9,400 μg/L. This concentration is above the PRG of 610 μg/L. Both methel ethyl ketone and acetone are major constituents in PVC cement, which was used to construct the sampling devise. Therefore, these constituents will not be considered COCs.

Tritium was detected at a concentration of 50 picocuries per liter (pCi/L), which is not distinguishable from background. The PRG for tritium is 540 pCi/l.

## Table A.3-8
## Sample Results for Gross Alpha/Beta Detected Above Minimum Reporting Limits at Horn Silver Mine

| Sample Number | Depth (ft bgs) | Contaminants of Potential Concern (pCi/g) | |
|---|---|---|---|
| | | Gross Alpha | Gross Beta |
| Preliminary Action Levels | | NI | NI |
| Horn Silver Mine 1 | | | |
| 527A0011 | 150 - 152 | 1.82 ± 0.48 (LT) | 1.63 ± 0.42 (LT) |
| 527A0021 | 200 - 202 | 2.08 ± 0.69 (LT) | 2.85 ± 0.77 (LT) |
| 527A0031 | 250 - 252 | 2.19 ± 0.56 (LT) | 1.83 ± 0.45 (LT) |
| 527A0041 | 280 - 282 | 1.79 ± 0.5 (LT) | 1.98 ± 0.47 (LT) |
| 527A0051 | 305 - 307 | 0.91 ± 0.32 (LT) | 1 ± 0.33 (LT) |
| 527A0061 | 305 - 307 | 1.13 ± 0.36 (LT) | 1 ± 0.33 (LT) |
| Horn Silver Mine 2 | | | |
| 527B0011 | 149 - 151 | 1.51 ± 0.52 (LT) | 3.75 ± 0.78 (LT) |
| 527B0021 | 199 - 201 | 2.07 ± 0.6 (LT) | 2.03 ± 0.53 (LT) |
| 527B0031 | 249 - 251 | 3.65 ± 0.89 (LT) | 3.58 ± 0.77 (LT) |
| 527B0041 | 299 - 301 | 1.59 ± 0.51 (LT) | 2.91 ± 0.66 (LT) |
| 527B0051 | 349 - 351 | 1.26 ± 0.42 (LT) | 2.62 ± 0.56 (LT) |
| 527B0061 | 399 - 401 | 2.24 ± 0.68 (LT) | 1.94 ± 0.6 (LT) |
| 527B0071 | 449 - 451 | 2.98 ± 0.78 (LT) | 2.29 ± 0.57 (LT) |
| 527B0081 | 469 - 471 | 1.38 ± 0.58 (LT) | 3.27 ± 0.81 (LT) |
| 527B0111 | 478 - 481 | 3.6 ± 1 (LT) | 2.5 ± 0.73 (LT) |
| 527B0121 | 478 - 481 | 2.06 ± 0.7 (LT) | 3.39 ± 0.84 (LT) |
| Horn Silver Mine 3 | | | |
| 527C0011 | 681 - 683 | 2.7 ± 1.2 (LT) | 3.2 ± 1.2 (LT) |

ft bgs = Feet below ground surface
pCi/g = Picocuries per gram
NI = Not identified
LT = Result is less than the required minimum detectable concentration, but greater than the specific minimum detectable concentration.

## Table A.3-9
## Core Sample Results Detected Above Minimum Reporting Limits at Horn Silver Mine

| Sample Number | Sample Matrix | Parameter | Result | Units |
|---|---|---|---|---|
| **Horn Silver Mine 3** | | | | |
| 527C0041 | Solid | Actinium-228 | 1.32 ± 0.34 | pCi/g |
| 527C0041 | Solid | Bismuth-214 | 0.96 ± 0.26 | pCi/g |
| 527C0041 | Solid | Lead-212 | 1.78 ± 0.29 | pCi/g |
| 527C0041 | Solid | Lead-214 | 1.04 ± 0.21 | pCi/g |
| 527C0041 | Solid | Thallium-208 | 0.52 ± 0.14 | pCi/g |
| 527C0041 | Solid | Uranium-234 | 0.72 ± 0.15 | pCi/g |
| 527C0041 | Solid | Uranium-238 | 0.55 ± 0.12 | pCi/g |
| 527C0041 | Solid | Gross Beta | 3 ± 1.7 (LT) | pCi/g |
| 527C0041 | Solid | Gross Alpha | 3.6 ± 1.7 (LT) | pCi/g |
| 527C0041 | Solid | Arsenic | **32.6** | mg/kg |
| 527C0041 | Solid | Beryllium | 1.9 | mg/kg |
| 527C0041 | Solid | Barium | 793 | mg/kg |
| 527C0041 | Solid | Chromium | 37 | mg/kg |
| 527C0041 | Solid | Lead | 19.2 | mg/kg |
| 527C0041 | Solid | Nickel | 13 | mg/kg |
| 527C0041 | Solid | Selenium | 29.6 | mg/kg |
| 527C0041 | Solid | Zinc | 37.2 | mg/kg |
| 527C0041 | Solid | Mercury | 0.378 | mg/kg |

Core sample 527C0041 was collected beneath the mineshaft in boring HSM-3 at a drilled depth of ~717 to 720 ft.
LT = Result is less than the required minimum detectable concentration, but greater than the specific minimum detectable concentration.

pCi/g = Picocuries per gram
mg/kg = Milligrams per kilogram

### A.3.4.16 Analytical Results for Air Samples

Air samples were collected for laboratory analyses from all three boreholes (Table A.2-1) using a summa canister and sent to the laboratory for VOC analysis (Section A.2.3.5). As a preliminary screening methodology, the results of these air samples were compared to a screening action level (SAL) equivalent to EPA Region 9 PRG values for lifetime risk from inhalation of contaminants in a residential setting (EPA, 2002b). Analytical results for subsurface air samples detected at concentrations greater than MRLs are shown in Table A.3-10 along with the corresponding SALs.

***Problem Statement***

Contaminant concentrations in subsurface air spaces cannot be compared to Region 9 ambient air PRGs because the PRGs were developed based on the risk to human receptors from contaminant concentrations in the breathing zone. The only pathway for contaminants in subsurface air to human receptors at ground surface is by migration of vapors through the native material (comprised mainly of low porosity Tertiary intrusive volcanic rock [Table A.3-10] overlain by a thin layer of soil). Therefore, the following conservative method was developed to evaluate the risk posed by contaminant concentrations measured in the HSM drifts based on Region 9 PRG methodologies.

***Methodology***

1. It was assumed that contaminant concentrations measured in the HSM drifts are present in surface soil air spaces. This assumes that a direct pathway of infinite conductivity and transmissivity exists from the subsurface to the surface such that there is no attenuation or degradation of contaminants. The concentration of contaminant vapors in the surface soil pore space was assumed to be equal to the highest concentration found in any sample of subsurface air.

2. The maximum relative risk was posed by benzene - detected at a concentration of 1,628 milligrams per cubic meters (mg/m$^3$) (over 7,000 times the SAL) in the drift near the bottom of the HSM 2 borehole. The constituent posing the next highest risk was tetrachloroethylene that was detected at just over 250 times its corresponding SAL (3.6 percent of the relative risk posed by benzene). The preponderance of risk is associated with benzene and the other contaminants add little to the evaluation; therefore, if the risk associated with benzene is acceptable, the risk associated with other detected contaminants is also acceptable.

3. The concentration of benzene in surface soil was calculated that would result in an air-space concentration equal to the maximum measured HSM drift air-sample concentration. The soil

# Table A.3-10
# Air Sample Results for Horn Silver Mine
(Page 1 of 3)

| Sample Number | Depth (ft bgs) | Parameter | Result (µg/m3) | Screening Level (µg/m3) | Screening Level Ratio |
|---|---|---|---|---|---|
| **Horn Silver Mine #1** | | | | | |
| 527A00622 | 300 | 1,2,4-Trichlorobenzene | 34.86 | 208.05 | 0.17 |
| 527A00642 | 280 | 1,2,4-Trimethylbenzene | 18.18 | 6.21 | 2.93 |
| 527A00652 | 280 | 1,2,4-Trimethylbenzene | 16.70 | 6.21 | 2.69 |
| 527A00652 | 280 | 1,3,5-Trimethylbenzene | 24.07 | 6.21 | 3.88 |
| 527A00622 | 300 | Benzene | 10.86 | 0.23 | 46.82 |
| 527A00632 | 300 | Benzene | 12.13 | 0.23 | 52.33 |
| 527A00642 | 280 | Benzene | 12.13 | 0.23 | 52.33 |
| 527A00652 | 280 | Benzene | 12.77 | 0.23 | 55.08 |
| 527A00622 | 300 | Ethylbenzene | 14.32 | 1.75 | 8.20 |
| 527A00632 | 300 | Ethylbenzene | 14.32 | 1.75 | 8.20 |
| 527A00642 | 280 | Ethylbenzene | 21.70 | 1.75 | 12.42 |
| 527A00652 | 280 | Ethylbenzene | 22.13 | 1.75 | 12.67 |
| 527A00622 | 300 | M+P-Xylene | 56.42 | 105.85 | 0.53 |
| 527A00632 | 300 | M+P-Xylene | 52.08 | 105.85 | 0.49 |
| 527A00642 | 280 | M+P-Xylene | 86.79 | 105.85 | 0.82 |
| 527A00652 | 280 | M+P-Xylene | 86.79 | 105.85 | 0.82 |
| 527A00622 | 300 | O-Xylene | 19.53 | 105.85 | 0.18 |
| 527A00632 | 300 | O-Xylene | 18.66 | 105.85 | 0.18 |
| 527A00642 | 280 | O-Xylene | 32.98 | 105.85 | 0.31 |
| 527A00652 | 280 | O-Xylene | 32.11 | 105.85 | 0.30 |
| 527A00622 | 300 | Toluene | 86.61 | 401.50 | 0.22 |
| 527A00632 | 300 | Toluene | 86.61 | 401.50 | 0.22 |
| 527A00642 | 280 | Toluene | 101.68 | 401.50 | 0.25 |
| 527A00652 | 280 | Toluene | 109.21 | 401.50 | 0.27 |
| 527A00662 | 287 - 289 | Toluene | 1242.70 | 401.50 | 3.10 |
| 527A00662DL | 287 - 289 | Toluene | 1468.64 | 401.50 | 3.66 |

# Table A.3-10
## Air Sample Results for Horn Silver Mine
(Page 2 of 3)

| Sample Number | Depth (ft bgs) | Parameter | Result (µg/m3) | Screening Level (µg/m3) | Screening Level Ratio |
|---|---|---|---|---|---|
| **Horn Silver Mine #2** | | | | | |
| 527B0092 | 476 | 1,1,2-Trichloro-1,2,2-Trifluoroethane | 99.57 | 31280.50 | 0.00 |
| 527B0102 | 476 | 1,1,2-Trichloro-1,2,2-Trifluoroethane | 107.23 | 31280.50 | 0.00 |
| 527B0132 | Within Drill Pipe | 1,2,4-Trimethylbenzene | 103.17 | 6.21 | 16.63 |
| 527B0132 | Within Drill Pipe | 1,3,5-Trimethylbenzene | 31.93 | 6.21 | 5.15 |
| 527B0092 | 476 | Benzene | 30.33 | 0.23 | 130.82 |
| 527B0102 | 476 | Benzene | 27.78 | 0.23 | 119.80 |
| 527B0132 | Within Drill Pipe | Benzene | 1436.71 | 0.23 | 6196.69 |
| 527B0132DL | Within Drill Pipe | Benzene | 1628.27 | 0.23 | 7022.91 |
| 527B0132 | Within Drill Pipe | Chloromethane | 183.67 | 1.07 | 172.10 |
| 527B0092 | 476 | Dichlorodifluoromethane | 64.25 | 208.57 | 0.31 |
| 527B0102 | 476 | Dichlorodifluoromethane | 69.19 | 208.57 | 0.33 |
| 527B0092 | 476 | Ethylbenzene | 24.30 | 1.75 | 13.91 |
| 527B0102 | 476 | Ethylbenzene | 25.60 | 1.75 | 14.66 |
| 527B0132 | Within Drill Pipe | Ethylbenzene | 156.21 | 1.75 | 89.45 |
| 527B0092 | 476 | M+P-Xylene | 78.11 | 105.85 | 0.74 |
| 527B0102 | 476 | M+P-Xylene | 86.79 | 105.85 | 0.82 |
| 527B0132 | Within Drill Pipe | M+P-Xylene | 368.87 | 105.85 | 3.48 |
| 527B0092 | 476 | O-Xylene | 32.55 | 105.85 | 0.31 |
| 527B0102 | 476 | O-Xylene | 33.42 | 105.85 | 0.32 |
| 527B0132 | Within Drill Pipe | O-Xylene | 173.58 | 105.85 | 1.64 |
| 527B0132 | Within Drill Pipe | Tetrachloroethylene | 142.34 | 0.67 | 211.70 |
| 527B0092 | 476 | Toluene | 173.22 | 401.50 | 0.43 |

**Table A.3-10**
**Air Sample Results for Horn Silver Mine**
(Page 3 of 3)

| Sample Number | Depth (ft bgs) | Parameter | Result (µg/m3) | Screening Level (µg/m3) | Screening Level Ratio |
|---|---|---|---|---|---|
| **Horn Silver Mine #2** | | | | | |
| 527B0102 | 476 | Toluene | 195.82 | 401.50 | 0.49 |
| 527B0132 | Within Drill Pipe | Toluene | 903.78 | 401.50 | 2.25 |
| 527B0132DL | Within Drill Pipe | Toluene | 1016.75 | 401.50 | 2.53 |
| **Horn Silver Mine #3** | | | | | |
| 527C0022 | NA | 1,2,4-Trichlorobenzene | 43.02 | 208.05 | 0.21 |
| 527C0052 | 622 - 624 | Toluene | 2485.39 | 401.50 | 6.19 |
| 527C0052DL | 622 - 624 | Toluene | 2861.96 | 401.50 | 7.13 |
| 527C0062 | 335 - 337 | Toluene | 2297.10 | 401.50 | 5.72 |
| 527C0062DL | 335 - 337 | Toluene | 2560.71 | 401.50 | 6.38 |

ft bgs = Feet below ground surface
DL = Duplicate
NA = Not applicable
µg/m$^3$ = Micrograms per cubic meter

parameters were input into the public domain NAPLANAL phase-partitioning calculator along with the maximum vapor concentration for benzene. NAPLANAL calculates the phase partitioning of petroleum hydrocarbons in soil and ground water samples, allocating it between nonaqueous, aqueous, sorbed, and vapor phases. This calculation indicates that a benzene pore space concentration of 1,628 µg/m$^3$ would require a benzene concentration in soil of 0.0026 mg/kg (2.6 ppb). The model calculations are available in project files. This calculation determined that a benzene concentration of 0.0026 mg/kg (2.6 ppb) in the surface soil would generate 1,628 µg/m$^3$ of benzene vapor in the pore space. This soil concentration was calculated using an established phase-partitioning software NAPLANAL (Mariner et al., 1997).

4. The Region 9 industrial soil PRG for benzene of 1.3 mg/kg was determined based on the direct inhalation exposure of benzene vapors by a human receptor from a concentration of benzene in surface soil because the EPA toxicity evaluation demonstrated that risks from exposure to benzene via inhalation far outweigh the risk via ingestion (EPA, 2002b). Therefore, exposure of a human receptor due to a concentration of benzene in soil air-space

can be evaluated by comparing the concentration of benzene in surface soil to the Region 9 industrial soil PRG.

*Conclusion*

The concentration of benzene in surface soil (0.0026 mg/kg) that would account for the maximum benzene air concentration of 1,628 mg/m$^3$ is 500 times less than the industrial soil PRG of 1.3 mg/kg. These conservative assumptions and calculations clearly illustrate that contaminant concentrations found in the subsurface mine drifts do not pose a significant risk to human receptors at land surface and do not require remedial action. Therefore, no contaminant detected in HSM air samples is considered to be a COC.

#### A.3.4.17 Contaminants of Concern

Based on the aforementioned analytical results and discussions, nitrobenzene was identified as a COC at the floor of the drift at HSM-2. However, other COCs are assumed to exist based on historical documentation on the types of waste placed into the shaft.

### A.3.5 Nature and Extent of Contaminants of Concern

The COC nitrobenzene was detected at 2,100 mg/kg from the floor of the drift at HSM-2 (sample 527B0121) at a depth between 478 to 481 ft bgs. Nitrobenzene was not detected in any sample taken above this interval. Nitrobenzene is an aromatic hydrocarbon that is used primarily for the manufacture of aniline (a component of many explosives, dies, and lubricating oils) and is suspected to be a residue from the mining operations and is not associated with materials in the shaft. Nitrobenzene was not detected laterally in HSM-1, which was drilled in close proximity to the 300-ft drift, or vertically in HSM-3 (angle hole), which was drilled beneath the drifts and the mineshaft.

No other COCs were identified in the samples collected at CAU 527. The HSM and the associated drifts are considered to be contaminated above action levels. A subsurface volume (from 150 ft to 670 ft bgs) to a radius of 300 ft around the HSM will be considered for a use restriction. Use-restriction signs will be placed on the existing fence around the HSM.

### A.3.6 Revised Conceptual Site Model

Biased samples were collected in accordance with the CAIP and the site-specific conditions were consistent with the preliminary CSM developed during the DQO process and provided in the CAIP. Therefore, no revision to the CSM was needed.

# A.4.0 Waste Management

## A.4.1 Waste Minimization

Corrective Action Unit 527 integrated waste minimization into the field activities. The investigation-derived waste (IDW) was segregated to the greatest extent possible and controls were put in place to minimize the use of hazardous materials and the unnecessary generation of hazardous and/or mixed waste. Additionally, decontamination activities were planned and executed to minimize the volume of rinsate generated.

Potentially hazardous waste generated during the investigation was placed in 55-gallon (gal) steel drums and labeled as "Hazardous Waste - Pending Analysis." One Hazardous Waste Accumulation Area (HWAA) was established to manage the waste generated during the CAI. The amount, type, and source of waste placed into each drum was recorded in the waste management logbook.

### A.4.1.1 Characterization

Analytical results for each drum of waste or associated samples were reviewed to ensure compliance with federal regulations (CFR, 2003), state regulations (NAC, 2003), DOE directives/policies, guidance, waste disposal criteria, and SNJV Standard Quality Practices. Analytical data were reviewed through Tier I, II, and III validation.

### A.4.1.2 Waste Streams

Investigation-derived waste generated during the investigation was segregated into the following waste streams:

- Decontamination rinsate
- Debris including, but not limited to, plastic sheeting, oil filters, and absorbent pads
- Used motor oil from drilling operations

### A.4.2 Investigation-Derived Waste Generated

A total of 17 drums of IDW were generated during the CAI:

- Eight drums were characterized as sanitary waste and recommended for disposal at the NTS-permitted sanitary lagoon (NDEP, 1997 and 1999).
- Five drums of hydrocarbon-contaminated soil, pads, and plastic sheeting were generated due to leaking equipment. The recommended disposal of these drums is the hydrocarbon landfill.
- Three drums of rinsate exhibiting an oily sheen were generated. The recommended disposal path for these drums in the oil/water separator.
- One drum of used motor oil was generated (17 gal). A Chlor-detect test kit was run to determine the recommended disposal method for this drum. Based on the fact that the results were below 1,000 ppm chlorine, the motor oil can be recycled.
- Additional waste (e.g., decontamination pad liners) may be generated during completion of waste management activities and closure of the HWAA.

The radiological analytical data for all waste from CAU 527 has been evaluated. None of the IDW exhibited radionuclide concentrations that were statistically distinguishable from the PALs or greater than the Performance Objective for Certification (POC), or exceeded the release to sewers limit.

#### A.4.2.1 Waste Management Samples

No waste management samples were collected at CAU 527.

# A.5.0 Quality Assurance

This section contains a summary of the QA/QC process implemented during the sampling and analysis activities conducted in support of the CAU 527 corrective action investigation. Laboratory analyses were conducted for samples used in the decision-making process to provide a quantitative measurement of any COPCs present. Rigorous QA/QC was implemented for all laboratory samples including documentation, verification, and validation of analytical results, and affirmation of DQI requirements related to laboratory analyses. Detailed information regarding the QA program is contained in the Industrial Sites QAPP (NNSA/NV, 2002b). A discussion of the DQIs, including the datasets, is provided in Appendix B.

## A.5.1 Data Validation

Data validation was performed in accordance with the Industrial Sites QAPP (NNSA/NV, 2002b) and approved protocols and procedures. All laboratory data from samples collected and analyzed for CAU 527 were evaluated for data quality according to the *EPA Functional Guidelines* (EPA, 1999 and 2002a). These guidelines are implemented in a tiered process and are presented in Section A.5.1.1 through Section A.5.1.3. Data were reviewed to ensure that samples were appropriately processed and analyzed, and the results passed data validation criteria. Documentation of the data qualifications resulting from these reviews is retained in project files as a hard copy and electronic media.

One hundred percent of the data generated as part of this investigation were subjected to Tier I and Tier II evaluations as defined below. A Tier III evaluation was performed on six percent of the data.

### A.5.1.1 Tier I Evaluation

Tier I evaluation for chemical and radiological analyses included but was not limited to:

- Sample count/type consistent with chain of custody
- Analysis count/type consistent with chain of custody
- Correct sample matrix
- Significant problems stated in the cover letter or case narrative
- Completeness of certificates of analysis
- Completeness of Contract Laboratory Program (CLP) or CLP-like packages

- Completeness of signatures, dates, and times on chain of custody
- Condition-upon-receipt variance form included
- Requested analyses performed on all samples
- Date received/analyzed given for each sample
- Correct concentration units indicated
- Electronic data transfer supplied
- Results reported for field and laboratory QC samples
- Whether or not the deliverable met the overall objectives of the project
- Proper field documentation accompanies project packages

### A.5.1.2 Tier II Evaluation

Tier II evaluation for chemical and radiological analyses included but was not limited to the following.

***Chemical:***

- Correct detection limits achieved
- Sample date, preparation date, and analysis date for each sample
- Holding time criteria
- QC batch association for each sample
- Cooler temperature upon receipt
- Sample pH for aqueous samples, as required
- Detection limits properly adjusted for dilution, as required
- Blank contamination evaluated and qualifiers applied to sample results
- Matrix spike/matrix spike duplicate, percent recovery (%R), and relative percent difference (RPDs) evaluated and qualifiers applied to laboratory results
- Field duplicate RPDs evaluated using professional judgement and qualifiers applied to laboratory results
- Laboratory duplicate RPDs evaluated and qualifiers applied to laboratory results as necessary
- Surrogate %Rs evaluated and qualifiers applied to laboratory results as necessary
- Laboratory control sample %R evaluated and qualifiers applied to laboratory results

- Initial and continuing calibration evaluated and qualifiers applied to laboratory results
- Internal standard evaluated and qualifiers applied to laboratory results
- Mass spectrometer tuning criteria
- Organic compound quantitation
- Inductively coupled plasma (ICP) interference check sample evaluation
- Graphite furnace atomic absorption quality control
- ICP serial dilution effects
- Recalculation of 10 percent of laboratory results from raw data

***Radioanalytical:***

- Correct detection limits achieved
- Blank contamination evaluated and, if significant, qualifiers were applied to sample results
- Certificate of Analysis consistent with data package documentation
- Quality control sample results (i.e., duplicates, laboratory control samples, laboratory blanks) evaluated and used to determine laboratory result qualifiers
- Sample results, uncertainty, and minimum detectable concentration evaluated
- Detector system calibrated to National Institute for Standards and Technology (NIST)-traceable sources
- Calibration sources preparation was documented, demonstrating proper preparation and appropriateness for sample matrix, emission energies, and concentrations
- Detector system response to daily, weekly, and monthly background and calibration checks for peak energy, peak centroid, peak full-width half-maximum, and peak efficiency, depending on the detection system
- Tracers NIST-traceable, appropriate for the analysis performed, and recoveries that met QC requirements
- Documentation of all QC sample preparation complete and properly performed

- Spectra lines, photon emissions, particle energies, peak areas, and background peak areas support the identified radionuclide and its concentration
- Recalculation of 10 percent of laboratory results from raw data

#### A.5.1.3 Tier III Review

The Tier III review is an independent examination of the Tier II evaluation. The Tier III review independently duplicates the Tier II review for 6 percent of the samples and included the following additional evaluations.

***Chemical:***

- Recalculation of laboratory results from raw data

***Radioanalytical:***

- QC sample results (e.g., calibration source concentration, percent recovery, and RDP) verified
- Radionuclides and their concentration validated, as appropriate, considering their decay schemes, half-lives, and process knowledge of the site
- Each identified line in spectra verified against emission libraries and calibration results
- Independent identification of spectra lines, area under the peaks, and quantification of radionuclide concentration in a random number of sample results
- Recalculation of 10 percent of the laboratory results from raw data

A Tier III review of approximately ten percent of the samples was conducted by TechLaw, Inc. in Lakewood, Colorado. Tier II and Tier III results were compared and where differences were noted, data were reviewed, and changes made accordingly.

### A.5.2 Quality Control Samples

There were 6 trip blanks, 1 field blank, 2 source blanks (1 from the source water used to decontaminate drill pipe and 1 summa canister air sample collected from inside the drill pipe with an inflated packer), 1 equipment rinsate blank, 2 matrix spike/matrix spike duplicates (MS/MSDs), and 4 field duplicates collected and submitted for analysis by laboratory analytical methods as shown in Table A.2-2. The quality control samples were assigned individual sample numbers and sent to the laboratory "blind." Additional samples were selected by the laboratory to be analyzed as laboratory duplicates.

### *A.5.2.1 Field Quality Control Samples*

Review of the field-blank analytical data for the CAU 527 sampling indicates that cross-contamination from field methods did not occur during sample collection. Field, equipment rinsate, and source blanks were analyzed for the applicable parameters listed in Table A.2-2 and trip blanks were analyzed for VOCs only. No contaminants were detected in samples above the contract-required detection limits.

The TPH contamination (Section A.3.4.3) from the compressor and vacuum system used for the drilling circulation was not detected in QC samples. There were no field blanks or other QC samples collected from the circulation system that may have detected this contaminant.

During the sampling events, five field duplicate cuttings samples were sent as blind samples to the laboratory to be analyzed for the parameters listed in Table A.2-2. For these samples, the duplicate results precision (i.e., RPDs between the environmental sample results and their corresponding field duplicate sample results) were evaluated to the guidelines set forth in EPA Functional Guidelines (EPA, 2002a). Based on the evaluation of the field duplicates, there is no indication of poor field or laboratory precision.

### *A.5.2.2 Laboratory Quality Control Samples*

Analysis of method QC blanks were performed on each sample delivery group (SDG) for inorganics. Analysis for surrogate spikes and preparation blanks (PBs) were performed on each SDG for organics only. Initial and continuing calibration and laboratory control samples (LCS) were performed for each SDG. The results of these analyses were used to qualify associated environmental sample results according to EPA Functional Guidelines (EPA, 1999 and 2002a). Documentation of data qualifications resulting from the application of these guidelines is retained in project files as both hard copy and electronic format.

The laboratory included a PB, LCS, and a laboratory duplicate sample with each batch of field samples analyzed for radionuclides.

### *A.5.3 Field Nonconformances*

No field nonconformances were identified for the CAI.

### *A.5.4 Laboratory Nonconformances*

Laboratory nonconformances are due to inconsistencies in analytical instrumentation operation, sample preparations, extractions, missed holding times, and fluctuations in internal standard and calibration results. Four nonconformances were issued by the laboratory that resulted in qualifying data and have been accounted for during the data qualification process.

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# Appendix B

# Data Assessment for CAU 527

# B.1.0 Data Assessment

This appendix provides an assessment of CAU 527 investigation results to determine whether the data collected met the DQOs and can support their intended use in the decision-making process. This assessment includes a reconciliation of the data with the general CSM established for this project.

## B.1.1 Statement of Usability

This section provides an evaluation of the DQIs in determining the degree of acceptability or usability of the reported data for the decision-making process.

Data were evaluated against specific criteria to verify the achievement of DQI goals established to meet the project DQOs as provided in the Industrial Sites QAPP (NNSA/NV, 2002b). The DQIs for this project include precision, accuracy, completeness, representativeness, and comparability.

### B.1.1.1 Precision

Precision is a measure of agreement among a replicate set of measurements of the same property under similar conditions. This agreement is expressed as the RPD between duplicate measurements (EPA, 1996).

#### B.1.1.1.1 Precision for Chemical Analyses

For the purpose of determining data precision of sample analyses for CAU 527, all water and soil samples, including field QC samples (i.e., Trip blanks, equipment rinsate samples, field blanks, etc.) were evaluated and incorporated into the precision calculation.

Table B.1-1 provides the field and laboratory duplicate precision analysis results.

Field Duplicate percent (FD) Precision for Mercury is 50 percent. Based on the sample concentration (< Contract-Required Detection Limit [CRDL]), it is the opinion of the data validator that the variability (RPD > 35 percent) does not indicate poor field or laboratory precision.

# Table B.1-1
# Chemical Precision Measurements for CAU 527

| | ORGANICS | | | | | | | INORGANICS | |
|---|---|---|---|---|---|---|---|---|---|
| | VOCs | TO14 | SVOCs | TPH-DRO | TPH-GRO | PCBs | Explosives | Metals* | Mercury |
| **Matrix Spike Duplicate (MSD) Precision** | | | | | | | | | |
| Total Number of MSD Measurements | 20 | 0 | 22 | 2 | 3 | 4 | 28 | 0 | 2 |
| Total Number of RPDs within Criteria | 20 | 0 | 22 | 2 | 3 | 4 | 28 | 0 | 2 |
| MSD Percent Precision | 100 | NA | 100 | 100 | 100 | 100 | 100 | NA | 100 |
| **Laboratory Control Sample Duplicate (LCSD) Precision** | | | | | | | | | |
| Total Number of LCSD Measurements | 40 | 25 | 22 | 3 | 4 | 6 | 28 | 44 | 4 |
| Total Number of RPDs within Criteria | 40 | 25 | 22 | 3 | 4 | 6 | 28 | 44 | 4 |
| LCSD Percent Precision | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| **Field Sample Duplicate (FD) Precision** | | | | | | | | | |
| Total Number of FD Measurements | 207 | NA | 138 | 2 | 2 | 14 | 28 | 22 | 2 |
| Total Number of RPDs within Criteria | 207 | NA | 138 | 2 | 2 | 14 | 28 | 21 | 1 |
| FD Percent Precision | 100 | NA | 100 | 100 | 100 | 100 | 100 | 95.45 | 50.00 |
| **Laboratory Sample Duplicate (Lab-Dup) Precision** | | | | | | | | | |
| Total Number of Lab-Dup Measurements | NA | NA | NA | NA | NA | NA | NA | 33 | 3 |
| Total Number of RPDs within Criteria | NA | NA | NA | NA | NA | NA | NA | 33 | 3 |
| Lab-Dup Percent Precision | NA | NA | NA | NA | NA | NA | NA | 100 | 100 |

* Measurements include arsenic, barium, cadmium, chromium, lead, selenium, silver, beryllium, nickel, and zinc
NA = Not applicable

#### *B.1.1.1.2 Precision for Radiological Analysis*

Table B.1-2 through Table B.1-4 provide the field and laboratory duplicate precision analysis results. For the purpose of determining data precision of sample analyses for CAU 527, all water and soil duplicates were evaluated and incorporated into the tables.

**Table B.1-2**
**Laboratory Duplicate Precision**

| | Gamma Spectroscopy | Isotopic Uranium | Isotopic Plutonium | Strontium-90 | Tritium | Gross Alpha | Gross Beta | Technetium-99 |
|---|---|---|---|---|---|---|---|---|
| | RPD | | | | | | | |
| No. Performed | 4 | 12 | 0 | 1 | 3 | 1 | 1 | 0 |
| No. within Limits | 4 | 11 | 0 | 1 | 3 | 1 | 1 | 0 |
| Percent within Limits | 100 | 92 | NA | 100 | 100 | 100 | 100 | NA |
| | Normalized Difference | | | | | | | |
| No. Performed | 106 | 4 | 8 | 3 | 3 | 3 | 3 | 4 |
| No. within Limits | 106 | 4 | 8 | 3 | 3 | 3 | 3 | 4 |
| Percent within Limits | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Table B.1-3**
**Laboratory MS/MSD Precision**

| | Tritium | Gross Alpha | Gross Beta |
|---|---|---|---|
| Relative Percent Difference | | | |
| No. Performed | 3 | 3 | 3 |
| No. within Limits | 3 | 3 | 3 |
| Percent within Limits | 100 | 100 | 100 |

### *B.1.1.2 Accuracy*

Accuracy is a measure of the closeness of an individual measurement or the average of a number of measurements to the true value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that result from sampling and analytical operations. Accuracy is expressed as percent recovery (% R) for the purposes of evaluating the quality of data reported for CAU 527.

**Table B.1-4**
**Field Duplicate Precision**

| | Gamma Spectrometry | Isotopic Uranium | Isotopic Plutonium | Strontium-90 | Gross Alpha | Gross Beta | Tritium | Technetium-99 |
|---|---|---|---|---|---|---|---|---|
| **Relative Percent Difference** | | | | | | | | |
| No. Performed | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| No. within Limits | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Percent within Limits | 100 | 100 | NA | NA | NA | NA | NA | NA |
| **Normalized Difference** | | | | | | | | |
| No. Performed | 42 | 2 | 4 | 2 | 2 | 2 | 2 | 2 |
| No. within Limits | 42 | 2 | 4 | 2 | 2 | 2 | 2 | 2 |
| Percent within Limits | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

NA = Not applicable

### *B.1.1.2.1 Accuracy for Chemical Analysis*

Table B.1-5 identifies the number of matrix spike, laboratory control, and surrogate measurements performed for CAU 527. The table presents the total number of measurements analyzed, the number of measurements within the specified criteria, and the percent-accuracy of each method. For organic analyses, each sample had surrogates analyzed; therefore, the number of surrogates is significantly greater than the number of matrix spike and laboratory control samples.

The matrix spike accuracy results for organic analyses in Table B.1-5 includes the total number of matrix spike measurements per analysis and the number of matrix spike measurements within criteria. All samples for organic analyses within the associated SDG are not qualified, only the native sample in which the spike was added. Inorganic matrix spike results outside of the established control criteria do result in data qualified as estimated for all the samples in that batch. However, only the analyte(s) outside of control requires qualification.

Table B.1-5 includes the total number of sample measurements performed for each method and the total number of sample measurements qualified for surrogate recoveries exceeding criteria. The estimated organic data in this CAU do not necessarily indicate the data is not useful. Data qualification is one factor to be considered in the overall assessment of the data quality and the impact to the project's objectives.

**Table B.1-5**
**Laboratory Accuracy Measurements for CAU 527**

| | ORGANICS | | | | | | | INORGANICS | |
|---|---|---|---|---|---|---|---|---|---|
| | VOCs | TO14 | SVOCs | TPH-DRO | TPH-GRO | PCBs | Explosives | Metals* | Mercury |
| **Matrix Spike (MS) Accuracy** | | | | | | | | | |
| Total Number of MS Measurements | 40 | 0 | 44 | 4 | 6 | 8 | 56 | 33 | 5 |
| Total Number of MS Measurements within Criteria | 38 | 0 | 40 | 4 | 4 | 8 | 56 | 31 | 5 |
| MS % Accuracy | 95 | NA | 90.91 | 100 | 66.67 | 100 | 100 | 93.94 | 100 |
| **Laboratory Control Sample (LCS) Accuracy** | | | | | | | | | |
| Total Number of LCS Measurements | 85 | 50 | 66 | 7 | 8 | 14 | 84 | 88 | 8 |
| Total Number of LCS Measurements within Criteria | 85 | 50 | 66 | 7 | 8 | 14 | 84 | 88 | 8 |
| LCS % Accuracy | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| **Surrogate Accuracy** | | | | | | | | | |
| Total Number of Measurements Analyzed | 2,277 | 555 | 1,656 | 22 | 22 | 154 | 308 | NA | NA |
| Total Number of Measurements not Affected by Out-of-Control Surrogates | 2,193 | 533 | 1,587 | 17 | 21 | 154 | 308 | NA | NA |
| Surrogate % Accuracy | 96.31 | 96.04 | 95.83 | 77.27 | 95.45 | 100 | 100 | NA | NA |

* Measurements include arsenic, barium, cadmium, chromium, lead, selenium, silver, beryllium, nickel, and zinc

For the purpose of determining data accuracy of sample analysis for CAU 527, all water and soil samples including field QC samples (i.e., trip blanks, equipment rinsate samples, field blanks, etc.) were evaluated and incorporated into the accuracy calculation.

Although MS percent accuracy for GROs is 66.67 percent, only one sample was qualified as estimated due to low matrix spike recoveries for gasoline-range organics. Compared to all 22 samples analyzed for GRO, the sample MS percent accuracy is 95.45 percent, which is an acceptable level of accuracy.

#### *B.1.1.2.2 Accuracy for Radiological Analysis*

For the purpose of determining data accuracy of sample analysis for CAU 527, all water and soil samples including field QC samples (i.e., trip blanks, equipment rinsate samples, field blanks, etc.) were evaluated and incorporated into the accuracy calculation. Table B.1-6 provides the number of laboratory control samples, including soil and water matrices, measured for each radiochemical measurement for CAU 527.

**Table B.1-6**
**Laboratory Control Sample (LCS) Accuracy**

| | Gamma Spectroscopy | Isotopic Uranium | Isotopic Plutonium | Strontium-90 | Gross Alpha | Gross Beta | Tritium | Technetium-99 |
|---|---|---|---|---|---|---|---|---|
| Total Number | 20 | 14 | 5 | 7 | 5 | 5 | 7 | 5 |
| Total Number within Criteria | 20 | 14 | 5 | 7 | 5 | 5 | 7 | 5 |
| LCS Percent Accuracy | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

The results of MS samples measured for the gross alpha and gross beta analyses are contained in Table B.1-7.

Four gross alpha MS recoveries were outside control limits but no samples were qualified because measuring a MS by gross alpha has inherent problems.

**Table B.1-7**
**Laboratory Matrix Spike (MS) Accuracy**

| | Gross Alpha | Gross Beta | Tritium |
|---|---|---|---|
| Total Number | 7 | 7 | 7 |
| Total Number within Criteria | 3 | 6 | 7 |
| MS Percent Accuracy | 43 | 86 | 100 |

### *B.1.1.3 Completeness*

Completeness is defined as the acquisition of sufficient data of the appropriate quality to satisfy DQO decision data requirements. Table B.1-8 and Table B.1-9 contain results of completeness per analytical method. The specified sampling locations were used as planned and all samples were collected as specified in the CAU 527 CAIP (NNSA/NV, 2002a).

**Table B.1-8**
**Chemical Completeness for CAU 527**

| Completeness Parameters | ORGANICS | | | | | | | INORGANICS | |
|---|---|---|---|---|---|---|---|---|---|
| | VOCs | TO14 | SVOCs | TPH-DRO | TPH-GRO | PCBs | Explosives | Metals* | Mercury |
| **Sample Analysis Completeness** | | | | | | | | | |
| Total Samples Sent to Laboratory | 28 | 11 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| Total Samples Analyzed | 28 | 11 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| Total Samples Not Analyzed by the Laboratory | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Percent Completeness** | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| **Measurement Usability Completeness** | | | | | | | | | |
| Total Measurements ** | 2277 | 555 | 1656 | 22 | 22 | 154 | 308 | 242 | 22 |
| Total Measurements Rejected - Field | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Measurements Rejected - Lab/Matrix | 37 | 0 | 24 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Percent Completeness** | 98.38 | 100 | 98.55 | 100 | 100 | 100 | 100 | 100 | 100 |

* Measurements include Arsenic, Barium, Cadmium, Chromium, Lead, Selenium, Silver, Antimony, Beryllium, Nickel, and Zinc
** Measurements include re-analyses

In accordance with the CAU 527 CAIP (Table 6-1), 80 percent of noncritical parameters had valid results. Critical parameters were not identified in the CAIP.

### *B.1.1.4 Rejected Data*

Table B.1-10 lists the rejected results per analytical method (VOCs and SVOCs) for Horn Silver Mine. All other results are considered usable. The VOCs and SVOCs that were rejected were not detected in any other samples except for acetone. These rejected cuttings and core results are considered an acceptable data gap because it does not affect closure decisions.

### *B.1.1.5 Representativeness*

The DQO process, as identified in Appendix A of the CAIP, was used to ensure that samples collected would be representative of the populations of interest. During this process, appropriate

**Table B.1-9**
**Radiological Completeness for CAU 527**

| Completeness Parameters | HASL300 | ISOU | SM7110 | SR7500 | TC99 | UGTAISOPU | EPA906.0 |
|---|---|---|---|---|---|---|---|
| **Sample Analysis Completeness** | | | | | | | |
| Total Samples Sent to Laboratory | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| Total Samples Analyzed | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| Total Samples Not Analyzed by the Laboratory | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Percent Completeness** | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| **Measurement Usability Completeness** | | | | | | | |
| Total Measurements ** | 483 | 66 | 44 | 22 | 22 | 44 | 22 |
| Total Measurements Rejected | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Percent Completeness** | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

* Measurements include re-analyses

biased locations were selected. Biased sampling was performed to ensure sampling of suspected or known contamination. In addition, analytical requirements were specified in order to ensure appropriate methods were selected for COPCs. This was performed to address the concerns of all stakeholders and project personnel. The DQO approach was based upon process knowledge gained during the preliminary assessment. Therefore, the analytical data acquired during the CAU 527 corrective action investigation are considered representative of the populations of interest.

### *B.1.1.6 Comparability*

Field sampling, as described in the CAU 527 CAIP, was performed and documented in accordance with approved procedures that are comparable to standard industry practices. Approved analytical methods and procedures per DOE were used to analyze, report, and validate the data. These are comparable to other methods used in industry and government practices, but most importantly are comparable to other investigations conducted for the NTS. Therefore, datasets within this project are considered comparable to other datasets generated using these same standardized DOE procedures,

# Table B.1-10
# CAU 527 Rejected Data
(Page 1 of 2)

| Sample Number | Laboratory Method | Parameter | Sample Matrix |
|---|---|---|---|
| Horn Silver Mine 1 | | | |
| 527A0061 | SW8270C | 2,4-Dinitrophenol | Soil |
| 527A0011DL | SW8270C | 2,4-Dinitrophenol | Soil |
| 527A0011 | SW8270C | 2,4-Dinitrophenol | Soil |
| 527A0011 | SW8260B | Bromoform | Soil |
| 527A0021 | SW8270C | 2,4-Dinitrophenol | Soil |
| 527A0011 | SW8260B | 1,1,2,2-Tetrachloroethane | Soil |
| 527A0011 | SW8260B | 1,2,3-Trichlorobenzene | Soil |
| 527A0011 | SW8260B | 1,2,3-Trichloropropane | Soil |
| 527A0011 | SW8260B | 1,2,4-Trichlorobenzene | Soil |
| 527A0011 | SW8260B | 1,2,4-Trimethylbenzene | Soil |
| 527A0011 | SW8260B | 1,2-Dibromo-3-Chloropropane | Soil |
| 527A0011 | SW8260B | 1,2-Dichlorobenzene | Soil |
| 527A0011 | SW8260B | 1,3,5-Trimethylbenzene | Soil |
| 527A0011 | SW8260B | 1,3-Dichlorobenzene | Soil |
| 527A0011 | SW8260B | 1,4-Dichlorobenzene | Soil |
| 527A0011 | SW8260B | 2-Chlorotoluene | Soil |
| 527A0011 | SW8260B | 4-Chlorotoluene | Soil |
| 527A0011 | SW8260B | Bromobenzene | Soil |
| 527A0011 | SW8260B | Hexachlorobutadiene | Soil |
| 527A0011 | SW8260B | Isopropyl Benzene | Soil |
| 527A0011 | SW8260B | Methylene Chloride | Soil |
| 527A0011 | SW8260B | N-Butylbenzene | Soil |
| 527A0011 | SW8260B | Naphthalene | Soil |
| 527A0031 | SW8270C | 2,4-Dinitrophenol | Soil |
| 527A0011 | SW8260B | P-Isopropyltoluene | Soil |
| 527A0011 | SW8260B | Sec-Butylbenzene | Soil |
| 527A0011 | SW8260B | Tert-Butylbenzene | Soil |

**Table B.1-10**
**CAU 527 Rejected Data**
(Page 2 of 2)

| Sample Number | Laboratory Method | Parameter | Sample Matrix |
|---|---|---|---|
| Horn Silver Mine 1 | | | |
| 527A0041 | SW8270C | 2,4-Dinitrophenol | Soil |
| 527A0011 | SW8260B | N-Propylbenzene | Soil |
| 527A0051 | SW8270C | 2,4-Dinitrophenol | Soil |
| Horn Silver Mine 2 | | | |
| 527B0081 | SW8270C | 2,4-Dinitrophenol | Soil |
| 527B0021 | SW8270C | 2,4-Dinitrophenol | Soil |
| 527B0111 | SW8270C | 2,4-Dinitrophenol | Soil |
| 527B0121 | SW8270C | 2,4-Dinitrophenol | Soil |
| 527B0041 | SW8270C | 2,4-Dinitrophenol | Soil |
| 527B0051 | SW8270C | 2,4-Dinitrophenol | Soil |
| 527B0061 | SW8270C | 2,4-Dinitrophenol | Soil |
| 527B0071 | SW8270C | 2,4-Dinitrophenol | Soil |
| 527B0031 | SW8270C | 2,4-Dinitrophenol | Soil |
| 527B0011 | SW8270C | 2,4-Dinitrophenol | Soil |
| Horn Silver Mine 3 | | | |
| 527C0011 | SW8270C | 2,4-Dinitrophenol | Soil |
| 527C0041 | SW8260B | Acetone | Solid |
| 527C0041 | SW8270C | 2,4-Dinitrophenol | Solid |
| 527C0031 | SW8270C | 2,4-Dinitrophenol | Soil |

thereby meeting DQO requirements. The employed methods and procedures also ensured that data were appropriate for comparison to action levels specified in the CAIP and this CADD/CR.

### B.1.2 Reconciliation of Conceptual Site Model to the Data

This section provides a reconciliation of the data collected and analyzed during this investigation with the CSM established in the DQO process.

#### B.1.2.1 Conceptual Site Model

The HSM CSM was developed for CAU 527 as presented in the CAIP (NNSA/NV, 2002a). The CSM was based on historical information and process knowledge. The primary source of potential contamination is associated with the Horn Silver Mine, which was used for disposal of waste and classified materials. The primary mechanisms for this type of release include groundwater (perched water and intermittent percolation) and vapor transport from the mineshaft into the open drifts, if groundwater is present, or large volumes of volatile waste disposal occurred. Fracture flow in the rock is the only other significant feasible preferential pathway. There is no evidence of surface soil contamination at CAU 527; therefore, surface and near-surface soil and rock are not affected by the waste. The waste is contained in the mineshaft and associated drifts; covered by concrete, clean fill, and a locked cover; and is not exposed to the surface.

The rock surrounding the waste is hard, fractured, tertiary igneous rock. The waste is solid, nonmobile material with little or no potential for migration into the solid rock. There is no evidence of a mechanism for the rock to become contaminated by the waste, other than limited surface contact where the waste physically contacts the sides of the mineshaft.

This CSM was determined to be valid for CAU 527.

#### B.1.2.2 Investigation Design and Contaminant Identification

The CSM was used as the basis for identifying appropriate sampling strategies and data collection methods. The model was designed to determine the extent of impact on contaminated effluent released to the surrounding rock.

The investigation results showed that the nature and extent of contamination at the HSM fit the physical system, release mechanisms, and pathways described by the CSM.

### *B.1.2.3 Contaminant Nature and Extent*

The absence of contamination was observed by sample results showing COPC sample concentrations not exceeding PALs established in the CAIP. In general, sample results demonstrated that the vertical and lateral extent of COCs was limited to the physical boundaries of the CSM defined in the CAIP. Field screening was conducted and samples were collected at locations to bound contaminated areas with results below action levels. This confirmed that the extent of contamination was limited to anticipated regions defined by the CSM. The investigation findings, analytical results, and descriptions of site conditions are presented in Appendix A of this CADD.

## *B.1.3 Conclusions*

Samples were collected and analyzed as planned and within acceptable performance limits except where noted.

The DQIs (i.e., precision, accuracy, representativeness, and comparability) were evaluated for acceptability of the dataset. All of the data, except data qualified as rejected, can be used in project decisions. The rejected data have been discussed and determined to have no impact on closure decisions.

Thus, the DQIs for the investigation have been met, and the dataset can be used to recommend the corrective action of close in place with administrative controls.

## B.2.0 References

EPA, see U.S. Environmental Protection Agency.

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

U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office. 2002a. *Corrective Action Investigation Plan for Corrective Action Unit 527: Horn Silver Mine, Nevada Test Site, Nevada,* DOE/NV--856--REV. 1. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office. 2002b. *Industrial Sites Quality Assurance Project Plan, Nevada Test Site, Nevada,* Rev. 1, DOE/NV--372. Las Vegas, NV.

U.S. Environmental Protection Agency. 1996. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846 CD ROM PB97-501928GEI, which contains updates for 1986, 1992, 1994, and 1996. Washington, DC.

# Appendix C

# DQO Summary

# C.1.0 DQOs as Developed in the CAIP

### *Introduction*

This appendix presents a summary of the DQO requirements stipulated in the CAIP and reconciled with investigation results presented in the CADD. The DQO requirements are presented followed by an evaluation of how these requirements were met by the investigation results.

### *Describe the Problem*

***DQO Requirement:*** CAU 527 is being investigated to determine if radioactive and/or hazardous constituents from waste and material disposed in the Horn Silver Mine pose an unacceptable risk to human health and the environment.

***Investigation Results:*** The investigation results indicate that hazardous constituents do not pose an unacceptable risk to human health and the environment. This is evidenced by the absence of contamination at concentrations exceeding PALs at any location of potential exposure.

### *Develop a Decision Statement*

***DQO Requirement***: Determine if significant contaminant transport mechanisms (i.e., groundwater and vapor transport) exist near CAU 527 or if contamination migration has occurred within open fractures or drifts.

***Investigation Results***: Groundwater was not found in the formation at or below the depths of the waste. Except for contaminant vapors, contamination has not occurred within the open fractures or drifts. Contaminant vapors are present within the drifts.

***DQO Requirement***: If no groundwater exists near CAU 527 and no contamination is found within open fractures or drifts, then it will be assumed that contamination has not migrated and will not pose a significant threat to human health and the environment and no further characterization will be necessary.

If groundwater is found to exist near CAU 527 or if significant contamination is found within the open drifts or fractures, then the decision statement for the extent of contamination determination is: "Determine to what extent COCs from waste have migrated."

***Investigation Results***: No contamination (other than vapor) was found within open fractures or drifts. It is assumed that contamination has not migrated and will not pose a significant threat to human health and the environment. No further characterization will be necessary.

Vapor contamination was found within the open drifts. It was assumed that the extent of vapor contamination extends throughout all drifts.

***Alternative Actions to the Decision***

***DQO Requirement***: If groundwater is encountered during drilling activities, water samples will be collected and analyzed to determine if any of the COPCs are above PALs, which will result in a COC. Samples of core material or cuttings from boreholes and pore-gas samples from open drifts and fractures will be collected and analyzed to determine if any COPCs are above PALs, which will result in a COC. If COCs are not detected in the groundwater, drill core, and pore gas, additional samples will not be required. If COCs are detected, the extent of contamination will be determined based on computer modeling.

***Investigation Results***: Samples were collected of core material and cuttings from boreholes and pore-gas samples from open drifts and fractures. A sample was also collected from a moist section of the HSM-3 borehole. No COPCs were detected above PALs in any of these samples. Additional samples were not required and computer modeling was not required to define extent of contamination.

***Information Needs and Information Sources***

***DQO Requirement***: To determine if groundwater flow exists, data must be collected and analyzed following these two criteria: (1) data must be collected in an area that demonstrates that groundwater could make direct contact with the waste (e.g., borehole location must represent the geology of the mineshaft), and (2) data collection method must be adequate to detect groundwater.

***Investigation Results***: Monitoring wells were established in three boreholes in the formation containing the waste. Electronic sensing devices were installed in each of the boreholes capable of detecting small accumulations of groundwater.

***DQO Requirement:*** Biasing factors to support this decision statement require that the lithology of the borehole match the lithology of the mineshaft and that monitoring equipment for groundwater must be able to detect groundwater in the borehole.

***Investigation Results***: Three boreholes were drilled into the formation containing the waste. The lithology of each of the borehole locations showed that the formation was consistent in composition. This supports the conclusion that the lithology of the location containing the waste is the same or very similar to the lithology of the boreholes.

***DQO Requirement***: To determine if fracture flow is possible, data must be collected and analyzed following these two criteria: (1) data must be collected in an area that demonstrates that liquid or vapor from waste disposal activities could have migrated through open fractures (e.g., borehole location must represent the geology of the mineshaft), and (2) data collection method must be adequate to detect fracture flow of liquids or vapors.

***Investigation Results***: Three boreholes were drilled into the formation containing the waste. The lithology of each of the borehole locations showed that the formation was consistent in composition. This supports the conclusion that the lithology of the location containing the waste is the same or very similar to the lithology of the boreholes.

Permeability testing was conducted by SEA to determine the capacity of the fracture systems to transmit vapor and to supply information necessary to support a modeling effort, if needed, to define the extent of migrating contamination. Results are discussed in Section A.2.3.8.

***DQO Requirement***: Data must be collected in areas likely to be contaminated by migration (i.e., in groundwater adjacent to the lateral and vertical extent of waste).

***Investigation Results***: Data was collected in the locations established in the DQOs as meeting this criterion.

***DQO Requirement***: Analytical suite selection must be sufficient to detect any contamination present in the samples.

***Investigation Results***: All samples were analyzed using the analytical methods stipulated in the DQOs.

***DQO Requirement***: To determine if contaminant migration has occurred, samples of pore gas, drill core or cuttings, or liquid will be collected and submitted for laboratory analysis. The basis to determine if contaminant migration has occurred will be detection of nonnaturally occurring chemicals or radionuclides greater than achievable detection limits. If nonnaturally occurring chemicals or radionuclides are detected, then the extent will be determined through modeling. Computer modeling software must be adequate for the groundwater regime and waste type.

***Investigation Results:*** Contaminants were not detected in the samples that were collected to define the extent of contamination. Therefore, computer modeling was not necessary to define the extent of contamination.

***Potential Sampling Techniques and Appropriate Analytical Methods***

***DQO Requirement***: Samples of core material will be collected at 50-ft intervals starting at approximately 150 ft bgs (i.e., the top of the waste disposal cell) and continuing to the bottom of each borehole. The samples will be screened and a minimum of five samples will be submitted for laboratory analysis based on field-screening results and visual observations. Samples will be submitted for radiological and chemical analysis. Selected samples will also be submitted for geotechnical and hydrological analysis.

Gas samples will be collected from within intercepted drifts at 300- and/or 500-ft depths. If drifts are not directly intercepted, then sections of the borehole will be isolated with packers at depths corresponding with the drifts, and gas samples will be collected.

Liquid samples (if sufficient volume is present) will be collected from within intercepted drifts at 300 and/or 500 ft.

***Investigation Results***: Samples were collected as specified in the DQOs with the following exceptions. Rock cuttings samples were substituted for core samples due to the costs associated with core collection. Gas samples were collected directly from the 500-ft drift and within the interval corresponding to the 300-ft drift. No samples were collected from the intercepted drift because liquid was not encountered.

***DQO Requirement***: Once the drilling is complete, monitoring will be conducted continuously for one year. Data from the monitoring will be logged once per 24-hour period to track trends and will consist of measuring groundwater levels in the borehole using an electric sounder or electric depth gauge (to determine water level). The monitoring will follow approved procedures for measuring groundwater in wells. A determination will be made after one year, if additional monitoring is required.

***Investigation Results:*** Monitoring of the boreholes for liquid is currently being conducted. Data from the monitoring is being logged every 6 hours to track trends and consists of measuring groundwater levels in the borehole using transducers.

***DQO Requirement***: To determine if fracture flow is possible, a fracture flow test will be conducted within each of the vertical boreholes. The test will consist of sealing off sections of the borehole with packers or other appropriate methods, and injecting a tracer gas. Additional sections of the borehole, above and possibly below the injection point, will also be sealed using packers, and pore-gas samples will be collected to determine fracture flow rate and distance.

***Investigation Results***: Permeability testing was conducted by SEA following a review of the geophysical logs and drill cuttings to determine the capacity of the fracture systems to transmit vapor and to supply information necessary to support a modeling effort, if needed, to define the extent of migrating contamination. Results are discussed in Section A.2.3.8.

***Decision Rule***

***DQO Requirement***: If during initial drilling no evidence of groundwater is found or if evidence is inconclusive, borehole monitoring will be conducted for one year. If any time during the monitoring period groundwater is measured as described in measurement and analysis methods, samples will be collected for laboratory analysis. A determination will be made after one year if additional monitoring is required.

***Investigation Results***: No evidence of groundwater was found at or below the depth of the waste. Therefore, monitoring of the borehole for groundwater accumulation will be conducted for one year.

***DQO Requirement***: If no evidence of contamination is found in samples of core, liquids, or pore gas collected from within the boreholes, open drifts, or fractures, then no further characterization will be necessary.

***Investigation Results:*** No evidence of contamination was found in samples of core or liquids collected from within the boreholes. Contamination was found in pore gas collected from within the open drifts or fractures; however, this contamination was shown not to pose a significant risk to a receptor (see Section A.3.4.16). Therefore, no further characterization is necessary.

***DQO Requirement***: If the groundwater model estimates that COPCs exceed PALs (i.e., COCs) beyond the mineshaft, then migration has occurred. The model will estimate the extent to where the plume boundary no longer exceeds PALs.

***Investigation Results***: Contaminants were not detected in samples collected to define the extent of contamination; therefore, computer modeling was not necessary to define the extent of contamination.

***DQO Requirement***: If contamination is inconsistent with the CSM or extends beyond the spatial boundaries, then work will be suspended and the investigation strategy will be reevaluated.

***Investigation Results***: Sample results demonstrated that contamination was confined within the study area. These results were consistent with the CSM of wastes disposed in the vertical mineshaft, migrating downward with infiltrating precipitation, and vapors migrating through drifts and fractures.

***Specify the Tolerable Limits on Decision Errors***

***DQO Requirement***: A false rejection decision error (where consequences are more severe) is controlled by having a high degree of confidence that the investigation borehole will detect if groundwater is present by using established drilling and casing techniques that have been demonstrated to produce groundwater bearing holes. Using monitoring techniques per established SOPs and experienced personnel will provide a high level of confidence that groundwater will be detected.

To satisfy these criteria, data will be collected in areas most likely to present groundwater saturation. The location of waste in the mineshaft, lithology surrounding the waste, and the location of fault will be considered to accomplish the data collection.

A false acceptance decision error (where consequences are less severe) is controlled by having a high degree of confidence that the investigation borehole will detect groundwater, if present.

***Investigation Results***: A high degree of confidence that the investigation borehole would detect groundwater, if present, was proven during the investigation by using experienced personnel and established techniques per established Standard Operating Procedures (SOPs) that have been demonstrated to produce groundwater-bearing monitoring wells. This was demonstrated by the discovery of a zone of increased moisture at the 200 ft bgs level in HSM-3. Since this moisture was found above the waste, it was not possible to have migrated through the waste. However, this discovery demonstrated the ability to detect areas within the borehole containing groundwater, if any had existed.

Data was collected throughout the boreholes but focused on depths equivalent to and below the depths of the waste in the mineshaft, within lithology equivalent to that of the buried waste, and within and on both sides of the main fault.

***Optimize the Design for Obtaining Data***

***DQO Requirement***: Vertical investigation boreholes will be drilled parallel to the mineshaft, no closer than 50 ft, to a depth of 50 ft below the waste. The boreholes will be drilled to be within as much of the foot-wall side of the fault within the zone of waste disposal to ensure that any groundwater found in the boreholes would be in the same geologic environment as the mineshaft. The vertical boreholes will be positioned to attempt to intercept the drifts at 300 and 500 ft bgs (Figure A.2-2).

An angled investigation borehole will be drilled such that the borehole will be completed no closer than 50 ft to the mineshaft and to a depth of 50 ft below the waste. The borehole will be drilled on the foot-wall side of the fault to ensure that any groundwater found in the borehole would be in the same geologic environment as the mineshaft.

***Investigation Results***: The HSM-1 and HSM-2 boreholes were drilled parallel to the mineshaft, no closer than 50 ft to the mineshaft, and to a depth equivalent to the bottom of the target drifts. The boreholes were drilled within the foot-wall side of the fault such that the boreholes were in the same geologic environment as the mineshaft wastes. The vertical boreholes intercepted the 500-ft drift and was in close proximity to the 300-ft drift (see Section A.2.3.8).

The angled borehole (HSM-3) was drilled such that the borehole did not come within 50 ft of the mineshaft and the bottom of the borehole terminated beneath the wastes. The borehole started on the hanging-wall side of the fault and was drilled through the fault into the foot-wall to ensure that any groundwater found within or on either side of the fault that might come into contact with the wastes would be discovered.

***DQO Requirement***: Drilling methods used will be appropriate to monitor for groundwater and collect computer modeling data. The established drill holes will be evaluated for evidence of groundwater. If no groundwater is found, the boreholes will be monitored for one year. A determination will be made after one year, if additional monitoring is required.

Core samples will be taken to collect geologic and hydrologic inputs into the model, if necessary.

Drilling will be done with a system that will not introduce water into the hole and can drill into the lithology to a depth of 50 ft below the waste (e.g., ODEX or air rotary methods). Exact method and other specific drilling information will be determined by the drilling subcontractor selected for the project.

***Investigation Results:*** Drilling was conducted using an air rotary method that did not introduce water into the formation and reduce the capability to detect formation moisture. The HSM-3 borehole was drilled to a depth of approximately 150 ft below the waste. Samples were collected to provide geotechnical data that would have been used in computer modeling, if computer modeling had been necessary. Since no groundwater was found within or beneath the depths of the waste, monitoring of the boreholes for liquid is currently being conducted and will continue for one year. At that time, it will be determined if additional monitoring will be required.

***DQO Requirement***: After the first boreholes are established, water level measurements will be taken to determine if the boreholes are dry or, if wet, the water level using standard water level measuring equipment and SOPs. The criteria for determining if groundwater is entering the monitoring well will be the detection of a water level increase in the monitoring well. This will be measured using a sounding device capable of detecting a 0.5-in. rise in the water level. A 1-in. rise in water level within a 48-hour period following purging of the well will be considered to be greater than measurement error; therefore, it is sufficient to make the decision that groundwater exists.

Monitoring will be conducted continuously for one year, with data being logged once per 24-hour period to track trends. The data logging will consist of measuring groundwater levels in the borehole using an electric sounder or electric depth gauge (to determine water level). Applicable SOPs for measuring groundwater in wells will be used. A determination will be made after one year if additional monitoring is required. The determination may be based on some or all of, but not limited to: groundwater-level measurement results and precipitation amounts (i.e., average, above or below average for the year). The decision whether or not to continue monitoring will be agreed upon by NNSA/NSO and NDEP and will be documented.

***Investigation Results***: No groundwater was detected in any of the boreholes at depths within or below the wastes. Monitoring of the boreholes for moisture is currently being conducted and will continue for one year. Data from the monitoring is being logged every 6 hours to track trends and consists of measuring groundwater levels in the borehole using transducers capable of detecting less than one inch (or ~50 milliliters) of groundwater accumulation.

***DQO Requirement***: Contamination with high vapor pressures may volatilize and the resulting vapors could be transported through the open drifts and fractures. The vapor transport will be investigated by attempting to drill into the open drifts at 300- and 500-ft bgs to collect pore-gas samples. The fractures will be investigated by isolating sections of the two vertical boreholes and injecting a tracer gas to check for the extent of open fractures.

***Investigation Results:*** The vertical boreholes intercepted the 500-ft drift and was in close proximity to the 300-ft drift (see Section A.2.3.8). Pore-gas samples were collected and air permeability testing was conducted in the area of both drifts to evaluate the extent of open fractures.

***DQO Requirement***: Intermittent contaminant migration may occur as a result of pulses of infiltrated precipitation or vapor flow. This intermittent driver for contaminant migration may have left residual COPCs within the open fractures. This will be investigated by sending core samples for laboratory analysis.

***Investigation Results***: Core samples from beneath the waste were evaluated for the presence of residual COPCs within the open fractures. No contaminants were detected in any of these samples. Therefore, it was determined that significant contaminant migration has not occurred as a result of intermittent pulses of infiltrated precipitation or vapor flow.

***DQO Requirement***: Samples of any groundwater found, drilling core, and pore gas will be taken for analysis to determine if COCs have migrated from the waste.

***Investigation Results***: Samples of core material and cuttings from boreholes were collected. A sample was also collected from a moist section of the HSM-3 borehole. No COPCs were detected above PALs in any of these samples.

Samples of pore gas were taken from open drifts and fractures within the intervals of the drifts. Contamination was found in pore gas collected from within the open drifts or fractures. This contamination is assumed to extend throughout all drifts; however, this contamination was shown not to pose a significant risk to a receptor (see Section A.3.4.16).

It is assumed that contamination has not migrated and will not pose a significant threat to human health and the environment.

# Appendix D

# Use Restrictions

# Use Restriction Form

## CAU Use Restriction Information

**CAU Number/Description:** CAU 527, Horn Silver Mine

**Applicable CAS Numbers/Descriptions:** CAS 26-20-01 Contaminated Waste Dump #1

**Contact (Organization/Project):** NNSA/NSO Industrial Sites Project Manager

**Surveyed Area (UTM, Zone 11, NAD 27, meters):** Horn Silver Mine (HSM) shaft coordinates Northing 4074887.16, Easting 574365.25. A subsurface cylindrical volume (150 ft to 670 ft bgs) from the HSM shaft to a radius of 300 ft. (See attached map)

**Survey Date:** 2/2/2004 **Survey Method (GPS, etc.):** GPS

**Site Monitoring Requirements:** None

**Required Frequency (quarterly, annually?):** Not Applicable

**If Monitoring Has Started, Indicate Last Completion Date:** Not Applicable

| **Use Restrictions** |
|---|
| The future use of any land related to this Corrective Action Unit (CAU), as described by the above surveyed location, is restricted from any DOE or U.S. Department of Defense activity that may alter or modify the containment control as approved by the state and identified in the CAU Closure Report or other CAU documentation unless appropriate concurrence is obtained in advance. |

**Comments:** See the Closure Report for additional information on the condition of the site(s) and any monitoring and/or inspection requirements. The Corrective Action Decision Document/Closure Report is available electronically at http://www/osti.gov/bridge.

**Submitted by:** ______________________ **Date:** ______________
Kevin J. Cabble, NNSA/NSO, Task Manager

**cc with copy of survey map (paper and digital (.dgn) formats):**
**CAU Files (2 copies)**

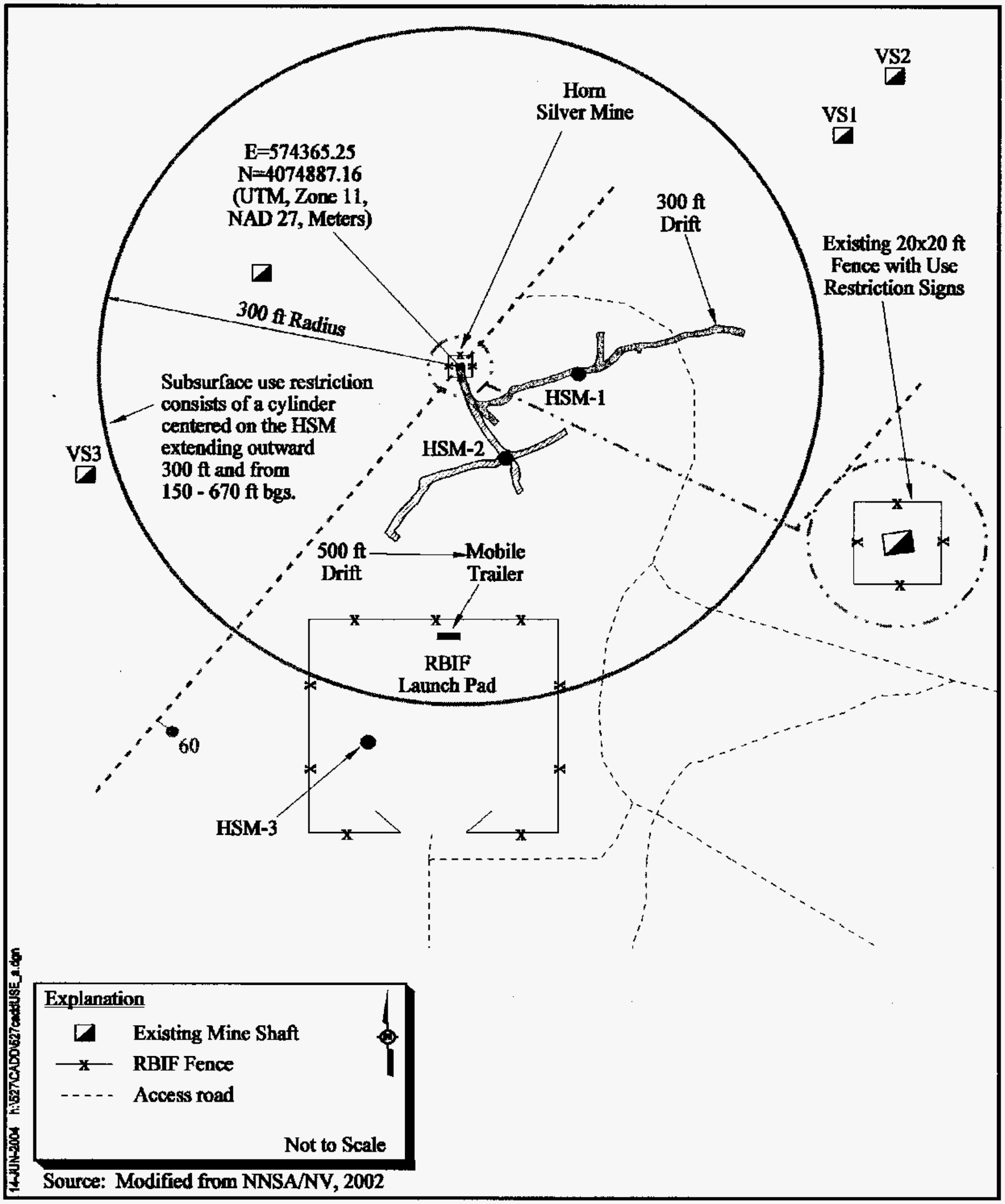


**Figure D.1-1**
**CAU 527, Horn Silver Mine**
**CAS 26-20-01 Contaminated Waste Dump #1 Use Restriction Map**

# D.1.0 References

U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office. 2002. *Corrective Action Investigation Plan for Corrective Action Unit 527: Horn Silver Mine, Nevada Test Site, Nevada*, Rev. 1, DOE/NV--865. Las Vegas, NV.

# Appendix E

# Air-Flow Measurements in NTS Boreholes HSM-1 and HSM-3

Prepared by Science and Engineering Associates, Inc.

( 13 pages)

# AIR-FLOW MEASUREMENTS IN NTS BOREHOLES
# HSM-1 AND HSM-3

January 19, 2004

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SEASF-LR-04-300

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Science & Engineering Associates, Inc.

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## LIST OF FIGURES



## LIST OF TABLES

# 1. INTRODUCTION

Science and Engineering Associates, Inc. (SEA) performed a series of in-situ gas permeability measurements in two boreholes (HSM-1 & HSM-3) within the Corrective Action Unit (CAU) 527 of Horn Silver Mine. This unit is located in Area 26 of the Nevada Test Site (NTS), Nevada. The boreholes were 300 and 724 feet (ft) in depth with a nominal 8.5-inch (in.) internal diameter. The boreholes were developed with steel surface casing and were open below the surface casing during the measurement period. Borehole HSM-1 is a vertical borehole whereas HSM-3 is angled at 60 degrees with respect to the ground surface.

Measurements were made using a straddle packer system, allowing values to be determined at discreet points along the boreholes. Caliper logs were performed prior to the permeability measurements. These data were used to identify areas where the diameter of the hole was greater than could be sealed by the packers, both preventing the measurement of artificially high permeabilities and preventing damage to the system. Measurements were performed at locations specified by the Site Supervisor. Borehole HSM-1 was logged December 4, and borehole HSM-3 was logged December 15 - 16 of 2003.

At the request of the Site Supervisor, a number of gas samples were collected with the packer system. Summa canister samples were taken in borehole HMS-1 at a depth of 297-299 ft and in HMS-3 at depths of 335-337 ft and 622-624 ft. The client was responsible for all sampling paper work and analysis of these samples.

This report provides the measured permeabilities for the two boreholes.

## 2. METHODOLOGY

Straddle packer permeability measurements have historically been performed to conduct air and water permeability measurements in porous media. For this application, a steady-state spherical flow model is used. The air injection (or extraction) source can be approximated as a sphere. The steady-state air flow into the source, the source equivalent radius, the source pressure, and the ambient soil gas pressure can be used to infer the effective gas permeability, k (Keller, Engstrom, and West 1973; Lowry and Narbutovskih 1991), using the following model:

$$k = \frac{\mu R T \dot{m}}{2\pi M\left(P_o^2 - P^2\right)} \bullet \left(\frac{1}{r_o}\right) \qquad \text{Eq. 1}$$

where:

| | | |
|---|---|---|
| $\mu$ | = | dynamic gas viscosity |
| R | = | universal gas constant |
| T | = | absolute temperature |
| $\dot{m}$ | = | gas mass flow into soil |
| M | = | gas molecular weight |
| $P_o$ | = | absolute pressure of source |
| P | = | ambient absolute soil gas pressure |
| $r_o$ | = | source radius |

This model is applied in straddle packer measurements by setting $r_o$ to be the radius of the sphere whose surface area is equal to the area of the exposed borehole wall (estimated to be the length of the packer spacing times the circumference of the borehole).

A schematic of the packer system is shown in Figure 1. Packers are located above and below an injection zone. The injection zone length is chosen based on borehole properties. Larger zones (typically around 2 feet) are used in more fractured media, while smaller zones (typically 1foot) are used in well consolidated media. The packers are inflated with an above ground air compressor. Air is injected/extracted from the measurement zone via a surface pump. An instrument package containing all of the measurement sensors, solenoid valves and switches required to operate the system is located above the upper packer. The electronics are controlled with either a computer or datalogger. The packers are each six feet in length, fabricated of a medium weight material, and operated at a pressure of 4 to 7 pounds per square inch (psi) during the measurement. The packers are able to seal a borehole of up to 9 inches in diameter. The packer/instrument package assembly is lowered into the borehole using a winch/cable system. Figure 2 shows a typical packer/instrument package assembly.

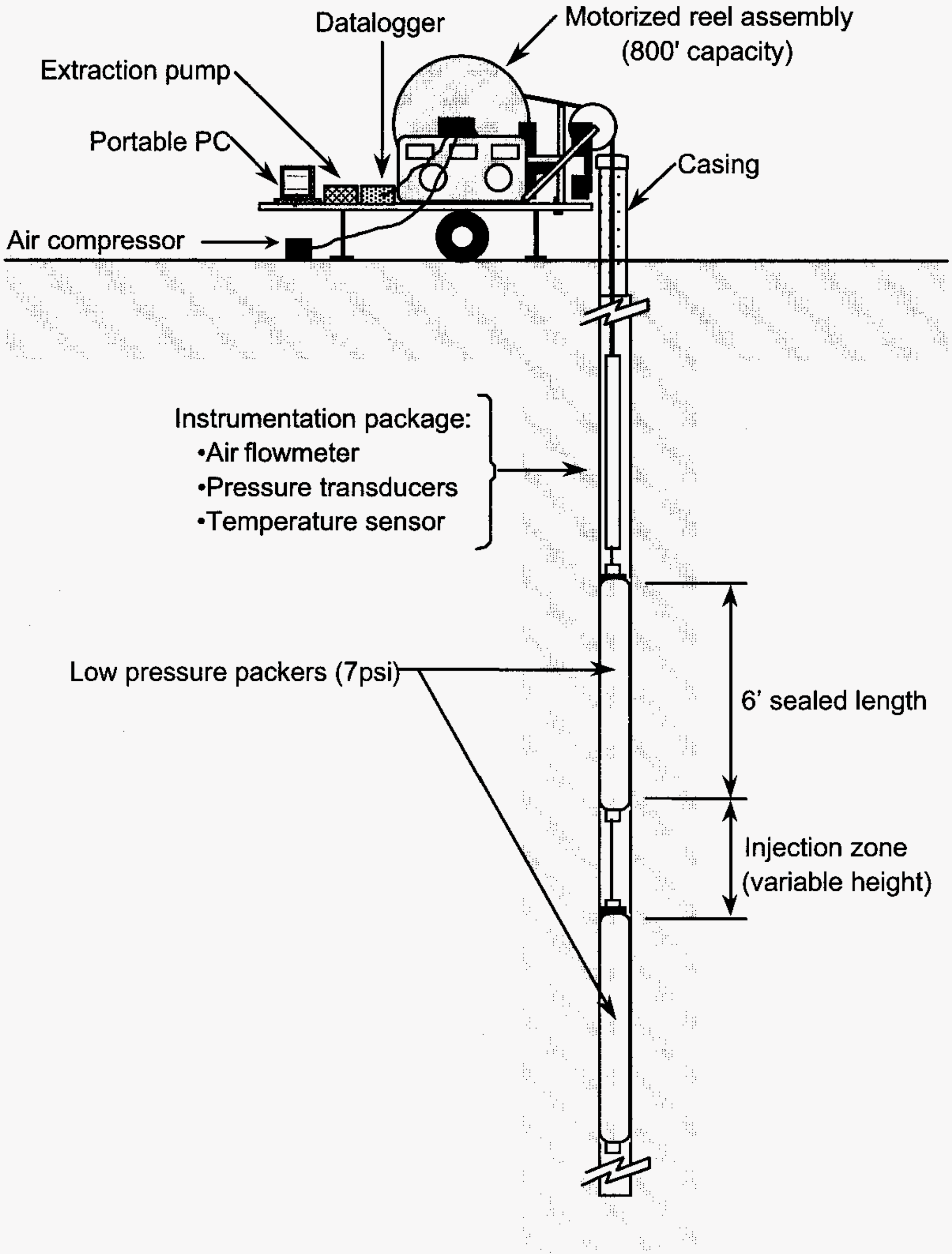



Figure 1. Air permeability measurement system.

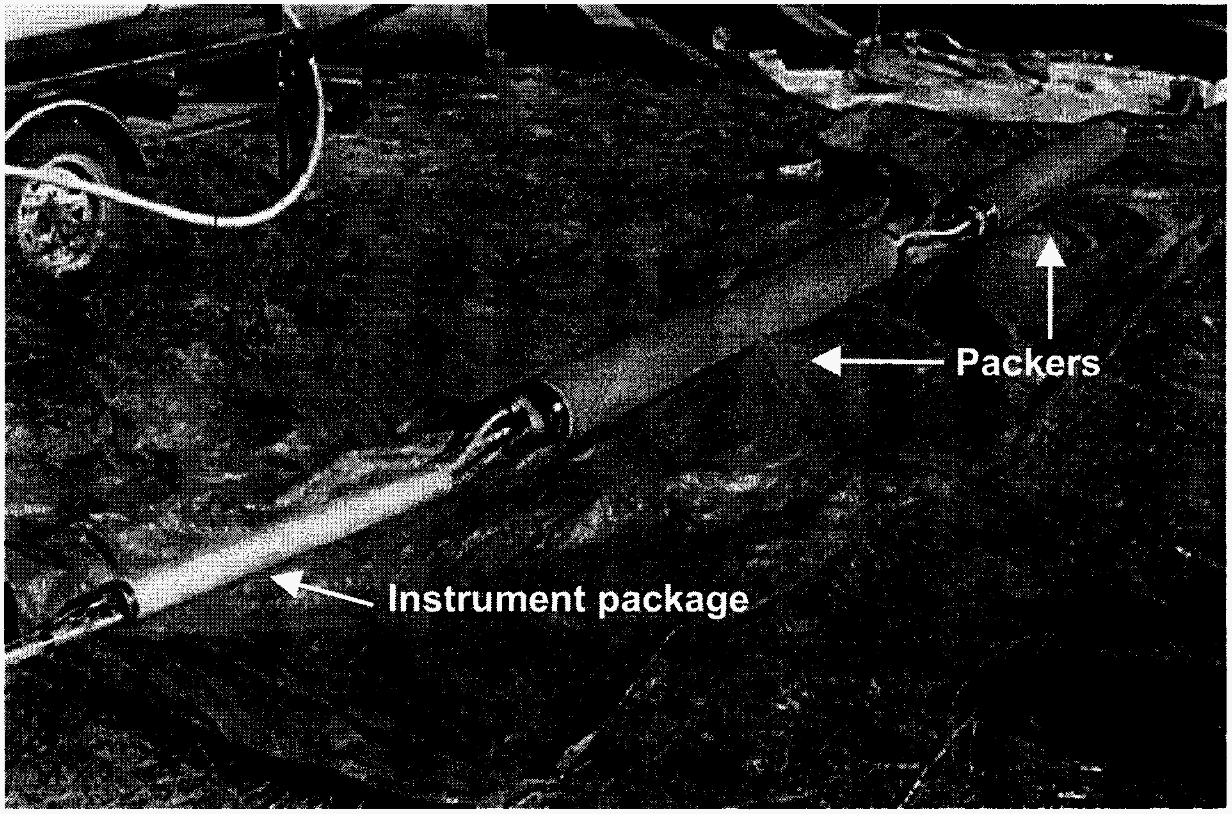



Figure 2. Downhole instrument package and packers.

During the measurement, the injection zone overpressure (if injecting) or vacuum (if extracting), ambient and packer pressures, temperature of the air being injected/extracted and the differential pressure across an orifice plate flowmeter are recorded. Table 1 provides a detailed list of the measurement sensors, including the output voltages and measurement ranges, and summary of how the measured data are used. The flow rate of the air injected/extracted from the measurement zone is calculated using the differential pressure across an orifice plate. The 0-3 in. water column (w.c.) differential pressure measurement equates to a 0-2.25 standard cubic feet per minute (scfm) flow range. The ambient pressure and packer sensors have a 0-15 psi range. The packers are typically inflated to 5-7 psi. The pressure change in the measurement zone is measured with a 0-1 psi differential pressure sensor. The pressure change is used in conjunction with the ambient pressure to determine the source pressure. The temperature of the air stream injected/extracted from the measurement zone is used in calculating the permeability, both as an absolute value (see Eq. 1) and in determining the appropriate dynamic viscosity of the air.

Table 1. Packer system sensor information.

**Instrumentation**

| Description | Manufacturer/(Model #) | Excitation | Output | Eng. Units | Component Function |
|---|---|---|---|---|---|
| Ambient Pressure | Data Instruments (XCA515AN) | 8 VDC | 1-6 VDC | 3 psia/VDC 0-15 psia | Measures downhole ambient pressure |
| Orifice Plate Differential Pressure | Data Instruments (LP9251906) | 12-24 VDC | 1-5 VDC | 0.75" WC/VDC 0-3" DWC | Measures orifice plate Dp used in flow calculation |
| Packer Pressure | Data Instruments (XCA515GN) | 8 VDC | 1-6 VDC | 3 psig/VDC 0-15 psig | Allows packers to be inflated and deflated accurately, and assures packers do not leak during the measurement period |
| Injection Zone Pressure | Data Instruments (LP9251912) | 12-24 VDC | 1-5 VDC | 0.25 psig/VDC 0-1 psig | Used in the permeability calculation |
| Air Temperature | Analog Devices (TMP01EP) | 4.5-13.2 VDC | See Eng. Units | 5mV/K | Measures temperature of air stream injected/extracted from the measurement zone; used in permeability calculation |

## 3. FIELD-MEASUREMENT RESULTS

Eight discrete permeability measurements were made in the vertical borehole HSM-1, between depths of 272 and 299 ft. Results show a region of low permeability, with all values except for that at the bottom of the borehole (299 ft) to be below 4 darcies. The caliper log showed the borehole to be very smooth, particularly between 270 to 285 ft, where the borehole was consistently 8.53 ● 0.25 in. in diameter. A slightly larger difference was seen at the 290 ft measurement position, where the borehole diameter was slightly larger (8.89 in.) and varied over the 2-ft sampling interval by approximately 0.75 in. The calculated uncertainty in the permeability is typically around 16%. The greatest sources of uncertainty include the measured pressure differential in the measurement zone and the measured flow rate of the injected air. The permeability at the bottom of the borehole, at 299 ft, was 66 darcies – higher than seen elsewhere. The diameter of the borehole allowed a reasonable seal at this location and the measured value, while higher, is still reasonable. The associated uncertainty with this measurement is significantly higher due to the very small recorded value of the measurement zone pressure difference from ambient (0.008 psi). The caliper logs as well as a profile of the measured permeability are shown in Figure 3. Associated data with the measurement are provided in Table 2.

Nineteen discreet permeability measurements were made in the angled borehole HSM-3. Eleven measurements were made between the depths of 696 and 716 ft (at 2-ft intervals); four measurements were made between the depths of 208 and 214 ft (also at 2-ft intervals); and solitary measurements were made at depths of 224, 335, 622 and 682 ft. Permeabilities in the lower portion of the borehole were typically less than 1 darcy, with slightly higher values (2-3 darcies) at the bottom-most points and a value of almost 6 darcies at a depth of 702 ft. Values near the 200-ft mark were between 6 and 9 darcies. Values between the two primary measurement zones were higher, between 25 and 47 darcies. The caliper log/geophysical logs for this borehole were not readily available during the reduction of the data. It is anticipated that these logs would support the higher permeabilities. Additionally, because the borehole logs were not available, a borehole diameter of 8.5 ± 0.5 in. was assumed in the calculation of both permeability and uncertainty. Similar to values from HSM-1, the higher uncertainties associated with the high permeability measurements are a function of the small pressure differential seen in the measurement zone. Calculated permeabilities, along with their associated uncertainty, are provided in Table 3 and shown in Figure 4.

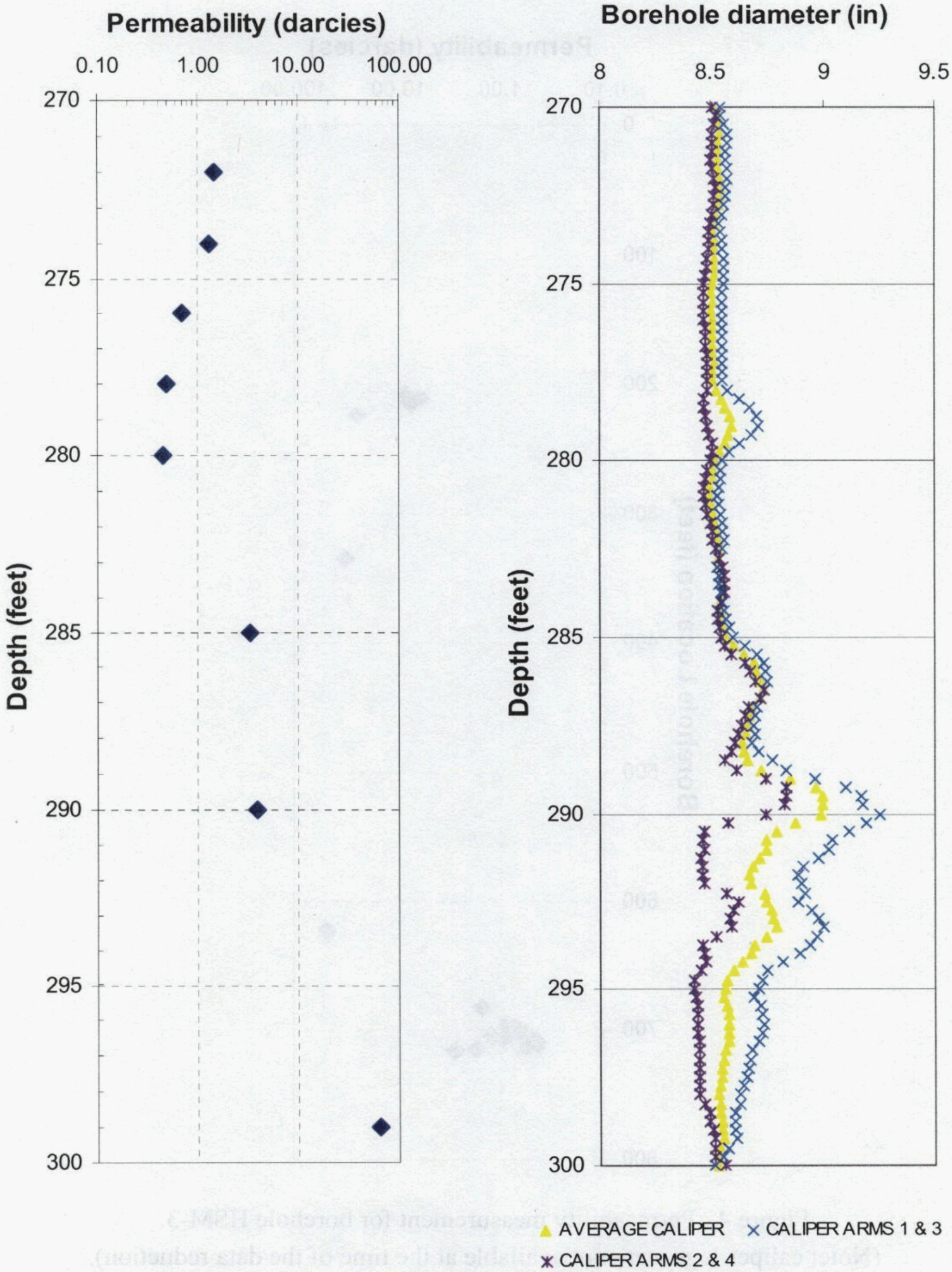



Figure 3. Permeability measurement results and caliper log for borehole HSM-1.

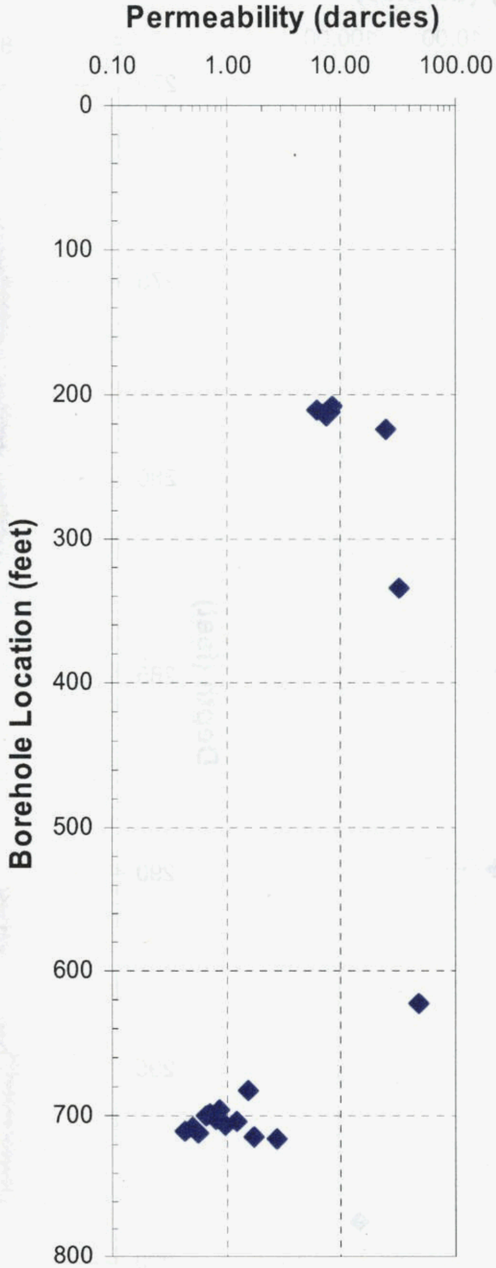



Figure 4. Permeability measurement for borehole HSM-3.
(Note: caliper logs were not available at the time of the data reduction).

Table 2. Depth vs. Permeability for HSM-1.

| Depth | Packer Pressure | | $T_{flow}$ | Orifice Plate dP | Calculated Flow rate | | Ambient Pressure | | Differential Pressure in measurement zone | | Calculated measurement zone Pressure | | Calculated permeability | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (ft) | psi | Pa | (C) | in. w.c. | scfm | lpm | psi | Pa | psi | Pa | psi | Pa | darcies | uncertainty % |
| 272 | 4.68 | 32268 | 24.45 | 0.155 | 0.66 | 18.80 | 13.02 | 89778 | 0.290 | 2001.3 | 13.31 | 91779 | 1.5 | 17.4% |
| 274 | 4.76 | 32847 | 25.25 | 0.179 | 0.71 | 20.11 | 13.02 | 89792 | 0.352 | 2423.6 | 13.37 | 92215 | 1.3 | 16.3% |
| 276 | 5.69 | 39231 | 25.85 | 0.185 | 0.72 | 20.37 | 13.02 | 89805 | 0.662 | 4562.8 | 13.69 | 94368 | 0.7 | 15.9% |
| 278 | 5.70 | 39333 | 26.45 | 0.180 | 0.71 | 20.11 | 13.02 | 89805 | 0.909 | 6265.8 | 13.93 | 96071 | 0.5 | 16.1% |
| 280 | 5.72 | 39464 | 27.05 | 0.184 | 0.72 | 20.29 | 13.02 | 89799 | 0.996 | 6864.0 | 14.02 | 96663 | 0.5 | 15.9% |
| 285 | 4.74 | 32717 | 28.05 | 0.217 | 0.77 | 21.93 | 13.03 | 89819 | 0.150 | 1036.0 | 13.18 | 90855 | 3.4 | 16.0% |
| 290 | 4.75 | 32737 | 27.45 | 0.215 | 0.77 | 21.88 | 13.03 | 89819 | 0.129 | 891.2 | 13.16 | 90710 | 3.9 | 16.8% |
| 299 | 4.74 | 32655 | 27.85 | 0.217 | 0.77 | 21.94 | 13.03 | 89839 | 0.008 | 53.4 | 13.04 | 89893 | 66.2 | 58.3% |

NOTE: Permeability at 290' calculated using a borehole diameter of 8.89 +/- 0.75"; all other values calculated using a borehole diameter of 8.53 +/- 0.25"

Table 3. Depth vs. Permeability for HSM-3.

| Depth | Packer Pressure | | $T_{flow}$ | Orifice Plate dP | Calculated Flow rate | | Ambient Pressure | | Differential Pressure in measurement zone | | Calculated measurement zone Pressure | | Calculated permeability | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (ft) | psi | Pa | (C) | in. w.c. | scfm | lpm | psi | Pa | psi | Pa | psi | Pa | darcies | uncertainty, % |
| 716 | 4.72 | 32561 | 24.45 | 0.064 | 0.44 | 12.50 | 13.28 | 91542 | 0.146 | 1006.7 | 13.42 | 92549 | 2.7 | 26.4% |
| 714 | 4.80 | 33126 | 25.65 | 0.094 | 0.53 | 14.95 | 13.27 | 91474 | 0.274 | 1885.8 | 13.54 | 93360 | 1.7 | 21.8% |
| 712 | 4.83 | 33317 | 26.45 | 0.092 | 0.52 | 14.76 | 13.27 | 91468 | 0.819 | 5645.3 | 14.08 | 97113 | 0.6 | 21.8% |
| 710 | 4.84 | 33364 | 27.25 | 0.056 | 0.41 | 11.67 | 13.27 | 91482 | 0.832 | 5733.2 | 14.10 | 97215 | 0.4 | 27.5% |
| 708 | 4.88 | 33650 | 27.65 | 0.093 | 0.52 | 14.79 | 13.27 | 91482 | 0.924 | 6372.7 | 14.19 | 97854 | 0.5 | 21.8% |
| 706 | 4.86 | 33535 | 28.05 | 0.119 | 0.59 | 16.64 | 13.27 | 91516 | 0.541 | 3728.5 | 13.81 | 95244 | 1.0 | 19.5% |
| 704 | 4.86 | 33514 | 28.65 | 0.131 | 0.61 | 17.40 | 13.27 | 91495 | 0.452 | 3114.8 | 13.72 | 94610 | 1.2 | 18.7% |
| 702 | 4.86 | 33508 | 25.45 | 0.095 | 0.53 | 15.04 | 13.33 | 91910 | 0.586 | 4037.0 | 13.92 | 95947 | 5.5 | 13.2% |
| 700 | 4.86 | 33480 | 26.65 | 0.111 | 0.57 | 16.15 | 13.33 | 91917 | 0.768 | 5295.4 | 14.10 | 97213 | 0.7 | 20.0% |
| 698 | 4.87 | 33589 | 27.25 | 0.127 | 0.61 | 17.18 | 13.33 | 91890 | 0.765 | 5271.2 | 14.09 | 97162 | 0.7 | 18.8% |
| 696 | 4.85 | 33446 | 28.05 | 0.140 | 0.63 | 17.96 | 13.32 | 91870 | 0.653 | 4504.2 | 13.98 | 96374 | 0.9 | 18.0% |
| 682 | 4.87 | 33555 | 28.65 | 0.159 | 0.67 | 19.09 | 13.32 | 91823 | 0.391 | 2692.5 | 13.71 | 94515 | 1.6 | 17.1% |
| 622 | 4.81 | 33173 | 29.25 | 0.186 | 0.73 | 20.54 | 13.30 | 91673 | 0.014 | 98.3 | 13.31 | 91771 | 47.2 | 44.2% |
| 335 | 4.81 | 33146 | 28.45 | 0.215 | 0.78 | 21.96 | 13.17 | 90841 | 0.022 | 150.0 | 13.20 | 90991 | 33.2 | 34.8% |
| 224 | 4.81 | 33187 | 27.65 | 0.213 | 0.77 | 21.84 | 13.13 | 90514 | 0.028 | 194.8 | 13.16 | 90709 | 25.4 | 30.1% |
| 214 | 4.80 | 33126 | 27.45 | 0.210 | 0.77 | 21.69 | 13.12 | 90460 | 0.094 | 644.7 | 13.21 | 91104 | 7.6 | 17.9% |
| 212 | 4.83 | 33310 | 27.25 | 0.211 | 0.77 | 21.73 | 13.12 | 90432 | 0.088 | 608.5 | 13.20 | 91041 | 8.1 | 18.1% |
| 210 | 4.82 | 33248 | 27.25 | 0.212 | 0.77 | 21.77 | 13.12 | 90432 | 0.113 | 780.9 | 13.23 | 91213 | 6.3 | 17.0% |
| 208 | 4.80 | 33126 | 27.25 | 0.222 | 0.79 | 22.28 | 13.11 | 90391 | 0.085 | 587.8 | 13.19 | 90979 | 8.6 | 18.0% |

## 4. REFERENCES


Keller, C., D. Engstrom, and F. West. 1973. "In-Situ Permeability Measurements for the Event in U1-C." Los Alamos Report LANL-5425-MS. Los Alamos National Laboratory, Los Alamos, NM.

Lowry, W. E., and S. M. Narbutovskih. 1991. "High Resolution Gas Permeability Measurements with the SEAMIST™ System." In *Proceedings of the Fifth National Outdoor Action Conference in Aquifer Restoration, Ground Water Monitoring, and Geophysical Methods*, 685-698. May 13-16, Las Vegas, NV. Dublin, OH: Water Well Journal.

# Appendix F

# Evaluation of TPH Contamination in Drill Cuttings

# F.1.0 Evaluation of TPH Contamination in Drill Cuttings

In Section A.3.4.3 of Appendix A, TPH (DRO) results were above the PAL of 100 mg/kg in sample cuttings from all three boreholes drilled around HSM. It is believed that the concentratrions of TPH (DRO) were introduced into the borings by the air circulating (compressor/vacuum) system. The compressor used to supply air to the circulating system uses an oil called "D-A Lubricant Torque Fluid II."

The air filter (Airtec GL 2000C) used on the compressor typically prevents compressor oil from getting into the circlulating system and cuttings samples. Observations made by the drilling subcontractor while drilling the first borehole indicated oil to be present on this filter (Record of Telecon July 27, 2004, from R.L. McCall (SNJV) to D. Forman (Dynatec Drilling Manager). The drilling subcontractor believes the vacuum system was pulling more volume than the compressor causing oil to come out of the compressor and onto the filter and into the circulating system.

A trend can be seen in the reduction of TPH (DRO) concentrations while drilling HSM-1 and HSM-2 and the reduced use of the compressor. The highest TPH (DRO) concentration for CAU 527 were in the first cuttings sample (527A0011) collected and analyzed and had a DRO concentration of 40,000 ppm. The concentrations rapidly declined in deeper samples collected at HSM-1. TPH (DRO) was not detected in the upper 450 ft of samples collected in HSM-2, likely due to using clean drill pipe and without using the compressor.

A sample of the compressor oil (D-A Lubricant Torque Fluid II) was sent to the analytical laboratory for comparison with the cutting samples. The chromatograms for sample 527A0011 (Figure F.1-1) and the compressor oil (Figure F.1-2) show consistency with one another. Both samples contain hydrocarbons that elute predominantly within the C20-C38 carbon range (motor oil range). Both have a hydrocarbon "hump" centered near C26. The same results were seen on the chromatograms for samples above PALs taken in boreholes HSM-2 and HSM-3. Additionally, the chromatograms from cuttings samples of all three boreholes do not indicate the presence of another petroleum product such as diesel oil or gasoline. Additional information regarding the TPH (DRO) contamination can be found in Section A.3.4.3 of Appendix A.

METHOD 8015 BY GC/FID
EMAX Analytical Laboratories, Inc.

| | |
|---|---|
| File | : c:\ezchrom\chrom\dg29\dg29.045 |
| Method | : c:\ezchrom\methods\ds43g01.met |
| Sample ID | : .01/1ML(1G/10ML) D |
| Acquired | : Aug 03, 2004 17:02:35 |
| Printed | : Aug 04, 2004 08:42:58 |
| User | : ALFRED |

Channel A Results

| # | Peak Name | Ret.Time | Area | Ave. CF | ESTD Conc.(ppm) |
|---|---|---|---|---|---|
| -- | Bromobenzene | 4.233 | 0 | 0.0 | 0.0 |
| 11 | Hexacosane | 13.917 | 1457777 | 18548.5 | 78.6 |
| G1 | Diesel(TOTAL) | | 18747254 | 17927.2 | 1045.7 |
| G2 | Diesel(C10-C24) | | 4435473 | 17778.8 | 249.5 |
| G3 | Diesel(C10-C28) | | 12321877 | 17795.1 | 692.4 |

DSL = 1045.7 x $\frac{10}{1g}$ x 100 = 1045,700

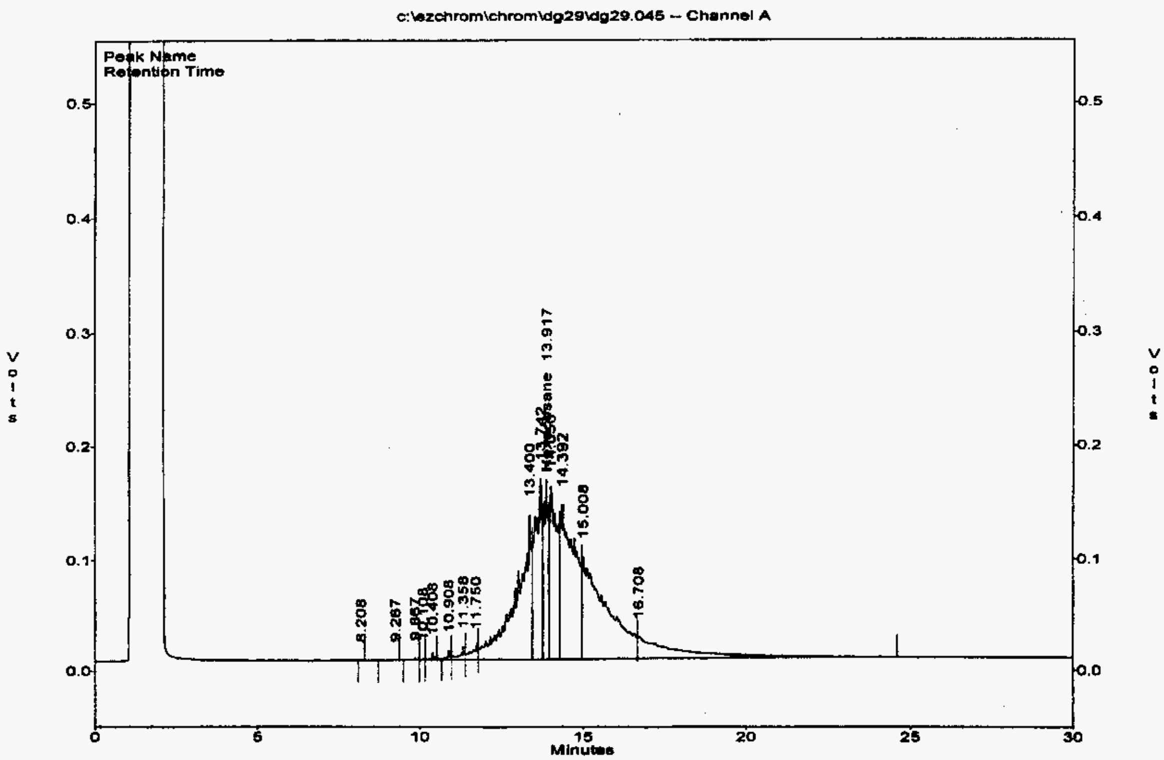


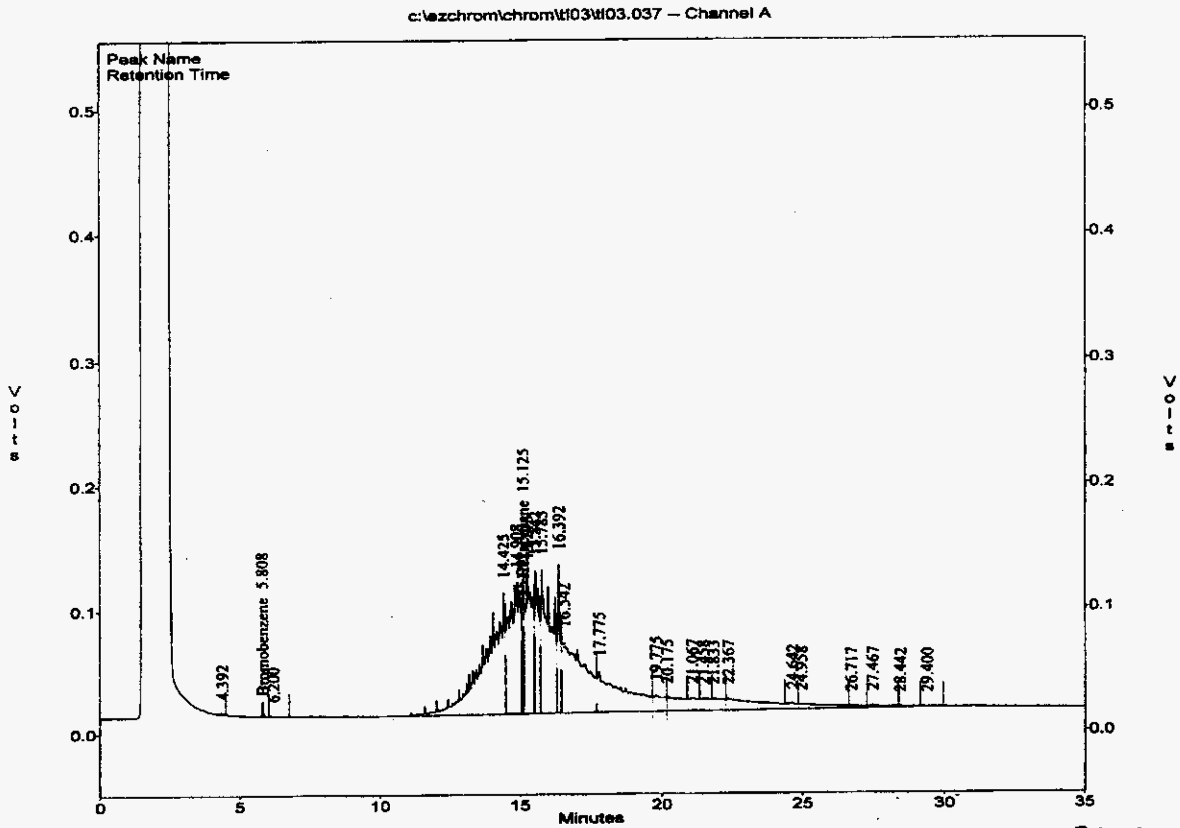

**Figure F.1-1**
**Chromatogram of Sample 527A0011**

METHOD 8015 by GC/FID
EMAX Analytical Laboratories, Inc.

File : c:\ezchrom\chrom\t103\t103.037
Method : c:\ezchrom\methods\ds50j15.met
Sample ID : 03K154-01T .02/1ML
Acquired : Dec 04, 2003 10:58:12
Printed : Dec 04, 2003 14:59:04
User : CALVIN

Channel A Results

| # | Peak Name | Ret.Time(Min) | Area | Ave. CF | ESTD Conc.(ppm) |
|---|---|---|---|---|---|
| 2 | Bromobenzene | 5.808 | 33189 | 14340.2 | 2.3 |
| 7 | Hexacosane | 15.125 | 290844 | 29600.2 | 9.8 |
| G1 | Diesel(TOTAL) | | 22741916 | 29179.5 | 779.4 |
| G2 | Diesel(C10-C24) | | 4765963 | 27961.0 | 170.5 |
| G3 | Diesel(C10-C28) | | 14456087 | 28003.3 | 516.2 |




50016
12/4/03

**Figure F.1-2**
**Chromatogram of Compressor Oil**

# Appendix G

# Nevada Division of Environmental Protection Comment Responses

# NEVADA ENVIRONMENTAL RESTORATION PROJECT
## DOCUMENT REVIEW SHEET

1. Document Title/Number Draft Corrective Action Decision Document/ Closure Report for Corrective Action Unit 527: Horn Silver Mine, Nevada Test Site, Nevada
2. Document Date June 2004
3. Revision Number 0
4. Originator/Organization Stoller-Navarro
5. Responsible DOE/NV ERP Project Mgr. Janet Appenzeller-Wing
6. Date Comments Due
7. Review Criteria Full
8. Reviewer/Organization/Phone No. Don Elle, NDEP, 486-2867
9. Reviewer's Signature

| 10. Comment Number/ Location | 11. Type[a] | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 1) Page 9 | | Among the bullets, it may be appropriate to note the water sample collected on May 3, 2004. | This modification was made to the sixth bullet. | Yes |
| 2) Section 2.2.1 Page 10 | | It is unclear why there is no discussion of liquids in HSM-3 as noted on page A-14 and A-37. | A brief discussion of the liquid sampled in HSM-3 was added to Section 2.2.1. | Yes |
| 3) Page 11 Paragraph 3 | | A typo in the second line, should be of not "or"?<br><br>Third line - was a deeper sample collected? The sentence is confusing and could be reworded for clarity.<br><br>Is there a stronger way to state the conclusion? | This change was made as requested.<br><br>No deeper sample was collected. The sentence was modified for clarity.<br><br>The conclusion was modified for clarity. | Yes |
| 4) Section 2.3 Page 12 | | It is not clear, based on the data collected, how one can conclude that "COC's have not migrated from...". It is more correct to say COC's were not detected and pathways for migration were not identified. Some rewording may be needed. | Sections 1.1 (third paragraph) and 2.3 were modified for clarification. | Yes |
| 5) Page A-3 Paragraph 1 | | How does the water sample fit in with field work time period? Was the sampling a unique event? | The last sentence was modified for clarity. The water sample was collected on May 3, 2004, after the main field work had been completed. This was a unique sampling event. | Yes |

# NEVADA ENVIRONMENTAL RESTORATION PROJECT
## DOCUMENT REVIEW SHEET

| 10. Comment Number/ Location | 11. Type[a] | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 6) Page A-27 | | The discussion of compressor air seems important. Were any samples of compressor air analyzed to support the conclusion? | Although no samples of the compressor air were collected, a sample of the oil used in the compressor contained constituents that matched the TPH range (gas chromatograph) that was detected in the cuttings.<br><br>The last sentence of the last paragraph of Section A.3.4.3 on page 29 was changed to strengthen the conclusion that the compressor oil is the source of the TPH in the cutting samples. The detailed comparison has been added as Appendix F of the report. | Yes |
| 7) General | | Verbal comment to K. Cabble, was to include more site history. | The HSM history was added to Section A.1.0 | Yes |

[a]Comment Types: M = Mandatory, S = Suggested.
Return Document Review Sheets to NNSA/NSO Environmental Restoration Division, Attn: QAC, M/S 505.

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