Nevada
Environmental
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DOE/NV--1326

National Nuclear Security Administration

Corrective Action Decision Document/Corrective Action Plan for the 92-Acre Area and Corrective Action Unit 111: Area 5 WMD Retired Mixed Waste Pits, Nevada Test Site, Nevada

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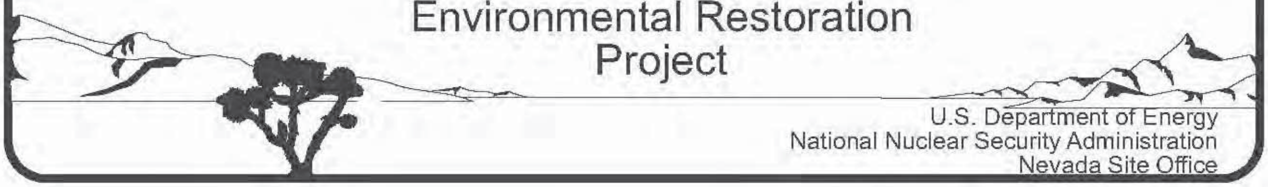
July 2009



Environmental Restoration
Project

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

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CORRECTIVE ACTION DECISION DOCUMENT/CORRECTIVE ACTION PLAN FOR THE 92-ACRE AREA AND CORRECTIVE ACTION UNIT 111: AREA 5 WMD RETIRED MIXED WASTE PITS, 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/CORRECTIVE ACTION PLAN FOR THE 92-ACRE AREA AND CORRECTIVE ACTION UNIT 111: AREA 5 WMD RETIRED MIXED WASTE PITS, NEVADA TEST SITE, NEVADA

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ACRONYMS AND ABBREVIATIONS

ALARA	as low as reasonably achievable
BN	Bechtel Nevada
°C	degree(s) Celsius
CAA	corrective action alternative
CADD/CAP	Corrective Action Decision Document/Corrective Action Plan
CAU	Corrective Action Unit
CFR	Code of Federal Regulations
cm	centimeter(s)
CSM	conceptual site model
DCG	Derived Concentration Guide
DOE	U.S. Department of Energy
DQI	Data Quality Indicator
DQO	Data Quality Objective
EPA	U.S. Environmental Protection Agency
FFACO	*Federal Facility Agreement and Consent Order*
GCD	Greater Confinement Disposal
IL	investigation level
kPa	kilopascal(s)
μCi/m^3	microcurie(s) per cubic meter
μg/L	microgram(s) per liter
m	meter(s)
m/s	meter(s) per second
MDC	minimum detectable concentration
mg/L	milligram(s) per liter
mm	millimeter(s)
mmhos/cm	millimho(s) per centimeter
mR/day	milliroentgen(s) per day
mrem/yr	millirem(s) per year
MWDU	Mixed Waste Disposal Unit
NAC	Nevada Administrative Code
NDEP	Nevada Division of Environmental Protection

ACRONYMS AND ABBREVIATIONS (continued)

NEPA	*National Environmental Policy Act*
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NNSA/NV	U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office
NSTec	National Security Technologies, LLC
NTS	Nevada Test Site
O	Order
pCi/L	picocurie(s) per liter
pCi/m^2s	picocurie(s) per square meter per second
pCi/m^3	picocurie(s) per cubic meter
per-Sv	person-Sievert(s)
QA	quality assurance
QC	quality control
RCRA	*Resource Conservation and Recovery Act*
REOP	Real Estate/Operations Permit
RWMS	Radioactive Waste Management Site
RWP	Radiological Work Permit
TCLP	Toxicity Characterization Leaching Procedure
TDR	time-domain reflectometry
TLD	thermoluminescent dosimeter
TRU	transuranic
UR	use restriction

EXECUTIVE SUMMARY

This Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) has been prepared for the 92-Acre Area, the southeast quadrant of the Radioactive Waste Management Site, located in Area 5 of the Nevada Test Site (NTS). The 92-Acre Area includes Corrective Action Unit (CAU) 111, "Area 5 WMD Retired Mixed Waste Pits."

Data Quality Objectives (DQOs) were developed for the 92-Acre Area, which includes CAU 111. The result of the DQO process was that the 92-Acre Area is sufficiently characterized to provide the input data necessary to evaluate corrective action alternatives (CAAs) without the collection of additional data. The DQOs are included as Appendix A of this document.

This CADD/CAP identifies and provides the rationale for the recommended CAA for the 92-Acre Area, provides the plan for implementing the CAA, and details the post-closure plan.

When approved, this CADD/CAP will supersede the existing Pit 3 (P03) Closure Plan, which was developed in accordance with Title 40 Code of Federal Regulations (CFR) Part 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities." This document will also serve as the Closure Plan and the Post-Closure Plan, which are required by 40 CFR 265, for the 92-Acre Area. After closure activities are complete, a request for the modification of the *Resource Conservation and Recovery Act* Permit that governs waste management activities at the NTS will be submitted to the Nevada Division of Environmental Protection to incorporate the requirements for post-closure monitoring.

Four CAAs, ranging from No Further Action to Clean Closure, were evaluated for the 92-Acre Area. The CAAs were evaluated on technical merit focusing on performance, reliability, feasibility, safety, and cost. Based on the evaluation of the data used to develop the conceptual site model; a review of past, current, and future operations at the site; and the detailed and comparative analysis of the potential CAAs, Closure in Place with Administrative Controls is the preferred CAA for the 92-Acre Area.

Closure activities will include the following:

- Constructing an engineered evapotranspiration cover over the 92-Acre Area
- Installing use restriction (UR) warning signs, concrete monuments, and subsidence survey monuments
- Establishing vegetation on the cover
- Implementing a UR
- Implementing post-closure inspections and monitoring

The Closure in Place with Administrative Controls alternative meets all requirements for the technical components evaluated, fulfills all applicable federal and state regulations for closure of the site, and will minimize potential future exposure pathways to the buried waste at the site.

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1.0 INTRODUCTION

This Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) has been prepared for the 92-Acre Area. The 92-Acre Area constitutes the southeast quadrant of the Radioactive Waste Management Site (RWMS), located in Area 5 of the Nevada Test Site (NTS) (Figures 1 and 2).

The Area 5 RWMS uses engineered shallow-land burial cells to dispose of packaged waste. The 92-Acre Area contains 13 Greater Confinement Disposal (GCD) boreholes, 16 narrow trenches, and 9 broader pits. With the exception of three active pits (P03, P06, and P09), all trenches and pits in the 92-Acre Area currently have operational covers approximately 2.4 meters (m) thick.

The units within the 92-Acre Area are grouped into the following six informal categories based on physical location, waste types, and regulatory requirements (Figure 2):

- Pit 3 Mixed Waste Disposal Unit (MWDU)
- Corrective Action Unit (CAU) 111
- CAU 207
- Low-level waste disposal units
- Asbestiform low-level waste disposal units
- One transuranic (TRU) waste trench (where 1.2 kilograms [2.6 pounds, or approximately 61.5 cubic centimeters] of TRU waste was inadvertently disposed)

Pit 3 MWDU, an active pit with a closure date of 2011, is governed by *Resource Conservation and Recovery Act* (RCRA) Permit NEV HW0021 (Nevada Division of Environmental Protection [NDEP], 2005). As such, Pit 3 must be closed in accordance with Title 40 Code of Federal Regulations (CFR) 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities" (CFR, 2006d), as adopted by Nevada Administrative Code (NAC) 444.8632, "Compliance with Federal Regulations Adopted by Reference" (NAC, 2006).

CAU 111, "Area 5 WMD Retired Mixed Waste Pits," which includes disposal units where mixed waste may have been placed prior to the implementation of RCRA, is listed in the *Federal Facility Agreement and Consent Order* (FFACO). The FFACO is a legally binding document that, by agreement, supersedes the corrective action requirements of RCRA (FFACO, 1996; as amended February 2008).

CAU 207, "Archived – Area 5 WMD Greater Confinement Disposal (GCD) Boreholes," consists of GCD boreholes containing TRU waste. CAU 207 was previously removed from the purview of the FFACO and archived.

As agreed by NDEP and the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) on February 14, 2008, the entire 92-Acre Area will be closed under the FFACO. This document follows the approved FFACO template for a CADD/CAP. The FFACO process not only meets all the requirements of RCRA (CFR, 2006d), it also includes development of a conceptual site model (CSM), data quality objectives (DQOs), and a detailed analysis and comparison of corrective action alternatives (CAAs).

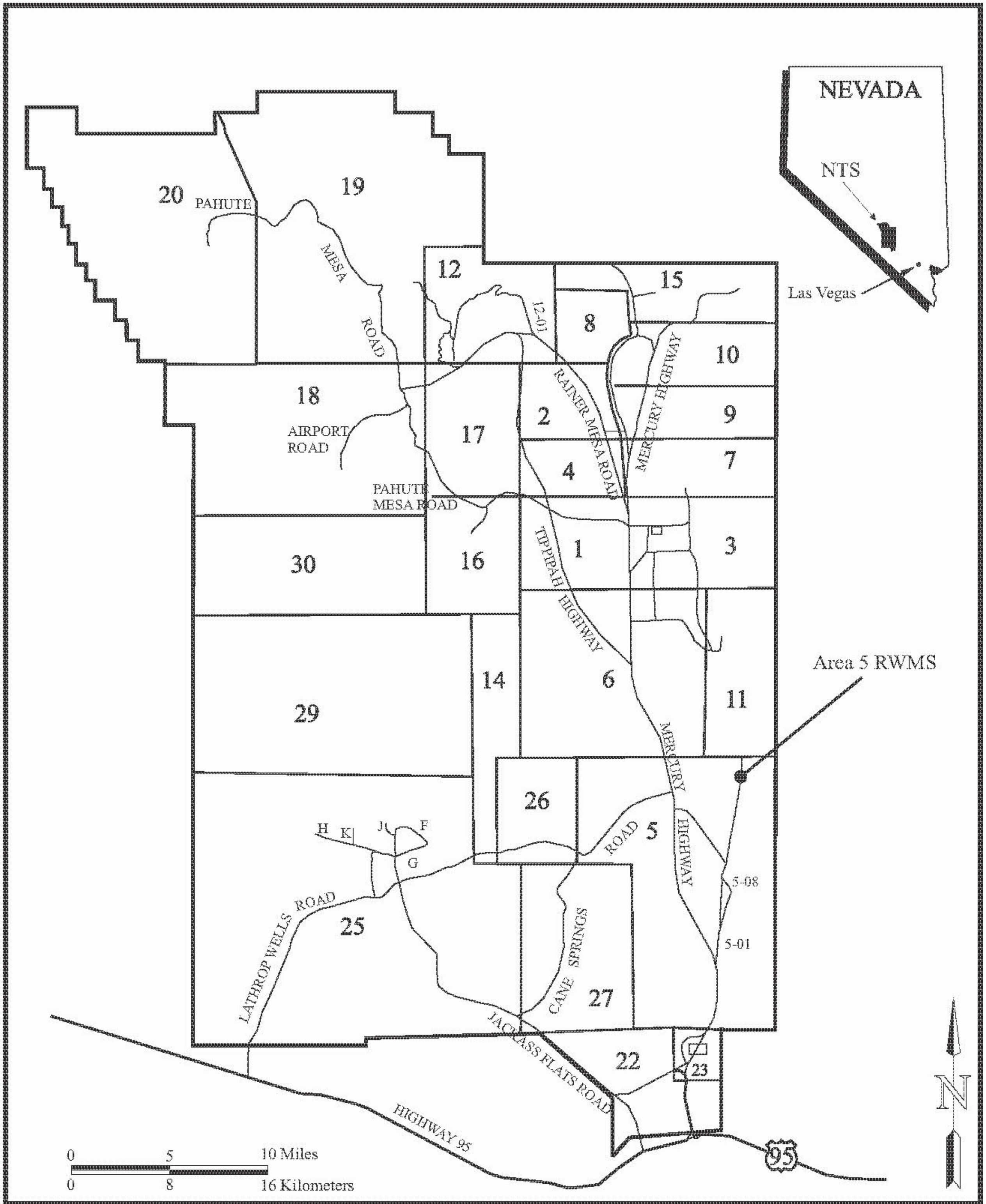

Figure 1
Area 5 Radioactive Waste Management Site Location Map

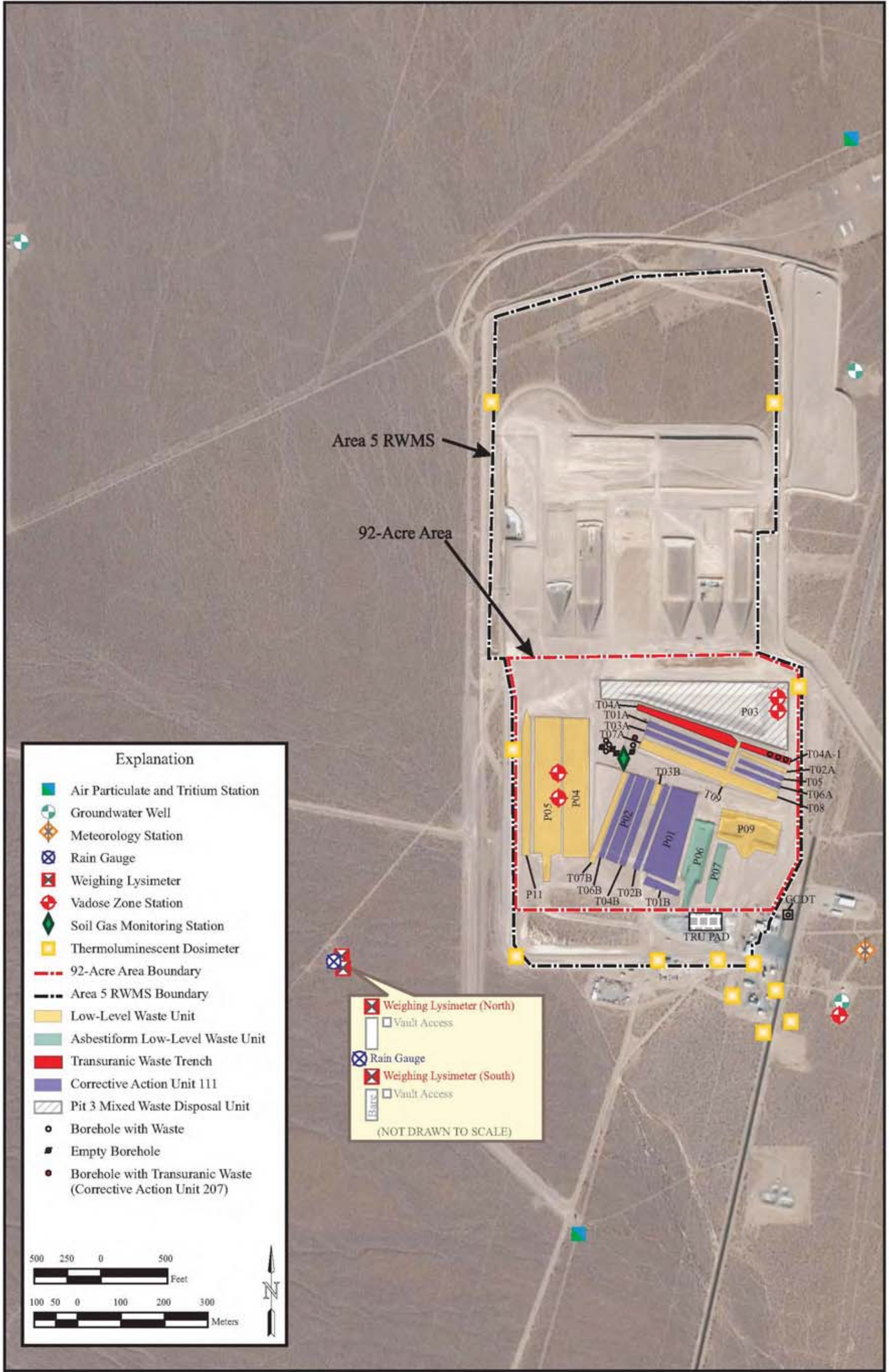

FIGURE 2. 92-ACRE AREA DISPOSAL UNITS AND MONITORING NETWORK

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Site characterization that began in the 1990s, modeling results, and waste inventories provide the data necessary to develop a CSM. The results of four assessments show that disposal operations are in compliance with U.S. Department of Energy (DOE) regulations and provide assurance that the public and the environment will be protected for 1,000 years under DOE Order (O) 435.1, "Radioactive Waste Management" (DOE, 1999) and for 10,000 years concerning TRU waste under 40 CFR 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes" (CFR, 2006b).

A detailed discussion of the site history and characteristics, compliance assessments, waste inventory and uncertainty, and ongoing monitoring activities is presented in the DQOs, which are included as Appendix A of this document. The result of the DQO process was that the 92-Acre Area is sufficiently characterized to provide the input data necessary to evaluate CAAs without collecting additional data.

1.1 PURPOSE

This CADD/CAP develops and evaluates potential CAAs and provides the rationale for the selection of the recommended CAA for the 92-Acre Area. This document also provides the plan for implementing the preferred CAA, presents the scope of work, and details the post-closure plan. The post-closure plan includes a progressive monitoring approach to address future monitoring. The progressive monitoring approach will provide a protective and cost-effective method to monitor and address potential contaminant migration in the future (See Section 7.0).

When approved, this CADD/CAP will supersede the existing Pit 3 Closure Plan, which was developed in accordance with 40 CFR 265. This document will also serve as the Closure Plan and Post-Closure Plan for the 92-Acre Area, which are required by 40 CFR 265. After completing closure activities, a request for modification of RCRA Permit NEV HW0021, to incorporate requirements for post-closure monitoring, will be submitted to NDEP (NDEP, 2005).

1.2 SCOPE

The scope of activities used to identify, evaluate, and recommend CAAs included the following:

- Evaluating corrective action objectives based on the DQOs and CAA screening criteria
- Recommending and justifying the preferred CAA

CAAs were evaluated for the 92-Acre Area on technical merit based on performance, reliability, feasibility, safety, and cost. Based on the evaluation of the data used to develop the CSM; a review of past, current, and future operations at the site; and the detailed and comparative analysis of the potential CAAs, Closure in Place with Administrative Controls is the preferred CAA for the 92-Acre Area. Closure activities will include the following:

- Constructing an engineered evapotranspiration cover over the 92-Acre Area
- Installing use restriction (UR) warning signs, concrete monuments, and subsidence survey monuments
- Establishing vegetation on the cover
- Implementing a UR
- Implementing post-closure inspections and monitoring

The Closure in Place with Administrative Controls alternative meets all requirements for the technical components evaluated, fulfills all applicable federal and state regulations, and minimizes potential future exposure pathways to the buried waste. Of the CAAs evaluated based on short-term reliability and effectiveness; reduction of toxicity, mobility, and/or volume; long-term reliability and effectiveness; feasibility; and cost, the Closure in Place with Administrative Controls alternative received the highest score and therefore will have the most desirable overall impact on these factors.

1.3 CORRECTIVE ACTION DECISION DOCUMENT/CORRECTIVE ACTION PLAN CONTENTS

This CADD/CAP consists of the following sections and appendices:

- Section 1.0 – Introduction: Summarizes this document's purpose, scope, and contents
- Section 2.0 – Corrective Action Investigation Summary: Summarizes investigation activities, results of the investigation, and the need for corrective action
- Section 3.0 – Evaluation of Alternatives: Describes, identifies, and evaluates the steps taken to determine the preferred CAA
- Section 4.0 – Recommended Alternative: Presents the preferred CAA and the rationale based on the corrective action objectives and screening criteria
- Section 5.0 – Detailed Statement of Work: Provides a description of the preferred CAA its planned implementation, identifies quality assurance (QA) and quality control (QC) activities, provides a summary of waste management, identifies activities to verify the objectives of the corrective actions, and identifies permits needed to implement the CAA
- Section 6.0 – Schedule: Identifies the schedule for major activities
- Section 7.0 – Post-Closure Plan: Describes the requirements for post-closure inspections, monitoring, maintenance, and repairs
- Section 8.0 – References: Provides a list of all referenced documents in this report
- Appendix A – Data Quality Objectives: Provides the DQOs, as presented to and approved by NDEP
- Appendix B – Cost Estimates: Presents cost estimates for each CAA
- Appendix C – Engineering Specifications and Drawings: Includes engineering specifications and drawings for the 92-Acre Area
- Appendix D – Project Organization: Identifies the NNSA/NSO Sub-Project Director and other appropriate personnel involved with characterization and closure activities
- Appendix E – Corrective Action Investigation Results: Not applicable
- Appendix F – Data Assessment: Not applicable
- Appendix G – Evaluation of Risk: Not applicable
- Appendix H – Sampling and Analysis Plan: Not applicable
- Appendix I – Revegetation Plan for the 92-Acre Area: Provides details on how vegetation will be established on the cover.
- Appendix J – Nevada Division of Environmental Protection Comment Response Form: Addresses comments received from NDEP on the draft report.

2.0 CORRECTIVE ACTION INVESTIGATION SUMMARY

The following sections summarize site characterization, modeling, and monitoring activities, and identify the need for corrective action for the 92-Acre Area.

2.1 INVESTIGATION ACTIVITIES

Site characterization activities at the Area 5 RWMS began in the early 1990s. Four assessments demonstrate that waste disposal operations are in compliance with federal regulations and provide assurance that members of the public and the environment will be protected after closure for 1,000 years under DOE O 435.1 (DOE, 1999) and for 10,000 years concerning TRU waste under 40 CFR 191 (CFR, 2006b). These assessments are summarized in the DQOs provided in Appendix A. The current monitoring network is summarized in Table 1 and shown in Figure 2 on Page 3 of this document. The following sections discuss monitoring and modeling results.

2.1.1 Direct Radiation Monitoring

To assess external radiation, measure gamma radiation levels, and detect changes, direct radiation monitoring is conducted with thermoluminescent dosimeters (TLDs) at 12 locations shown in Figure 2. TLDs measure ionizing radiation exposure from all sources, including natural and man-made radioactivity, and results represent the potential external dose to a hypothetical person residing at the Area 5 RWMS. At each location, a pair of TLDs is placed at 1 m above ground surface. The TLDs are exchanged for analysis on a quarterly basis, and analysis is conducted with automated TLD readers. Since monitoring began in 1998, exposure rate measurements have generally fallen within the range of background measurements collected at locations across the NTS and indicate that a member of the public will not receive a dose greater than 25 millirems per year (mrem/yr), even if they were to reside at the Area 5 RWMS. The highest measurement recorded was 0.6 milliroentgens per day (mR/day) in 2004.

2.1.2 Air Monitoring

Air monitoring of tritium and radioactive particulates is conducted at two locations downwind of the Area 5 RWMS. Tritium is monitored because it is a highly mobile radioactive isotope and is an indicator of volatile radionuclide migration from waste cells into the atmosphere. Atmospheric moisture is continuously collected using molecular sieve columns, and samples are analyzed every 2 weeks for tritium by liquid scintillation counting. Tritium concentrations in air have been well below the DOE Derived Concentration Guide (DCG) of 100,000 picocuries per cubic meter (pCi/m^3) for tritium. The DCG is the concentration of a radionuclide in air that, if inhaled for 1 year, would result in the DOE radiation limit of 100 mrem/yr committed dose equivalent to the public. The highest measurement recorded was 47.4 pCi/m^3 in 2006.

Air particulates are collected on glass fiber filters, which are screened weekly for gross alpha and beta radioactivity to detect changes in airborne radioactivity. Monthly composites of the weekly samples are analyzed by gamma spectroscopy for gamma-emitting radionuclides and by radiochemical analysis for americium and plutonium. Americium and plutonium concentrations in air have been well below the respective DCGs of 0.02 and 0.03 pCi/m^3. In 2007, the highest measurement recorded for americium was 0.00000595 pCi/m^3, and the highest measurement recorded for plutonium was 0.0000321 pCi/m^3.

TABLE 1. SUMMARY OF CURRENT MONITORING AT THE AREA 5 RWMS

ELEMENT	BRIEF DESCRIPTION	SUMMARY OF RESULTS
Direct Radiation Monitoring	TLDs at 12 locations	Typical exposure rate measurements are at background levels.
Air Monitoring	• Atmospheric moisture analysis for tritium at two locations every two weeks • Air particulates (americium and plutonium) sampled at two locations (weekly screening and monthly laboratory analysis)	• Tritium concentrations in air are below the DCG. • Particulate concentrations are below the DCGs.
Radon Flux Monitoring	Collected at various locations around the Area 5 RWMS	Radon fluxes are well below the regulatory limit.
Groundwater Monitoring	Monitoring at three wells: • Water levels every 3 months • Samples for contamination indicators and water chemistry parameters every 6 months	• The water table is essentially flat (i.e., little or no gradient). • There has been no measurable impact to the uppermost aquifer.
Meteorology Monitoring	• Precipitation • Air temperature • Relative humidity • Wind speed and direction • Barometric pressure	• Average annual rainfall is 131 mm. • Average annual temperature is 16°C. • Average humidity is 30 percent. • Average wind speed is 2.7 m/s. • Average pressure is 90.5 kPa.
Vadose Zone Monitoring	• TDR probes measure the volumetric moisture content of the soil in three operational covers • TDR probes measure the volumetric moisture content of the soil in one waste disposal unit floor • Two weighing lysimeters (vegetated and bare) provide information for the water balance of the soil	• Volumetric moisture content of the soil in covers continues to indicate dry conditions. • Volumetric moisture content of the soil in the floor of Pit 5 (P05) indicates no infiltration. • Vegetation and the arid climate prevent infiltration by evapotranspiration.
Soil Gas Monitoring	Soil gas monitoring for tritium at one waste cell	Upward migration of tritium through the soil from the waste is extremely slow.
Biota Monitoring	Biota (plant and animal) samples collected at an approximate 2-year interval	Biota monitoring results show tritium uptake.

°C: degree(s) Celsius
DCG: Derived Concentration Guide
kPa: kilopascal(s)
mm: millimeter(s)
m/s: meter(s) per second
TDR: time-domain reflectometry
TLD: thermoluminescent dosimeter

2.1.3 Radon Flux Monitoring

Radon flux measurements have been collected since 2000 at various locations at the Area 5 RWMS to meet the performance objective of DOE O 435.1 and assess whether radon levels exceed the regulatory limit. Measurements are collected once a year at one or two locations. These locations are chosen because they are most likely to have elevated results based on disposal units that contain radon and thorium-bearing waste. Radon flux domes placed on the ground surface collect the measurements. The highest measured radon flux was 4 picocuries per square meter per second (pCi/m^2s) in 2004, well below the regulatory limit of 20 pCi/m^2s.

2.1.4 Groundwater Monitoring

Groundwater monitoring has been conducted since 1993 at three wells shown in Figure 2. Water levels in each well are measured every 3 months, and water samples are collected every 6 months. Based on groundwater elevations, the water table under the Area 5 RWMS is essentially flat. Calculated groundwater flow velocities are approximately 0.1 m per year. Water samples are analyzed for indicators of contamination (pH, specific conductance, total organic carbon, total organic halides, and tritium) and general water chemistry parameters (calcium, magnesium, potassium, sodium, iron, manganese, bicarbonate, sulfate, silicate, chloride, and fluoride). Investigation levels (ILs) were established as the compliance criteria for indicators of contamination by NNSA/NSO and NDEP in 1998 (Bechtel Nevada [BN], 1998). Groundwater monitoring data have remained stable and below ILs since monitoring began; therefore, these indicate no measurable impact to the uppermost aquifer from the Area 5 RWMS.

2.1.5 Meteorology Monitoring

The Area 5 RWMS is located in a windy, arid climate with high average temperatures and low precipitation rates. Meteorological parameters, including precipitation, solar radiation, air temperature, relative humidity, wind speed and direction, and barometric pressure, are measured at a 3-m meteorology tower near the southeast corner of the Area 5 RWMS to quantify the exchange of water and heat between the soil and the atmosphere. Reference evapotranspiration, the rate at which readily available soil water is vaporized from the surface, is calculated from these meteorological parameters. The ratio of reference evapotranspiration to precipitation is then determined. In 2007, the ratio of reference evapotranspiration to precipitation was 12.9, indicating that the rate of evapotranspiration upwards through the cover far exceeds the rate of infiltration of precipitation downwards toward the waste cells.

2.1.6 Vadose Zone Monitoring

Vadose zone monitoring is conducted at three operational covers, one pit floor, and two weighing lysimeters to assess water balance, confirm the key assumption of no downward pathway to groundwater, and evaluate the performance of operational covers. Water balance studies use meteorology data to calculate evapotranspiration, directly measure evapotranspiration and bare-soil evaporation with weighing lysimeters, and measure volumetric moisture content of the soil, soil water potential, and temperature. Data indicate that vegetation and the arid climate prevent precipitation from percolating deep into the soil by returning moisture to the atmosphere by evapotranspiration. Vegetated lysimeter data were used to generate a vadose zone flow model that confirms there is no downward pathway under vegetated conditions. Time-domain reflectometry (TDR) data for the operational covers continue to indicate dry conditions.

2.1.7 Soil Gas Monitoring

Soil gas monitoring for tritium has been conducted since 1990 at borehole GCD-05 to evaluate tritium movement. This borehole has a large tritium inventory (approximately 2.2 million curies at the time of disposal) buried from 20 to 36 m below ground surface. Two strings of nine soil gas sampling probes are buried in the borehole. A depth profile of soil gas tritium concentration is measured from 3 to 36 m below ground surface to provide a direct measure of changes in tritium activity with depth as a result of degradation of waste containers, advection, and diffusion. During the 18-year measurement period, soil gas tritium concentrations show extremely slow upward movement of tritium through soil from the waste, which indicates that tritium and associated waste remain contained.

2.1.8 Biota Monitoring

Bioturbation and plant uptake are two release mechanisms that potentially transport tritium upward through waste covers and into the atmosphere. Plants can transport tritium by root uptake and subsequent evapotranspiration, and animal burrows may potentially intrude into waste; however, root depths of the species in this area are generally less than 2 m, and animal burrows only extend approximately 0.3 m below ground surface. Biota (plant and animal) samples are collected every 2 years to measure tritium concentrations. Analyses of samples collected at the Area 5 RWMS show detectable levels of tritium. Although these results show tritium uptake, there is no evidence that plants or animals have intruded into the waste, and it is unlikely that plant roots or animal burrows extend to a depth that could impact buried waste.

2.1.9 Performance Assessment Model

To evaluate the potential for contamination of environmental media, a model has been developed using GoldSim® software that assesses closure alternatives, optimizes the closure cover design, and demonstrates compliance with federal regulations (Shott et al., 1998; BN, 2006).

Model input parameters are represented by probability distributions to account for uncertainty. Comprehensive sensitivity analyses show that the parameters that have a significant effect on the outcome of the model are related to plant uptake and animal burrowing. Radionuclide inventories do not have a significant effect on the outcome of the model, highlighting the ability of the disposal system to contain waste and protect the public (Shott et al., 1998; BN, 2006).

The following conservative assumptions are accounted for in the model:

- The critical group is assumed to be a resident farmer 100 m from the site boundary. This assumption is conservative due to the remote location, arid climate, marginal agricultural soil, lack of resources such as surface water or shallow groundwater, and the presence of nearby nuclear craters that are likely to remind any potential residents of the probable presence of radioactive contamination. In addition, public access to the NTS is restricted.
- All radionuclides are assumed to be immediately available for release and transport (i.e., all waste containers have failed, and the waste is released directly into the cover soil). This assumption is conservative because containers and waste forms are likely to delay the release of radionuclides for decades if not hundreds of years.
- The critical group, located 100 m from the site boundary, is assumed to be exposed to the same concentrations of radionuclides that are present on the site itself. This assumption is conservative because 100 m from the site boundary, the actual concentrations are expected to be orders of magnitude less than onsite concentrations.

2.2 RESULTS

Monitoring results are reported annually in the *Nevada Test Site Waste Management Monitoring Report Area 3 and Area 5 Radioactive Waste Management Sites*. Groundwater monitoring results are reported annually in the *Nevada Test Site Data Report: Groundwater Monitoring Program Area 5 Radioactive Waste Management Site*. The following sections provide a summary of the most recent results of monitoring data and modeling activities.

2.2.1 Summary of Characterization and Monitoring Data

Extensive site characterization, environmental monitoring, and modeling have been performed for the Area 5 RWMS over the past several decades. These studies and the waste inventory are summarized in the DQOs provided in Appendix A of this document. Release pathways are upwards to the surface with negligible pathway to groundwater. The applicable transport processes are the release of volatile constituents to the cover and the atmosphere, and the migration of contaminants in the cover and to the atmosphere by erosion, animal burrowing/plant uptake, and inadvertent disturbance of waste. Table 2 summarizes the release pathways and associated exposure scenarios. Figure 3 illustrates the pathways to receptors and their applicability to the site.

2.2.1.1 *Direct Radiation Monitoring*

Quarterly direct radiation exposure data from 1998 to 2007 at the Area 5 RWMS and NTS background locations are presented in units of mR/day in Figure 4. The data indicate that direct radiation exposure is generally low or declining (National Security Technologies, LLC [NSTec], 2008).

2.2.1.2 *Air Monitoring*

Tritium concentrations in air are well below the DCG of 100,000 pCi/m^3 for tritium. On December 19, 2005, a puncture was discovered in a shipping container that was being retrieved. This allowed tritium to escape from the container. Although the container was quickly sealed, tritium from the soil surrounding the container was likely the source of slightly elevated levels of tritium through June 2006. Figure 5 shows the tritium air monitoring results since 2005 in pCi/m^3. All measured concentrations of tritium are below the DCG (NSTec, 2008).

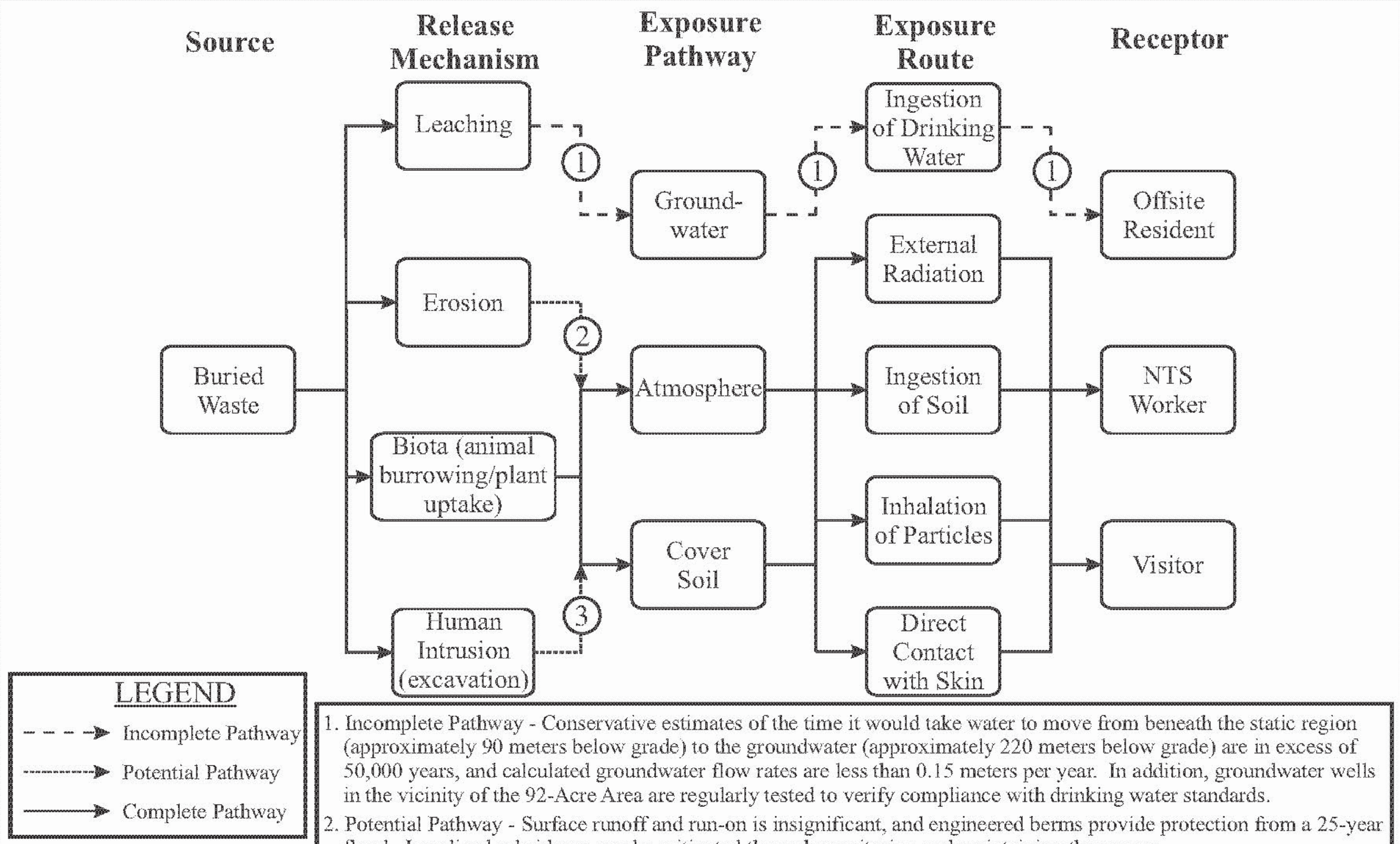
Gamma spectroscopy results for americium and plutonium have generally been below the sample-specific minimum detectable concentrations (MDCs). Figure 6, Figure 7, and Figure 8 show the results for americium and plutonium for 2007 in pCi/m^3. All measured concentrations of americium and plutonium are below the DCG for each radionuclide (NSTec, 2008).

2.2.1.3 *Radon Flux Monitoring*

Radon flux results for 2000 to 2008 are summarized in Figure 9. All radon flux measurements are at least 7 times lower than the regulatory limit of 20 pCi/m^{2}s (NSTec, 2008).

TABLE 2. 92-ACRE AREA EXPOSURE SCENARIOS

SOURCE OF POTENTIAL CONTAMINATION	RELEASE MECHANISM	EXPOSURE PATHWAY	EXPOSURE ROUTE	RECEPTOR	EXPOSURE SCENARIO
Buried Waste	Leaching	Groundwater	Ingestion of drinking water	Offsite resident	This is an incomplete pathway to exposure due to high evapotranspiration and low precipitation, low potential for downward transmission of water in the vadose zone below the waste cells, static zone below the vadose zone, large distance to groundwater, and low groundwater velocity.
	Erosion Biota (animal burrowing/plant uptake) Excavation	• Atmosphere • Cover soil	• External radiation • Ingestion of soil • Inhalation of particulates • Direct contact with skin	• NTS worker • Visitor	The potential for exposure is limited to NTS workers and visitors. These receptors may be exposed to contaminants through ingestion, inhalation, or direct contact due to inadvertent disturbance into the waste or contact with waste materials brought to the surface by erosion or biota.



1. Incomplete Pathway - Conservative estimates of the time it would take water to move from beneath the static region (approximately 90 meters below grade) to the groundwater (approximately 220 meters below grade) are in excess of 50,000 years, and calculated groundwater flow rates are less than 0.15 meters per year. In addition, groundwater wells in the vicinity of the 92-Acre Area are regularly tested to verify compliance with drinking water standards.
2. Potential Pathway - Surface runoff and run-on is insignificant, and engineered berms provide protection from a 25-year flood. Localized subsidence can be mitigated through monitoring and maintaining the covers.
3. Potential Pathway - This pathway is controlled through excavation permits and use restrictions. In addition, the depth of the buried waste makes intrusion into buried waste an unlikely scenario.

FIGURE 3
PATHWAYS TO RECEPTORS FOR THE 92-ACRE AREA

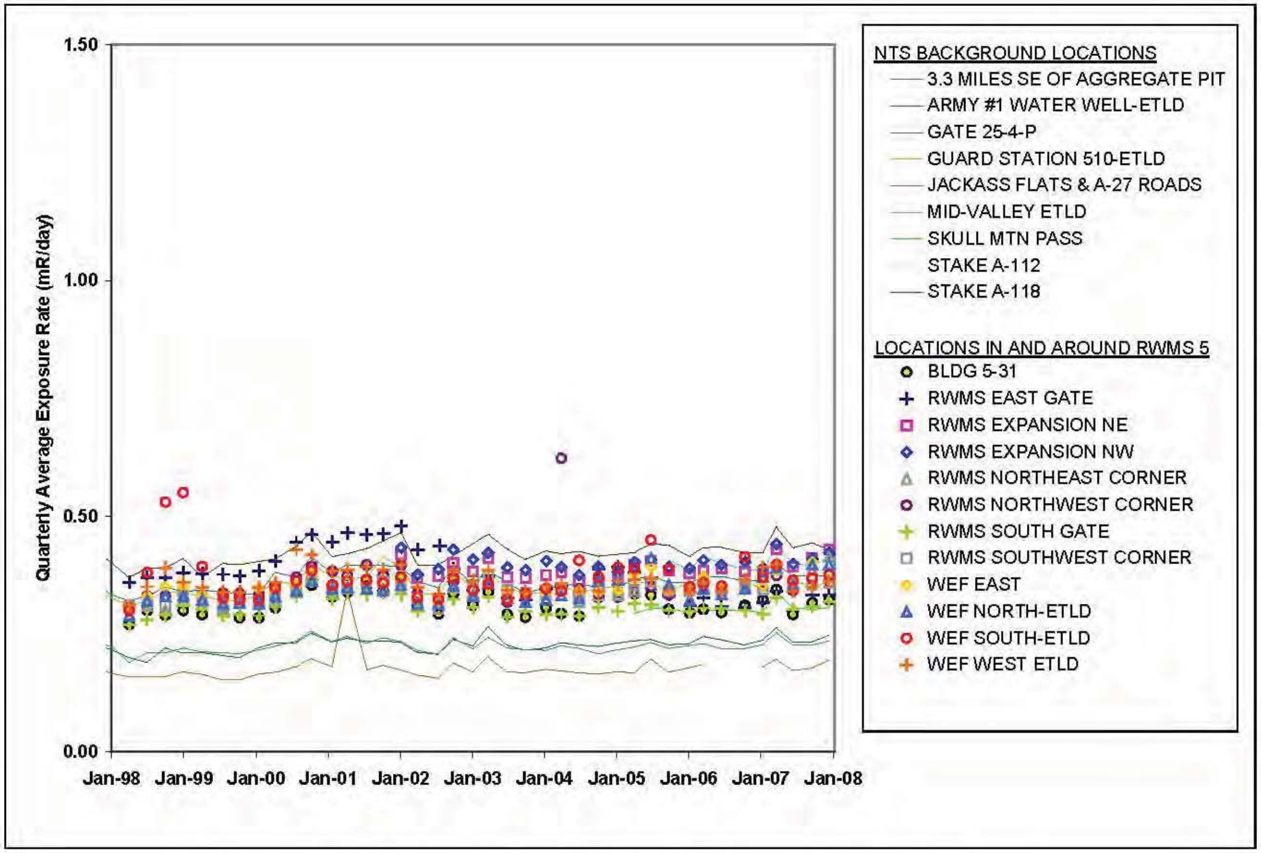


FIGURE 4. DIRECT RADIATION MONITORING RESULTS

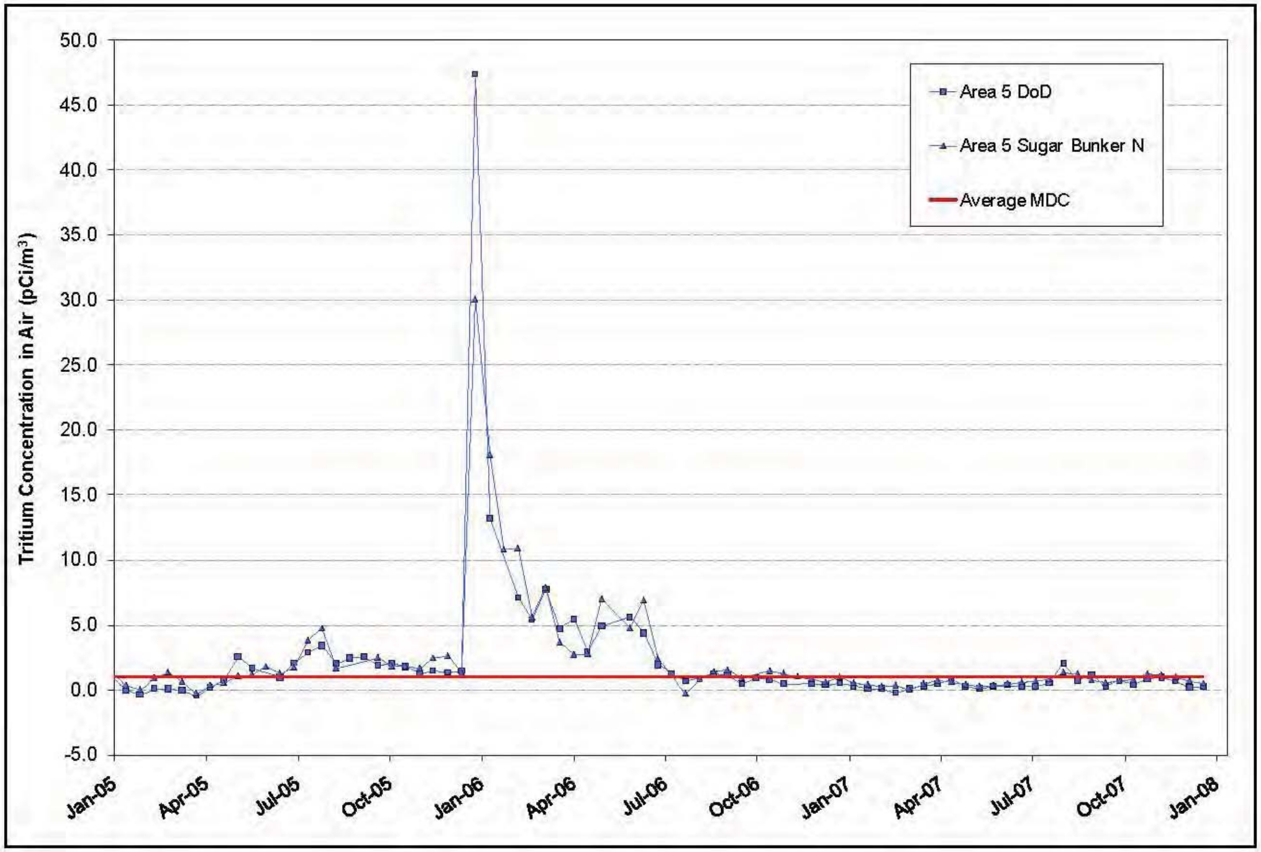


FIGURE 5. TRITIUM AIR MONITORING RESULTS

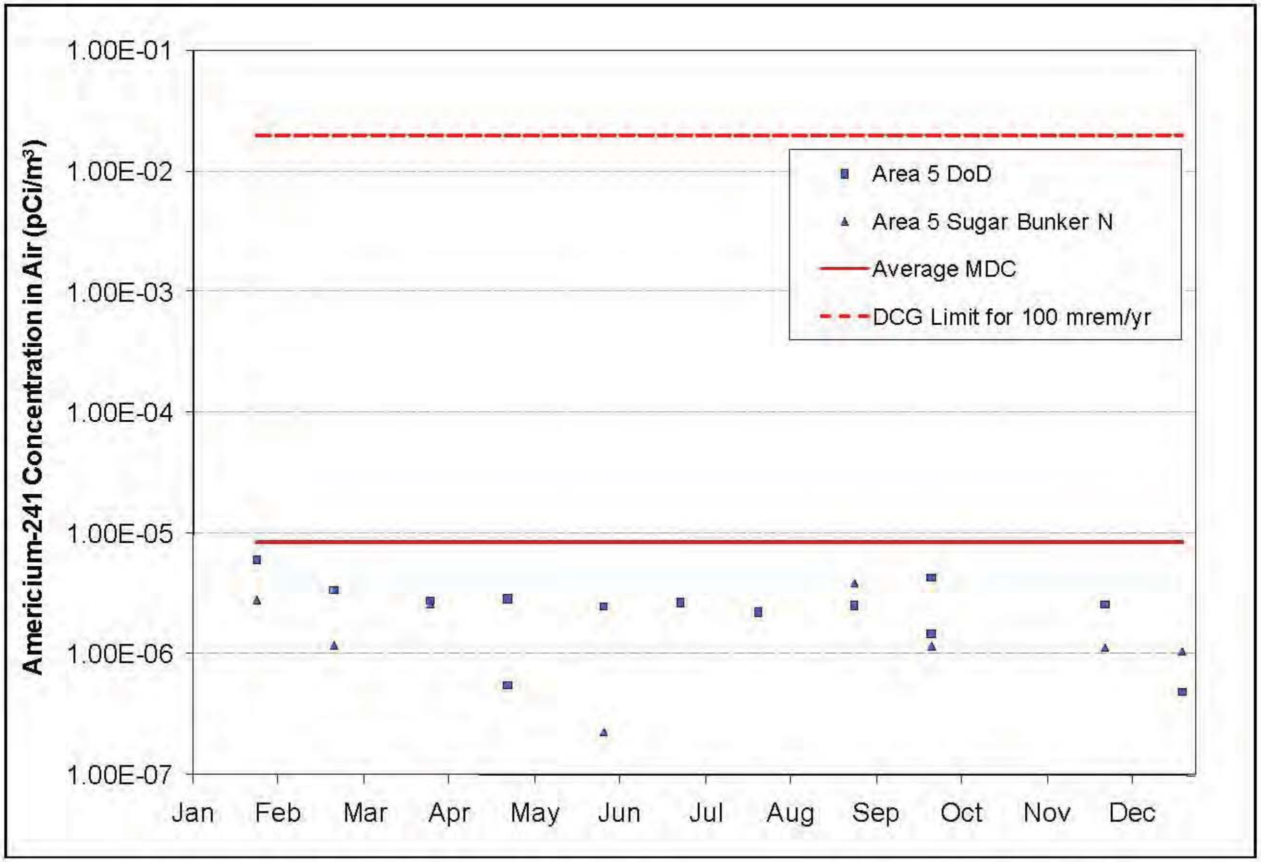


FIGURE 6. AMERICIUM-241 AIR MONITORING RESULTS IN 2007

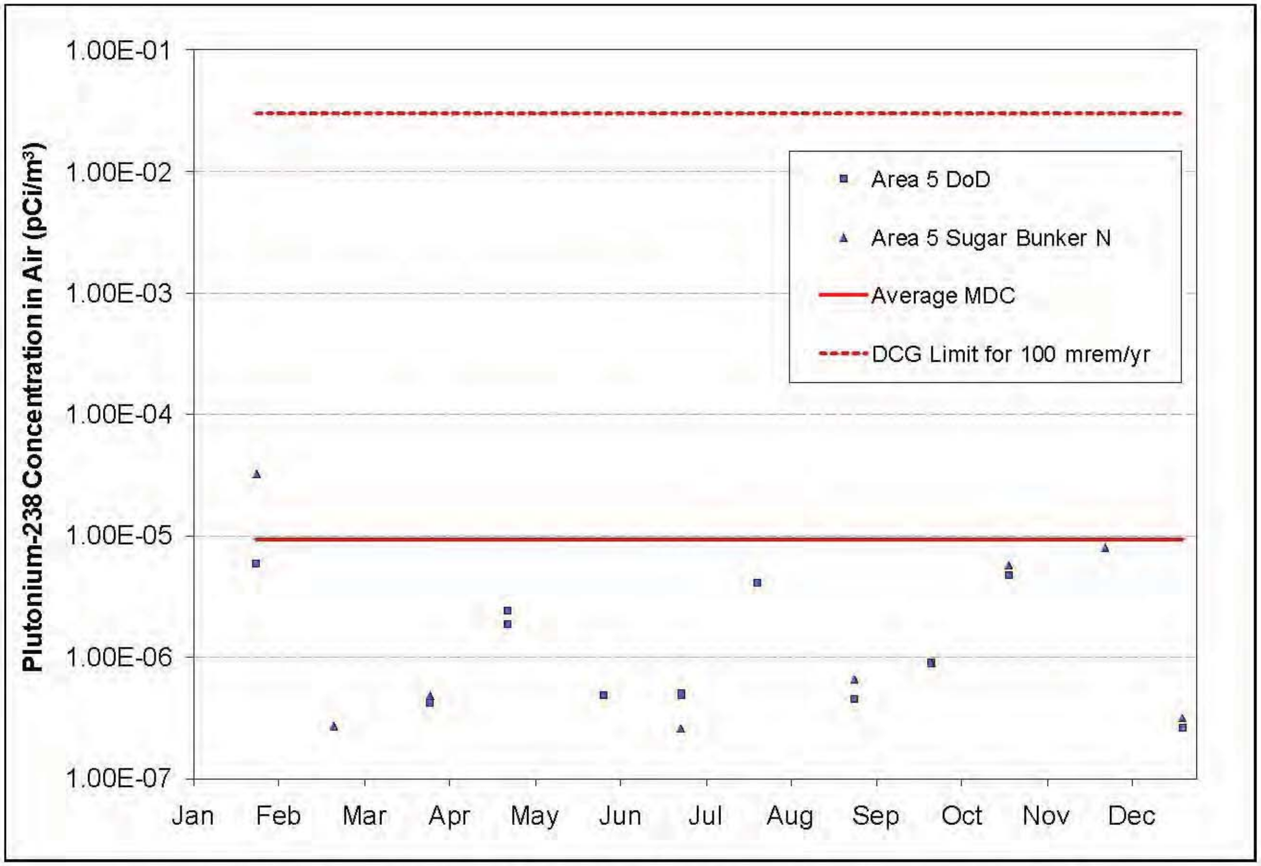


FIGURE 7. PLUTONIUM-238 AIR MONITORING RESULTS IN 2007

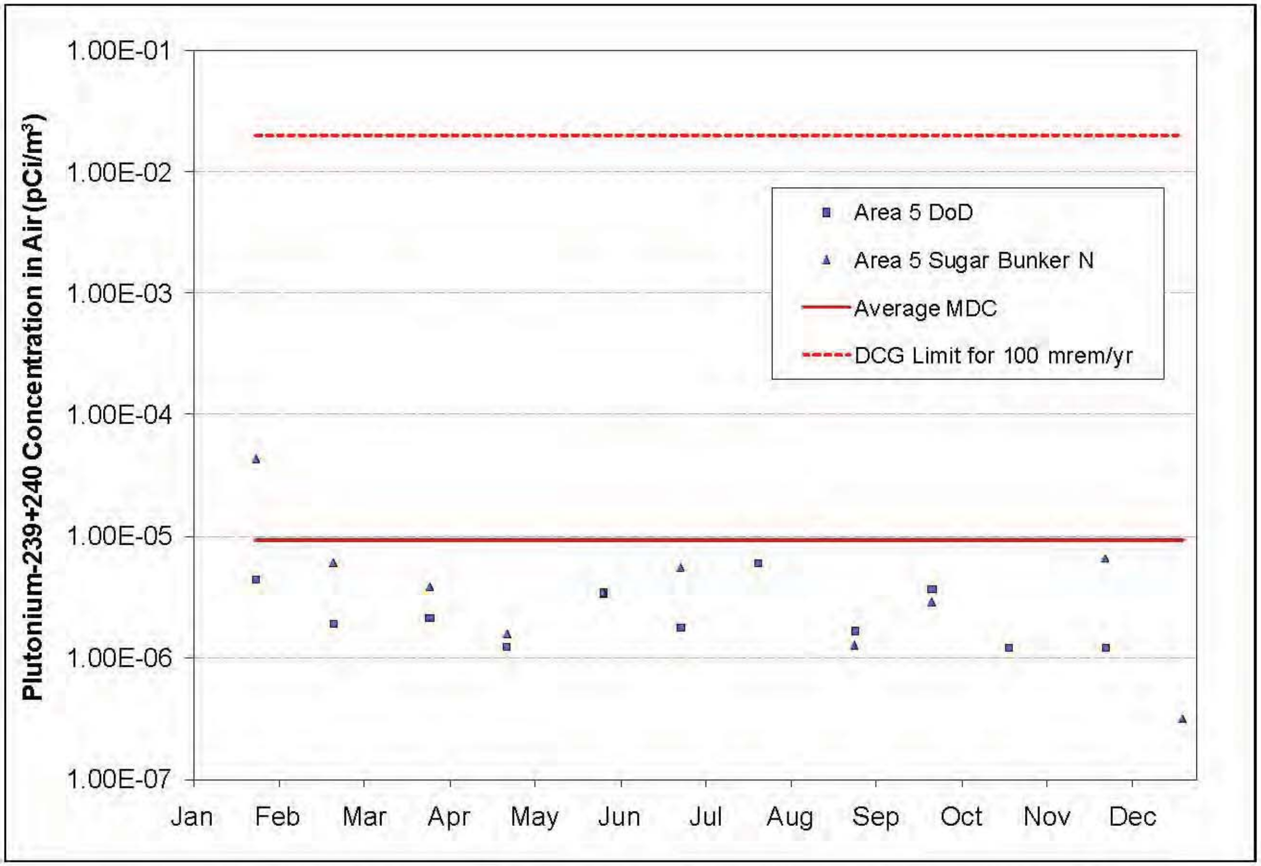


FIGURE 8. PLUTONIUM-239/240 AIR MONITORING RESULTS IN 2007

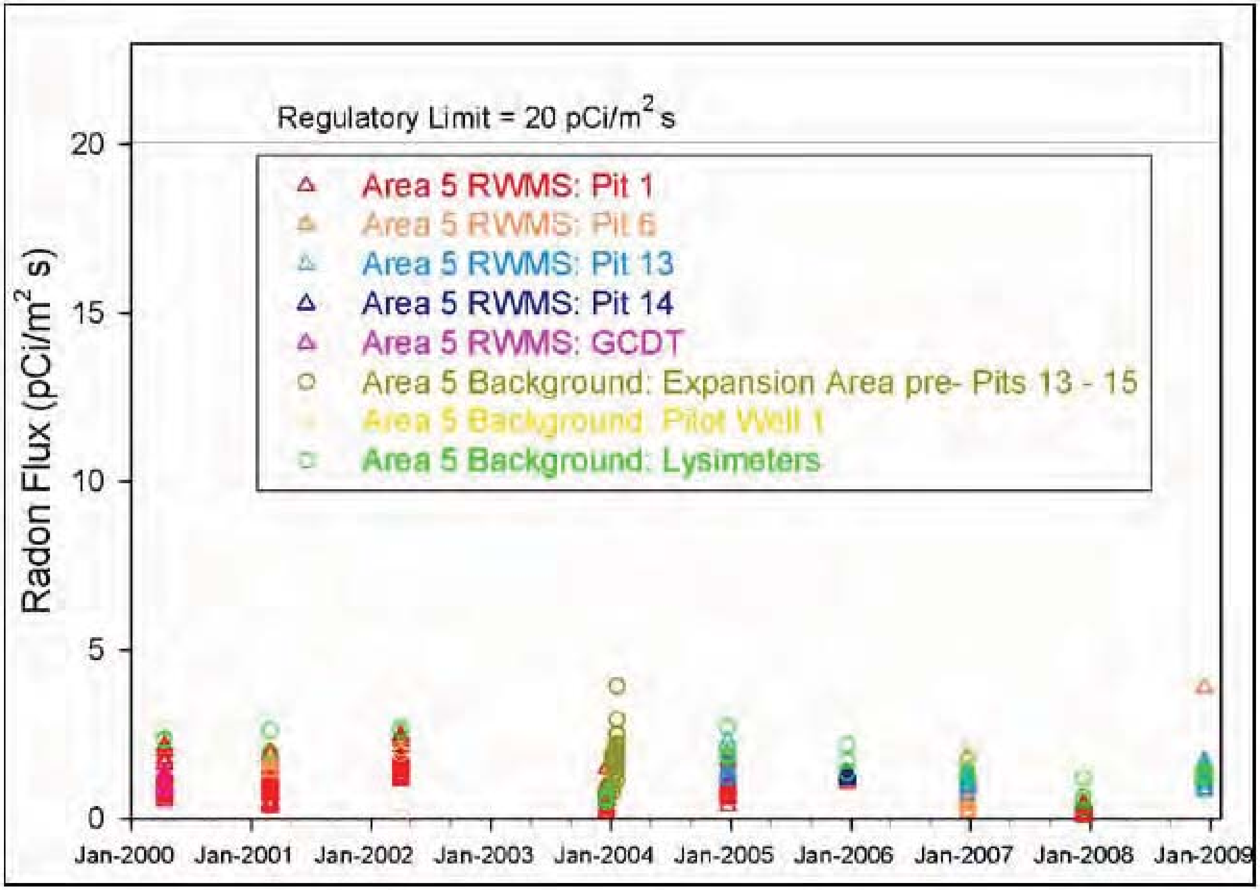


FIGURE 9. RADON FLUX MONITORING RESULTS

2.2.1.4 *Groundwater Monitoring*

Groundwater elevation data from manual measurements taken since the wells were drilled in 1993, as shown in Figure 10, indicate that the water table is flat, with low groundwater velocities. The locations of the three wells are shown on Figure 2.

Indicators of contamination (pH, specific conductance, total organic carbon, total organic halides, and tritium) show no groundwater contamination. Measured pH has remained stable and within the ILs of 7.6 and 9.2 (Figure 11). Specific conductance values have remained stable and below the IL of 0.44 millimhos per centimeter (mmhos/cm) (Figure 12). Total organic carbon values have remained low and stable, and are generally at or below the IL of 1 milligram per liter (mg/L) (Figure 13). Total organic halide values have remained stable and below the IL of 50 micrograms per liter (µg/L) (Figure 14). Tritium values have remained stable and below the IL of 2,000 picocuries per liter (pCi/L) and the MDC since monitoring began (Figure 15). Negative values for tritium shown in Figure 15 are the result of background subtraction.

General water chemistry parameters (calcium, magnesium, potassium, sodium, iron, manganese, bicarbonate, sulfate, silicate, chloride, and fluoride) indicate similar groundwater composition in the three wells and stable groundwater chemistry throughout the monitoring period (NSTec, 2009).

2.2.1.5 *Meteorology Monitoring*

The daily maximum and minimum air temperatures at the Area 5 RWMS for 2007 are shown in Figure 16. The average air temperature in 2007 was 16.4ºC. The maximum and minimum air temperatures in 2007 were 43.9ºC and -14.7ºC. The daily average relative humidity in 2007 was approximately 28 percent and ranged from 2 to 100 percent (Figure 17). The daily average barometric pressure in 2007 was 90.5 kilopascals (kPa) (Figure 18) (NSTec, 2008).

In 2007, the average wind speed was 2.7 meters per second (m/s), and the maximum gust was 20.9 m/s (Figure 19). Wind rose diagrams illustrate wind direction and wind speed distribution in each direction using hourly wind data. Generally, winds are more frequent from the north, with higher wind speeds from the south. The wind rose diagram for the Area 5 RWMS is presented in Figure 20 (NSTec, 2008).

Rainfall at the Area 5 RWMS in 2007 was below average, totaling 123.8 millimeters (mm). The average annual precipitation for 1995 to 2007 is 130.7 mm. Figure 21 depicts the daily total precipitation for 2007. Historical precipitation data recorded at the Well 5B station (approximately 5.5 kilometers south of the Area 5 RWMS) and the Area 5 RWMS are provided in Figure 22 (NSTec, 2008).

Reference evapotranspiration, calculated using solar radiation, air temperature, relative humidity, wind speed, and barometric pressure, was 1,594 mm in 2007. This is 12.9 times the amount of precipitation in 2007, indicating that precipitation will be removed from the soil by evapotranspiration before it is allowed to infiltrate into the covers toward the waste cells.

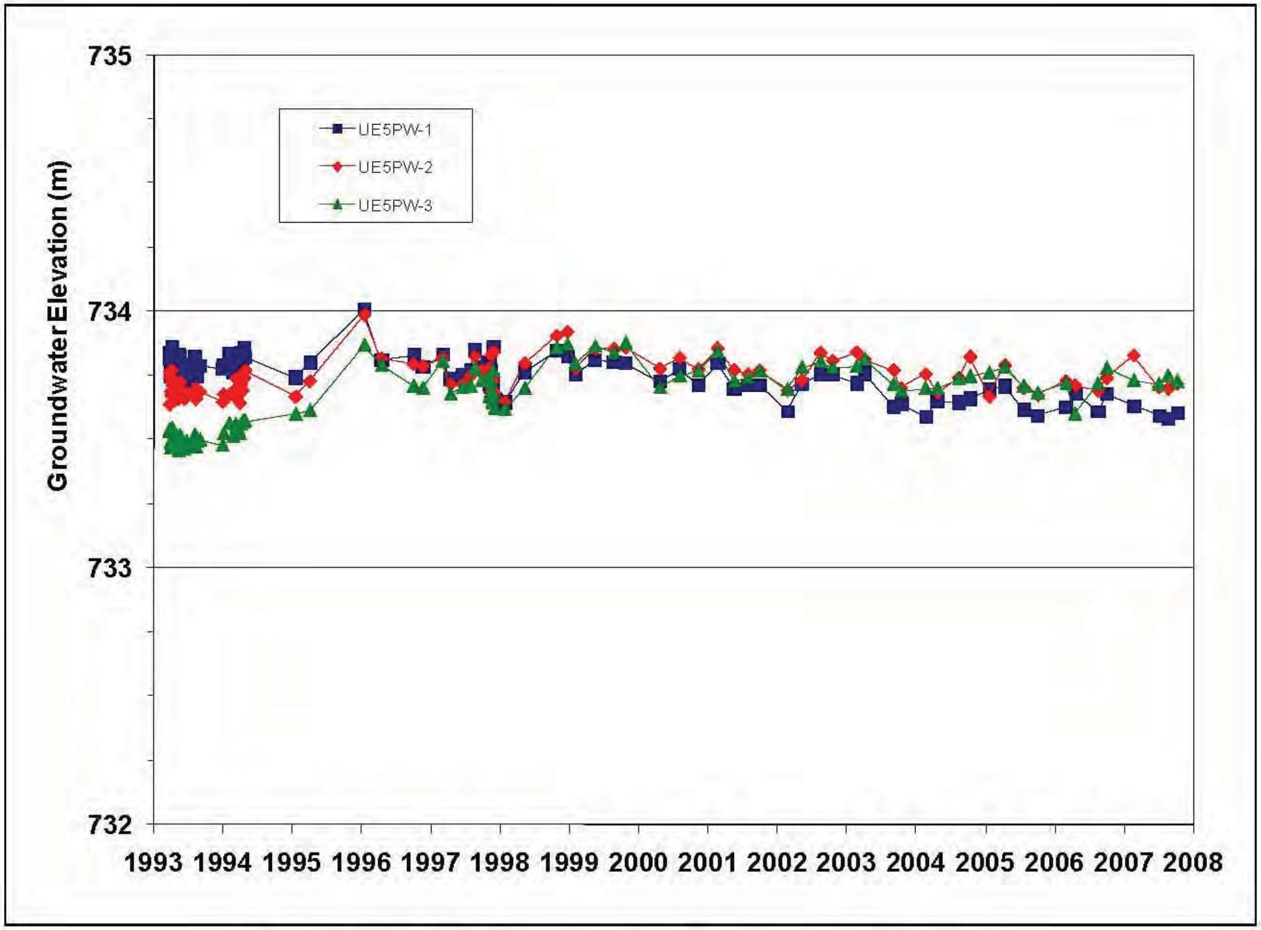


FIGURE 10. GROUNDWATER ELEVATION RESULTS

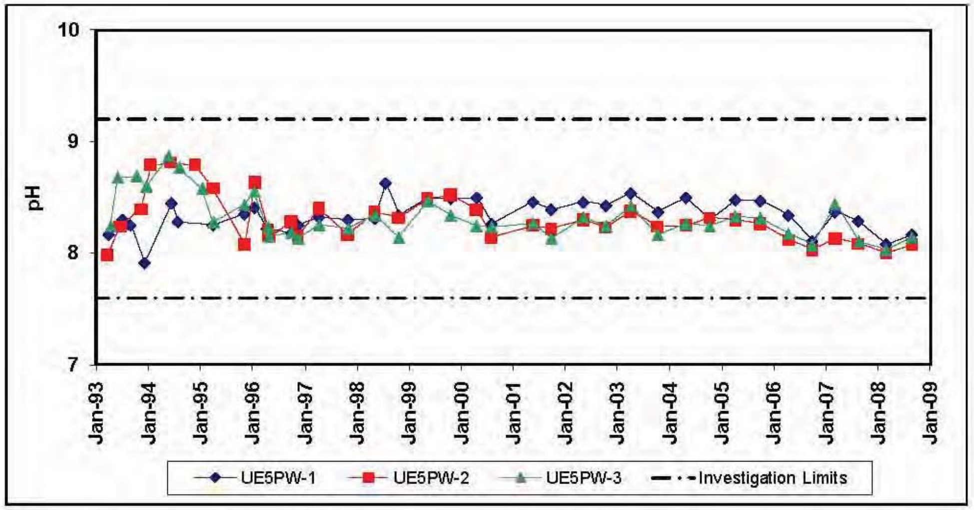


FIGURE 11. MEASURED PH GROUNDWATER MONITORING RESULTS

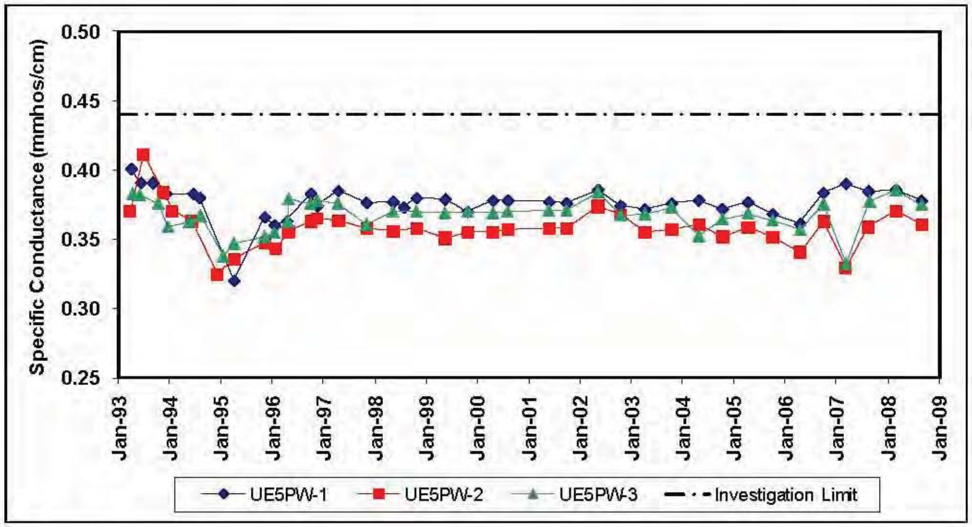


FIGURE 12. SPECIFIC CONDUCTANCE GROUNDWATER MONITORING RESULTS

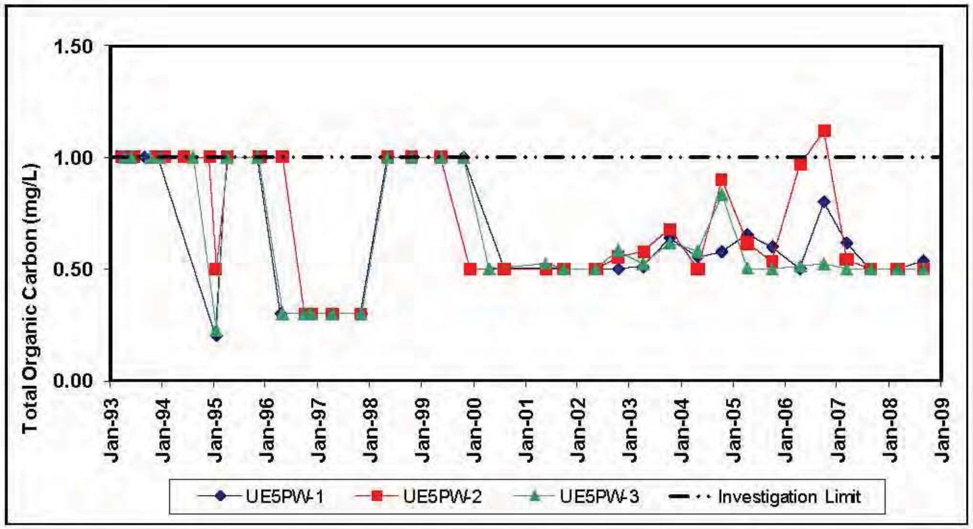


FIGURE 13. TOTAL ORGANIC CARBON GROUNDWATER MONITORING RESULTS

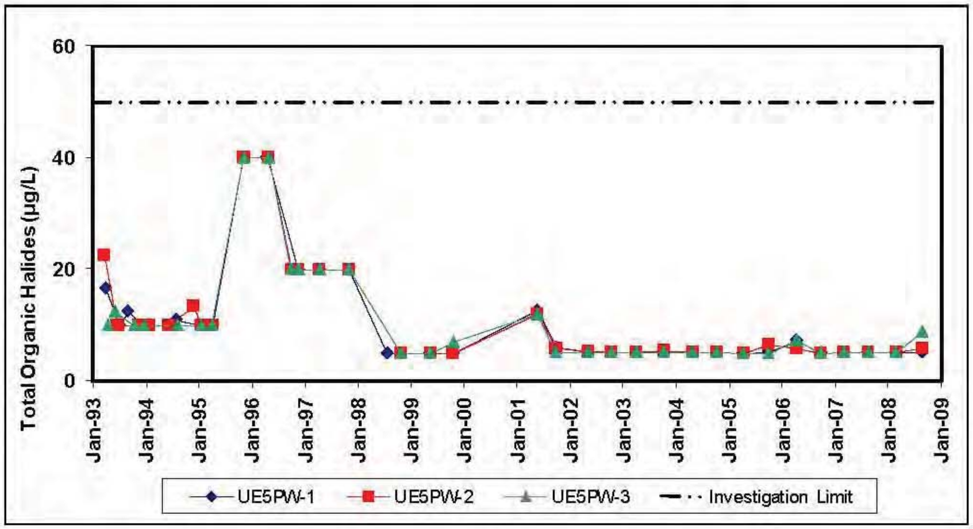


FIGURE 14. TOTAL ORGANIC HALIDES GROUNDWATER MONITORING RESULTS

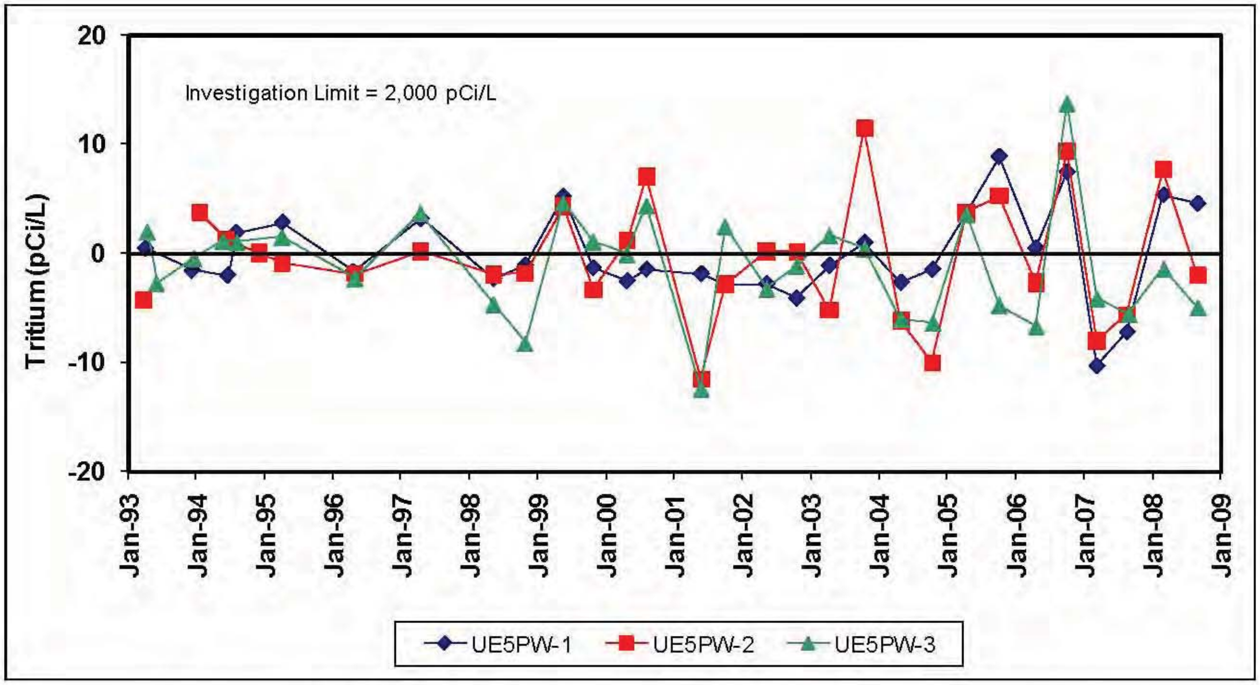


FIGURE 15. TRITIUM GROUNDWATER MONITORING RESULTS

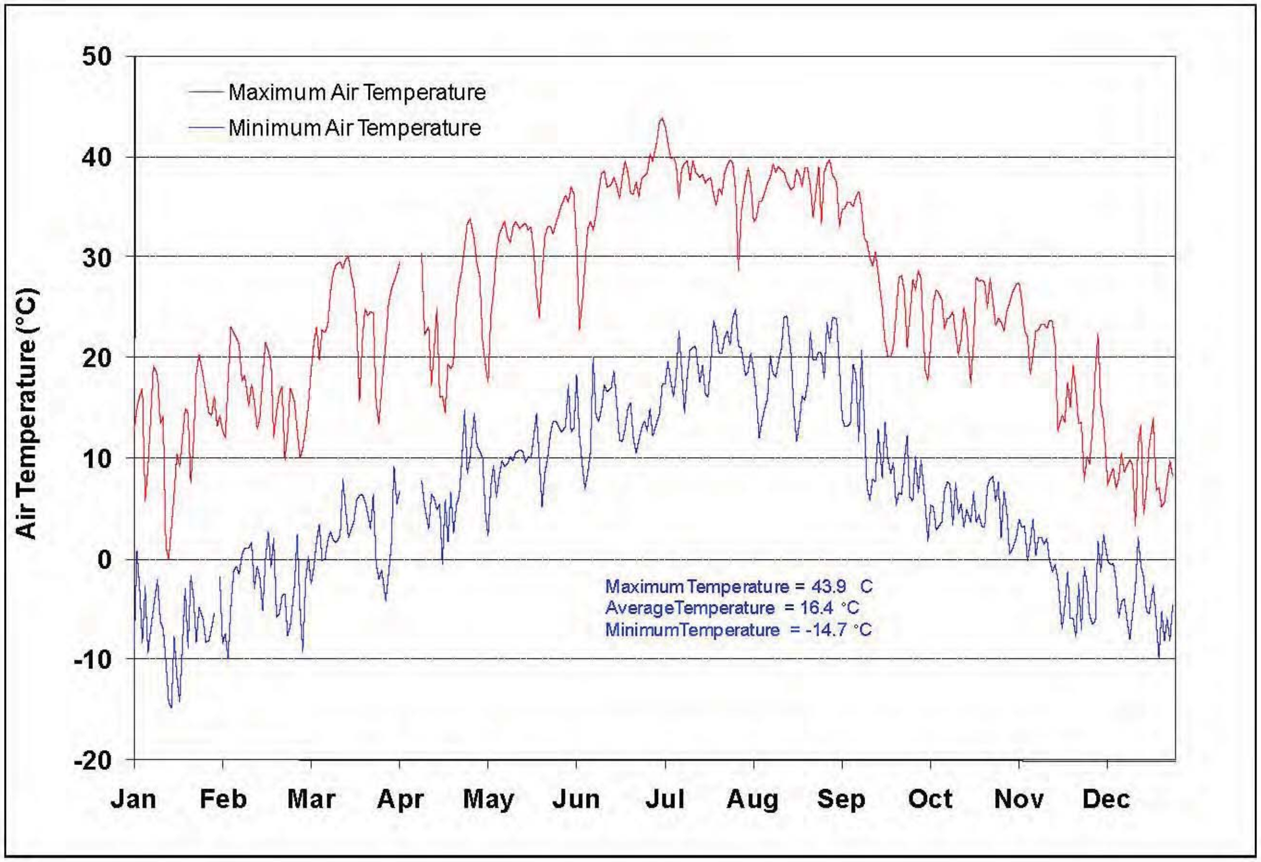


FIGURE 16. DAILY MAXIMUM AND MINIMUM AIR TEMPERATURE IN 2007

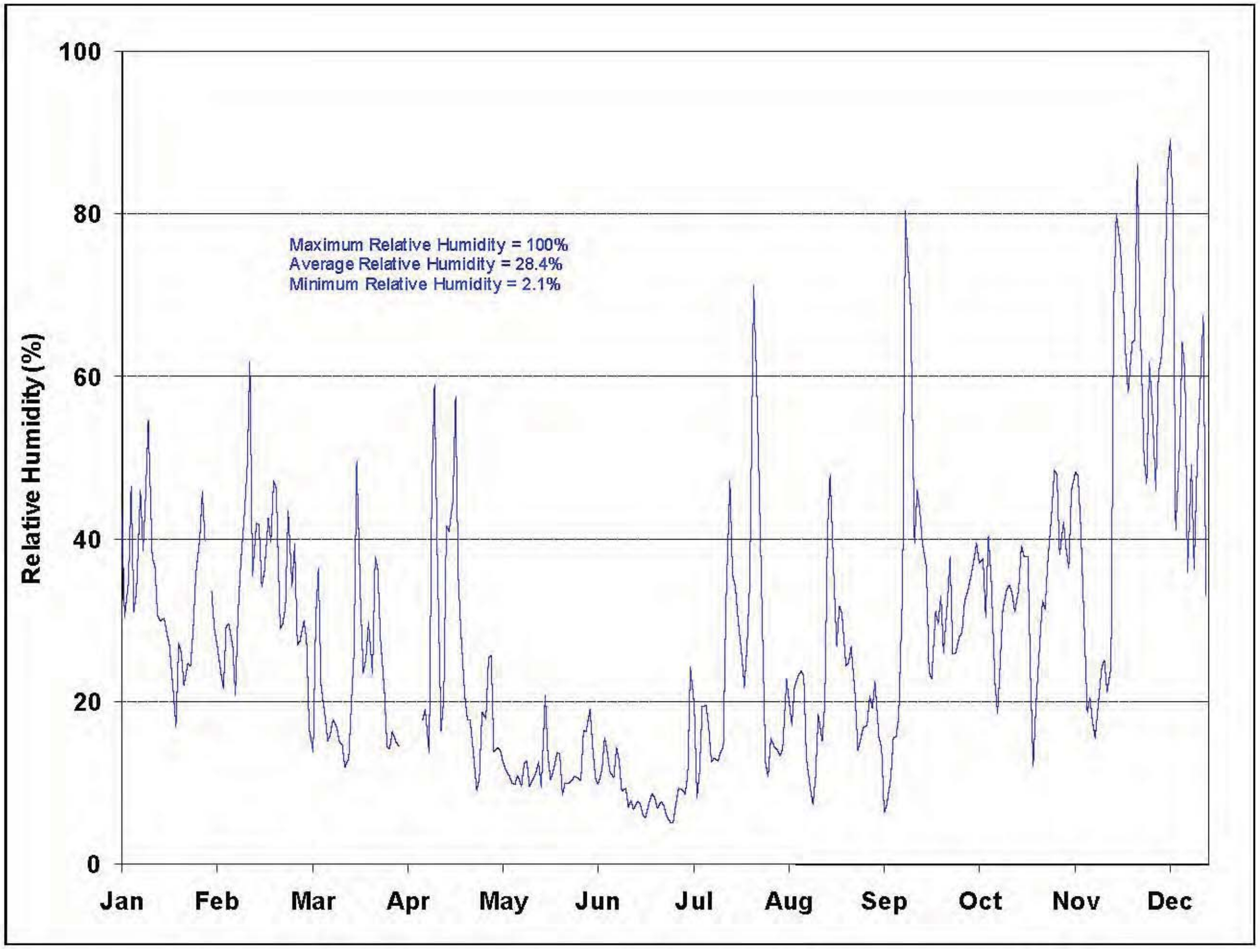


FIGURE 17. DAILY AVERAGE RELATIVE HUMIDITY IN 2007

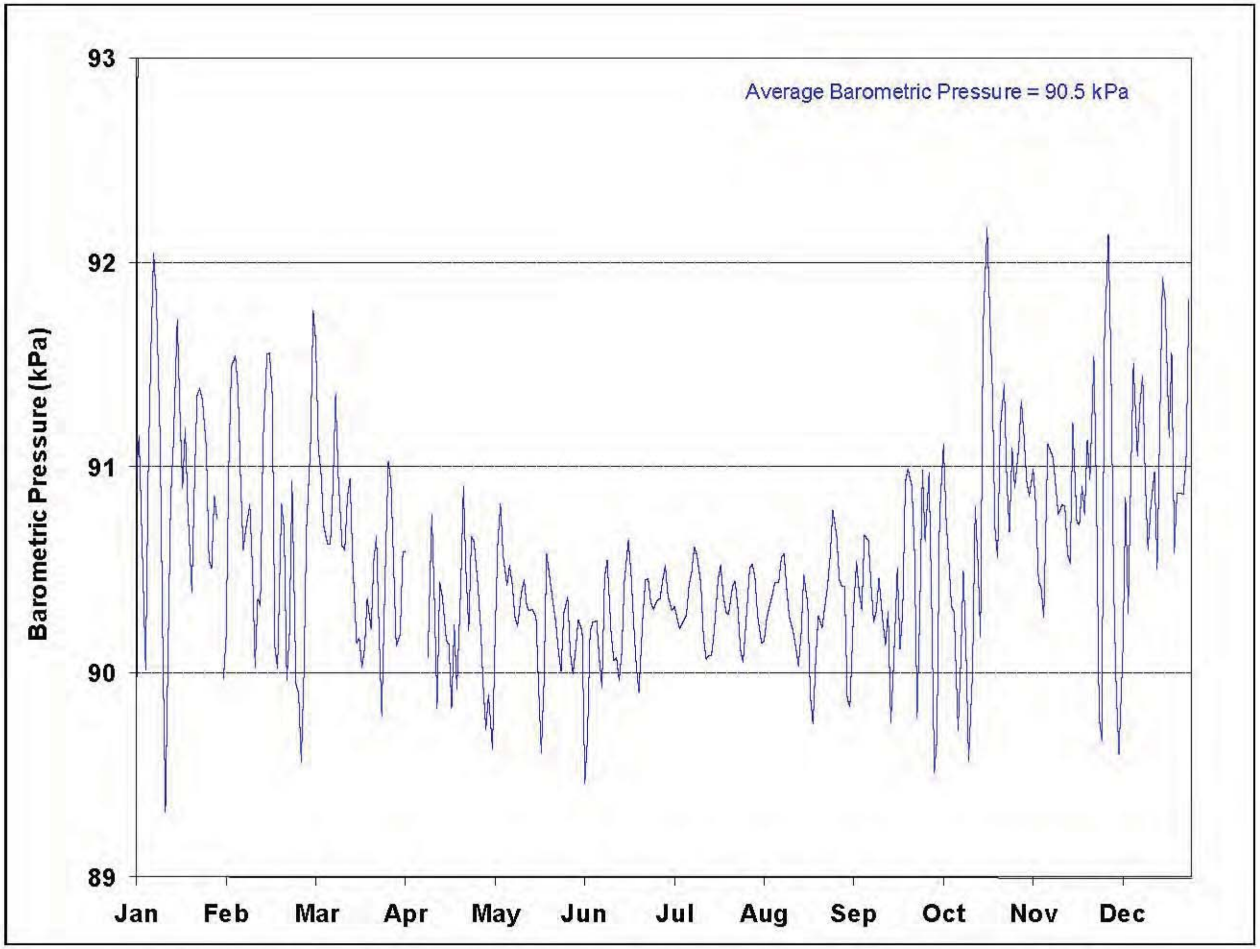


FIGURE 18. DAILY AVERAGE BAROMETRIC PRESSURE IN 2007

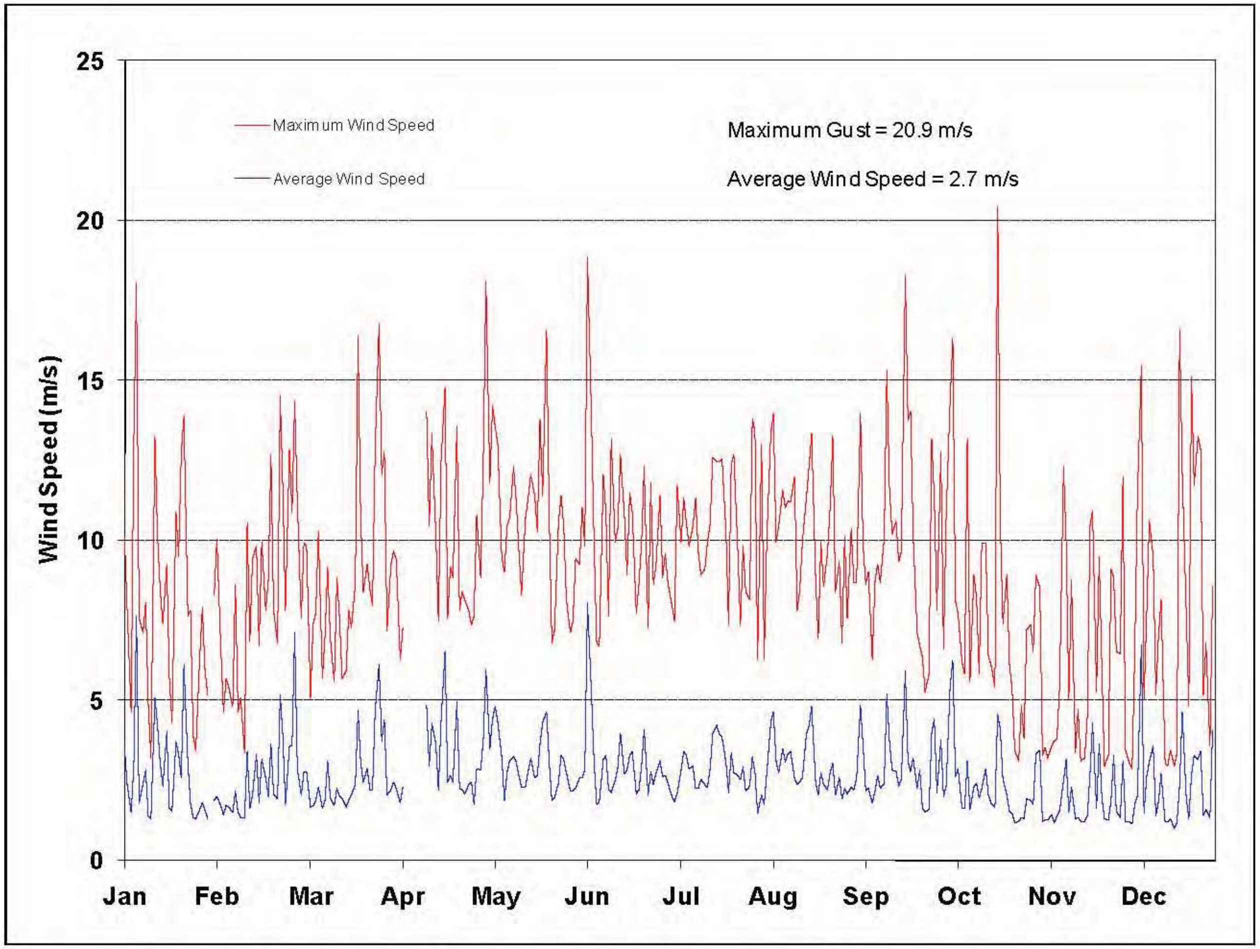


FIGURE 19. DAILY MAXIMUM AND AVERAGE WIND SPEED IN 2007

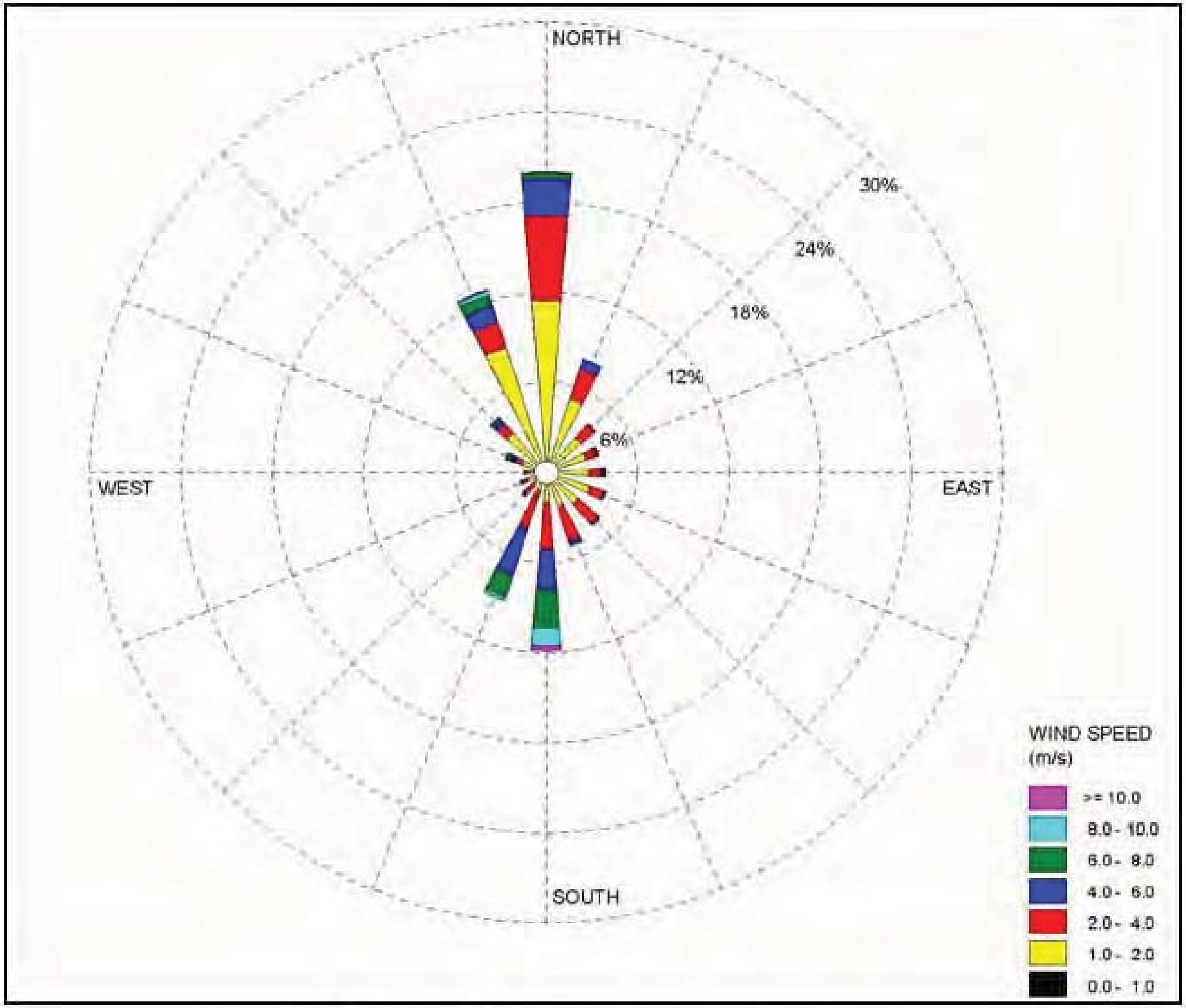


FIGURE 20. WIND ROSE DIAGRAM

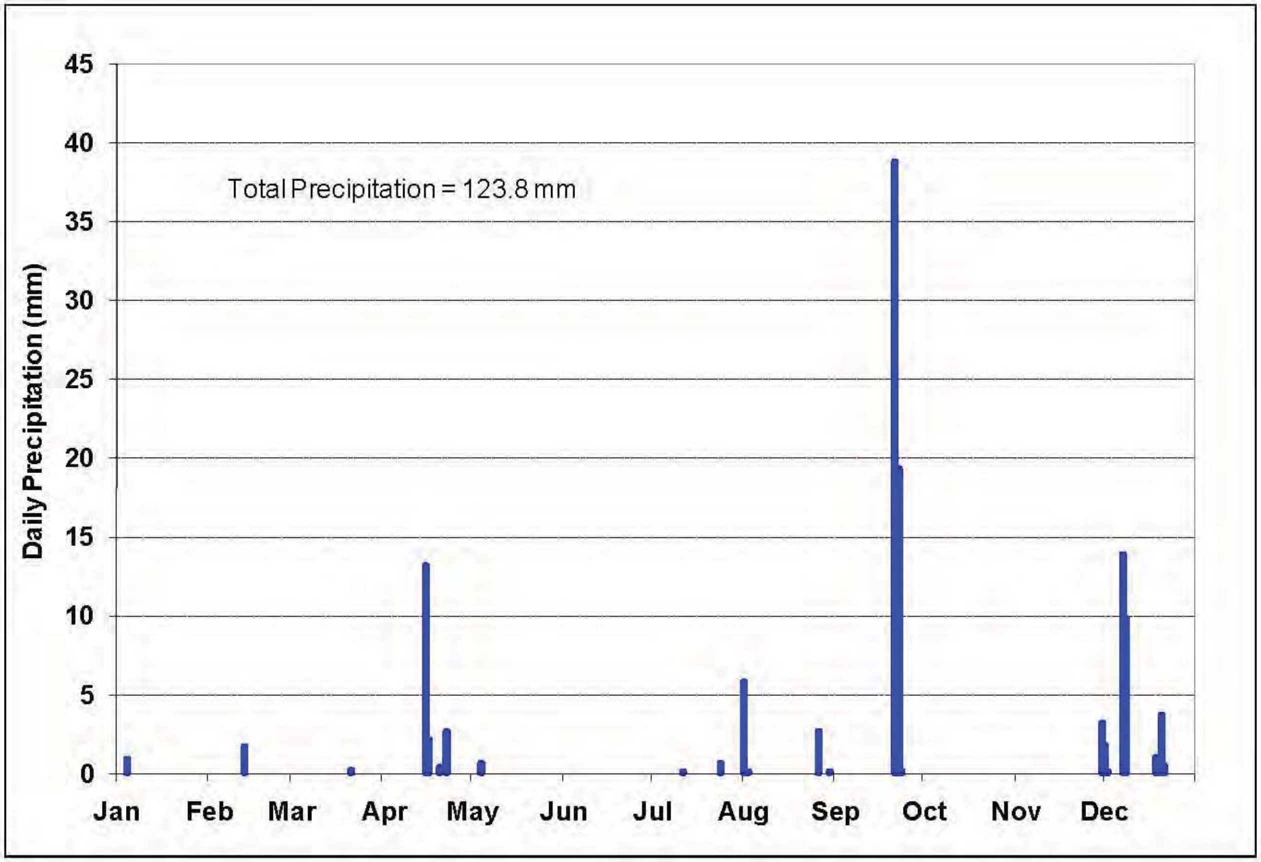


FIGURE 21. DAILY PRECIPITATION IN 2007

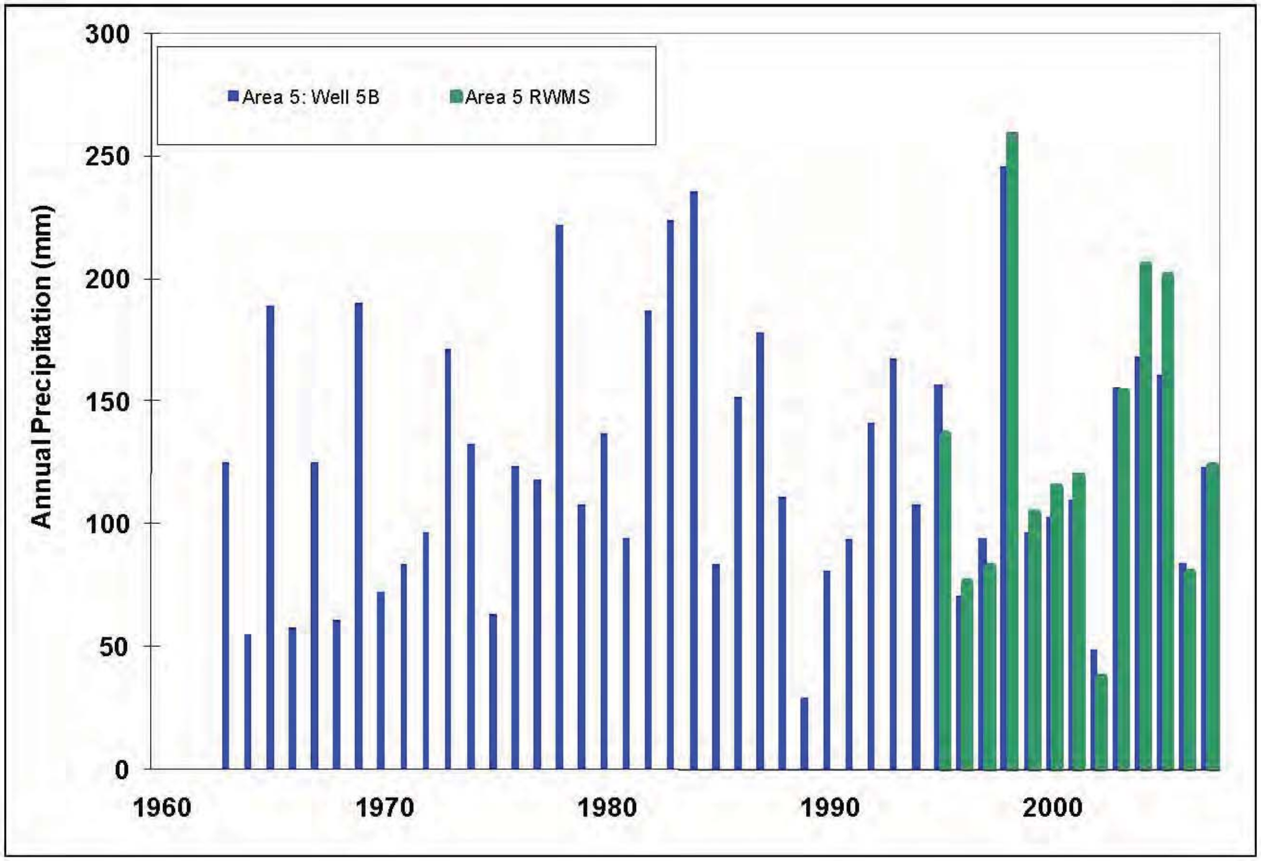


FIGURE 22. ANNUAL PRECIPITATION

2.2.1.6 *Vadose Zone Monitoring*

Total soil water storage at the weighing lysimeters for 1994 to 2007 is illustrated in Figure 23. The vegetated lysimeter is considerably drier than the bare-soil lysimeter. The average soil water storage depth in the vegetated lysimeter from 1996 to 2007 was 114 mm. This is equivalent to an average volumetric moisture content of 5.72 percent. For the same period, the average soil water storage depth in the bare lysimeter was 207 mm, which is equivalent to an average volumetric moisture content of 10.35 percent. In 2007, the average soil water storage depth in the vegetated lysimeter was 110 mm, and the average water storage depth in the bare lysimeter was 206 mm (NSTec, 2008).

In 1998, TDR probes were buried 1.2 m beneath the floor of Pit 5 (P05). Approximately 4.4 m of waste and approximately 2.3 m of operational cover were placed above these probes during disposal operations. Measured volumetric moisture content in the floor of Pit 5 has remained constant at approximately 10 percent since monitoring began (Figure 24). The stable moisture content indicates that no moisture has percolated to 1.2 m below the waste (NSTec, 2008).

In 1999, TDR probes were installed in the operational cover of Pit 3 (P03) at two locations (north and south) at depths ranging from 10 to 180 centimeters (cm) below the top of the cover. Precipitation events beginning in October 2004 infiltrated into the cover and percolated below the deepest probe at both the north (Figure 25) and south (Figure 26) locations in early March 2005. This depth is below the range where surface evaporation can have an effect on soil moisture. During 2006 and 2007, the gradual drying of the soil profile at Pit 3 continued. By September 2007, the volumetric moisture content at 180 cm at both locations had returned to approximately 12 percent (NSTec, 2008).

In 2000, TDR probes were installed in the operational cover of Pit 5 (P05) at depths ranging from 15 to 180 cm below the top of the cover. Precipitation events beginning in October 2004 infiltrated into the cover and percolated below the deepest probe in April 2005 (Figure 27). Similar to Pit 3 (P03), the gradual drying of the soil profile continued in 2007 (NSTec, 2008).

2.2.1.7 *Soil Gas Monitoring*

Sample results for soil gas tritium since 1990 indicate that upward migration of tritium from the waste is extremely slow. Tritium concentrations with depth and time are illustrated in Figure 28. Concentrations have remained constant and low from the surface to 12.2 m. At 15.2 m, concentrations slowly increased through 1997 but then leveled off. Concentrations at 19.8, 25.9, 33.5, and 36.3 m, which are adjacent to the tritium source, have increased since 1990. The highest measured tritium concentration of 363.9 microcuries per cubic meter ($\mu Ci/m^3$), collected at a location adjacent to buried waste, indicates that the 2.2 million curies of tritium originally buried at the site remains contained. Risk from tritium exposure is low due to lack of an exposure pathway, tritium's relatively short half-life of 12.3 years, and the low migration rate (NSTec, 2008).

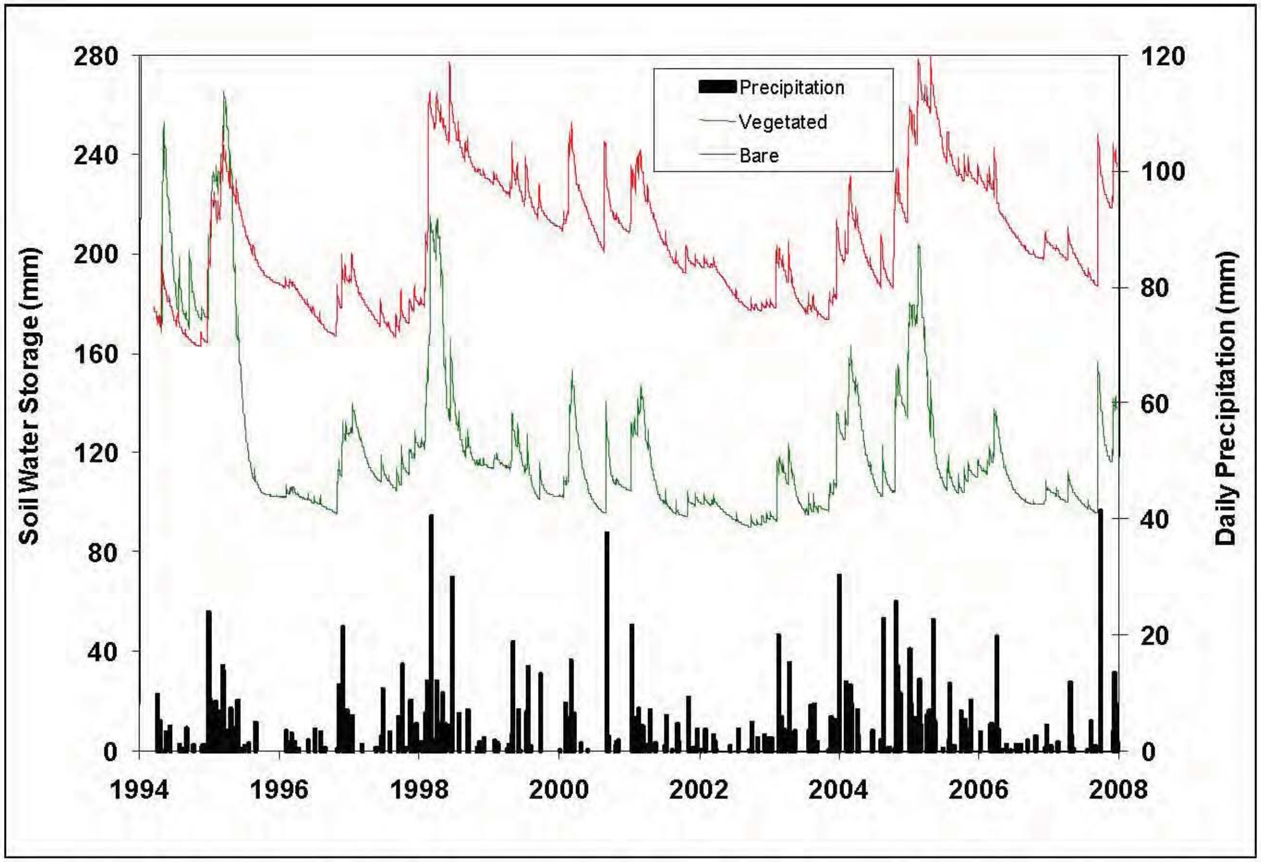


FIGURE 23. VADOSE ZONE MONITORING RESULTS AT THE WEIGHING LYSIMETERS

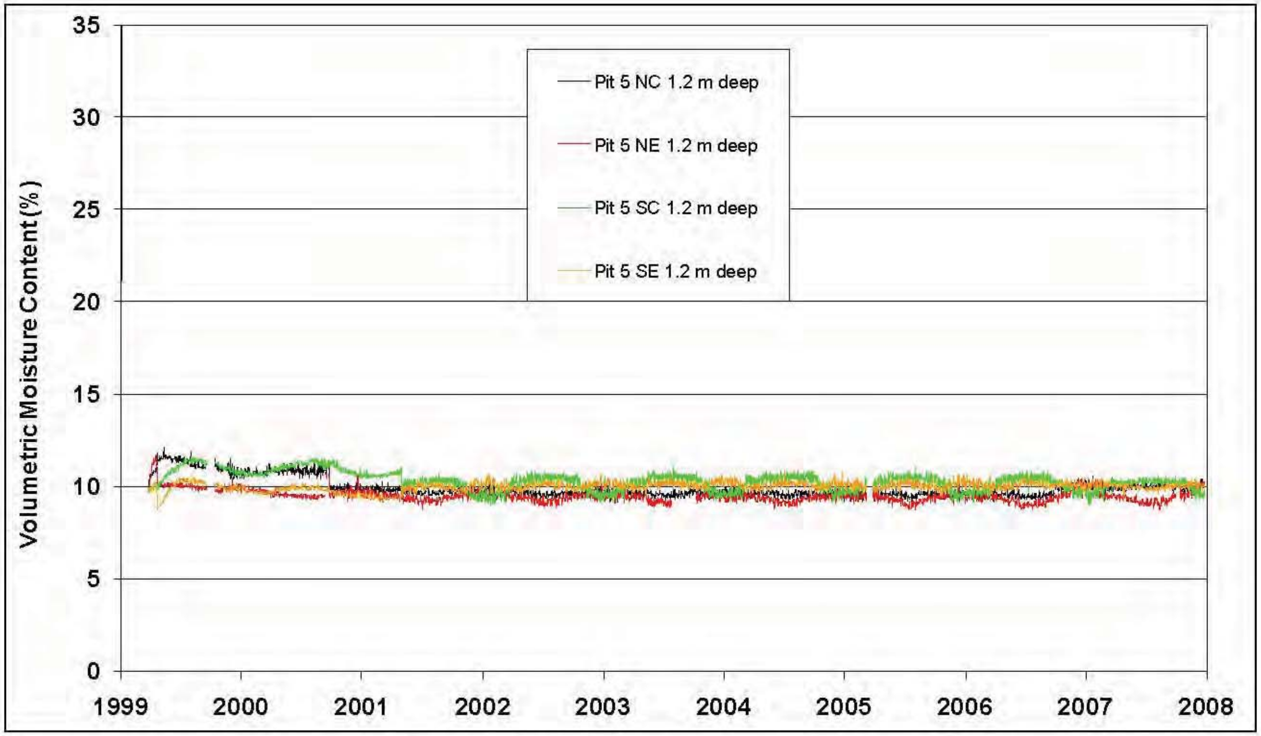


FIGURE 24. VADOSE ZONE MONITORING RESULTS IN THE FLOOR OF PIT 5

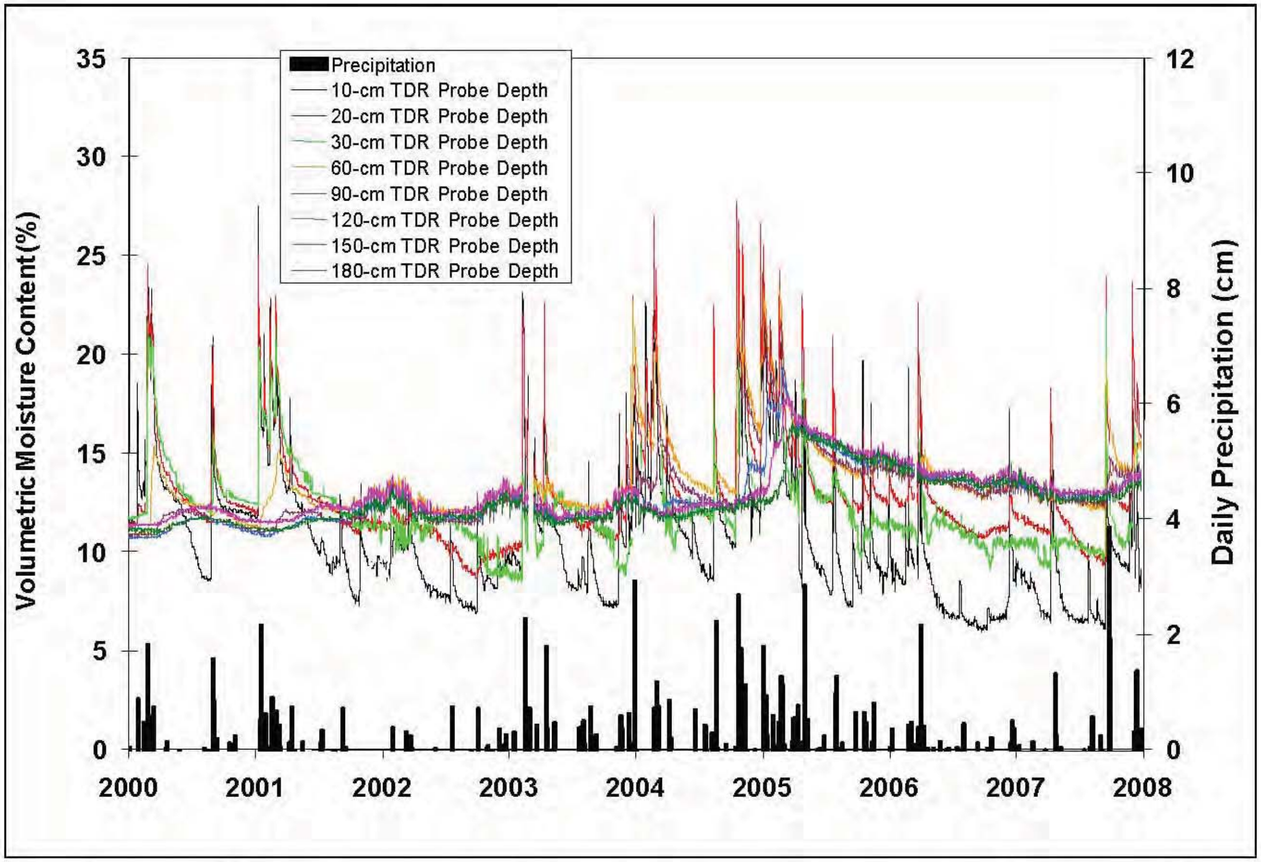


FIGURE 25. VADOSE ZONE MONITORING RESULTS IN THE OPERATIONAL COVER OF PIT 3 NORTH

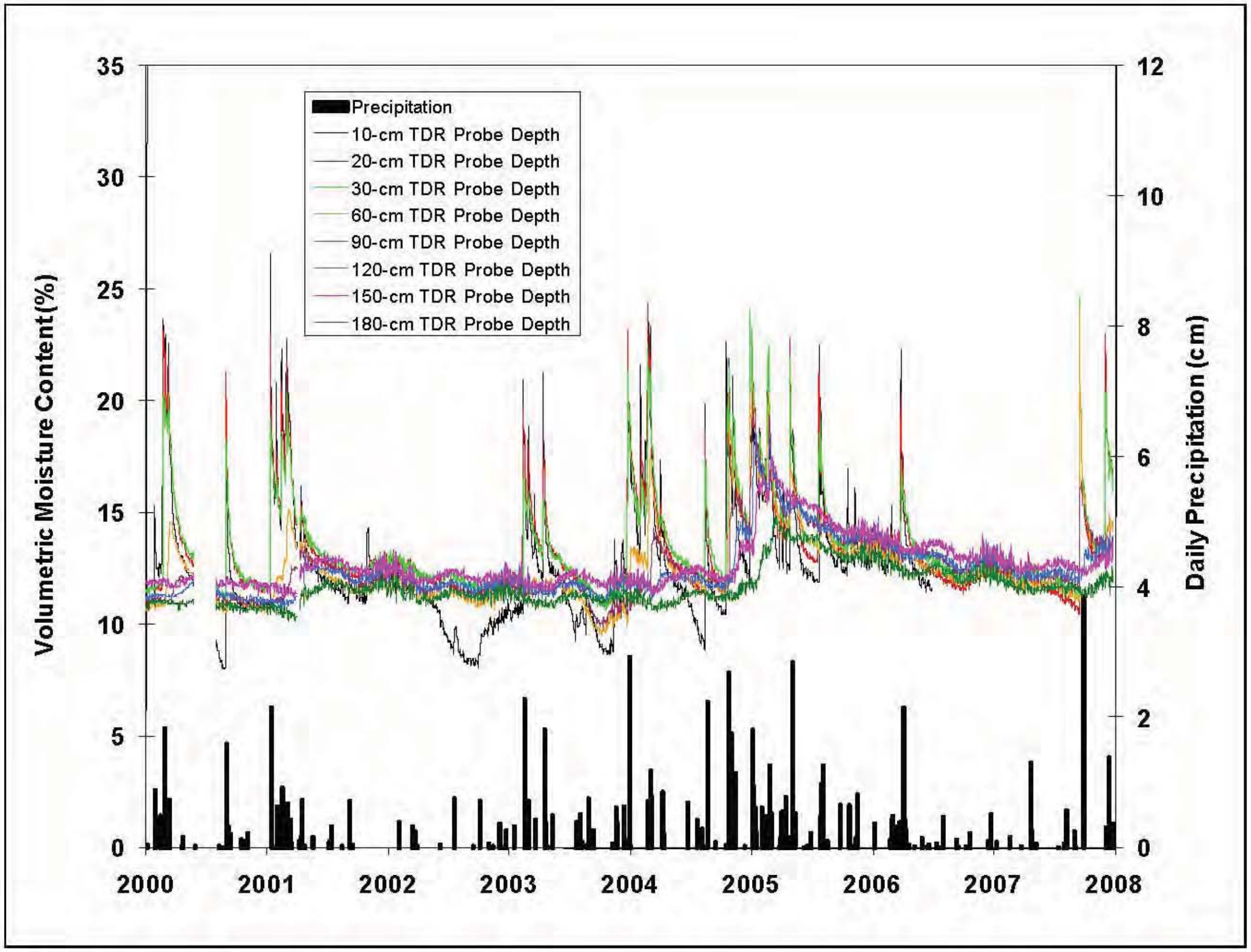


FIGURE 26. VADOSE ZONE MONITORING RESULTS IN THE OPERATIONAL COVER OF PIT 3 SOUTH

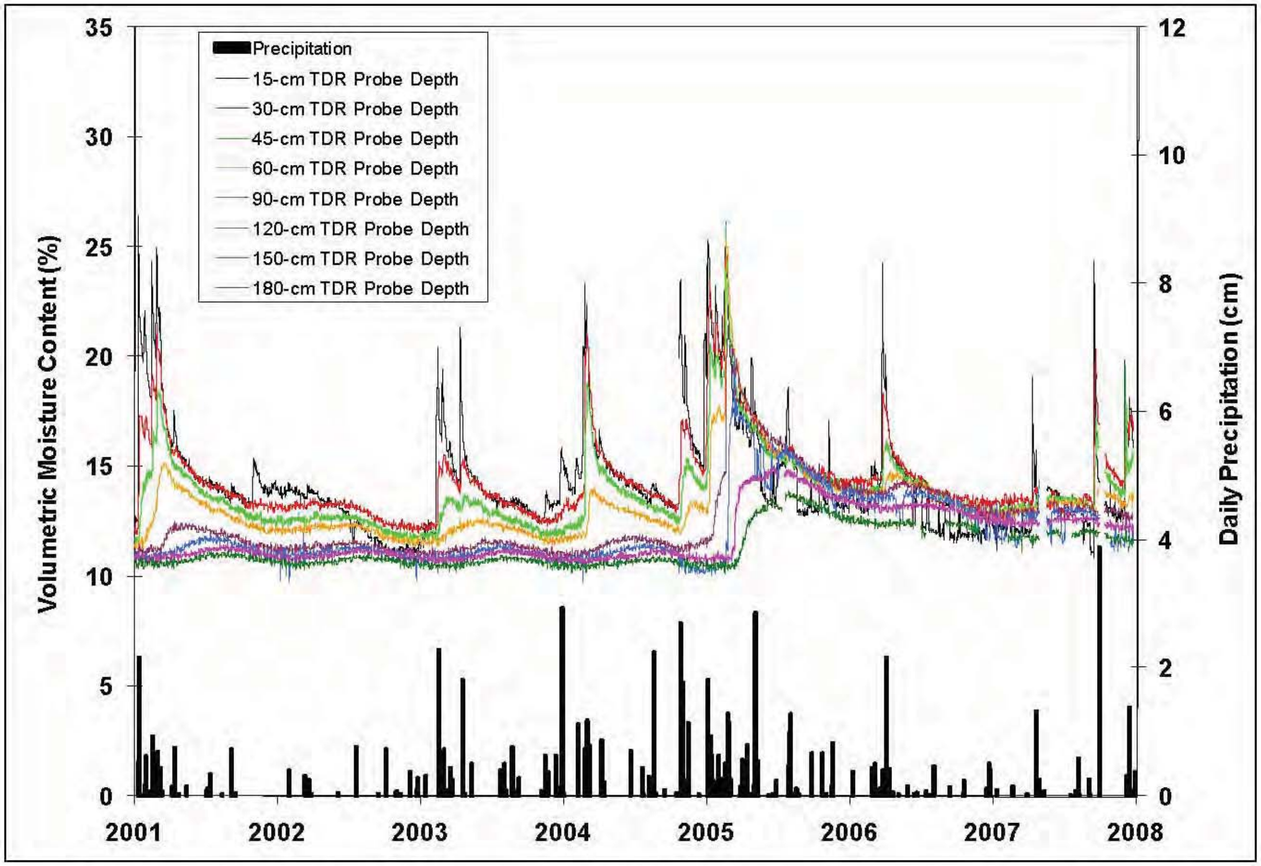


FIGURE 27. VADOSE ZONE MONITORING RESULTS IN THE OPERATIONAL COVER OF PIT 5

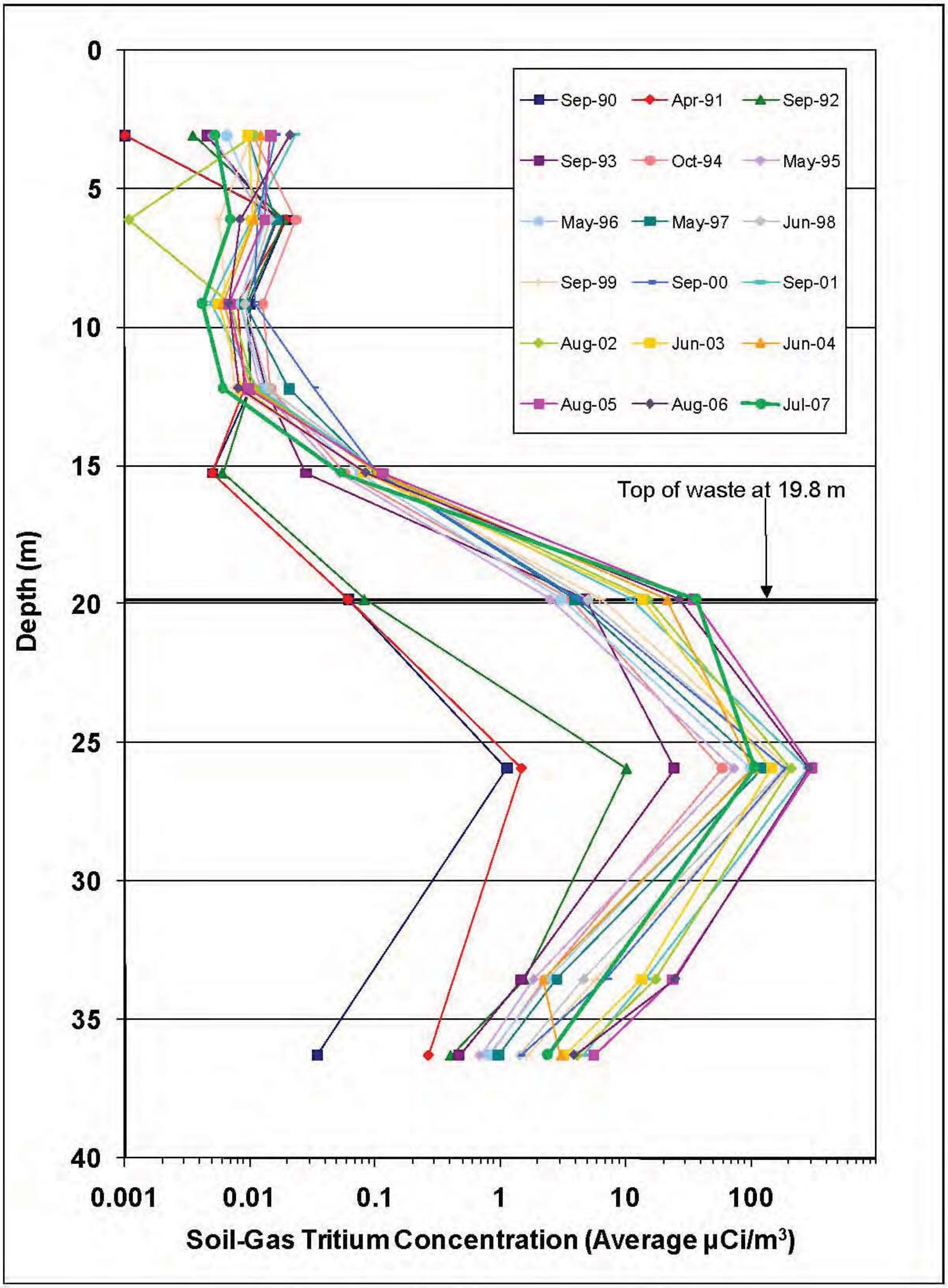


FIGURE 28. SOIL GAS MONITORING RESULTS

2.2.1.8 *Biota Monitoring*

The locations of small mammal burrows and ant nests at the Area 5 RWMS in 2007 are mapped in Figure 29. Burrows are concentrated on the side slopes of the operational covers. Most burrow entrances appear to be inactive. Burrow densities are much higher in older covers (e.g., P01, P02, T02B, and T04B) compared to newer covers (e.g., P04 and P05). Low radionuclide concentrations in soil excavated by small mammals and ants indicate that these animals have not intruded into the waste (NSTec, 2008).

In 2007, biota samples were collected from five plants, one small mammal, and three small mammal burrows or ant nests. Figure 30 shows the sample locations and tritium results in pCi/L. Historical tritium concentrations are illustrated in Figure 31 and Figure 32. Tritium uptake by biota is due to its high mobility as tritiated water. Tritiated water moves upward through waste covers by gaseous diffusion, gaseous and liquid advection, plant uptake and transpiration, and soil evaporation. Due to the very low water content in soil samples collected in 2007, tritium could not be measured. Radionuclide concentrations for strontium, cesium, plutonium, and americium were not statistically different from background (NSTec, 2008).

2.2.1.9 *Performance Assessment Model*

A dynamic model of the movement of moisture established through the performance assessment model of the vadose zone is illustrated in Figure 33. The model hypothesized four regions in the vadose zone. Zone I, approximately 35 m thick at the top of the vadose zone, is a dynamic region of upward liquid flux. This upward flux is driven by the evapotranspiration of plant roots. Zone II, occurring from approximately 35 to 90 m, is a static region with no liquid flux. Zone III consists of a region where downward liquid flux is driven by gravity. The Zone I region of upward flux coupled with the Zone II static region make the potential for downward transmission of precipitation extremely low (BN, 2006).

2.2.2 Data Assessment Summary

A wide range of information is available about physical, chemical, and climate characteristics, as well as facility design, operation, and source materials. These data provide the information necessary to complete performance assessments, perform sensitivity and uncertainty analyses, and evaluate closure options. Model results show that all regulatory objectives are easily met and are not impacted by data limitations, and monitoring data confirm the model. The DQOs provided in Appendix A of this document present detailed information about the CSM, waste inventory, and release and transport parameters, with a discussion of their uncertainty.

2.3 NEED FOR CORRECTIVE ACTION

The evaluation of the need for corrective action includes buried waste potentially affecting the public or the environment. Monitoring data, modeling results, and the CSM show that risk associated with No Further Action is negligible; however, the closure units must comply with multiple regulations, including 40 CFR 265, 40 CFR 191, DOE O 435.1, and the FFACO. According to 40 CFR 265, Subpart G, §265.111, "Closure Performance Standard," closure must minimize the need for further maintenance, and control, minimize, or eliminate, to the extent necessary to protect human health and the environment, migration of waste to the groundwater, surface water, or atmosphere (CFR, 2006d). Therefore, corrective action is required.

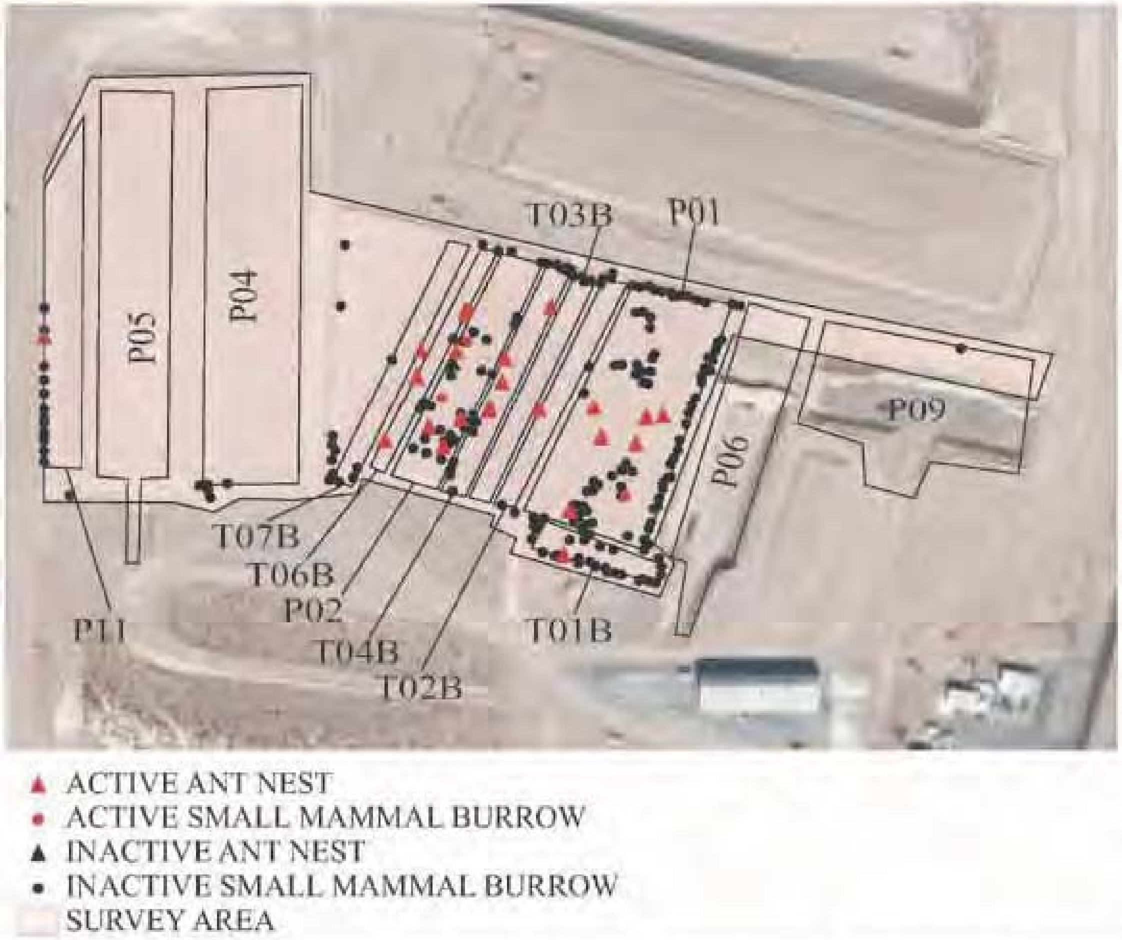
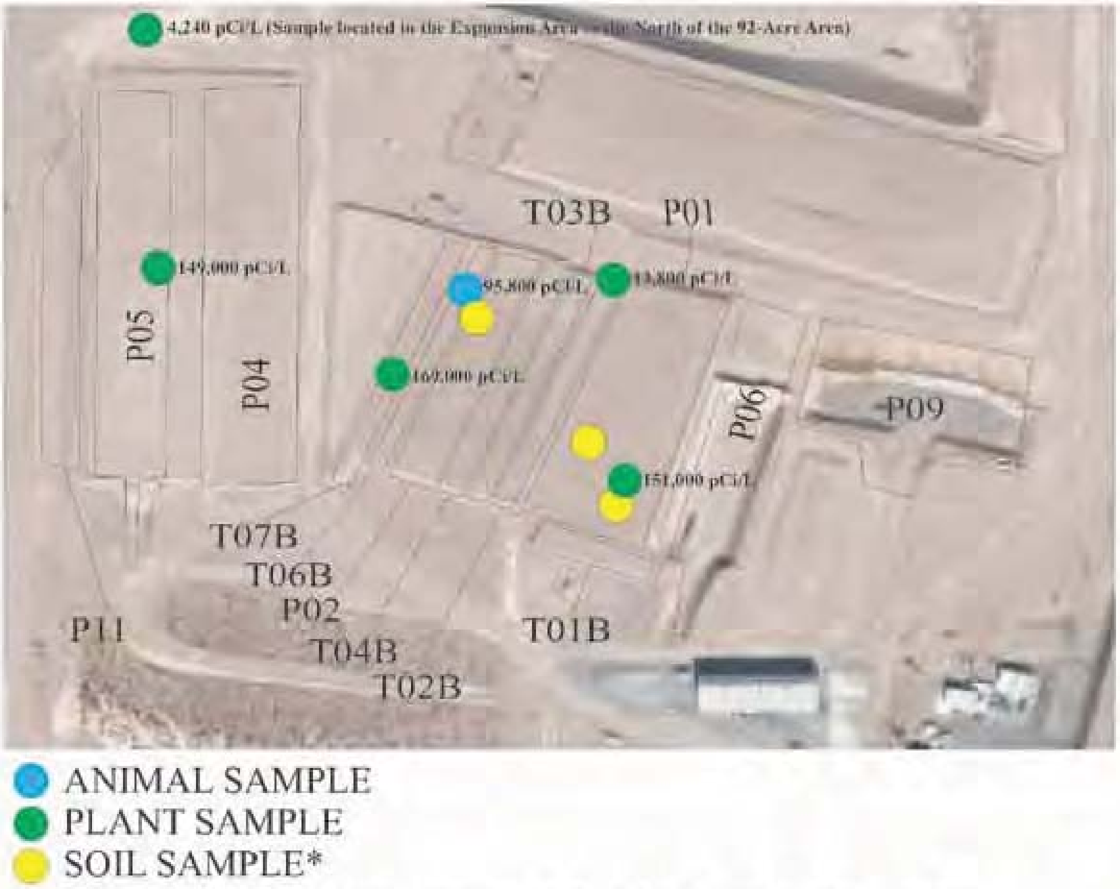
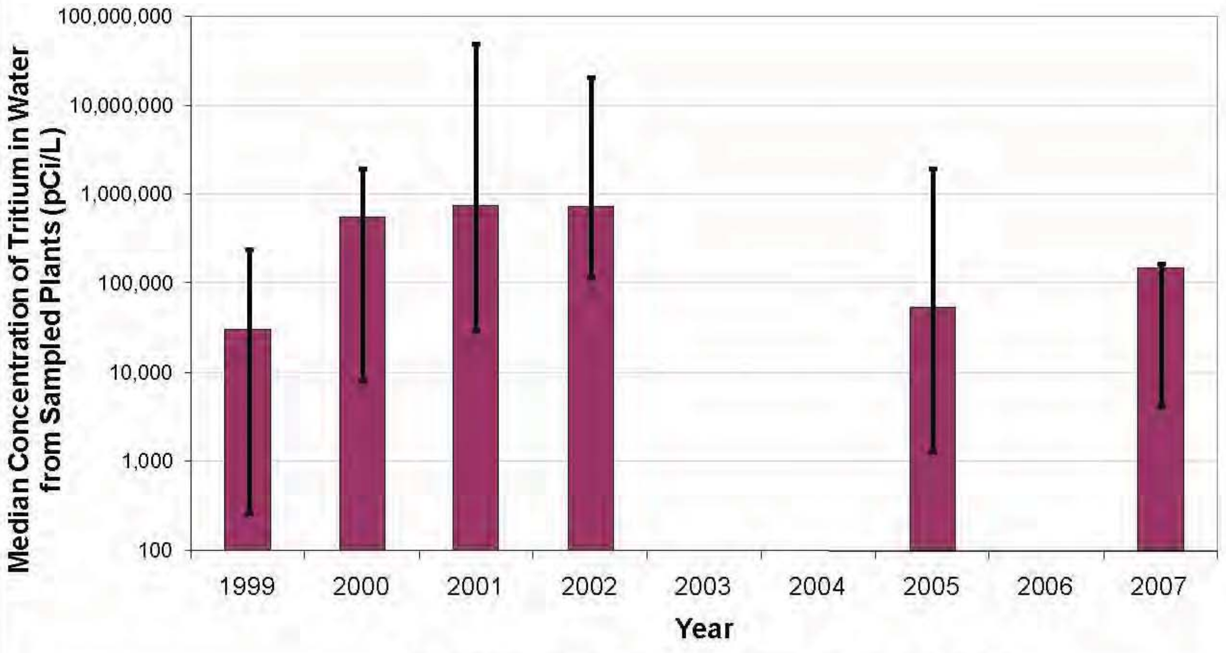


FIGURE 29. SMALL MAMMAL AND ANT BURROWING ACTIVITY IN 2007



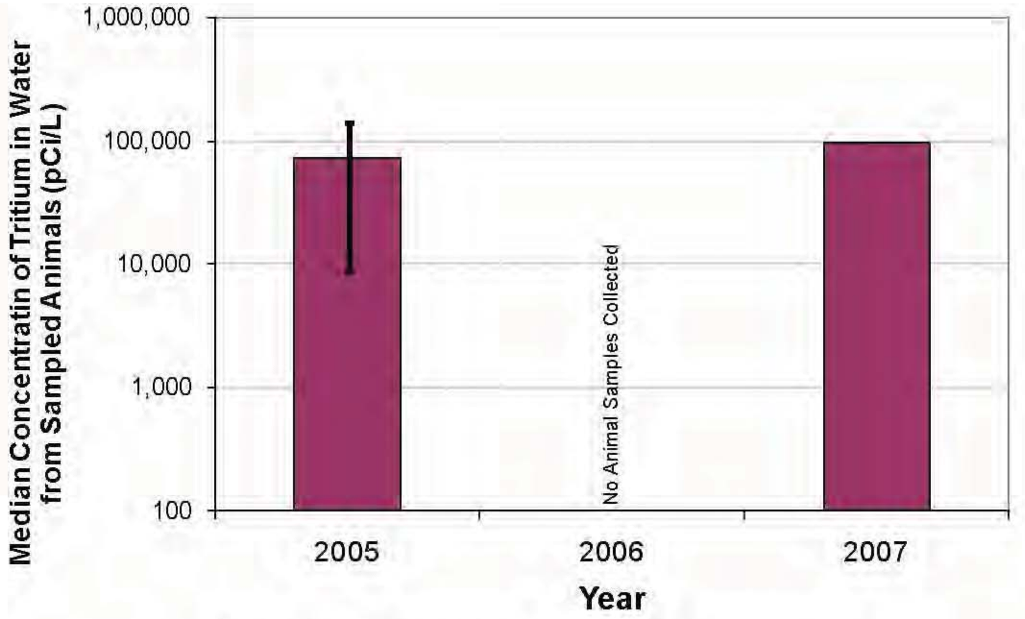
*Soil samples did not have tritium results due to too little water in soil for sample.

FIGURE 30. BIOTA MONITORING RESULTS FOR TRITIUM IN 2007



Error bars extend from the minimum to the maximum value observed in that year.

FIGURE 31. HISTORICAL PLANT MONITORING RESULTS FOR TRITIUM



Error bars extend from the minimum to the maximum value observed in that year.
In 2007, only one sample was collected; therefore, no error bars are shown.

FIGURE 32. HISTORICAL ANIMAL MONITORING RESULTS FOR TRITIUM

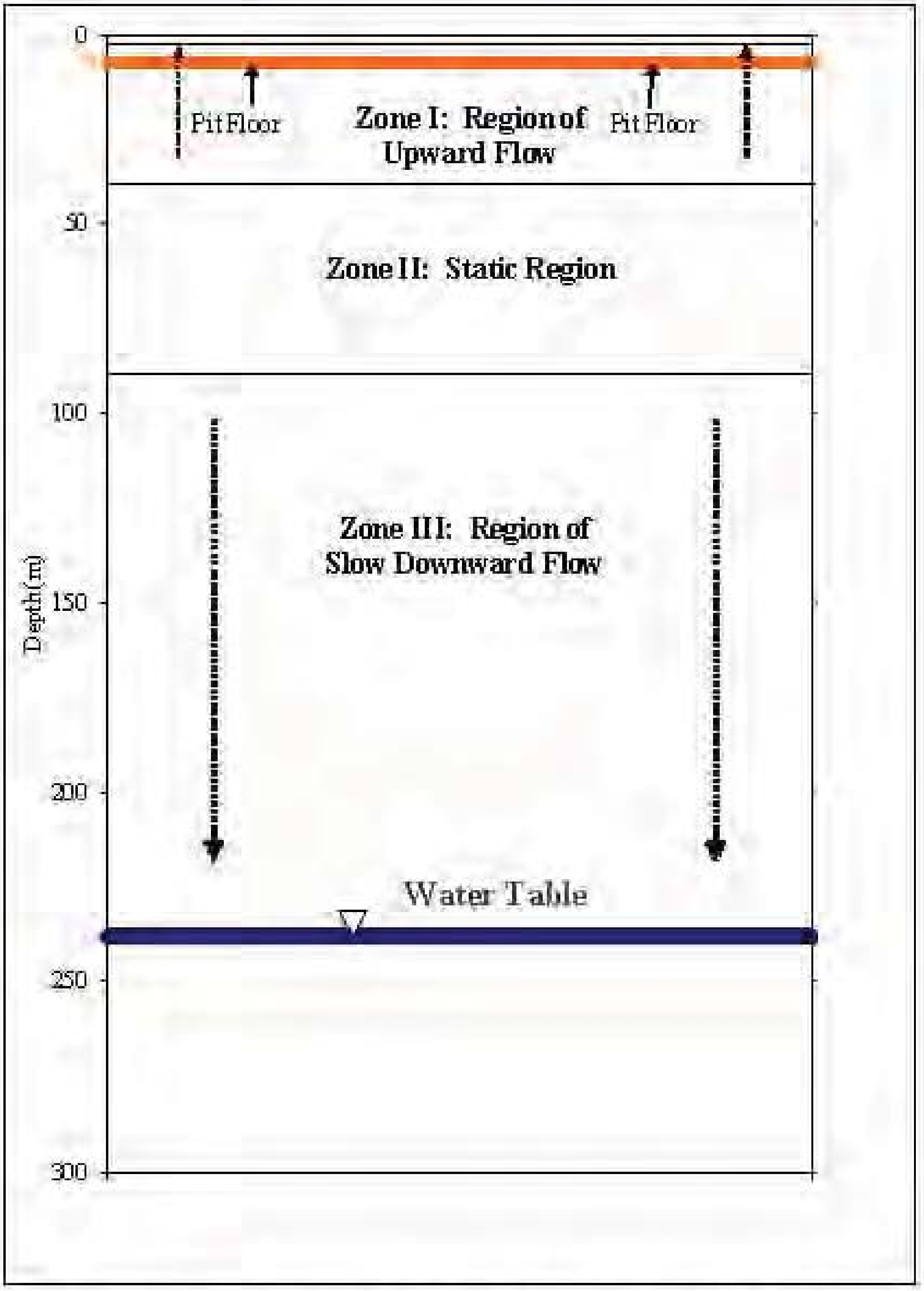


FIGURE 33. PERFORMANCE ASSESSMENT MODEL RESULTS

3.0 EVALUATION OF ALTERNATIVES

This section presents the corrective action objectives for the 92-Acre Area, describes the general standards and decision factors used to screen the various CAAs, and develops and evaluates a set of selected CAAs that will meet the corrective action objectives.

3.1 CORRECTIVE ACTION OBJECTIVES

The corrective action objective is to ensure that receptors are not subjected to unacceptable risk from an exposure to contamination. As illustrated in Figure 3 and summarized in Table 2, the only viable receptors are NTS workers and visitors that may be exposed to contaminants through ingestion, inhalation, or direct contact due to inadvertent disturbance into the waste (i.e., excavation) or contact with contaminants brought to the surface by erosion or biota. There is essentially no pathway to offsite residents. It would take more than 50,000 years for water to move from beneath the static region (approximately 90 m below grade) to the groundwater (approximately 220 m below grade), and calculated groundwater flow rates are less than 0.15 m per year. Implementation of the corrective action will ensure that the site will not pose an unacceptable risk to human health and the environment and that site conditions are in compliance with all applicable laws and regulations.

3.2 SCREENING CRITERIA

The screening criteria used to evaluate and select the preferred CAAs are identified in the U.S. Environmental Protection Agency (EPA) *Guidance on RCRA Corrective Action Decision Documents* (EPA, 1991) and the *Final RCRA Corrective Action Plan* (EPA, 1994). The CAAs are evaluated based on four general corrective action standards and five remedy selection decision factors. The CAAs must meet the four general corrective action standards to be selected for evaluation using the remedy selection decision factors.

The four general corrective action standards are as follows:

- Protection of human health and the environment
- Compliance with media cleanup standards
- Control of the source(s) of the release
- Compliance with applicable federal, state, and local standards for waste management

If a CAA does not meet one or more of the four general corrective action standards listed above, the CAA is not considered for further evaluation. If a CAA meets all four general corrective action standards listed above, the CAA is evaluated based on the following five remedy selection decision factors:

- Short-term reliability and effectiveness
- Reduction of toxicity, mobility, and/or volume
- Long-term reliability and effectiveness
- Feasibility
- Cost

3.2.1 Corrective Action Standards

The following sections describe the four general corrective action standards used to determine whether the CAAs will be considered for further evaluation.

3.2.1.1 *Protection of Human Health and the Environment*

Protection of human health and the environment is a general mandate of the RCRA statute (EPA, 1994). This mandate requires that the corrective action include any necessary protective measures. These measures may or may not be directly related to media cleanup, source control, or management of waste. The CAAs are evaluated for the ability to protect human health and the environment.

3.2.1.2 *Compliance with Media Cleanup Standards*

The CAAs are evaluated for the ability to meet the proposed media cleanup standards.

3.2.1.3 *Control of the Source(s) of the Release*

The CAAs are evaluated for the ability to control further environmental degradation by controlling or eliminating additional releases that may pose a threat to human health and the environment.

3.2.1.4 *Compliance with Applicable Federal, State, and Local Standards for Waste Management*

The CAAs are evaluated for the ability to be conducted in accordance with applicable federal and state regulations.

3.2.2 Remedy Selection Decision Factors

The following sections describe the five remedy selection decision factors used to evaluate the CAAs that meet all four general corrective action standards.

3.2.2.1 *Short-Term Reliability and Effectiveness*

Each CAA is evaluated with respect to its effects on human health and the environment during implementation of the selected corrective action. The following factors are addressed for each alternative:

- Protection of the community from potential risks associated with implementation, such as fugitive dusts, transportation of waste, or explosion
- Protection of workers during implementation
- Environmental impacts that may result from implementation
- The time required to achieve the corrective action objectives

3.2.2.2 *Reduction of Toxicity, Mobility, and/or Volume*

Each CAA is evaluated for its ability to reduce the toxicity, mobility, and/or volume of the contaminated media. Reduction in toxicity, mobility, and/or volume refers to changes in one or more characteristics of the contaminated media by the use of corrective measures that decrease the inherent threats associated with those media.

3.2.2.3 *Long-Term Reliability and Effectiveness*

Each CAA is evaluated in terms of risk remaining at the site after the CAA has been implemented. The primary focus of this evaluation is on the extent and effectiveness of the control that may be required to manage the risk posed by transportation, treatment, and disposal of excavated waste.

3.2.2.4 *Feasibility*

The feasibility criterion addresses the technical and administrative feasibility of implementing a CAA and the availability of services and materials needed for implementation. Each CAA is evaluated for the following criteria:

- *Construction and Operation* – The feasibility of implementing a CAA given the existing site-specific conditions
- *Administrative Feasibility* – The administrative activities needed to implement the CAA (e.g., permits, URs, public acceptance, rights-of-way, offsite approval)
- *Availability of Services and Materials* – The availability of adequate offsite and onsite treatment, storage capacity, disposal services, necessary technical services and materials, and prospective technologies for each CAA

3.2.2.5 *Cost*

Costs for each alternative are estimated for comparison purposes only. The cost estimate for each CAA is provided in Appendix B of this document. The following is a brief description of each component:

- *Capital Costs* – These include direct costs for material, labor, construction material, equipment purchase and rental, excavation and backfilling, sampling and analysis, waste disposal, demobilization, and health and safety measures. Indirect costs are separate and not included in the estimates.
- *Operation and Maintenance* – These costs are separate and include labor, training, sampling and analysis, maintenance material, utilities, and health and safety measures. These costs are not included in the estimates.

3.3 DEVELOPMENT OF CORRECTIVE ACTION ALTERNATIVES

This section identifies and summarizes the viable CAAs considered for the 92-Acre Area. Based on the review of existing data, future use, and current operations, the following alternatives have been developed for consideration:

- Alternative 1 – No Further Action
- Alternative 2 – Clean Closure
- Alternative 3 – Closure in Place with Administrative Controls
- Alternative 4 – Closure in Place with Administrative Controls with Removal of TRU Waste from Trench T04A

3.3.1 Alternative 1 – No Further Action

Alternative 1 is the baseline with which to compare and assess the other CAAs and their ability to meet the corrective action standards. The No Further Action alternative includes continuing the current monitoring activities at the 92-Acre Area, as described in Section 2.1, and maintaining the current operational covers.

3.3.2 Alternative 2 – Clean Closure

Alternative 2 involves the excavation, transportation, certification, and disposal of all waste present in the entire 92-Acre Area. Waste would be transported to and disposed at another (unspecified) location.

3.3.3 Alternative 3 – Closure in Place with Administrative Controls

Alternative 3 includes the administrative activities and costs associated with implementing a UR to restrict inadvertent contact with the waste by prohibiting any activity that would cause significant exposure of receptors to contaminants. The Closure in Place with Administrative Controls alternative includes leaving all buried waste in place, constructing an engineered cover over the 92-Acre Area, installing UR warning signs and concrete monuments, and implementing post-closure monitoring.

3.3.4 Alternative 4 – Closure in Place with Administrative Controls with Removal of TRU Waste from Trench T04A

Alternative 4 includes excavation and disposal of TRU waste that was inadvertently disposed in trench T04A in addition to implementing a UR for remaining waste. This alternative includes sorting the waste in trench T04A; packaging the TRU waste from the trench; returning the remaining waste to the trench; certifying, transporting, and disposing of the TRU waste; constructing an engineered cover over the 92-Acre Area; installing UR warning signs and concrete monuments; and implementing post-closure monitoring.

3.4 EVALUATION AND COMPARISON OF ALTERNATIVES

Each CAA presented in Section 3.3 has been evaluated based on the four general corrective action standards described in Section 3.2.1. Table 3 presents the results of this evaluation. If a CAA does not comply with all of the general corrective action standards, it is not considered for further evaluation. Alternatives 1, 3, and 4 comply with all of the general corrective action standards and have been further evaluated.

Alternative 2, Clean Closure, will not be considered for further evaluation because it does not comply with the first corrective action standard, protection of human health and the environment. This alternative would reduce the localized risk to the environment, but it would not reduce the overall risk because the waste and associated risk would simply be moved to another disposal location. This alternative would present significant risk to workers during excavation, repackaging, transportation, and placement of waste, with no overall benefit or reduction of risk to the environment. Therefore, the Clean Closure alternative will not be considered for further evaluation.

TABLE 3. EVALUATION OF GENERAL CORRECTIVE ACTION STANDARDS

<table>
<tr><th colspan="3">ALTERNATIVE 1 – NO FURTHER ACTION</th></tr>
<tr><th>Standard</th><th>Comply</th><th>Explanation</th></tr>
<tr><td>Protection of human health and the environment</td><td>Yes</td><td>The current monitoring network assures the protection of human health and the environment.</td></tr>
<tr><td>Compliance with media cleanup standards</td><td>Yes</td><td>Waste will not be removed, and NTS workers will not be exposed to excavation risks.</td></tr>
<tr><td>Control of the source(s) of the release</td><td>Yes</td><td>Characterization and monitoring show there is no migration beyond the waste cells, and current monitoring assures future migration will not occur.</td></tr>
<tr><td>Compliance with federal, state, and local standards for waste management</td><td>Yes</td><td>This alternative will not generate waste.</td></tr>
<tr><th colspan="3">ALTERNATIVE 2 – CLEAN CLOSURE, ALL WASTE IN THE 92-ACRE AREA</th></tr>
<tr><th>Standard</th><th>Comply</th><th>Explanation</th></tr>
<tr><td>Protection of human health and the environment</td><td>No</td><td>Workers will be exposed to unacceptable risk, with increased risk to the community from transport of waste.</td></tr>
<tr><td>Compliance with media cleanup standards</td><td>Yes</td><td>Waste will be removed.</td></tr>
<tr><td>Control of the source(s) of the release</td><td>Yes</td><td>Waste will be removed.</td></tr>
<tr><td>Compliance with federal, state, and local standards for waste management</td><td>Yes</td><td>Excavated waste can be managed in compliance with all standards.</td></tr>
<tr><th colspan="3">ALTERNATIVE 3 – CLOSURE IN PLACE WITH ADMINISTRATIVE CONTROLS</th></tr>
<tr><th>Standard</th><th>Comply</th><th>Explanation</th></tr>
<tr><td>Protection of human health and the environment</td><td>Yes</td><td>A UR and post-closure monitoring will be implemented to protect receptors from exposure to waste.</td></tr>
<tr><td>Compliance with media cleanup standards</td><td>Yes</td><td>Waste will remain in place, and NTS workers will not be exposed to excavation risks.</td></tr>
<tr><td>Control of the source(s) of the release</td><td>Yes</td><td>Characterization and monitoring show there is no migration beyond the waste cells, and post-closure monitoring will be implemented to assure future migration will not occur.</td></tr>
<tr><td>Compliance with federal, state, and local standards for waste management</td><td>Yes</td><td>This alternative will not generate waste.</td></tr>
<tr><th colspan="3">ALTERNATIVE 4 – CLOSURE IN PLACE WITH ADMINISTRATIVE CONTROLS
WITH REMOVAL OF TRU WASTE FROM TRENCH T04A</th></tr>
<tr><th>Standard</th><th>Comply</th><th>Explanation</th></tr>
<tr><td>Protection of human health and the environment</td><td>Yes</td><td>TRU waste will be removed from Trench T04A, and a UR and post-closure monitoring will be implemented to protect receptors from exposure to waste.</td></tr>
<tr><td>Compliance with media cleanup standards</td><td>Yes</td><td>Most of the waste will remain in place, but NTS workers will be exposed to waste removed from Trench T04A.</td></tr>
<tr><td>Control of the source(s) of the release</td><td>Yes</td><td>Characterization and monitoring show there is no migration beyond the waste cells, and post-closure monitoring will be implemented to assure future migration will not occur.</td></tr>
<tr><td>Compliance with federal, state, and local standards for waste management</td><td>Yes</td><td>Excavated waste can be managed in compliance with all standards.</td></tr>
</table>

NTS: Nevada Test Site
TRU: transuranic
UR: use restriction

Each of the remaining CAAs has been further evaluated based on the five remedy selection decision factors described in Section 3.2.2. Table 4 presents this evaluation. For each remedy selection decision factor, the CAAs are ranked relative to one another. The CAA with the least desirable impact on the remedy selection decision factor is given a ranking of 1. CAAs with increasing desirable impacts on the remedy selection decision factor receive increasing rank numbers. CAAs with equal impact on the remedy selection decision factor receive an equal ranking number.

For example, for the remedy selection decision factor of "feasibility," the CAA with the least desirable impact (in this case, the CAA that is the least feasible) is given a ranking of 1, and the CAA with the most desirable impact (in this case, the CAA that is the most feasible) is given a ranking of 3. For the remedy selection decision factor of "cost," the CAA with the least desirable impact (in this case, the CAA with the highest cost) is given a ranking of 1, and the CAA with the most desirable impact (in this case, the CAA with the lowest cost) is given a ranking of 3.

The total score presented in Table 4 is the sum of the remedy selection decision factor rankings for each CAA. The CAA with the highest total score is selected as the preferred CAA. This evaluation shows that the CAA with the highest total score has the most desirable overall impact on short-term reliability and effectiveness; reduction of toxicity, mobility, and/or volume; long-term reliability and effectiveness; feasibility; and cost.

TABLE 4. EVALUATION OF REMEDY SELECTION DECISION FACTORS

ALTERNATIVE 1 – NO FURTHER ACTION

Factor	Rank	Explanation
Short-term reliability and effectiveness	2	Reliable and effective in providing protection of workers, the community, and the environment by continuing current monitoring activities
Reduction of toxicity, mobility, and/or volume	2	Does not reduce toxicity or mobility of buried waste, but will not generate excavation waste volumes
Long-term reliability and effectiveness	1	Current ongoing monitoring is reliable in the long term, but less reliable than Alternatives 3 and 4
Feasibility	3	Most easily implemented alternative
Cost	3	Involves low cost for maintaining the current monitoring system
Score	**11**	

ALTERNATIVE 2 – CLEAN CLOSURE, ALL WASTE IN THE 92-ACRE AREA

Factor	Rank	Explanation
This CAA did not meet the general corrective action standards and was therefore not further evaluated.		

ALTERNATIVE 3 – CLOSURE IN PLACE WITH ADMINISTRATIVE CONTROLS

Factor	Rank	Explanation
Short-term reliability and effectiveness	3	Most reliable and effective in providing protection of workers, the community, and the environment by preventing contact with buried waste
Reduction of toxicity, mobility, and/or volume	3	Reduces toxicity and mobility of buried waste through construction of engineered cover and will not generate excavation waste volumes
Long-term reliability and effectiveness	2	Reliable in the long term by providing increased protection of human health and the environment by preventing contact with buried waste and implementing post-closure monitoring
Feasibility	2	Easily implemented but requires implementation of post-closure monitoring
Cost	2	Involves lower cost for construction of an engineered cover and post-closure monitoring
Score	**12**	

ALTERNATIVE 4 – CLOSURE IN PLACE WITH ADMINISTRATIVE CONTROLS WITH REMOVAL OF TRU WASTE FROM TRENCH T04A

Factor	Rank	Explanation
Short-term reliability and effectiveness	1	Of the alternatives that complied with all of the general corrective action standards, involves the highest risk to workers, the community, and the environment during excavation, transport, and disposal of waste
Reduction of toxicity, mobility, and/or volume	1	Could decrease mobility; however, will generate large excavation waste volumes
Long-term reliability and effectiveness	2	Increases long-term protection of human health and the environment because TRU waste will be removed; however, TRU waste does not pose a risk to human health and the environment in its current configuration, so this is equally as reliable as Alternative 3
Feasibility	1	Involves the most complicated implementation
Cost	1	Involves the highest cost for excavation of TRU waste, construction of an engineered cover, and future monitoring for remaining waste
Score	**6**	

TRU: transuranic

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4.0 RECOMMENDED ALTERNATIVE

Alternative 3, Closure in Place with Administrative Controls, is the preferred CAA for the 92-Acre Area. The preferred CAA was evaluated on technical merits with focus on performance, reliability, feasibility, safety, and cost. The Closure in Place with Administrative Controls alternative was judged to meet all requirements for the technical components evaluated; meets all applicable federal and state regulations for closure of the site, including 40 CFR 265, 40 CFR 191, and DOE O 435.1; and will minimize potential future exposure pathways to the buried waste at the site.

Selection of this CAA is consistent with past practices for sites that contain buried waste where the removal of buried waste is not feasible. For example, CAU 92, Area 6 Decon Pond Facility, a RCRA unit consisting of an unlined pond used for the disposal of untreated liquid effluent from the laundering of radioactively contaminated clothing and decontamination of heavy equipment, was closed in place. A Corrective Measures Study found that this was the most cost-effective method of meeting the closure objectives and complying with regulatory requirements (DOE, 1997). CAU 110, Area 3 RWMS U-3ax/bl Disposal Unit, was closed in place with an engineered RCRA alternative cover designed to accommodate differential subsidence. The cover is a vegetated natural alluvium mono-layer cover. It was determined that the disposal unit could accommodate infiltration, evaporation, and plant and animal activity in its present state and keep buried waste contained (U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office [NNSA/NV], 1999).

Closure activities will include the following:

- Constructing an engineered cover over the 92-Acre Area
- Installing UR warning signs, concrete monuments, and subsidence survey monuments
- Establishing vegetation on the cover
- Implementing a UR
- Implementing post-closure inspections and monitoring

There are several engineered cover options available, including, but not limited to, clay covers, native soil covers, multi-layer covers, and asphalt covers. Numerous studies have evaluated the performance of each of these. In arid environments, the native soil evapotranspiration cover has proven to be the most protective with long-term stability and effectiveness (Reynolds Electrical and Engineering Company, Inc, 1994; Dwyer et al., 1999; DOE, 2000; Madalinski et al., 2003). An extensive evaluation of cover alternatives was performed for CAU 110, Area 3 RWMS U-3ax/bl Disposal Unit, a historic RCRA disposal unit located in Area 3 of the NTS. An evapotranspiration cover was selected from nine cover options (NNSA/NV, 2000). The CAU 110 cover has been demonstrated to be very effective since its installation in 2000. Consistent with industry experience and the successful cover at CAU 110, an evapotranspiration cover has been selected as the appropriate engineered cover for the 92-Acre Area.

To evaluate closure alternatives and demonstrate compliance with federal regulations, an optimization of the closure cover design was performed and tested with the current performance assessment model to confirm that all performance objectives can be met. The optimization included a quantitative analysis of closure cover thickness with respect to protection of human health and the environment. Five discrete cover thickness options ranging from 2.5 to 4.5 m were evaluated (Shott and Yucel, 2009).

The optimum cover thickness that maintains doses as low as reasonably achievable (ALARA) was determined to be 2.5 m. A 2.5-m closure cover can meet all applicable regulatory requirements and maintain radionuclide releases ALARA (Shott and Yucel, 2009).

Figure 34 illustrates that increasing the cover thickness above 2.5 m provides no significant increase in protection of human health or the environment. There is no significant decrease in dose to the public, which is shown in Figure 34 in units of person-Sieverts (per-Sv) (Shott and Yucel, 2009). In fact, increasing cover thickness beyond this optimum value would increase the risk to the workers who construct the cover due to unnecessary exposure to standard industrial risks associated with heavy equipment operation during soil excavation, transportation, and placement.

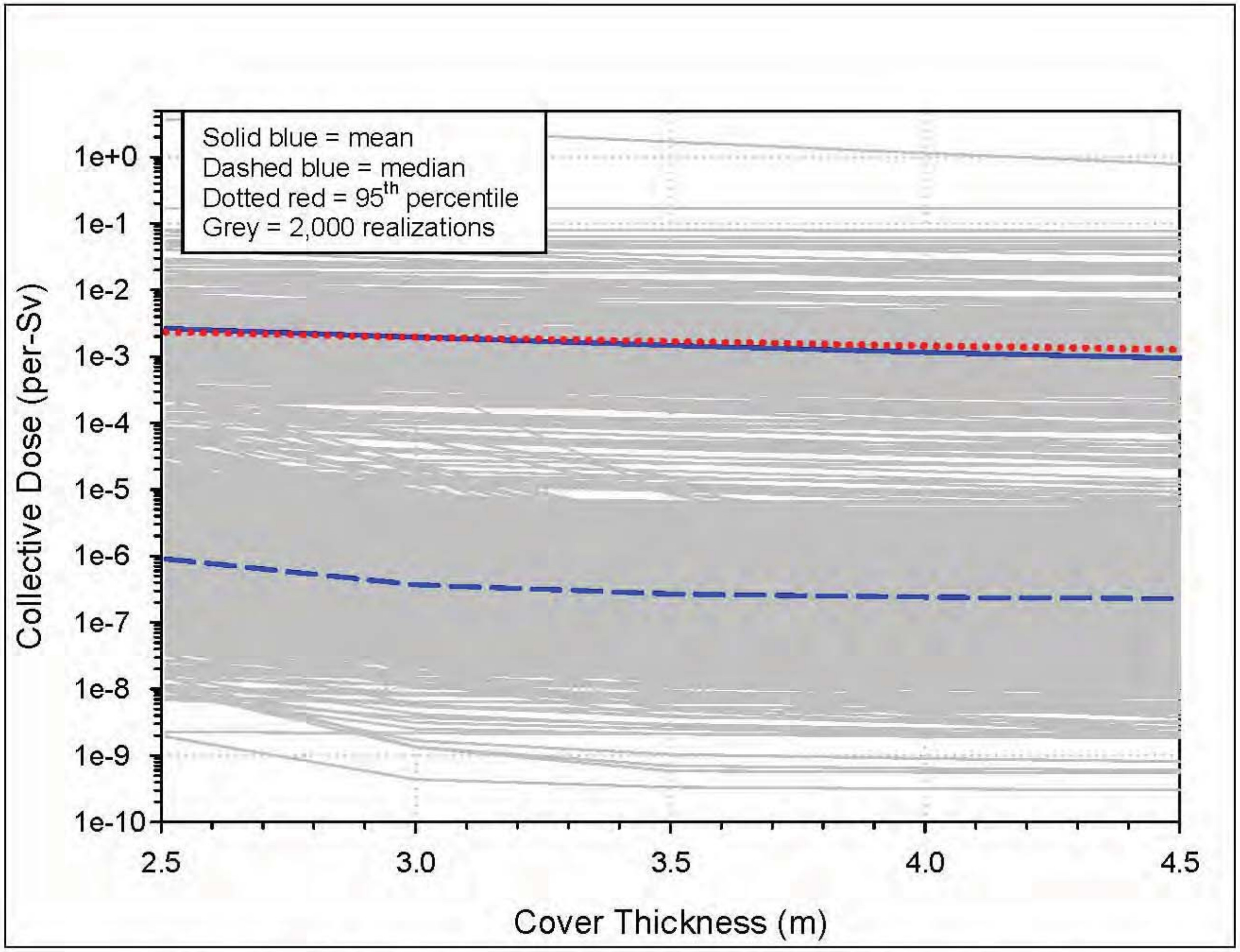

FIGURE 34. COLLECTIVE DOSE VERSUS COVER THICKNESS

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5.0 DETAILED STATEMENT OF WORK

The following sections provide a description of the preferred CAA, identify the QA/QC requirements, describe waste management activities, present activities that will be completed to confirm the corrective actions, and identify the permits required to complete the corrective actions.

5.1 PREFERRED CORRECTIVE ACTION ALTERNATIVE

The preferred CAA for the 92-Acre Area, as evaluated in Section 3.0 and identified in Section 4.0, is Closure in Place with Administrative Controls. A 2.5-m-thick engineered evapotranspiration cover will be installed over the 92-Acre Area. The engineering drawings, specifications, and calculations are included as Appendix C of this document.

The cover has been designed to meet the following requirements, according to 40 CFR 265, Subpart N, §265.310, "Closure and Post-Closure Care," (CFR, 2006d):

- Provide long-term minimization of migration of liquid through the landfill
- Function with minimum maintenance
- Promote drainage and minimize erosion of the cover
- Accommodate settling and subsidence to maintain the cover's integrity

5.1.1 Site Preparation

The site will be cleared and grubbed prior to installation of the cover. All aboveground electrical panels, monitoring devices, and junction boxes, except as noted in the engineering design, will be removed. The existing chain link and smooth wire fencing will be removed. The GCD boreholes will be backfilled. The TDR monitoring cabinets in Pit 3 and Pit 4 will be raised and reinstalled on the new surface. All existing underground water, sewer, and communication lines will remain in place. Underground power lines will be abandoned in place. The siren pole that is currently located near Pit 1 will be relocated to a location outside the cover.

5.1.2 Engineered Cover Construction

With the exception of three active pits (P03, P06, and P09), all trenches and pits in the 92-Acre Area have current operational covers approximately 2.4 m thick; therefore, construction of the cover over these units will consist of augmenting the current operational covers to the final thickness, grade, and slope required by the final engineering design. For the open pits, the backfill will be placed in 12-inch lifts and compacted to not less than 90 percent of the maximum dry unit weight according to American Society for Testing of Materials Standard D1557.

An existing stockpile of clean soil located at the site will be used for backfill and for construction of the cover. The soil does not require conditioning prior to use, as it meets the engineering specifications. To minimize the volume of soil needed for construction of the cover while promoting drainage and minimizing erosion, the cover will consist of three smaller covers separated by drainage channels, a concrete culvert, and corrugated metal culverts. Riprap will also be installed in select areas to minimize erosion of the covers, side slopes, and drainage channels. The typical surface side slope of the covers will be 5:1.

5.1.3 Subsidence Monument Installation

A total of 68 concrete subsidence survey monuments, measuring 2 feet by 2 feet by 6 inches high, will be installed on the covers. Brass caps will be installed on the monuments and stamped with the elevation and geographical coordinates measured at the time of installation.

5.1.4 Vegetation Establishment

After cover construction is complete, the cover will be seeded with a mixture of shallow rooting native plant species. The vegetation will minimize wind and water erosion and remove water from the cover through evapotranspiration. The top 12 to 18 inches of soil will be prepared to provide a suitable environment for the establishment of the seeds. This includes adding amendments to the soil and alleviating soil compaction. Straw mulch will be applied over the seeds to protect them from erosion and conserve soil moisture. Irrigation will initially be used to augment precipitation and provide optimal conditions to ensure successful seed germination. Irrigation will be minimized to limit infiltration through the cover. Additional details on the establishment of vegetation on the cover are included in Appendix I.

5.1.5 Fence Installation

A fence is not required around the 92-Acre Area. A 3-strand wire fence currently exists around the entire RWMS, and this fence serves to enhance access control to the site as a best management practice. Quarterly post-closure inspections, as described in Section 7.1, will identify any animal burrows that may affect the integrity of the cover. These animal burrows will be backfilled within 60 calendar days of discovery.

5.1.6 Use Restriction Implementation

UR warning signs and concrete monuments will be installed according to the *FFACO Use Restriction Posting Guidance* to delineate the UR area (FFACO, 2003). Concrete monuments that currently mark the boundaries of disposal units and measure 2 feet by 2 feet by 5 feet high will be re-installed along the perimeter of the UR area, and UR warning signs will be attached to the monuments. A UR will be implemented to prohibit any unauthorized intrusive activity. A final survey plat will be prepared and certified by a professional land surveyor. Post-closure inspections and monitoring will be implemented according to the requirements in Section 7.0.

5.2 CONSTRUCTION QUALITY ASSURANCE/QUALITY CONTROL

Engineering drawings, specifications, and calculations are included as Appendix C.

5.2.1 Construction Field Sample Collection Activities

Additional details on construction field sample requirements are included in the engineering specifications in Appendix C. Sieve analysis will be performed at a frequency of one test per 1,000 cubic yards of fill, and at least once per day, to ensure backfill has a maximum particle size of 3 inches and a maximum of 20 percent passing the number 200 sieve. Compaction tests will be performed near the bottom of each lift at a frequency of one test per 10,000 square feet, and at least three per lift, to ensure backfill is compacted to at least 90 percent of the maximum dry unit weight according to American Society for Testing of Materials Standard D1557.

5.2.2 Construction Laboratory/Analytical Data Quality Indicators

Construction activities are limited to installation of a native soil cover and do not include structural activities. A construction QA/QC plan is not required, and construction Data Quality Indicators (DQIs) are not applicable.

5.3 WASTE MANAGEMENT

Waste is not expected to be generated during closure of the 92-Acre Area. However, if generated, all waste will be managed and disposed according to applicable federal and state regulations and company waste management procedures.

5.3.1 Waste Minimization

If waste is generated, care will be taken to properly characterize and segregate waste streams to avoid the generation of additional waste.

5.4 CONFIRMATION OF CORRECTIVE ACTIONS

The corrective actions will be confirmed by visual inspection and photographic documentation of the final site conditions, and the cover will be as-built surveyed. The final survey plat that will be prepared and certified by a professional land surveyor will be included in the Closure Report for the site. In addition, a registered professional engineer will review this Closure Plan and sign a certification of closure that states that the site has been closed in accordance with the specifications of this plan. The certification of closure will be included in the Closure Report for the site. DQIs are not applicable to this project because verification samples will not be collected for site closure.

5.5 PERMITS

Prior to beginning closure activities, planning documents and permits will be prepared. These documents will include a *National Environmental Policy Act* (NEPA) Checklist, a Real Estate/Operations Permit (REOP), Radiological Work Permits (RWPs), excavation permits, and blind penetration permits. After closure activities are complete, a request for the modification of RCRA Permit NEV HW0021 to incorporate the requirements for post-closure monitoring will be submitted to NDEP (NDEP, 2005).

5.5.1 *National Environmental Policy Act* Checklist

A NEPA Checklist will be completed prior to all closure activities at the site to ensure closure activities will follow all applicable federal, state, and local laws, regulations, and permits regarding protection of the environment. A new borrow pit will not be developed for closure of the site because an existing stockpile of clean soil is located at the site for backfill and construction of the cover; therefore, an additional NEPA evaluation will not be required.

5.5.2 Real Estate/Operations Permit

A REOP will be obtained prior to beginning closure activities. The permit will establish NNSA/NSO as the prime authority possessing control of the site.

5.5.3 Radiological Work Permit

RWPs will be implemented when radiological conditions require, as determined by Health Physics. RWPs will inform workers of the specific personal protective equipment necessary to protect them while performing their tasks and identify site-specific controls. The workers will be required to sign RWPs and acknowledge understanding of the requirements before entry into any radiologically controlled area. RWPs will be maintained by the Radiological Control Technician at the entrance to the radiologically controlled area. All site workers will be required to be Radiation Worker II-trained to perform work within a radiologically controlled area.

5.5.4 Utility Clearances, Excavation Permits, and Blind Penetration Permits

An excavation permit and a blind penetration permit will be obtained prior to beginning land-disturbing activities. These permits require that a utility clearance be performed. A copy of the permit will be available on site throughout the duration of the project.

5.5.5 *Resource Conservation and Recovery Act* Permit

After closure activities are complete, a request for the modification of RCRA Permit NEV HW0021, to incorporate the requirements for post-closure monitoring identified in Section 7.0, will be submitted to NDEP (NDEP, 2005).

6.0 SCHEDULE

According to 40 CFR 265, Subpart G, "Closure and Post-Closure," the following schedule restraints will be adhered to (CFR, 2006d):

- This Closure Plan will be submitted to NDEP at least 180 days prior to the date on which closure is expected to begin.
- NDEP will be notified in writing at least 60 days prior to the date on which closure is expected to begin.
- The public will have 30 days to submit written comments on the plan and request modifications to the plan.
- Closure activities will be completed within 180 days after receiving the final volume of waste or 180 days after approval of this Closure Plan, whichever is later.
- Certification that the facility has been closed in accordance with the specifications in the approved Closure Plan will be submitted to NDEP by registered mail within 60 days of completion of closure.

Figure 35 illustrates the schedule for closure of the 92-Acre Area. Pit 3 MWDU is scheduled to receive its final shipment of waste on November 30, 2010. Closure is expected to begin immediately thereafter. Therefore, this Closure Plan must be submitted to NDEP by June 3, 2010, which is 180 days prior to the date on which closure is expected to begin. Closure activities for the entire 92-Acre Area will be completed by May 29, 2011, which is 180 days after the final volume of waste will be received. Certification of closure will be submitted to NDEP by July 28, 2011, which is 60 days after closure will be completed. The Closure Report will be prepared with this final due date in mind.

All preparation and field activities are scheduled for completion in 2011. Sufficient flexibility will be incorporated into the field schedule to allow for minor difficulties (e.g., weather, equipment failure). NNSA/NSO shall notify NDEP of any condition or event that may impact the project schedule.

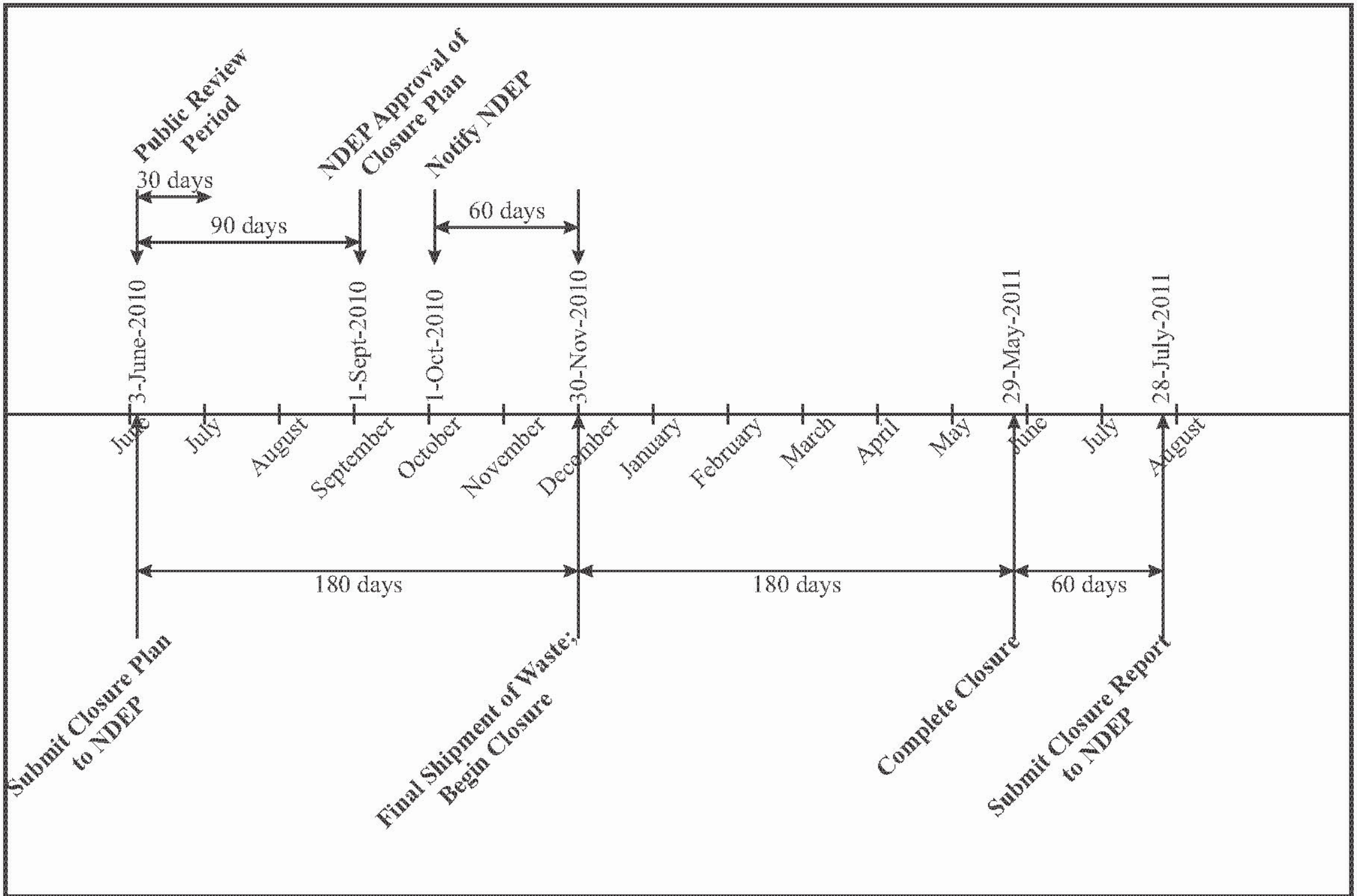


FIGURE 35
92-ACRE AREA CLOSURE SCHEDULE

7.0 POST-CLOSURE PLAN

The 92-Acre Area will be closed in place with administrative controls, and a UR will be implemented to prohibit any unauthorized intrusive activities. Post-closure inspections and monitoring will be required. This section serves as the Post-Closure Plan, which is required by 40 CFR 265, for the 92-Acre Area. These requirements will be submitted to NDEP as part of the request for the modification of RCRA Permit NEV HW0021 (NDEP, 2005).

This post-closure plan meets the following requirements of 40 CFR 265, Subpart N, §265.310, "Closure and Post-Closure Care" (CFR, 2006d):

- Maintain the integrity and effectiveness of the cover by making repairs to correct the effects of settling, subsidence, and erosion
- Monitor groundwater quality
- Prevent run-on and runoff from damaging the cover
- Maintain surveyed benchmarks

7.1 INSPECTIONS

Quarterly visual site inspections will be completed at the 92-Acre Area for at least 30 years. Inspections will be conducted to verify that the UR warning signs are in place and readable and that the UR has been maintained. During the quarterly inspections, the cover will be inspected for cracks, animal burrows, or other evidence of subsidence or erosion, and the integrity of the berms will be verified. In addition, non-scheduled inspections will be conducted if precipitation occurs in excess of 1.0 inch in a 24-hour period at the rain gauge shown in Figure 2, which is located near the southeast corner of the Area 5 RWMS. These inspections will be conducted to verify the continued integrity of the cover and document any ponding or erosion.

The subsidence survey monuments will be land surveyed on an annual basis to determine if the cover has subsided. In addition, an annual assessment will be conducted by an ecological specialist or biologist to evaluate the success of the establishment of vegetation on the cover and make recommendations for maintenance of the vegetation.

The results of inspections, subsidence surveys, and vegetation surveys will be documented in the annual combined post-closure report for closed RCRA CAUs and submitted to NDEP. The post-closure report will include a discussion of observations made during the inspections, record the subsidence survey results, summarize the results of the vegetation survey, and provide a record of repair and maintenance activities. In addition, copies of the completed inspection checklists, field notes recorded during the inspections, and photographs taken during the inspections to document site conditions will be included in the post-closure report.

7.2 MONITORING

Post-closure monitoring will consist of continuing the current monitoring activities identified in Section 2.1, enhanced with a progressive approach for vadose zone monitoring. The current monitoring network is shown in Figure 2 and summarized in Table 1. Of the current monitoring activities identified in Table 1, soil gas monitoring and biota monitoring are not proposed to be continued during the post-closure period. Table 5 summarizes the post-closure inspection and monitoring activities that will be conducted, the compliance criteria established for each activity, and the actions required if the compliance criteria are exceeded.

TABLE 5. POST-CLOSURE REQUIREMENTS AND COMPLIANCE CRITERIA FOR THE 92-ACRE AREA

ACTIVITY	REQUIREMENT	COMPLIANCE CRITERIA AND ACTIONS
Visual Inspections	• Quarterly visual site inspections for cracks, animal burrows, subsidence, erosion, and FFACO UR compliance • Additional inspections for ponding and erosion after precipitation events in excess of 1.0 inch in a 24-hour period	Cracks or settling imperfections greater than 15 cm deep that extend 1.0 m or more on the cover (through animal burrows, erosion, or subsidence) will be reported to NDEP within 14 days and repaired within 60 days of discovery. Damaged or missing UR warning signs will be repaired or replaced within 60 days of discovery. Evidence of human intrusion into the cover will be reported to NDEP immediately upon discovery.
Subsidence Surveys	Annual land surveys of subsidence survey monuments	Significant subsidence will be reported to NDEP within 14 days and repaired within 60 days of discovery.
Vegetation Surveys	Annual survey by an ecological specialist or biologist	Recommendations made by ecological specialist or biologist will be implemented.
Direct Radiation Monitoring	Quarterly measurements from TLDs	TLD exposure rate measurements greater than 3 times background will be reported to NDEP within 14 days of discovery.
Air Monitoring	Atmospheric moisture samples analyzed for tritium every two weeks and air samples submitted for laboratory analysis of gamma-emitting and isotopic radionuclides monthly	Radionuclide concentrations in air that exceed the limits identified in Table 6 will be reported to NDEP within 14 days of discovery.
Radon Flux Monitoring	Annual measurements of radon flux	Radon fluxes that exceed the regulatory limit of 20 pCi/m^2s will be reported to NDEP within 14 days of discovery.
Groundwater Monitoring	Water levels in the three existing wells measured quarterly and groundwater samples analyzed for contamination indicators and water chemistry parameters every 6 months	Groundwater indicators of contamination that exceed the limitations listed in Table 7 or water chemistry parameters that exceed the National Primary Drinking Water Standards (CFR, 2006a) will be reported to NDEP within 14 days of discovery.
Meteorology Monitoring	Precipitation, air temperature, relative humidity, wind speed and direction, and barometric pressure recorded daily	None
Vadose Zone Monitoring	TDR probe and lysimeter data downloaded quarterly	See Table 8.
Evaluation of Monitoring Program	Monitoring program evaluated every 5 years to determine whether the frequency and/or approach should be modified	None

CFR: Code of Federal Regulations
cm: centimeter(s)
FFACO: *Federal Facility Agreement and Consent Order*
m: meter(s)
NDEP: Nevada Division of Environmental Protection
pCi/m^2s: picocurie(s) per square meter per second
TDR: time-domain reflectometry
TLD: thermoluminescent dosimeter
UR: use restriction

TABLE 6. COMPLIANCE CRITERIA FOR AIR MONITORING

PARAMETER	DCG
Tritium	25,000 pCi/m^3
Americium-241	0.005 pCi/m^3
Plutonium-238	0.0075 pCi/m^3
Plutonium-239/240	0.005 pCi/m^3

DCG: Derived Concentration Guide (scaled to a 25-millirem per year inhaled dose to the public constraint) (U.S. Department of Energy, 1993)
pCi/m^3: picocurie(s) per cubic meter

TABLE 7. LIMITATIONS FOR GROUNDWATER INDICATOR PARAMETERS

PARAMETER	LIMITATIONS
pH	Between 7.6 and 9.2
Specific Conductance	< 0.440 mmhos/cm
Total Organic Carbon	< 1 mg/L
Total Organic Halides	< 50 µg/L
Tritium	< 2,000 pCi/L

mmhos/cm: millimho(s) per centimeter
mg/L: milligram(s) per liter
µg/L: microgram(s) per liter
pCi/L: picocurie(s) per liter

Because there is some uncertainty associated with the contents of the landfill units, this monitoring program is sufficient to identify migration of any potential contaminants within the landfill units.

According to 40 CFR 265, Subpart G, §265.117, "Post-Closure Care and Use of Property," post-closure monitoring will be conducted for at least 30 years (CFR, 2006d). Every 5 years, the monitoring program will be evaluated to determine whether the frequency and/or approach should be modified based on monitoring results, changes in climatic conditions, potential change in the direction of the aquifer flow, and offsite activities that could impact water quality. During these 5-year monitoring evaluations, NNSA/NSO may request that the frequency and/or complexity of monitoring be adjusted.

The proposed monitoring program is more conservative and more protective than required by 40 CFR 265 or precedence. According to 40 CFR 265, Subpart F, §265.90, "Ground-Water Monitoring," all or part of the groundwater monitoring requirements in this subpart may be waived if it can be demonstrated that there is a low potential for migration of hazardous constituents via the uppermost aquifer to water supply wells or to surface water (CFR, 2006d). For CAU 110, Area 3 RWMS U-3ax/bl Disposal Unit, a historic RCRA disposal unit located in Area 3 of the NTS with similar climatic and geologic conditions to the 92-Acre Area, such a waiver was requested and approved, and as such, groundwater monitoring is not required for CAU 110 (NNSA/NV, 2000).

At the 92-Acre Area, the average annual potential evapotranspiration is many times the average precipitation rate. The site is far from surface waters, surface runoff and run-on is insignificant, and engineered berms provide protection from a 25-year flood. Plant evapotranspiration minimizes potential water transport through the cover, and the plant canopy and roots help control erosion of the surface by wind and rain.

The vadose zone below the waste cells has low water potentials, low conductivity rates, and ample water storage capacity. Therefore, the potential for downward transmission of water is extremely low. Below this zone, water potential measurements indicate a static zone where essentially no vertical liquid flow is currently occurring. Conservative modeling estimates suggest it would take more than 50,000 years for water to move from beneath the static region to the groundwater, which is over 200 m below ground surface.

If water were to carry contaminants to the groundwater, water levels indicate that the gradient is nearly flat, and calculated groundwater flow velocities have generally been less than 0.15 m per year. Effectively, there is no groundwater pathway, and the potential for groundwater contamination from waste disposal activities at the Area 5 RWMS is negligible.

A groundwater monitoring waiver is not being requested for the 92-Acre Area, even though it has been demonstrated by extensive site characterization, environmental monitoring, and modeling over the past several decades that the potential for groundwater contamination at the Area 5 RWMS is negligible. Rather, a continuation of current groundwater monitoring with the existing wells is proposed, coupled with aggressive monitoring of the vadose zone to provide early indication of contaminant transport towards groundwater.

The current monitored groundwater parameters are sufficient indicators of contamination in the groundwater. The *Revised Area 5 Radioactive Waste Management Site Outline of a Comprehensive Groundwater Monitoring Program* details an appropriate groundwater monitoring program for the Area 5 RWMS. The program ensures the earliest possible detection of contaminants based on a thorough analysis of site characteristics, current and future waste streams, past and present monitoring data, and 40 CFR 265 requirements. The parameters are good indicators of the waste constituents at the Area 5 RWMS, and the ILs defined are protective of the environment (BN, 1998). This program was agreed upon by NNSA/NSO and NDEP and has been followed since 1998.

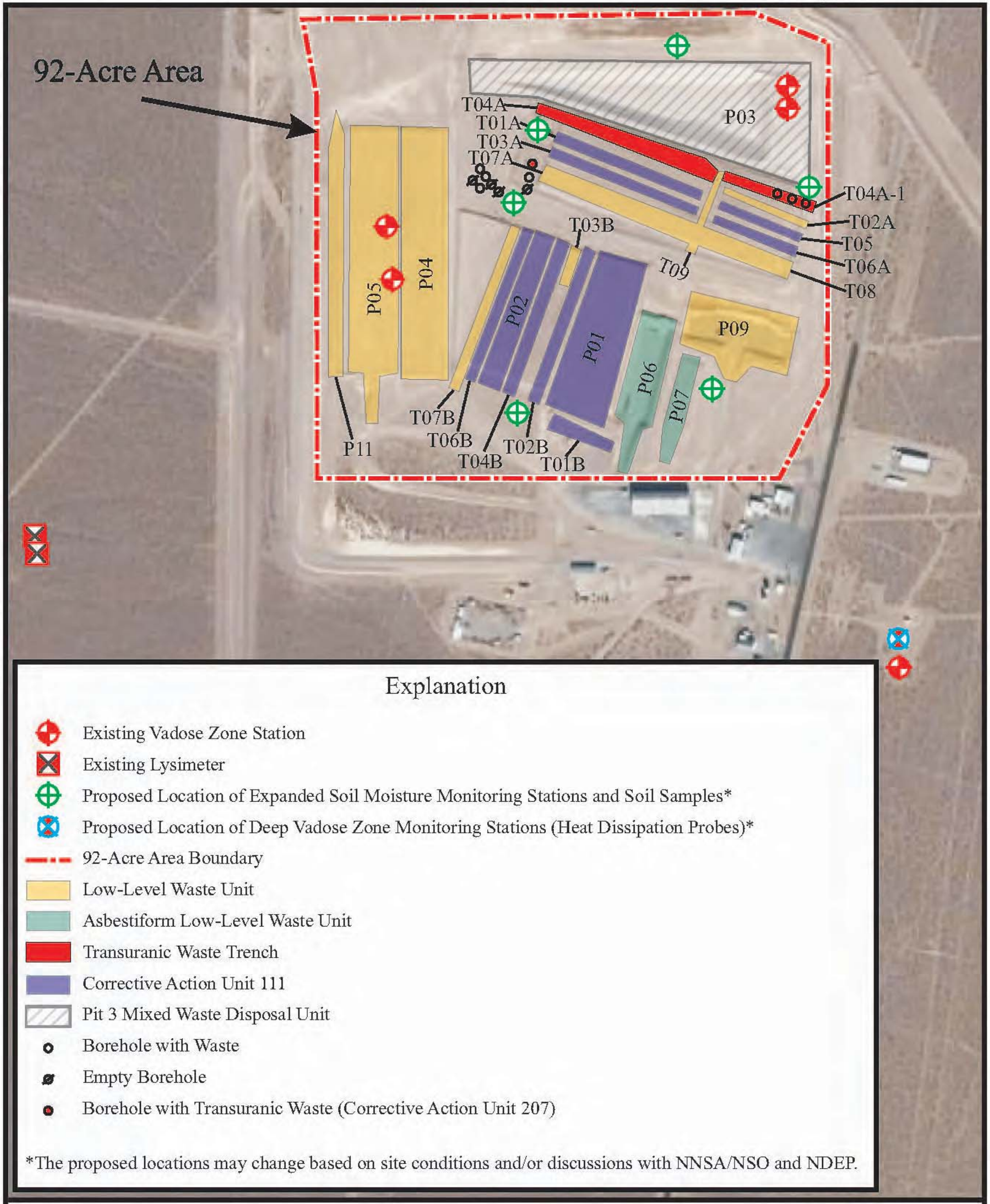
There is no requirement for vadose zone monitoring in 40 CFR 265; however, this will provide additional assurance that any future contaminant migration through the vadose zone towards the groundwater will be detected. At any time in the future, if there is any indication of movement of contamination through the vadose zone or potential groundwater contamination, the monitored groundwater parameters may be expanded based upon discussions between NNSA/NSO and NDEP at that time.

The only known potential conduit to the groundwater is groundwater monitoring wells themselves. Therefore, rather than installing additional wells at this time, which could potentially become conduits for contamination, and would likely become unserviceable long before any contaminants have time to reach the groundwater, a rigorous progressive, or graduated, monitoring approach will be implemented for vadose zone monitoring (Table 8). This approach does not preclude the installation of additional groundwater monitoring wells or the expansion of the monitored groundwater parameters in the future, as needed.

TABLE 8. PROGRESSIVE APPROACH FOR VADOSE ZONE MONITORING FOR THE 92-ACRE AREA

PROGRESSIVE MONITORING STEP	DESCRIPTION	BASELINE/ACCEPTABLE CONDITION	TRIGGER CONDITION FOR PROGRESSING TO THE NEXT STEP
Step 1: Base Monitoring	Current TDR and lysimeter monitoring network, as described in Section 2.1.6 and Section 2.2.1.6 (See Figure 36)	No indication of contaminant migration beneath the waste zone	Volumetric moisture content greater than 30 percent* for 2 consecutive years at the deepest TDR probe location (1.2 m beneath the floor of Pit 5)
Step 2: Expanded Soil Moisture Monitoring Beneath the Waste Zone	Drill borehole for neutron probe monitoring or install TDR probes adjacent to waste cells to a depth of 3 m beneath the waste zone (See Figure 36)	No indication of contaminant migration beneath the waste zone	Volumetric moisture content greater than 30 percent* for 2 consecutive years at the deepest probe location (3 m beneath the waste zone)
Step 3: Soil Sampling for Contaminants Beneath the Waste Zone	Collect soil samples at 3 m below the waste zone (e.g., geoprobe, core drill) near the location(s) exceeding the trigger condition in Step 2 and analyze for RCRA toxicity characteristic contaminants (CFR, 2006c) and radionuclides, or other contaminants, as agreed upon by NNSA/NSO and NDEP (See Figure 36)	No contaminants detected above TCLP (CFR, 2006c) or radionuclide action levels in the soil beneath the waste zone	Contaminants detected in soil sample above TCLP (CFR, 2006c) or radionuclide action levels (after background comparison)
Step 4: Deep Vadose Zone Monitoring	Install heat dissipation probes at 10-m increments to 100 m below ground surface at one location outside the 92-Acre Area to measure the water potential gradient (See Figure 36)	No downward movement of water in the deep vadose zone	Trend of downward movement of water in the deep vadose zone for 2 consecutive years
Step 5: Expanded Groundwater Monitoring	Install additional groundwater monitoring well(s) at location(s) agreed upon by NNSA/NSO and NDEP	No contaminants or indicators of contamination detected in the groundwater	Groundwater is the point of compliance. Indicators of contamination that exceed the limitations listed in Table 7 will be reported to NDEP within 14 days of discovery.

*A volumetric moisture content of 30 percent is a conservative field capacity value for the soil in this area.
m: meter(s)
NNSA/NSO: U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NDEP: Nevada Division of Environmental Protection
RCRA: *Resource Conservation and Recovery Act*
TCLP: Toxicity Characterization Leaching Procedure
TDR: time-domain reflectometry



*The proposed locations may change based on site conditions and/or discussions with NNSA/NSO and NDEP.

FIGURE 36
CURRENT AND PROPOSED VADOSE ZONE MONITORING LOCATIONS

Given the geologic and climatic conditions of the area, this progressive monitoring approach begins with simple, near-surface monitoring that is currently conducted at the 92-Acre Area and progresses to deeper, more complex monitoring only upon indication of potential contaminant migration or drastic changes in climatic conditions. Using this approach, additional groundwater wells would be installed upon indication of potential contaminant migration through the vadose zone. Table 8 provides the specific details of the progressive monitoring approach for vadose zone monitoring.

If at any time, a trigger condition for vadose zone monitoring, as identified in Table 8, is exceeded, vadose zone monitoring will progress to the next, more rigorous, monitoring step. Exceeding a trigger condition does not imply an out-of-compliance condition; rather, it indicates that expanded monitoring is required to ensure the continued protection of human health and the environment. This progressive monitoring approach provides the greatest assurance that potential contaminant transport will be identified early without the unnecessary introduction of additional direct conduits to the groundwater.

The most current and acceptable technology for each progressive monitoring step is identified in Table 8; however, it is expected that as technology progresses over time, improved technology may be available at the time of implementation and will be used in lieu of those described in Table 8.

The proposed locations of expanded soil moisture monitoring stations, soil samples, and deep vadose zone monitoring stations, as shown in Figure 36, were chosen based on the locations of the landfill units, the types of waste present in each unit, and the locations of existing vadose zone stations. The proposed locations may change based on site conditions and/or discussions between NNSA/NSO and NDEP if these monitoring activities are required in the future.

Results of monitoring will continue to be documented annually in the *Nevada Test Site Waste Management Monitoring Report Area 3 and Area 5 Radioactive Waste Management Sites* and in the *Nevada Test Site Data Report: Groundwater Monitoring Program Area 5 Radioactive Waste Management Site*. A copy of these reports will be included as an appendix to the annual combined post-closure report for closed RCRA CAUs.

7.3 MAINTENANCE AND REPAIR

Any identified maintenance or repair requirements will be reported to NDEP and completed within 60 calendar days of discovery. Repair work shall preserve the original "as-built" cover design. If the cover repair requires the modification of the cover design, NNSA/NSO shall present a formal design modification request to NDEP prior to making the design modification. All repair and maintenance activities will be documented in writing at the time of the repair and included in the annual combined post-closure report for closed RCRA CAUs.

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8.0 REFERENCES

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APPENDIX A

DATA QUALITY OBJECTIVES

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FIGURES

TABLES

ACRONYMS AND ABBREVIATIONS

ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
BN	Bechtel Nevada
Bq L^{-1}	Becquerel(s) per liter
Bq m^{-2} s^{-1}	Becquerel(s) per square meter per second
CA	composite analysis
CADD/CAP	Corrective Action Decision Document/Corrective Action Plan
CAU	Corrective Action Unit
CFR	Code of Federal Regulations
CR	containment requirement
CSM	conceptual site model
DAS	Disposal Authorization Statement
DASH	Deep Arid System Hydrodynamic
DCG	Derived Concentration Guide
DOE	U.S. Department of Energy
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
FEHM	finite element heat and mass transfer
FFACO	*Federal Facility Agreement and Consent Order*
ft	foot (feet)
ft^3	cubic foot (feet)
FY	fiscal year
GCD	Greater Confinement Disposal
GCDT	Greater Confinement Disposal Test
ICMP	integrated closure and monitoring plan
in.	inch(es)
IPR	individual protection requirement
LLW	low-level waste
LWIS	Low-Level Waste Information System
M	Manual
MFP	mixed fission product
mi	mile(s)
mm/yr	millimeter(s) per year

ACRONYMS AND ABBREVIATIONS (continued)

MOP	member of the public
mph	mile(s) per hour
mR/day	milliroentgen(s) per day
mrem/yr	millirem(s) per year
mSv/yr	milliSievert(s) per year
MTRU	mixed transuranic
MW	mixed waste
MWDU	Mixed Waste Disposal Unit
NAC	Nevada Administrative Code
NDEP	Nevada Division of Environmental Protection
NCRP	National Council on Radiation Protection and Measurements
NFB	no-flux boundary
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NTS	Nevada Test Site
NWAR	nuclear weapons accident residue
O	Order
PA	performance assessment
PET	potential evapotranspiration
pdf	probability density function
QA/QC	quality assurance/quality control
RCRA	*Resource Conservation and Recovery Act*
REECo	Reynolds Electrical and Engineering Company, Inc.
RWM	Radioactive Waste Management
RWMS	Radioactive Waste Management Site
SA	special analysis
SLB	Shallow Land Burial
TDR	time-domain reflectometry
TEDE	total effective dose equivalent
TRU	transuranic
WMD	Waste Management Division

1.0 INTRODUCTION

The data quality objective (DQO) process is a seven-step systematic planning method based on the scientific method. The information presented in this document is based on characterization and monitoring data, historical documentation and records, modeling studies, evaluations, and process knowledge for the southeast quadrant of the Area 5 Radioactive Waste Management Site (RWMS), which is referred to as the "92-Acre Area." The DQOs were developed according to the U.S. Environmental Protection Agency (EPA) *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA, 2006). The steps systematically build on the data acquired during preliminary assessment work and background research.

The Area 5 RWMS uses engineered shallow-land burial cells to dispose of packaged waste. The cells in the 92-Acre Area include 13 boreholes, 16 narrow trenches, and 9 broader pits. The waste disposal units have been established over a 45-year operation period. Three disposal units within the 92-Acre Area are currently active. All other pits and trenches have been operationally closed with temporary earthen covers of at least 8 feet (ft) of native fill.

The 92-Acre Area includes *Federal Facility Agreement and Consent Order* (FFACO) Corrective Action Unit (CAU) 111, Area 5 WMD Retired Mixed Waste Pits, which consists of 11 trenches and pits that may have received both low-level waste (LLW) and mixed waste (MW) prior to the promulgation of the *Resource Conservation and Recovery Act* (RCRA). The 92-Acre Area also contains an active MW pit, two units which received asbestiform LLW, and six disposal units that are known or suspected to have received some transuranic (TRU) waste. The 92-Acre Area has been divided into six units based on physical location, waste types, and regulatory requirements:

- Pit 3 Mixed Waste Disposal Unit (MWDU)
- CAU 111, Area 5 WMD Retired Mixed Waste Pits
- CAU 207, Archived – Area 5 WMD Greater Confinement Disposal (GCD) Boreholes
- LLW disposal units
- Asbestiform LLW disposal units
- One TRU waste trench

Sufficient information is available about the physical, chemical, hydrological, plant, animal, and climate characteristics, as well as facility design, operation, and source materials to provide the input data necessary to evaluate closure options without the collection of additional data. Site characterization activities at the Area 5 RWMS began in the early 1990s. These activities have provided the necessary data to develop a conceptual site model (CSM) for the fate and transport of the waste inventory. The CSM, inventory, and release and transport parameters are presented in this document along with a discussion of their uncertainty. References that provide detailed information regarding characterization and modeling studies are provided.

1.1 DOCUMENTS SUPPORTING SITE CHARACTERIZATION

Documents related to characterization and site performance are listed below:

- *Area 5 Site Characterization Project Report FY 1994* (Albright et al., 1994)
- *Characterization Report: Operational Soil Covers for the Area 5 Radioactive Waste Management Sites at the Nevada Test Site* (Bechtel Nevada [BN], 2005a)
- *Hydrogeologic Characterization Data from the Area 5 Shallow Soil Trenches, Nevada Test Site, Nye County, Nevada* (BN, 2005b)
- *Site Characterization and Monitoring Data for the Area 5 Pilot Wells, Nevada Test Site, Nye County, Nevada* (BN, 2005c)
- *Addendum 2 to the Performance Assessment of the Area 5 RWMS at the NTS, Nye County, Nevada Update of the Performance Assessment Methods and Results* (BN, 2006)
- *Site Characterization Data from the Area 5 Science Boreholes, Nevada Test Site, Nye County, Nevada* (Blout et al., 1995)
- *Use of Long-Term Lysimeter Data in Support of Shallow Land Waste Disposal Cover Design* (Desotell et al., 2006)
- *Hydrogeologic Data for Existing Excavations at the Area 5 Radioactive Waste Management Site, Nevada Test Site, Nye County, Nevada* (Reynolds Electrical and Engineering Company, Inc. [REECo], 1993a)
- *Hydrogeologic Data for Science Trench Boreholes at the Area 5 Radioactive Waste Management Site, Nevada Test Site, Nye County, Nevada* (REECo, 1993b)
- *Flood Assessment at the Area 5 Radioactive Waste Management Site and the Proposed Hazardous Waste Storage Unit, Nevada Test Site, Nye County, Nevada* (Schmeltzer et al., 1993)
- *Performance Assessment of the Area 5 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada, Revision 2.1* (Shott et al., 1998)
- *Soil-Water Flux in the Southern Great Basin, United States: Temporal and Spatial Variations over the Last 120,000 Years* (Tyler et al., 1996)
- *Vadose-zone Fluid and Solute Flux: Advection and Diffusion at the Area 5 Radioactive Waste Management Site* (Wolfsberg and Stauffer, 2003)

1.2 COMPLIANCE ASSESSMENTS

Four major assessments have been completed that demonstrate waste disposal operations at the Area 5 RWMS are in compliance with the U.S. Department of Energy (DOE) regulations and provide assurance that members of the public (MOPs) and the environment will be protected for 1,000 years after closure. These assessments include (1) the LLW performance assessment (PA), (2) the composite analysis (CA), (3) the PA for the TRU waste in the GCD boreholes, and (4) the special analysis (SA) for the TRU waste in trench T04A.

The PA, the CA, and the integrated closure and monitoring plan (ICMP) are the basis for the Disposal Authorization Statement (DAS) for the Area 5 RWMS. DOE issued the DAS for the operation of the Area 5 disposal facility in December 2000.

1.2.1 Performance Assessment for the Area 5 RWMS

The Area 5 PA evaluates radiological impacts of LLW regulated by DOE Order (O) 435.1, "Radioactive Waste Management" (DOE, 1999a). Regulated LLW is limited to waste disposed from September 26, 1988, to the assumed closure date of September 30, 2028. Radiological hazards are assessed for a period of 1,000 years after site closure. The purpose of the PA is to determine if there is a reasonable expectation of compliance with the performance objectives in the DOE Radioactive Waste Management Manual, Chapter IV, Section P(1) (DOE, 1999a):

1) The dose to representative MOPs shall not exceed 0.25 milliSieverts per year (mSv/yr) total effective dose equivalent (TEDE) from all exposure pathways, excluding the dose from radon and its progeny in air.
2) The dose to representative MOPs via the air pathway shall not exceed 0.10 mSv/yr TEDE, excluding the dose from radon and its progeny.
3) The release of radon shall be less than an average flux of 0.74 Becquerel per square meter per second (Bq m^{-2} s^{-1}) at the surface of the disposal facility. Alternatively, a limit of 0.0185 Becquerel per liter (Bq L^{-1}) of air may be applied at the boundary of the facility.

Representative MOPs are interpreted to be members of the critical group engaged in typical activities expected for the region. The critical group includes those MOPs exposed to the highest radionuclide releases from the site. The MOP is assumed to be located 100 meters from the boundary of the total area of the disposal units. The average radon flux is interpreted to be the spatially averaged flux density calculated as the total site radon flux from the ground surface to the atmosphere, divided by the total area of the disposal units. In addition to providing a reasonable expectation that the performance objectives are not exceeded, the PA must also demonstrate that radionuclide releases are as low as reasonably achievable (ALARA).

Under DOE Manual (M) 435.1-1, "Radioactive Waste Management Manual" (DOE, 1999b), a PA must include an assessment of (1) impacts to groundwater and (2) impacts to a hypothetical person assumed to inadvertently intrude for a temporary period into the disposal facility. The results are used to set limits for radionuclides disposed in the near-surface. Groundwater impacts are assessed against the standards in the National Primary Drinking Water Regulations (Title 40 Code of Federal Regulations [CFR] Part 141). Intruder impacts are limited to ensure that the TEDE received by a chronically exposed intruder is less than 1.0 mSv. In the case of the Area 5 RWMS, the groundwater protection criteria are not used to set limits for radionuclides disposed in the near-surface. Site characterization data support a conclusion that a groundwater pathway is extremely unlikely (Shott et al., 1998). Table A-1 summarizes the PA results.

The PA was approved after a peer review with conditions by DOE in August 1996 (Shott et al., 1998). The DAS conditions were removed in May 2002 with acceptance of an addendum to the PA (BN, 2001a). Under the PA maintenance program, disposal site operations, waste inventories, research and development, and environmental monitoring results are reviewed annually, and the adequacy of the PA is evaluated. The 2004 annual review concluded that significant changes have occurred since preparation of the PA, and consequently, a second addendum was prepared and accepted without conditions in 2006 (BN, 2006).

TABLE A-1. SUMMARY OF PA RESULTS AND COMPLIANCE EVALUATION

PERFORMANCE OBJECTIVE	LIMIT	LIMITING RESULT			CONCLUSION
		SCENARIO	MEAN	95TH PERCENTILE	
Air Pathway	0.1 mSv/yr	Transient Occupancy	4.1E-5 mSv/yr	4.7E-4 mSv/yr	Complies
All Pathways	0.25 mSv/yr	Resident Farmer	4.4E-2 mSv/yr	3.9E-2 mSv/yr	Complies
Intruder Protection (Acute Exposure)	5 mSv	Bounded by chronic exposure scenarios			Complies
Intruder Protection (Chronic Exposure)	1 mSv	SLB Intruder Agriculture	0.12 mSv*	0.43 mSv*	Complies
Radon Flux Density	0.74 Bq m^{-2} s^{-1}	All Disposal Units	0.044 Bq m^{-2} s^{-1}	0.096 Bq m^{-2} s^{-1}	Complies
Groundwater Protection	40 CFR 141	No groundwater pathway in 1,000 years			Complies
Releases ALARA	No Limit	Optimum cover thickness less than 13 feet			ALARA

ALARA: as low as reasonably achievable
Bq m^{-2} s^{-1}: Becquerel(s) per square meter per second
CFR: Code of Federal Regulations
mSv/yr: milliSievert(s) per year
SLB: Shallow Land Burial
*Weighted with probability of intrusion

1.2.2 Composite Analysis for the Area 5 RWMS

The purpose of the CA is to determine if the continuing operation of the Area 5 RWMS poses an acceptable risk to the public considering the total waste inventory, regardless of disposal date, and all other interacting sources of radioactive material in the vicinity. Continuing operation of the facility is acceptable if the TEDE is less than 100 millirems per year (mrem/yr). If the TEDE exceeds 30 mrem/yr, a cost-benefit options analysis must be performed to determine if cost-effective management options exist to reduce the dose further. If the TEDE is found to be less than 30 mrem/yr, an analysis may be performed to determine if doses are ALARA.

The maximum CA dose to a MOP for the 1,000-year compliance period is 1 mrem/yr (0.01 mSv/yr) at 1,000 years after closure. The Area 5 CA was accepted by DOE with conditions in 2001 (BN, 2001b), and an addendum was issued in 2001 (BN, 2001c). The CA evaluated the dose to a future MOP from all sources of radionuclides in the ground in Frenchman Flat and the releases from the facility, including all pre-1988 waste in the disposal cells. Table A-2 summarizes the CA results for the Area 5 RWMS.

TABLE A-2. SUMMARY OF CA RESULTS AND COMPLIANCE EVALUATION

PERFORMANCE OBJECTIVE	LIMIT	LIMITING RESULT			CONCLUSION
		SCENARIO	MEAN	95TH PERCENTILE	
All Pathways/All Sources	0.3 mSv	Resident	0.01 mSv	0.04 mSv	Complies

mSv: milliSievert(s)

1.2.3 Performance Analysis for the TRU Waste in the GCD Boreholes

The TRU waste in GCD boreholes 1 through 4 was evaluated to demonstrate compliance with the requirements of 40 CFR 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Wastes." Relevant standards for TRU waste disposal are found in 40 CFR 191 Subpart B, "Environmental Standards for Disposal," and Subpart C, "Environmental Standards for Groundwater Protection." Subpart B standards include containment requirements (CRs), assurance requirements, and individual protection requirements (IPRs). The CRs are probabilistic limits for the normalized cumulative radionuclide release to the accessible environment for 10,000 years. The cumulative release is normalized to release limits scaled to the total TRU inventory disposed. The CRs limit the probability of exceeding the release limit to 1 chance in 10, and the probability of exceeding 10 times the release limit to 1 chance in 1,000. The assurance requirements specify institutional controls and disposal system features to increase confidence in the long-term compliance with the CRs. The required controls and features are active and passive institutional controls, monitoring, natural and engineered barriers, lack of attractive natural resources, and ability to retrieve wastes for a reasonable time period. The IPRs limit the committed effective dose to a MOP through all pathways for 10,000 years to 0.15 mSv/yr. Subpart C requires that sources of underground drinking water in the accessible environment comply with the limits in 40 CFR 141 for a period of 10,000 years.

Sandia National Laboratories prepared a PA for the TRU GCD boreholes in 2001 (Cochran et al., 2001). In 2002, DOE determined that the PA met all requirements with the exception of the 40 CFR 191.14 assurance requirements for institutional controls; a monitoring program; markers, records, and other passive institutional controls; an engineered barrier system; information to support the claim that there are no economically useful minerals in the area; and removal of waste. The U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) committed to resolve these issues during the closure planning process for the Area 5 RWMS (Colarusso et al., 2003). The TRU Federal Review Group would review closure and post-closure documents to determine compliance with the 1993 version of 40 CFR 191 (Fiore and Berube, 2002). A new assurance requirements document is being prepared. Table A-3 summarizes the PA results for the TRU waste in the GCD boreholes.

Table A-3. Summary of PA Results and Compliance Evaluation under the 1985 Version of 40 CFR 191 for the TRU Waste in the GCD Boreholes

Performance Objective	Limit	Limiting Result			Conclusion
		Scenario	Mean	Maximum	
Containment Requirements	P(R > 1) < 0.1	P(R>1) < 0.0002			Complies
Containment Requirements	P(R > 10) < 0.001	P(R>10) < 0.0002			Complies
Individual Protection Requirements	0.25 mSv Whole Body	Resident Farmer	4.7E-5 mSv	1.6E-3 mSv	Complies
Individual Protection Requirements	0.75 mSv Any Organ	Resident Farmer	1.2E-3 mSv Bone	4.5E-2 mSv Bone	Complies
Groundwater Protection Standard	40 CFR 141	Not applicable under 1985 version of 40 CFR 191			Complies

P(·): Probability of an event
R: Normalized cumulative release as defined in 40 CFR 191.27
mSv: milliSievert(s)

1.2.4 Special Analysis for the TRU Waste in Trench T04A

In 1986, 102 55-gallon drums of TRU waste from Rocky Flats were inadvertently buried in T04A. The T04A TRU inventory was included in the 2001 CA; however, in order to provide further assurance that this small quantity of TRU in T04A will not pose a risk to future members of public, a 40 CFR 191 evaluation is considered relevant.

The SA was performed in 2007 to determine the likelihood that T04A meets the requirements of 40 CFR 191 (Shott et al., 2008). The SA concludes that there is a reasonable expectation that all 40 CFR 191 disposal requirements for a period of 10,000 years under climate change are met. Table A-4 summarizes the SA results for the TRU waste T04A.

TABLE A-4. SUMMARY OF SA RESULTS AND COMPARISON WITH THE STANDARDS CONTAINED IN THE 1997 VERSION OF 40 CFR 191 FOR THE TRU WASTE IN TRENCH T04A

PERFORMANCE OBJECTIVE	LIMIT	LIMITING RESULT			CONCLUSION
		SCENARIO	MEAN	95TH PERCENTILE	
Containment Requirements	$P(R > 1) < 0.1$	$P(R>1) = 0.009$			Meets Standard
Containment Requirements	$P(R > 10) < 0.001$	$P(R>10) < 0.0001$			Meets Standard
Individual Protection Requirements	0.15 mSv	Resident	0.055 mSv	0.15 mSv	Meets Standard
Groundwater Protection Standard	40 CFR 141	No groundwater pathway in 10,000 years			Meets Standard

P(·): Probability of an event
R: Normalized cumulative release as defined in 40 CFR 191.27
mSv: milliSievert(s)

1.3 MANAGEMENT OF UNCERTAINTY AND WASTE INVENTORIES

Performance assessment is an iterative process. The process begins with conservative deterministic screening models. The goal of each iteration is to reduce uncertainty in system performance. As the understanding of system performance improves and additional site characterization and monitoring results become available, conservative models can be replaced with increasingly realistic probabilistic models, parameterized with probability density functions (pdfs) that represent expected values and their uncertainty.

The current PA model in GoldSim® is probabilistic with all input parameters represented by probability distributions, thus accounting for the uncertainty in the parameter values. The parameter distributions have been developed with additional field work since 2000. The Maintenance Plan for the Area 5 PA and CA calls for additional field investigations for those parameters that are shown to be sensitive and uncertain. If a parameter is found to be highly sensitive, further investigation is justified. However, for those parameters that are uncertain but insensitive, no further data collection and reduction in uncertainty is warranted.

Comprehensive sensitivity analyses were performed for the PA model using local and global methods to explore sensitivity in model response over the entire parameter value ranges (BN, 2006). The sensitive parameters are related to plant uptake and animal burrowing. Individual radionuclide inventories were found to be insensitive; therefore, additional inventory characterization is not warranted. The relative insensitivity of the inventory highlights the robust nature of the disposal system to contain waste and protect public health and safety.

The Area 5 RWMS PA/CA model has undergone several iterations. The probabilistic model's parameter distributions are selected to represent expected values and their uncertainty. The following conservative assumptions reflect areas with persistent parameter or model uncertainty:

- The critical group is assumed to be a resident farmer 100 meters from the site. The Area 5 RWMS is extremely remote and arid with marginal agricultural soils. The lack of attractive resources, including surface water or shallow groundwater, makes this an unlikely site for future residential development. The lack of water and suitable soils makes agriculture at the site extremely unlikely. The presence of nuclear subsidence craters in the area is also likely to remind residents far in the future of the potential presence of radioactive contamination. In addition to natural conditions, land use plans are to restrict public access in perpetuity.
- All radionuclides are assumed to be immediately available for release and transport. However, containers and waste forms are likely to delay the release of radionuclides to the near field for decades if not hundreds of years.
- The critical group, 100 meters from the site boundary, is assumed to be exposed to onsite surface soil radionuclide concentrations. Actual soil concentrations, 100 meters from the site boundary, are expected to be orders of magnitude less than onsite concentrations.
- The radon-222 emanation coefficient, a sensitive model parameter, is assumed to be uniformly distributed from 0.02 to 0.8. This distribution reflects a maximum state of uncertainty, and the limits are the physically reasonable limits for this parameter in a solid sample. A more conservative distribution is a physical impossibility.
- The technetium plant-soil concentration ratio, a sensitive model parameter, is assumed to be lognormally distributed with a geometric standard deviation of 5.70. This implies that 95 percent of sampled values will fall within a broad 1,300-fold range. This range represents a maximum state of uncertainty reflecting spatial and temporal variation, and variability among species, climates, and soil types.

Tables A-5 and A-6 summarize the relative influence of parameters for the air pathway and all pathways. The relative influence measures the percent of the regression model variance that is explained by the parameter. The sensitivity analysis indicates that the Area 5 RWMS PA model is insensitive to waste inventory for the air pathway and all pathways TEDE for the scenarios with the highest dose.

TABLE A-5. SENSITIVITY OF THE TRANSIENT VISITOR AIR PATHWAY TEDE AT 1,000 YEARS

PARAMETER	RELATIVE INFLUENCE
Messor pergandei burrow volume depth distribution (b parameter)	37.1
Shallow land burial radon-222 emanation coefficient	8.73

TABLE A-6. SENSITIVITY OF THE RESIDENT FARMER ALL PATHWAYS TEDE AT 1,000 YEARS

PARAMETER	RELATIVE INFLUENCE
Technetium plant-soil concentration ratio for crops	23.9
Depth of the no liquid flux boundary	5.95

Table A-7 illustrates that the radon-222 flux density is moderately sensitive to the Pit 13 thorium-230 inventory and the future thorium-230 inventory.

TABLE A-7. SENSITIVITY OF THE RADON-222 FLUX DENSITY AT 1,000 YEARS

PARAMETER	RELATIVE INFLUENCE
Shallow land burial radon-222 emanation coefficient	40.0
Pit 13 thorium-230 inventory	26.1
Future shallow land burial thorium-230 inventory	14.8
Pit 13 radon-222 emanation coefficient	11.2

The parameter sensitivity of the CA was assessed using the rank correlation coefficient. The CA TEDE at 1,000 years was moderately sensitive to the closure cover thickness, the maximum depth of biological activity, the technetium plant-soil concentration ratio, the chlorine plant-soil concentration ratio, the technetium-99 inventory, and the chlorine-36 inventory.

Due to the difficulty of modeling the releases from the waste containers and waste forms (e.g., corrosion rates, and dissolution and diffusive properties of the various waste forms) with any certainty, the PAs make the bounding assumption that all waste is released into the backfill soil at closure. Although not quantified, it is reasonable to assume that the integrity of some containers would significantly reduce release of waste, at least in the near term. For example, Figure A-1 shows how steel drums have been over-packed into larger steel containers.

Since no credit is taken for waste containers and waste forms, the PA results are conservative. Moreover, the results, with conservative assumptions, are far below the performance objectives, indicating further reduction of uncertainty of source material is not warranted. In summary, further data collection is not necessary to evaluate closure options for these disposal units.

FIGURE A-1. STEEL DRUMS OVER-PACKED INTO LARGER STEEL CONTAINERS AT THE AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE

2.0 BACKGROUND INFORMATION

This section summarizes the waste disposal operations at the Area 5 RWMS. The site location, operational history, and waste inventory are discussed briefly. More detail can be found in the *Integrated Closure and Monitoring Plan for the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada Test Site* (BN, 2005d) and the Area 5 RWMS PA (Shott et al., 1998).

2.1 SITE LOCATION

The 92-Acre Area is located in Area 5 of the Nevada Test Site (NTS), which is approximately 65 miles (mi) northwest of Las Vegas, Nevada. The 92-Acre Area constitutes the southeast quadrant of the Area 5 RWMS (Figure A-2).

The Area 5 RWMS is located in a topographically closed basin approximately 14 mi north of Mercury, Nevada, in the north-central part of Frenchman Flat, and approximately 15 mi south of the Area 3 RWMS, which is in south-central Yucca Flat.

Figure A-3 shows the disposal units of the 92-Acre Area. The disposal unit names are coded. Each shallow excavation is categorized as either a “trench” (designated with the prefix “T”) or a “pit” (designated with the prefix “P”), based on width. Generally pits are greater than 100 ft wide and are large enough for a truck to turn around. The borehole designations have the prefix “GCD.”

2.2 OPERATIONAL HISTORY

Both classified and unclassified materials have been managed at the Area 5 RWMS. Disposal records and historic records for the 92-Acre Area include the following waste types: LLW, MW, asbestiform waste, TRU waste, and mixed transuranic (MTRU) waste. The majority of the inventory is LLW. Most of the TRU and MTRU waste was placed in boreholes more than 70 ft below ground surface. Two disposal units have been designated for asbestos waste. Much of the MW was deposited in the oldest disposal units prior to the promulgation of RCRA.

The precursor to the Area 5 RWMS, the Sugar Bunker Dump, began receiving waste by 1960 and began burying waste in January 1961, prior to the origination of federal radioactive waste management regulations and RCRA. Information on the earliest inventory and disposal practices is more general and less complete than in later years. Disposal records for some trenches are limited. Analytical profiling initially focused on radioactivity, but from process knowledge and general descriptions, it is assumed that some of the older wastes are MW.

The Sugar Bunker Dump accepted waste for surface storage as early as January 1960, and began burying waste by January 1961 when Pit No. 1 (later designated T01B) was opened. In 1965, trenches T03A, T06B, and T01A began receiving LLW. Trench T04B began receiving waste in 1970 and was the principal Area 5 disposal unit from 1970 through 1972. Trench T02B opened in July 1972. Trenches T05 and T06A were operating by 1974 and appeared to be mostly full by mid-1976. These eight shallow disposal trenches all received LLW and waste that contained hazardous constituents or suspected hazardous constituents. All eight trenches were operationally closed by 1978.

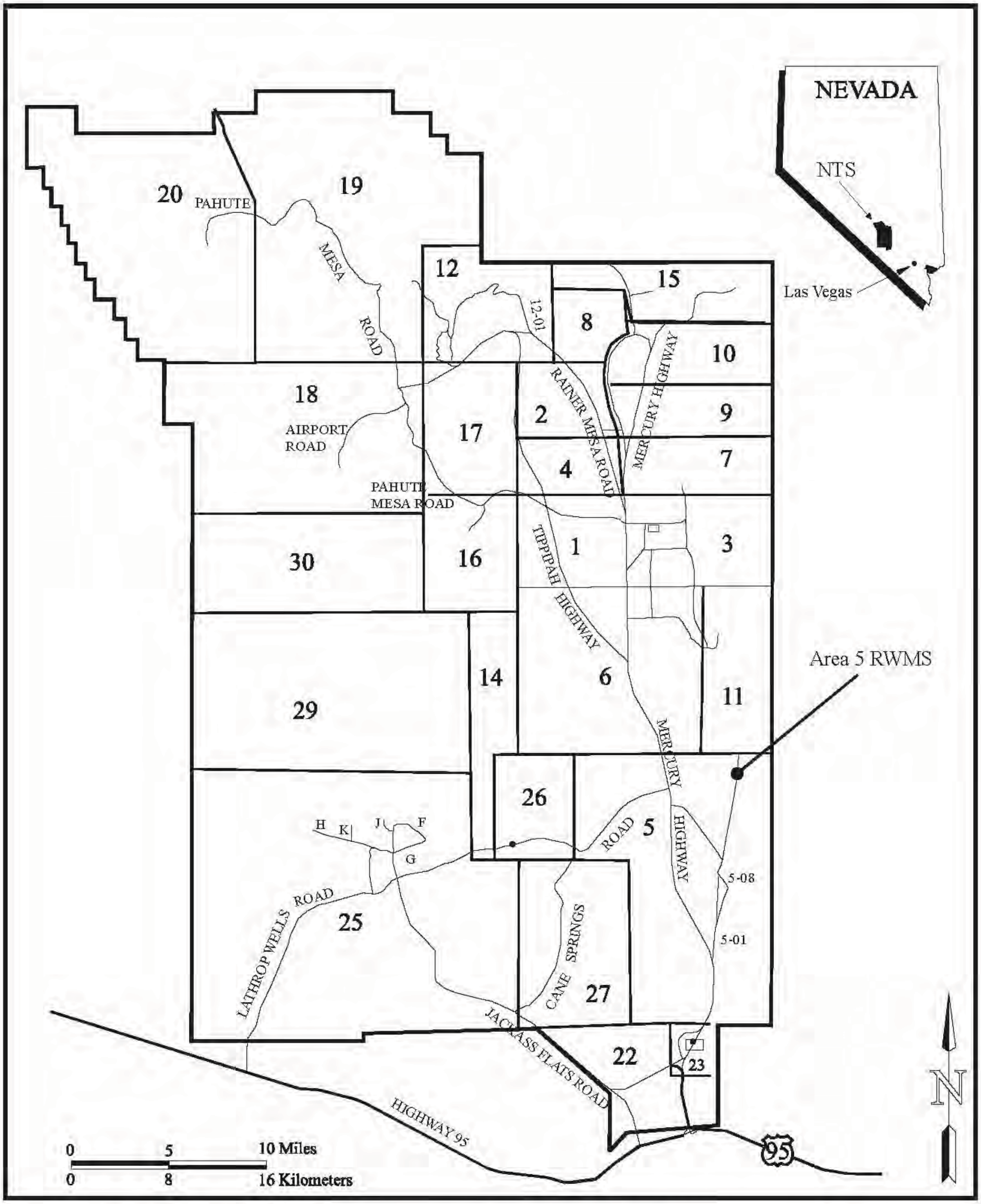


FIGURE A-2. AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE LOCATION MAP

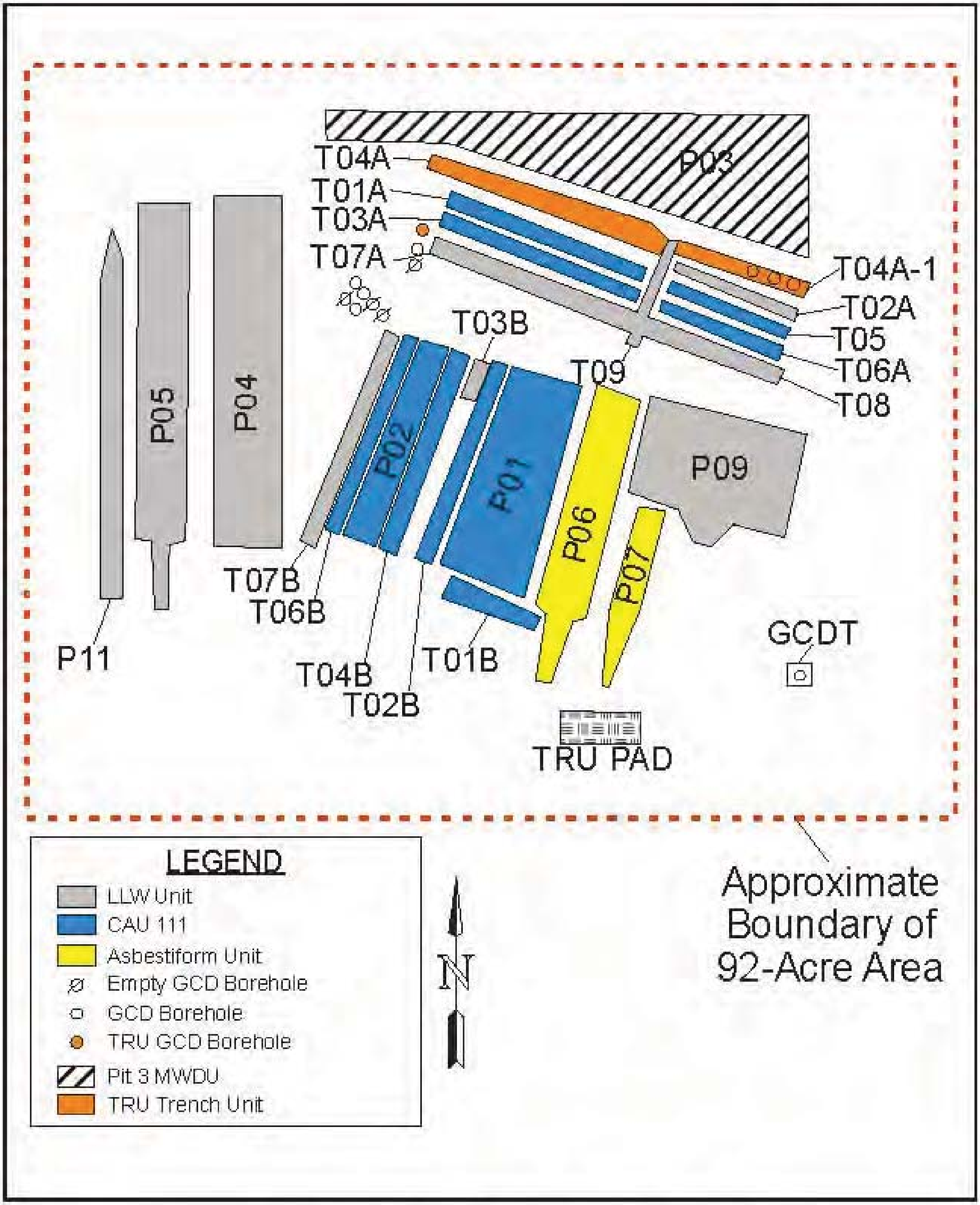


FIGURE A-3. 92-ACRE AREA DISPOSAL UNITS

Trench T04A began receiving waste in March 1969. In 1986, approximately 2.6 pounds of TRU waste from Rocky Flats were inadvertently disposed in trench T04A. In 1995, when trench T09 was excavated perpendicular to the T04A trench, the east end of the trench was renamed T04A-1. The T04A and T04A-1 trenches were operationally closed in August 1995.

DOE established the NTS Waste Management Program in 1978, and the Area 5 RWMS was established on a 732-acre site incorporating the existing Sugar Bunker Dump waste cells in the southeast corner. The site began receiving LLW from offsite DOE generators. Trench T07B was opened by 1978 and received waste from Rocky Flats. There is no evidence in the disposal records of hazardous material being disposed in T07B.

Between 1978 and September 26, 1988 (when DOE O 5820.2A, "Radioactive Waste Management" [now replaced with DOE O 435.1] was promulgated), P01, P02, and T07B were filled and operationally closed.

In 1981, the Greater Confinement Disposal Test (GCDT) borehole was equipped to evaluate the feasibility of disposing high specific activity waste at the NTS. The waste included encapsulated radioactive sources, strontium-90 in thermoelectric generators, and drums of radioisotopes. Nine 120-ft boreholes were drilled around the GCDT, at locations 10, 16, and 22 ft from the GCDT, and were equipped with instruments to monitor soil temperature, soil moisture, and migration of tracers or radionuclides. The GCDT project ran for over 7 years and provided information on potential for waste migration. The GCDT was then operationally closed.

Based on results of the GCDT, 12 GCD boreholes were drilled for operational use in 1984. Three of the boreholes were drilled in the base of T04A-1. The rest were drilled from ground surface outside of the trenches. The GCD boreholes are generally 10 ft in diameter, 120 ft deep, and unlined, except for 10 ft of corrugated metal surface casing. Between 1984 and 1989, 8 of the 12 GCD boreholes were used to dispose of "special case" or "orphan" wastes. These are wastes that did not meet acceptance criteria for other facilities. They have subsequently been designated as high-specific-activity LLW (waste similar to Greater-than Class C), MW, TRU waste, and MTRU waste. Detailed inventories of waste and materials in the GCD boreholes are presented in Dickman (1989) and Chu and Bernard (1991).

Although the GCDT and the Area 5 RWMS monitoring data suggest burial in these boreholes was safe and effective, disposal of waste in GCD boreholes was discontinued in 1989 when the Nevada Division of Environmental Protection (NDEP) determined the boreholes to be Class IV injection wells, which are prohibited by EPA regulations and Nevada Administrative Code (NAC). Six GCD boreholes have been filled with waste to a depth of about 70 ft below surface and operationally closed with backfill consisting of native soil. Two boreholes have received waste and remain open (although inactive), and four boreholes are empty. In 1993, EPA clarified that underground disposal of containerized radioactive waste in geologic repositories subject to the 40 CFR 191 standards does not constitute underground injection under the EPA's underground injection control program.

CAU 111 includes the following waste disposal units, which are all operationally closed: P01, P02, T01B, T02B, T04B, T06B, T01A, T03A, T05, and T06A. There are currently three active pits in the 92-Acre Area: P03, P06, and P09. P03 is the only active MWDU. P06 and P09 contain LLW. P06 accepts asbestiform LLW, and the bottom tier is used for disposal of thorium waste. Table A-8 summarizes the types of waste, operational status, and disposal volumes of the six closure units in the 92-Acre Area.

2.3 REGULATORY DRIVERS FOR CLOSURE

The closure units must comply with the closure requirements of multiple regulations. All units must comply with the requirements set forth in DOE O 435.1. A final PA and CA must be developed for the closure of the entire Area 5 facility, including the expansion area north of the 92-Acre Area. Partial unit closures are allowed under DOE O 435.1. The current PA evaluated the closure of the facility at the assumed closure date of 2028 and demonstrated compliance with the performance objectives of DOE O 435.1. The PA evaluated the radionuclide inventory disposed in the cells after September 1988 and the forecasted inventory at closure. The current CA shows compliance for all waste in all disposal units, including pre- and post-1988 inventory and TRU waste. The PA and CA evaluated the facility performance for 1,000 years after closure assuming an evapotranspirative cover. An optimization was performed in fiscal year (FY) 2009 to determine a final cover thickness for the potential final closure cover design.

For the TRU waste inadvertently disposed in trench T04A, a SA has been performed. The SA shows that leaving the TRU waste in T04A will meet the performance objectives of 40 CFR 191. The SA shows that the alternative of excavating, certifying, and shipping the TRU waste elsewhere would involve unacceptable risk to workers and prohibitive cost.

As discussed in Section 1.2, a PA was performed for GCD boreholes 1, 2, 3 and 4, which contain TRU waste. DOE approved the PA. The 70 ft of backfill over the waste in the boreholes provides assurance that the transport of radionuclides from the waste zone to the ground surface through plant uptake and animal burrowing activity will not be possible. Minimal quantities of waste could reach the surface through diffusion and advective transport associated with upward flux. As demonstrated in the PA, the releases over a 10,000-year post-closure period under a wetter and cooler climate regime will be negligible.

The radionuclide component of waste in the legacy CAU 111 units has been evaluated under the CA and found to meet the performance objective of a 100-mrem/yr dose, as discussed in Section 1.2. The radionuclide inventories in the Pit 3 MWDU and the Asbestiform Unit have been evaluated under the PA. The hazardous component of waste in all units will perform similarly to the radionuclide component that has been modeled. Since the transport behavior of hazardous metals and volatiles is similar to that of particulate and volatile radionuclides, there is assurance that there will not be any significant release of hazardous materials to the surface soils from the waste zones through the predominantly upward pathways of bioturbation and upward liquid flux.

2.4 WASTE INVENTORY

Waste inventory has been established through historical studies conducted to support compliance assessments under DOE O 435.1 and closure and monitoring activities. Uncertainty of the inventory was addressed by bounding estimates in the original PA and probabilistically in the 2005 addendum. As discussed in Section 1.0, the inventory is insensitive as far as the long-term performance of the facility is concerned because of limited releases of waste from the waste zones to the atmosphere above the disposal cells. Therefore, further effort to refine the inventory estimates in order to further reduce their uncertainty is not warranted. The following sections discuss historical disposal practices and provide information regarding data archives and data warehousing efforts. They also describe the GoldSim® inventory model developed for the Area 5 RWMS, which is updated annually as new waste disposal occurs.

TABLE A-8. 92-ACRE AREA WASTE UNIT STATUS

DISPOSAL UNIT	FIRST RECORD	LAST RECORD	RECORDED VOLUME $(\mathrm{FT}^3)^{\dagger}$	CALCULATED DISPOSAL UNIT VOLUME (FILLED WITH WASTE) $(\mathrm{FT}^3)^{\ddagger}$	RECORDED/ CALCULATED VOLUME	CURIES	OPERATIONAL STATUS	CONTENTS
P01	20-Sep-78	25-Apr-85	1.6E+06	3.8E+06	0.42	2.6E+06	Operationally Closed	LLW, lead, lead shielding, barium source, organic solvents
P02	18-Dec-84	19-Nov-95	8.9E+05	1.3E+06	0.68	2.0E+05	Operationally Closed	LLW, lead, lead shielding, barium source, organic solvents
P03	18-Sep-85	17-Jul-08	1.5E+06	3.0E+06	0.49	1.4E+05	Active	MW (RCRA permitted)
P04	14-Jun-88	25-Oct-95	2.5E+06	3.3E+06	0.75	1.2E+05	Operationally Closed	LLW
P05	15-May-95	27-Sep-07	2.2E+06	4.1E+06	0.53	2.2E+06	Operationally Closed	LLW
P06/P06A	3-Dec-04	7-Feb-08	5.0E+05	1.5E+06	0.33	4.0E+02	Active	Asbestiform LLW
P07	15-Sep-97	10-Feb-03	1.8E+05	4.4E+05	0.41	6.6E+01	Operationally Closed	Asbestiform LLW
P09	10-Dec-03	9-Oct-07	2.7E+05	5.9E+05	0.46	2.9E+04	Active	LLW
P11	27-Jan-04	5-Apr-05	1.2E+05	2.2E+05	0.54	2.9E+04	Operationally Closed	LLW
T01B	7-Jan-61	29-Jun-65	2.9E+04	2.6E+05	0.11	8.9E+00	Operationally Closed	LLW, lead bricks, lead shielding, cadmium, chromium, mercury, organic solvents
T02B	5-Jul-72	5-May-78	3.5E+04	4.7E+05	0.07	2.8E+00	Operationally Closed	LLW, organic solvents, lead
T03B	2-Mar-92	10-Sep-92	2.4E+04	5.4E+04	0.44	2.1E+00	Operationally Closed	LLW
T04B	25-Feb-70	29-Nov-77	5.1E+04	4.9E+05	0.10	3.3E+06	Operationally Closed	LLW, organic solvents, lead shielding, mercury
T06B	1-Jul-65	25-May-70	1.7E+05	3.7E+05	0.45	1.3E+04	Operationally Closed	LLW, laboratory waste containing lead, cadmium and mercury, organic solvents, lead bricks
T07B	16-May-78	22-Sep-78	1.1E+05	4.3E+05	0.27	5.3E+05	Operationally Closed	LLW

TABLE A-8. 92-ACRE AREA WASTE UNIT STATUS (CONTINUED)

DISPOSAL UNIT	FIRST RECORD	LAST RECORD	RECORDED VOLUME (FT^3)[†]	CALCULATED DISPOSAL UNIT VOLUME (FILLED WITH WASTE) (FT^3)[‡]	RECORDED/ CALCULATED VOLUME	CURIES	OPERATIONAL STATUS	CONTENTS
T01A	10-Oct-65	19-May-76	1.8E+04	3.6E+05	0.05	2.1E+03	Operationally Closed	LLW, lead
T02A	7-Nov-88	22-Jul-93	6.0E+04	1.3E+05	0.46	1.4E+02	Operationally Closed	LLW
T03A	26-Aug-69	10-Dec-76	2.5E+04	3.7E+05	0.07	2.0E+03	Operationally Closed	LLW, organic solvents, chromium, lead
T04A/T04A-1	12-Dec-85	3-Aug-95	6.4E+04	3.6E+05	0.17	1.7E+03	Operationally Closed	LLW, TRU (2.6 pounds TRU inadvertently disposed in 1986)
T05/T06A	31-Jan-74	31-Jan-74	2.0E+03	4.6E+05	0.00	0.0E+00	Operationally Closed	LLW, organic solvents
T07A/T08	14-May-01	23-Apr-03	6.6E+05	1.0E+06	0.64	2.5E+03	Operationally Closed	LLW
T09	3-Aug-95	31-Oct-02	4.4E+04	1.2E+05	0.37	7.1E+04	Operationally Closed	LLW
Unknown	30-Jun-70	15-Nov-90	1.8E+06	-	-	2.7E+05	-	-
Total	**7-Jan-61**	**18-Dec-07**	**1.4E+07**	**2.3E+07**	**0.58**[§]	**9.5E+06**		
GCDT	15-Dec-83	6-Mar-84	5.8E+02[§]	4.3E+03	0.14	5.3E+05	Operationally Closed	LLW
GCD-01C	1984	1984	1.4E+03[§]	4.3E+03	0.32	1.8E+02	Operationally Closed	TRU, lithium deuteride (may contain melted high explosives, lead, mercury)
GCD-02C	1984	1984	9.8E+02[§]	5.6E+03	0.18	1.0E+03	Operationally Closed	TRU (may contain melted high explosives, lead, mercury)
GCD-03C	1984	1984	1.9E+02[§]	5.6E+03	0.03	1.1E+02	Operationally Closed	TRU (may contain melted high explosives, lead, mercury)
GCD-04C	19-Jul-85	14-Jan-87	1.3E+03[†]	4.3E+03	0.31	6.8E+00	Operationally Closed	LLW, TRU, lithium hydride
GCD-05U	26-Jun-85	9-Apr-87	3.2E+03[†]	4.3E+03	0.74	2.1E+06	Operationally Closed	LLW

TABLE A-8. 92-ACRE AREA WASTE UNIT STATUS (CONTINUED)

DISPOSAL UNIT	FIRST RECORD	LAST RECORD	RECORDED VOLUME (FT^3)[†]	CALCULATED DISPOSAL UNIT VOLUME (FILLED WITH WASTE) (FT^3)[‡]	RECORDED/ CALCULATED VOLUME	CURIES	OPERATIONAL STATUS	CONTENTS
GCD-06U	16-Jul-86	20-Feb-87	2.4E+02[†]	4.3E+03	0.06	6.5E+03	Closed to waste, not yet backfilled	LLW
GCD-07C	7-Jul-89	7-Jul-89	3.8E+02[†]	4.3E+03	0.09	1.9E+00	Closed to waste, not yet backfilled	LLW
GCD-10U	11-Dec-87	27-Oct-89	2.0E+03[†]	5.9E+03	0.35	6.0E+05	Operationally Closed	LLW
GCD Total	**23-Feb-83**	**27-Oct-89**	**1.0E+04**	**4.3E+04**	**0.24**	**3.2E+06**		

[†] - Source: Table 10 of Denton et al., 2008

[‡] - Calculated by Area 5 Inventory GoldSim model, Version 2.022

[§] - Source: Chu and Bernard, 1991

ft^3: cubic foot (feet)
GCD: Greater Confinement Disposal
GCDT: Greater Confinement Disposal Test
LLW: low-level waste
MW: mixed waste
RCRA: *Resource Conservation and Recovery Act*
TRU: transuranic

Waste has been accepted at Area 5 since January 1960 and placed in disposal cells since January 1961. The oldest records for the original Sugar Bunker Dump generally show load origin, a brief description of the material and containers, estimated radioactivity, and date of disposal. When necessary, a specific trench or pit can be inferred from burial date and history of the development of the disposal features. The original paper records were scanned into a digital format, and then archived. The quality of some of these scanned images is poor, and some of the data are difficult to read. There is also uncertainty as to the completeness of the scanned records.

The Radioactive Waste Management (RWM) System was developed in 1988. The RWM System tabulated basic information on a per-shipment basis for waste received from August 13, 1974, through 1992. The RWM System had design flaws, typical in early databases due to limited programming capabilities, which resulted in inconsistent entries, incomplete records, and the creation of orphan records due to poor interrelationships between the master tables and detail tables. Users of the system could modify, delete, and add data in sub-tables without changing, deleting, or adding records to the master table.

After September 30, 1992, the Low-Level Waste Information System (LWIS) Oracle application was implemented. Data in this database were stored in a single record, indexed by package. The level of characterization and burial location detail improved. Burial location was provided based on an alphanumeric grid. The tier and location within the cell were recorded. The Oracle relational database structure of the LWIS prevented some of the quality and orphan data problems that plagued the RWM System. The web applications used by generators and waste operations personnel to input data also had built-in validation features to reduce errors in the database. Bar-coding and scanning systems were implemented to facilitate package tracking.

In May 1997, the Nevada Test Site Waste Acceptance Criteria system, an enhancement to LWIS, was implemented and accepts multiple waste profiles, includes more detailed information on waste form and treatment, and is currently in use. To document and improve the accuracy of the historic waste inventory for 1961 through 1978 and make the information more usable, several historic tracking systems, including paper records and scanned records, were reviewed and cross-checked. The data were incorporated into one searchable spreadsheet. Chemical hazards were not routinely profiled before landfill regulations and RCRA were implemented; therefore, the presence of hazardous constituents and suspected hazardous constituents, and consequently the characterization of some waste as being potential MW, was inferred from general descriptions, historic photographs, and other sources. The early RWM System database covering disposal from the mid-1970s through 1992 was also checked and cross-checked with other documentation to attempt to verify locations, volumes, and characteristics of waste disposed.

Table A-8 provides information on waste buried from 1961 through December 2004. These data are from three sources: scanned paper records, the RWM System database, and the LWIS database, with slightly overlapping periods of record.

2.5 HAZARDOUS WASTE INVENTORY

The hazardous waste inventory has been compiled from available records for all units that contain hazardous materials. Pit 3 and the Asbestiform Unit are permitted units with well-kept records. Waste in the CAU 111 units and the GCD boreholes contain hazardous materials of uncertain quantities. Estimates of hazardous components in these units are discussed below.

2.5.1 CAU 111 Disposal Units

The CAU 111 disposal units were in operation prior to the implementation of a detailed record keeping system. Table A-9 presents the Sugar Bunker Dump designations, if applicable. Waste was typically disposed in bulk form or containerized in plastic bags, steel drums, and cardboard, plywood, or steel boxes. Waste stream descriptions are limited. Typical waste stream descriptions include laundry wastes, laboratory wastes, scrap metal, contaminated soil, personal protective equipment, and samples.

Other waste streams include farm wastes from the historic EPA Farm operations, which may have included animal wastes. Many records do not indicate the exact location where the waste was disposed. Analytical waste profiling focused primarily on radioactivity but typically only stated a total curie estimate without identifying specific radionuclides. From process knowledge and general waste descriptions, it can be inferred that some wastes contain hazardous constituents. Approximately 40 percent of available records indicate hazardous constituents may be present; however, the amount of hazardous constituents present in these wastes is unknown.

Past laboratory operations at the NTS have typically included the use of organic solvents. Waste streams denoting laboratory wastes are therefore assumed to contain an unknown amount of organic solvent. Solvents may include those typically found in laboratories (e.g., toluene, acetone, trichloroethylene, benzene, and carbon tetrachloride). Lead shielding, loose lead, and lead bricks have also been noted in disposal records. Lead shielding is assumed to be present from any record denoting the disposal of radioactive sources.

Table A-10 presents the known or suspected hazardous constituents present in each CAU 111 disposal unit. Constituents consist primarily of organic solvents and lead. Estimated waste volumes presented in Table A-8 are based on disposal unit dimensions and disposal practices. A radionuclide inventory was developed based on historic characterization data, assumptions regarding the isotopic composition of uncharacterized waste streams, and estimated waste volumes as described in the PA (BN, 2006). The approach is consistent with the methods used to estimate the pre-1998 inventory and accounts for 100 percent of the estimated waste volumes.

TABLE A-9. CAU 111 CELL DESIGNATIONS

CURRENT DESIGNATION	SUGAR BUNKER DESIGNATION
P01	none
P02	none
T01B	Pit No.1
T02B	UF
T04B	UD
T06B	UA
T01A	CA
T03A	CC
T05	N-HA
T06A	S-HA

TABLE A-10. CAU 111 HAZARDOUS WASTE CONSTITUENTS

DISPOSAL UNIT	KNOWN OR SUSPECTED HAZARDOUS CONSTITUENTS
P01	lead, lead shielding, a barium source, organic solvents
P02	lead, lead shielding, a barium source, organic solvents
T01B	lead bricks, lead shielding, cadmium, chromium, mercury, organic solvents
T02B	organic solvents, lead
T04B	organic solvents, lead shielding, mercury
T06B	laboratory wastes containing lead, cadmium and mercury, organic solvents, lead bricks
T01A	lead
T03A	organic solvents, chromium, lead
T05	organic solvents
T06A	organic solvents

2.5.2 GCD Boreholes

Known hazardous waste in the GCD boreholes includes an estimated 60.5 kilograms of lithium hydride in borehole 4 and 45.0 kilograms of lithium deuteride in borehole 1 (Chu and Bernard, 1991). These exhibit the hazardous characteristic of reactivity. Some nuclear weapons accident residue (NWAR) waste in boreholes 1, 2, and 3 may contain melted high explosives in the waste matrix. Lead and mercury are also believed to be present in the NWAR waste matrix, which exhibit characteristics of toxicity.

2.6 INVENTORY MODEL

The first attempt to compile the radionuclide inventory in the Area 5 RWMS disposal cells occurred in the early 1990s to support the development of the Area 5 RWMS PA and CA documents (Shott et al., 1998; BN, 2001b). The second major review and revision to the inventory estimates occurred in 2004 during the preparation of the addendum to the Area 5 PA (BN, 2006).

To support the addendum, an inventory model was developed using GoldSim® software. The model includes all historic records and accounts for uncertainty of the inventories and volumes of the disposed waste. The Area 5 Inventory Model (currently at version v2.014) estimates the inventory of radionuclides disposed in various disposal units at the RWMS.

The model is implemented in the probabilistic GoldSim® modeling platform, which allows estimation of inventory uncertainty by Monte Carlo simulation. Inventory radioactive decay and ingrowth during the operational period are also handled by native GoldSim® routines for solution of the Bateman equations. Model input data, data sources, assumptions, and methods are documented in notes, comments, hyperlinks, and graphics included within the model (BN, 2006).

Inventory records are maintained in three sources: the waste management logbook, the Waste Management Division (WMD) database, and the LWIS. The waste management logbook is a paper record summarizing disposal at the Area 5 RWMS from 1960 until 1978. Beginning in 1976, some disposal records were entered into the WMD, an electronic database in use until 1993. From 1993 until the present, the LWIS has been in use. In addition to the database records, original records sent by the generator, survey records, and receipt records are maintained in an electronic imaging system. Records of disposals regulated under DOE O 435.1 are maintained in the WMD and LWIS. The data sources have numerous limitations (Shott et al., 1998). Records before 1994 are especially uncertain. Known problems include:

- Waste characterization before 1994 is not complete. Important radionuclides may not have been reported. In early records, radionuclides may not have been identified, and disposal is simply recorded as "curies." Some records indicate mixtures of radionuclides, such as mixed fission products (MFPs), depleted uranium, enriched uranium, plutonium, or plutonium scrap codes (PU51, PU52, or PU57).
- Inventory records are incomplete. Not all disposals were entered into waste management records. This problem occurs more commonly for older records.
- The pre-1993 relational database tables are not completely populated with data. Consequently, some records in different database tables cannot be linked and retrieved in queries. Detailed review of the database and supporting records in FY 2004 has reduced this problem significantly. It is estimated that there are approximately 3,300 packages that cannot be associated with an inventory. This represents less than 1 percent of the package records.
- The pre-1993 database radionuclide quantity data are recorded by shipment rather than by container. If containers within a shipment were sent to different disposal units, the total shipment inventory would have been recorded as disposed in each unit. This may cause multiple counting of some inventories.

2.7 INVENTORY REVISIONS

The 1998 PA added the activity of a limited list of fission products based on the activity recorded in the database as MFPs or disposed as strontium-90 or cesium-137. The fission product scaling factors were estimated from a literature source of fission yields for fast neutron fission of plutonium-239. The current model assigns activity to individual fission products based on the activity of only MFP or gross activity disposed. The list of radionuclides included and their scaling factors are based on an estimate of the radionuclide composition of the NTS underground testing areas.

The 1998 PA estimated the inventory of unreported uranium isotopes by assuming an isotopic mixture for each generator. The model assumes uranium-238 and uranium-235 disposed before FY 1994 were depleted and enriched uranium, respectively. Enriched uranium is stochastically divided for each FY into low and high enrichment fractions. The level of enrichment in each category (i.e., depleted, low enrichment, high enrichment) is selected randomly for each FY. The isotopic composition of each mixture is based on a published empirical relationship between specific activity and enrichment for the gaseous diffusion process (DOE, 2004). In addition to corrections for uranium isotopes, scaling factors for fission product and transuranic contamination from recycled uranium are estimated from data provided by waste generators.

The 1998 PA estimated the inventory of unreported radionuclides in weapons-grade plutonium disposed as PU52, an American National Standards Institute (ANSI) plutonium scrap code (ANSI, 1987). The current model performs similar revisions, but also includes calculations for PU51 and PU57. The inventory of plutonium-239 disposed before FY 1994 is assumed to represent the activity of PU52 weapons-grade plutonium, and corrections are made for other transuranic radionuclides expected to be present.

Important model inputs are set up as pdfs representing uncertainty. Input pdfs are repeatedly sampled and propagated through the model to produce a distribution of model results. The model output distributions are well represented by lognormal distributions and are entered into the Area 5 RWMS GoldSim® model as lognormal distributions with the geometric mean and standard deviation of the inventory model outputs. The assumptions made in the inventory model include:

- Waste disposed from October 1, 1988, through September 30, 2028, is regulated by DOE O 435.1. There is no official closure date for the site. The 2028 closure date is an arbitrary assumption based on an assumed 50-year operational period starting in 1978, when the Area 5 RWMS opened to offsite generators.
- Uncertainty in disposed waste inventories is poorly known. Therefore, waste uncertainty is represented by what is believed to be a conservative distribution. The annual sums of radionuclide activity disposed after October 1, 1988, are assumed to be the median of a lognormal distribution. The 99th percentile of the distribution is assumed to be equal to ten times the median (geometric standard deviation = 2.69).
- Waste disposed before FY 1994 is assumed to be incompletely characterized. Radionuclide disposal rates before FY 1994 are corrected for unreported radionuclides. Activity disposed as gross activity or MFP activity is scaled to estimate individual radionuclide activities by assuming that the mixture has the same radionuclide composition as the NTS underground testing areas (Bowen et al., 2001). The reported gross activity or fission product activity is assumed to be the activity of cesium-137, and all other fission product and activation product activity is scaled from cesium-137. The activity of uranium-238 and uranium-235 disposed before FY 1994 is assumed to be the activity of depleted and enriched uranium, respectively. Scaling factors for other uranium isotopes are based on a published relationship between specific activity and enrichment of uranium for the gaseous diffusion process (DOE, 2004). Scaling factors for minor contaminants in uranium are estimated from data provided by generators. Plutonium disposed as PU51, PU52, and PU57 are assigned individual radionuclide activities based on isotopic composition of standard plutonium scrap codes (ANSI, 1987) and typical values expected for weapons-grade plutonium.
- The WMD database does not include data for all disposed wastes. Some waste shipments were not recorded in the databases. Some database tables are not fully populated, and waste inventories cannot be retrieved by queries. The potential missing waste has been estimated by subtracting the volume of disposed waste retrieved from the databases from the physical volume of filled waste disposal units. The missing volume has been added to the inventory assuming it has the mean concentration of disposed waste. This correction is applied to pre-1988 waste only.
- The volume of future waste is based on estimates provided by waste generators. The concentration of waste in future FYs is assumed to be equal to randomly selected concentrations from past FYs.

3.0 STATE THE PROBLEM (STEP 1)

Step 1 of the DQO process describes the problem to be studied and develops a CSM to gain a sufficient understanding in defining the problem.

3.1 PROBLEM STATEMENT

The problem statement for the 92-Acre Area is, “Is the site sufficiently characterized to provide the input data necessary to evaluate corrective action alternatives without the collection of additional data?”

3.2 CONCEPTUAL SITE MODEL

The CSM describes the site performance (source term, releases, fate, and transport). It reflects the best interpretation of available site information and describes the most probable scenario for current conditions at the site. The CSM is based on historical documentation, personnel interviews, site process knowledge, and characterization, modeling, and monitoring data.

The CSM for the 92-Acre Area demonstrates that migration of contaminants is not occurring and that buried waste is not creating a dose to NTS workers. The CSM also demonstrates that the buried waste does not pose a risk to future MOPs and the environment. Characterization, modeling, and monitoring data have demonstrated this, and the geology, meteorology, surface water, vadose zone, groundwater, vegetation, wildlife, soil gas, natural hazards, subsidence, and air quality of the site have been studied extensively to support the CSM. The CSM that is implemented in the facility assessments is described in Section 3.2.2, following the site characteristics discussed below.

3.2.1 Site Characteristics

3.2.1.1 *Geography*

The Area 5 RWMS is located in the northern part of the Frenchman Flat hydrographic basin, at the juncture of three coalescing alluvial fan systems (Snyder et al., 1995). Frenchman Flat is a roughly circular, topographically closed basin bounded by the Massachusetts Mountains on the north, the Buried Hills and Ranger Mountains on the east and southeast, Mount Salyer on the west, and Mercury Ridge and Red Mountain on the south. The Area 5 RWMS is at an elevation of approximately 3,180 to 3,200 ft above mean sea level.

3.2.1.2 *Geology*

The mountain ranges surrounding Frenchman Flat consist primarily of Tertiary volcanic rocks and underlying Paleozoic sedimentary rocks. Erosion of the mountain ranges has resulted in deposition of a significant thickness of alluvium. Thickness of alluvium in Frenchman Flat ranges between 0 and 4,900 ft. Basalt flows are interbedded in the alluvium in the northern part of Frenchman Flat, approximately 900 ft below the ground surface. The alluvium is underlain by interbedded Tertiary ash-flow and ash-fall tuff estimated to be over 3,900 ft thick (BN, 2005e).

Principal faults in Frenchman Flat are the Cane Spring Fault and the Rock Valley Fault. The Cane Spring Fault is a left-lateral, strike-slip fault that strikes southwest to northeast in the northern part of Frenchman Flat, 4 mi northwest of the Area 5 RWMS. The Rock Valley Fault is a left-lateral, strike-slip fault with a minor dip-slip component (down to the north) that strikes southwest to northeast in the southern part of Frenchman Flat, about 5.5 mi south of the Area 5 RWMS. Both of these faults are active and responsible for earthquakes within the recent past.

3.2.1.3 *Meteorology*

The NTS is located between the northern boundary of the Mojave Desert and the southern limits of the Great Basin Desert. This "transitional desert" is considered to be typical of either the dry mid-latitude or dry subtropical climatic zones. The climate is arid and characterized by low precipitation, a large diurnal temperature range, a large evaporation rate, and moderate to strong winds (BN, 2005f).

The average annual precipitation from 1963 to 2004 at the Well 5B meteorological station, 4 mi south of the Area 5 RWMS, is 4.92 inches (in.). Potential evapotranspiration (PET) is a measure of the exchange of water and heat between the earth's surface and the atmosphere and an important component of the water balance calculation used to evaluate the potential for precipitation to infiltrate and percolate to the waste cells. PET at the NTS is high because of the large incident solar radiation and high average wind speeds, and occurs at a potential, or energy-limiting, rate. Average annual PET from 1995 through 2004 was 60.2 in., many times the average precipitation rate.

The open and sparsely vegetated Frenchman Flat basin is windy and enhances evaporation rates. In 2004, the average daily wind speed was 5.8 miles per hour (mph), and the maximum gust measured was 45.6 mph. Winds are primarily from the southwest during spring and summer months and from the north during winter months. Wind speeds tend to be greatest in spring.

3.2.1.4 *Surface Water*

No permanent surface water is present within Frenchman Flat, with the exception of small artificial impoundments and Cane Spring, which issues from a perched aquifer recharged from infiltration through fractures in the nearby mountains. Cane Spring is approximately 9 mi southwest of the Area 5 RWMS. Alluvial fans within Frenchman Flat are cut by numerous arroyos that drain storm runoff to the playa. Water that accumulates on the playa typically evaporates or infiltrates, or both, within a short period of time. Frenchman Playa is approximately 4 mi southeast of the Area 5 RWMS.

Flood analyses for the 25-year and 100-year storm events have been conducted for the Area 5 RWMS (Schmeltzer et al., 1993). Although the southwest corner of the Area 5 RWMS is within the 100-year floodplain, most of the 92-Acre Area is outside the floodplain delineation. Disposal units within the Area 5 RWMS are protected from offsite flooding events by a RCRA-compliant berm and channel system capable of conveying flood flows from a 25-year, 24-hour storm event.

3.2.1.5 *Vadose Zone*

Several studies and models have been completed to characterize the stratigraphy and physical properties of the unsaturated zone in Area 5, the physical properties of the existing operational covers, and the potential for movement of water through the vadose zone (Albright et al., 1994; Blout et al., 1995; BN, 2005b; BN, 2005c; BN, 2005e; REECo, 1993a; REECo, 1993b).

Time-domain reflectometry (TDR) data from automated waste cover monitoring systems provide direct measurement of moisture content in soil. Measured volumetric soil water content at the P03 and P05 floor sensors has consistently been approximately 10 percent, which indicates that moisture has not migrated more than 4 ft below the waste (BN, 2005f).

The Area 5 Weighing Lysimeter Facility, located approximately 1,300 ft southwest of the Area 5 RWMS, consists of two precision weighing lysimeters. One lysimeter is vegetated with native plant species at the approximate density of the surrounding desert. The other is not vegetated to simulate the bare operational waste covers at the Area 5 RWMS. Each of the weighing lysimeters is instrumented with TDR probes to measure volumetric soil-water content at depths ranging from 4 to 67 in. Due to transpiration, the vegetated lysimeter is significantly drier than the bare-soil lysimeter. Wetting fronts at the vegetated lysimeter have not exceeded 4 ft in depth except in the spring of 2005, in comparison with the bare-soil lysimeter, where moisture reached the base of the lysimeter at 6.6 ft and began to pond.

Model simulations calibrated to the weighing lysimeter data set indicate that once vegetated, drainage through a cover is essentially eliminated (Desotell et al., 2006). Climate and vegetation strongly influence the movement of water in the near-surface alluvium (upper 6.5 ft). Except for periods following precipitation events, water content in the near-surface region is low. Below this region is a zone where steady upward movement of water is occurring, primarily via evaporation (Tyler et al., 1996). This zone extends to depths as great as 10 to 131 ft. Below this zone, water potential measurements indicate the existence of a static zone between approximately 131 and 295 ft below ground surface (Shott et al., 1998). In this static zone, essentially no vertical liquid flow is currently occurring. Below this static zone, flow is downward, due to gravity.

In the unlikely event contaminants migrate below the static region to where vertical gravitational flow is possible, movement to the groundwater would be extremely slow. Conservative median modeling estimates of the time it would take water to move from beneath the static region (approximately 300 ft below ground surface) to the groundwater (approximately 720 ft below ground surface) are in excess of 50,000 years (Shott et al., 1998). Under model assumptions, there is a 99 percent probability that the time would exceed 30,000 years (Shott et al., 1998).

3.2.1.6 *Groundwater*

Frenchman Flat is in the Ash Meadows sub-basin (Laczniak et al., 1996) of the Death Valley Regional Flow System, a major hydrologic subdivision of southern Great Basin. Groundwater primarily flows through the lower carbonate-rock aquifer and discharges along a line of springs in Ash Meadows. Water levels within the lower carbonate-rock aquifer indicate that the gradient is nearly flat (less than 1.6 ft per mi), and calculated groundwater flow velocities have generally been less than 0.5 ft per year. The depth to the static water level in Frenchman Flat ranges from 690 ft near the central playa to more than 1,150 ft at the northern end of the valley.

Groundwater from the uppermost aquifer (Laczniak et al., 1996) is sampled semiannually. Water samples collected from three wells are analyzed for radioactive and nonradioactive constituents. Groundwater monitoring data are presented in detail in the annual groundwater monitoring data report (BN, 2005g). All groundwater sampling data to date indicate that the groundwater in the uppermost aquifer is unaffected by RWMS or DOE weapons testing activities.

The potential for groundwater quality impacts from the Area 5 RWMS waste storage is low because vertical movement of percolating water is limited by many factors including climate and geology. Except for short-term events, evapotranspiration is much higher than precipitation. There is insignificant stormwater runoff, there has been no apparent recharge in the immediate vicinity, and there are no known potential conduits deeper than the GCD boreholes that could speed transmission of potential leachate to deeper strata.

3.2.1.7 *Vegetation (Flora) and Wildlife (Fauna)*

The nature and distribution of plants and animals and their ecological interactions are of interest both as agents of contaminant transport and as potential receivers of contaminants. They have a complex role in potential transport of water and radioactive particles through soil landfill covers.

The type, maturity, and density of vegetation affect the potential for evapotranspiration, soil erosion, and rainwater infiltration (Hunter and Medica, 1989; Ostler et al., 2000). Rooting depth is tied to soil moisture availability. Shrubland species at the Area 5 RWMS have shallow root systems, and observed root depths are generally less than 6.6 ft (Foxx et al., 1984a; 1984b; Hansen and Ostler, 2003). The potential for plants to enhance downward movement of water towards buried waste is offset by their use of water to live and grow. Decomposition of roots provides channels for water and vapor and may enhance infiltration and percolation through the rooting depth, but plants remove water from the soil, store it in biomass, and transpire it back to the atmosphere. Plant evapotranspiration minimizes potential water transport through the cover, and the plant canopy and roots help control erosion of the surface by wind and rain.

Because plant roots absorb radionuclides from soil water, draw radionuclides up into leafy parts of the plant, and potentially release some to the atmosphere via transpiration, vegetation can also be a factor in the movement of radionuclides in the near surface. Biota monitoring has mainly focused on sampling vegetation for tritium due to its high mobility as tritiated water. Vegetation from on and near waste covers, as well as vegetation from control areas far from waste covers, is usually sampled in mid-summer. Plant water is extracted from the vegetation samples by room temperature vacuum distillation and analyzed by liquid scintillation for tritium. If tritium concentrations in vegetation are exceedingly high, or if animal burrows on or near waste covers are observed in significant numbers, wild animals and soil from animal burrows may be sampled. Vegetation sampling may be limited year to year, depending on rainfall and waste cover operations during operational closure. Traces of tritium have been found in plant tissue.

Fauna have a potential role in transport of radioactive contaminants through burrowing and the food chain. Fauna within the Mojave Desert plant communities at Frenchman Flat are diverse. Ants and termites are the most numerous burrowing animals on the NTS (O'Farrell and Emery, 1976). Vertebrates are less numerous and diverse and include game and burrowing species. Both small and large burrowing mammals are present in the areas of the Area 5 RWMS. Rodents are the most common of the mammalian species on the NTS (Allred et al., 1963).

The depth of burrowing is tied to soil conditions and rooting depths. Most animals at the NTS burrow in the upper 10 ft of soil. Termites have been known to excavate as deep as 20 ft; however, because roots are their primary food source, burrowing depths are also closely related to rooting depth (Cochran et al., 2001). Vertebrate animal burrows at the RWMS tend to be below shrubs. Most of the burrows are 2 to 4 in. in diameter and extend approximately 1 ft below ground surface.

3.2.1.8 *Soil Gas*

Monitoring of tritium concentrations in soil gas at multiple depths over time provides key data for evaluating the rate of vertical migration of radionuclides. Gas-phase tritium monitoring has been conducted via soil-gas sampling at GCD-05U since 1990. This disposal unit has a large tritium inventory (2.2 million curies at time of disposal) and is instrumented with two strings of nine soil-gas sampling ports buried at depths ranging from 10 to 120 ft below surface. Tritium sampling at GCD-05U provides a direct measure of tritium migration from waste packages with time due to degradation of waste containers and the natural transport processes of advection and diffusion. Results from 1990 through 2004 indicate that soil-gas tritium concentrations have gradually increased at depths between 50 and 120 ft, but vertical migration is extremely slow.

3.2.1.9 *Natural Hazards and Subsidence*

Subsidence is expected to occur as waste and cover fill materials settle through time. Differential settling, especially across disposal feature margins, can cause cracks at ground surface, which could provide vertical migration pathways for water, vapor, and mobile contaminants. Depressions, which can retain water after rainstorms, allow more water to infiltrate and more plants to grow on the landfill covers. Large-volume groundwater withdrawals could also cause regional subsidence as the alluvial aquifer is dewatered, should groundwater pumping increase substantially in the future.

Many factors affect potential subsidence of the landfill covers, including structural integrity of containers, how containers were packed into units, weight of stacked containers and soil covers, void space within and around containers, and compaction of soil covers. Subsidence monitoring is conducted monthly at all disposal units.

Natural hazards that may affect the disposal areas include seismic activity and flooding. While these natural and incidental hazards are unpredictable, studies have been done to determine the relative risk of these hazards impacting the disposal sites, and measures have been implemented to reduce the risk of containment failure. Active faults nearest the Area 5 RWMS are within the Rock Valley fault system (O’Leary, 1996). These faults are over 3 mi from the facility. Effects of future seismic events have been judged to not significantly impact the waste isolation performance of the Area 5 disposal facility (BN, 2006).

Three watersheds make up the drainage area that could impact the Area 5 RWMS. The southwest corner of the Area 5 RWMS is within a 100-year flood hazard zone. This zone is defined to have 0.01 percent probability that a flood with a depth of flow greater than 1 ft could occur within any given year. Other parts of the Area 5 RWMS are within an area referred to as Zone X, a flood-hazard designation that corresponds to areas outside of the 100-year flood hazard zone. Sheet flow resulting from a 100-year, 6-hour precipitation event is anticipated to be less than 1 ft deep (Schmeltzer et al., 1993). In the mid-1990s new channels and berms were designed and built. The berm system is adequate to handle a 25-year, 24-hour storm.

3.2.1.10 *Air Quality*

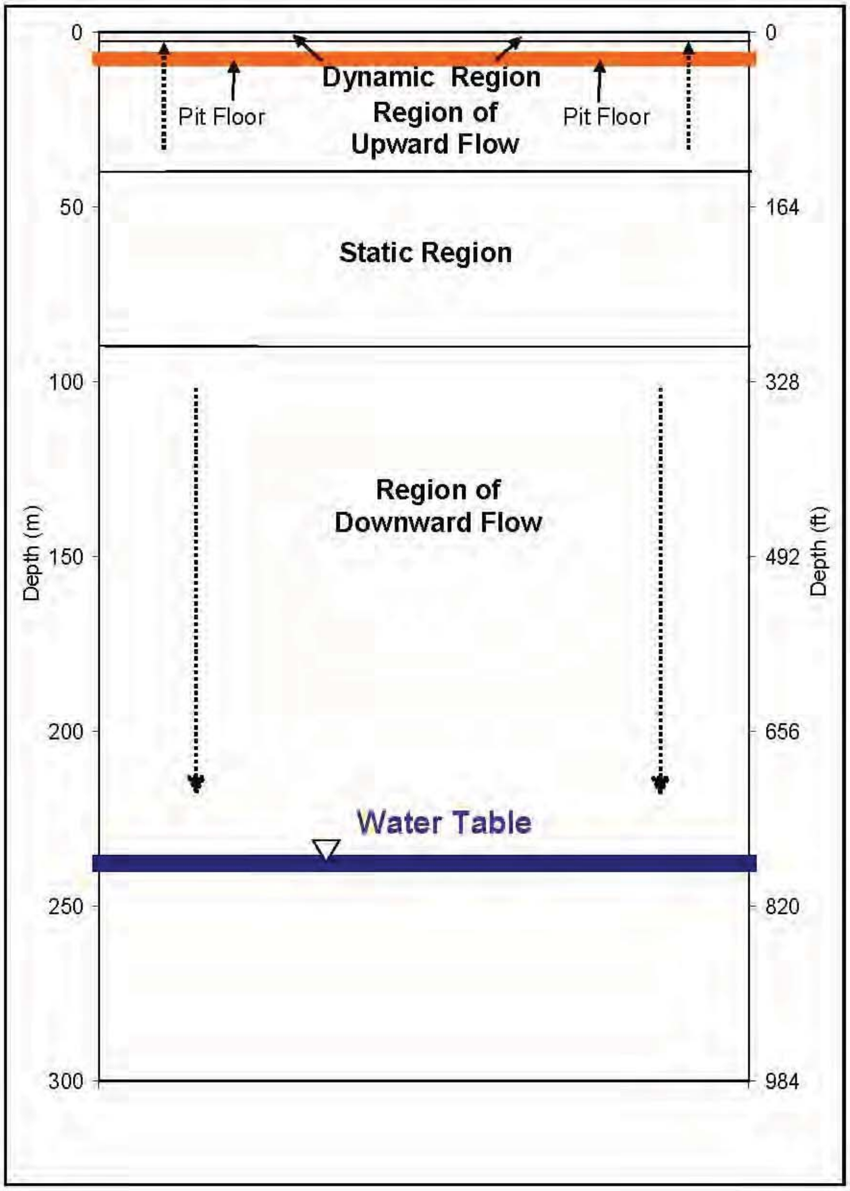
Air monitoring is conducted to confirm that RWMS activities do not result in significant radionuclide concentrations above background. Air quality results are summarized in the annual *Waste Management Monitoring Report* (BN, 2005f). The tritium concentration in the air near the RWMS, compared to background concentrations at the NTS, is an indicator of how well the waste disposal cells are mitigating migration of volatile radionuclides from waste cells. Tritium concentrations at the Area 5 RWMS are less than the DOE Derived Concentration Guide (DCG) for tritium. According to DOE O 5400.5, "Radiation Protection of the Public and the Environment," the DCG is the concentration of a radionuclide in the air that could be inhaled for 1 year and not exceed the DOE radiation standard of 100 mrem/yr committed effective dose equivalent to the public (DOE, 1993).

Air particulate samples are collected weekly from monitoring stations near the RWMS and are screened for gross alpha and gross beta activity to provide early detection of any changes. Monthly composites of filters from each sampling location are analyzed for americium, plutonium, and gamma emitters. Air particulate monitoring data indicate that radionuclide concentrations in air at the RWMS are not above those of other nearby stations. The concentrations of all the analytes in samples from the RWMS are similar to concentrations elsewhere at the NTS.

Ionizing radiation from both natural and man-made sources is measured quarterly through a network of thermoluminescent dosimeters. Data collected from 1998 through 2004 indicate that direct radiation exposure at the Area 5 RWMS is low. Levels at all the sites were below 1.8 milliroentgens per day (mR/day). The average exposure rate at background NTS locations is 0.30 mR/day (BN, 2005f).

3.2.2 Facility Assessments Conceptual Model

The following discussion of the conceptual model is a summary from the second addendum to the PA (BN, 2006). Further details, including the implementation of the conceptual model in GoldSim® and the analyses performed to identify the sensitivities, are included in the PA. The 1998 PA model of unsaturated flow in the vadose zone was developed to understand liquid fluxes capable of transporting radionuclides. The model, based primarily on observed water potential and chloride profiles, hypothesized four regions of liquid flow in the vadose zone (Figure A-4). Zone boundaries are approximate and may vary from location to location within Frenchman Flat. In Zone I, a near-surface zone approximately 115 ft thick, the water potential indicates a potential for upward liquid flux. Zone II, occurring from approximately 115 to 295 ft, is a static region with negligible liquid flux. Zone III, an intermediate region with downward liquid fluxes driven by gravity, occurs from approximately 295 ft to within a few inches of the saturated zone. The final region, Zone IV, which is a few inches thick, is a transitional zone between the vadose zone and the saturated zone where water potential and flow are negligible.



Dynamic Region: Magnitude and direction of liquid fluxes are variable and determined by episodic infiltration, evapotranspiration, and processes of biotic transport. The no-flux boundary is located at mean depth of 6 ft.

Zone I, Region of Slow Upward Flow: Region where the combination of low precipitation and high potential evapotranspiration leads to a dry zone, inducing upward flow of pore water in the unsaturated zone from as deep as about 100 ft. Mean upward flux is 0.004 mm/yr.

Waste zone located in region of upward flow.

Zone II, Static Region: Region of no vertical liquid flow (balance of matric suction and gravitational forces). The thickness and the depth below the surface of this region changes with the physical/textural properties of alluvium and in situ water content.

Zone III, Region of Slow Downward Flow: Region of steady downward flow (increased water content allows downward drainage). Water in the vadose zone is currently recharging the water table most likely infiltrated during past pluvial climate cycles.

There is no aerially distributed recharge to the groundwater table under current conditions.

FIGURE A-4. PA MODEL OF UNSATURATED FLOW IN THE VADOSE ZONE

Zone I includes a dynamic region in the upper few feet of the vadose zone where the water potential gradient periodically reverses as precipitation infiltrates and is returned to the atmosphere by evapotranspiration. A strong upward potential for flow is maintained in Zone I by the roots of xeric desert plants. Although there is a potential for upward flow in Zone I, the soil is normally so dry that liquid water advection is very slow. In the very near-surface, where plant roots maintain low soil moisture content, upward water movement occurs predominantly in the vapor phase (and through plant roots), and the upward advection of soluble radionuclides may become negligible. The boundary where upward liquid advection rates approach zero is referred to as the no-flux boundary (NFB) in the PA model.

The large accumulation of chloride in Zone I below 6.6 ft indicates that transient infiltration events are impeded above this depth and returned to the atmosphere by evapotranspiration. Assuming a constant atmospheric chloride source and downward liquid advection, the observed near-surface chloride accumulation below the root zone is estimated to require from 10,000 to 15,000 years to form, which corresponds with the end of the last pluvial period, approximately 8,000 to 15,000 years ago (Tyler et al., 1996; Walvoord et al., 2002a).

The chloride accumulated throughout the entire profile at pilot wells UE5PW-1 and UE5PW-3 suggests that infiltration at these locations has not reached the water table for 95,000 to 110,000 years (Tyler et al., 1996). The chloride profile at UE5PW-2 suggests that the sub-root zone chloride bulge was flushed from this profile at some time before 15,000 years ago, indicating that spatially variable recharge occurred during an earlier pluvial period. The chloride profiles in the vadose zone near the Area 5 RWMS suggest that recharge through the alluvium ended after the last pluvial period when the climate became drier and woodlands were replaced by more xeric desert shrubs.

The 1998 PA estimated upward liquid flux in Zone I using a process model. The estimated flux, 5×10^{-6} millimeters per year (mm/yr), was so low that upward liquid advection of radionuclides was not included in the 1998 PA release and transport model. Diffusion of radionuclides in the liquid phase was considered as an alternative upward release pathway, but was assumed to be negligible at the low water contents in the near-surface based on theoretical considerations and literature reports. Although upward liquid advection and diffusion were included in the 1998 PA conceptual model, their rates were assumed to be so low as to be negligible, and quantitative values were not included in the release and transport mathematical model.

3.2.2.1 *Recent Deep Vadose Zone Research and Development Results*

The understanding of how matric potential and chloride profiles develop in thick desert vadose zones has advanced since the 1998 PA. Although conditions in thick vadose zones appear to be stable over long periods, the upward liquid flux in Zone I and the downward liquid flux in Zone III suggest that the system cannot be at steady-state. Previous interpretations of the observed profiles had conceptual inconsistencies. Upward flow in Zone I and downward flow in Zone III cannot be maintained unless there is a water source in Zone II. If the source of water in Zone II is transient surface infiltration, the near-surface chloride accumulation is not expected. The chloride accumulation suggests that recharge is not occurring. However, purely physical models (i.e., without plants) that assume no recharge cannot simulate the large negative matric potentials observed in the near-surface.

Walvoord et al. (2002b) have developed and tested the Deep Arid System Hydrodynamic (DASH) model for thick desert vadose zones that supports the 1998 PA conceptual model and resolves apparent inconsistencies between the observed water gradients and chloride profiles. The DASH conceptual model assumes a constant, strongly negative matric potential maintained below the root zone by desert vegetation, a mean annual geothermal temperature gradient, and allows water vapor movement driven by temperature (thermal vapor flux) and matric potential (isothermal vapor flux). Implementing this model with the finite element heat and mass transfer (FEHM) model, Walvoord et al. (2002b) have shown that matric potential and chloride profiles similar to those observed at the Area 5 RWMS can be maintained at equilibrium. The model identifies water vapor driven upward from the water table by the geothermal temperature gradient as the probable source of water to the deep vadose zone. The water fluxes are extremely small, and the profiles are not currently at equilibrium. Zones II and III are most likely still draining infiltration that occurred during prior pluvial periods.

Using surface boundary conditions for infiltration and root-zone matric potentials based on a 110,000-year paleoclimate reconstruction for southern Nevada, Walvoord et al. (2002a) were able to simulate matric potential and chloride profiles observed at the Area 5 RWMS pilot wells, UE5PW-1, UE5PW-2, and UE5PW-3. Sub-root zone upward liquid fluxes were estimated to range from 2 x 10^{-5} to 1 x 10^{-3} mm/yr under the current climatic conditions. The hydraulic response time, the time required for an e-fold ($1 - e^{-1}$) change in matric potential from the initial to steady-state profile, was estimated to be 300,000 years for Frenchman Flat, again suggesting that the pilot well profiles are not at equilibrium, but drying very slowly.

3.2.2.2 *Recent Shallow Vadose Zone Research and Development Results*

A key assumption of the DASH model is that plants maintain a large negative matric potential in the root zone and extract all infiltrating water. Andraski (1997) has investigated water movement in the upper 16 ft of the vadose zone in the Amargosa Desert. On a vegetated native soil plot, no evidence of water accumulation or percolation below 3.3 ft was observed over a five-year period. Non-vegetated plots showed a small increase in water storage and percolation to depths of 6 ft.

The Area 5 weighing lysimeter facility, located approximately 1,300 ft southwest of the Area 5 RWMS, has been continuously recording water storage in two 6.6-ft-deep precision weighing lysimeters since March 1994. One lysimeter has been revegetated with native plants, and the other is maintained bare. No increase in water storage has been observed for the vegetated lysimeter. Early increases in water content for the vegetated lysimeter were caused by irrigation performed to establish native plants. The bare lysimeter shows a slowly increasing trend in water storage. Although water has never been observed to drain from the bottom of either lysimeter, it is likely that a small fraction of infiltrating precipitation will eventually drain from the bare lysimeter (BN, 2005f).

Water content in the near-surface has also been monitored at the Area 5 RWMS since 1995. Water content monitoring began with neutron moisture measurements in boreholes at Pit 3 (P03). Beginning in 1998, automated water content monitoring systems using TDR probes were installed in the operational cover and floor of Pit 3 and Pit 5, in the cover of Pit 4, and outside the Area 5 RWMS near UE5PW-1. With the installation of the automated TDR system, neutron moisture logging has been discontinued.

Automated TDR moisture content monitoring in the weighing lysimeter indicates that wetting fronts penetrate a short distance in the vegetated lysimeter before being evaporated. Wetting fronts, including some occurring during the particularly wet fall of 2004, are not observed to penetrate below 4.3 ft in the vegetated lysimeter. Percolation to greater depths may occur in unvegetated areas, including operational covers at the Area 5 RWMS. Wetting fronts from the fall of 2004 have been observed to penetrate to a depth of 4.9 ft at Pit 3 and Pit 4 (BN, 2005f). Monitoring systems installed below Pit 3 and Pit 5 continue to show constant water contents, indicating that no water has percolated through waste.

3.2.2.3 *Current Vadose Zone Conceptual Model*

The vadose zone conceptual model implemented in the Area 5 RWMS GoldSim® model is similar to the 1998 PA model. The mathematical implementation of the model in the Area 5 RWMS GoldSim® model includes a number of refinements and additional detail for the shallow vadose zone. Both models assume Zone I has a potential for upward transport of soluble radionuclides by upward liquid advection and diffusion in the liquid phase. The 1998 PA assumed that the upward liquid flux and liquid diffusion rate were negligible in Zone I. The Area 5 RWMS GoldSim® model divides Zone I into two regions with different upward liquid fluxes. Above the NFB, assumed to be at a mean depth of 6.6 ft, upward liquid flux is assumed to be zero. Below the NFB, a pdf of upward liquid fluxes is assumed. Complete documentation of the vadose zone conceptual model is found in the Area 5 RWMS GoldSim® model and its references (BN, 2006).

Upward liquid fluxes cannot be directly measured under the dry conditions at the Area 5 RWMS. Since preparation of the 1998 PA, upward water fluxes ranging over nearly six orders of magnitude have been estimated by several different modeling methods. Water balance and stable isotope methods have produced the highest estimates ranging from 0.1 to 1 mm/yr (Tyler et al., 1999). Physical models of liquid flow have produced lower estimates ranging from 5×10^{-6} to 0.2 mm/yr (BN, 2001b; Shott et al., 1998). The Area 5 RWMS CA (BN, 2001b) and Area 3 RWMS PA/CA used a mean water flux (vapor and liquid flux) of 0.3 mm/yr and 0.2 mm/yr, respectively, estimated using stable isotope methods (Chapman, 1995; 1997).

Although each of these methods has its advantages and disadvantages, the physical models are considered to give the most reliable estimates. The water balance and stable isotope methods are suspected to produce overestimates because they calculate average rates over long time intervals when rates were likely changing. The stable isotope method assumptions may also be violated as applied at the Area 5 RWMS (Wolfsberg and Stauffer, 2003). The physical model results are uncertain because of uncertainty in the unsaturated hydraulic conductivity at low moisture contents. Unsaturated hydraulic conductivities are difficult to measure at the low Area 5 moisture contents. Most past efforts to estimate upward liquid fluxes with physical models have used unsaturated hydraulic conductivities predicted from moisture retention data.

The simulations of Wolfsberg and Stauffer (2003) are assumed to be the best available estimate of upward liquid flux. Their simulations consider a full range of surface boundary conditions and material properties, including unsaturated hydraulic conductivities measured at expected water contents. The 32 realizations of upward liquid flux from the Wolfsberg and Stauffer (2003) simulations were used to develop an upward liquid flux pdf for the Area 5 RWMS GoldSim® model. The development of the upward liquid flux pdf is documented in the Area 5 RWMS GoldSim® model and its references (BN, 2006).

3.2.3 Conclusions

The Area 5 RWMS is well suited for the isolation and disposal of waste. The site is located in an access-controlled government facility many miles from residential populations. The site has a windy, arid climate. Average annual PET is 60.2 in., many times the average precipitation rate of 4.92 in. On an annual basis, even in wet, cool years, evaporative demand is high.

The site is far from surface waters. Surface runoff and run-on is insignificant, and engineered berms provide protection from a 25-year flood. Risks of significant earthquake hazards are low. Minor subsidence of the ground surface above the edges of waste containers and the margins of the cells is likely; however, this localized subsidence can be mitigated through monitoring and maintaining the covers to preclude cracks or depressions from allowing infiltration of rainwater. Plant evapotranspiration minimizes potential water transport through the cover, and the plant canopy and roots help control erosion of the surface by wind and rain.

The vadose zone below the waste cells has low water potentials, low unsaturated hydraulic conductivity rates, and ample water storage capacity. Therefore, the potential for significant downward transmission of water is extremely low. Below this zone, water potential measurements indicate the existence of a static zone where essentially no vertical liquid flow is currently occurring. Conservative modeling estimates suggest it would take more than 50,000 years for water to move from beneath the static region to the groundwater, which is over 700 ft below ground surface. If water were to carry contaminants to the groundwater, water levels indicate that the gradient is nearly flat, and calculated groundwater flow velocities have generally been less than 0.5 ft per year. Effectively, there is no groundwater pathway, and the potential for groundwater contamination from waste disposal activities at the Area 5 RWMS is negligible.

The majority of the waste inventory is LLW, and much of the LLW contains radionuclides that will decay significantly over the next several decades. Much of the radioactivity in the waste inventory is in relatively immobile forms, with the exception of tritium, a volatile radionuclide that can readily move with water.

The CSM indicates that contaminants are not readily released or transported. The waste acceptance criteria, packaging requirements, monitoring, climate characteristics, and other factors minimize the potential for release and transport of contaminants. Assessments and analyses indicate that the Area 5 RWMS will meet the DOE regulatory performance criteria for the 1,000-year compliance period. Predicted potential human exposures for various future potential land-use scenarios are negligible.

4.0 IDENTIFY THE GOAL OF THE STUDY (STEP 2)

Step 2 of the DQO process identifies the questions the study will attempt to resolve and what actions may result. The goal of the study is to answer the following questions satisfactorily.

1. Do historical information and monitoring data adequately allow for the development and evaluation of corrective action alternatives? If so, then the corrective action alternatives will be developed and evaluated to identify the risks and costs associated with each.
2. If not, is it possible to develop such data? If the historical information and monitoring data do not adequately allow for the evaluation of corrective action alternatives, a sampling strategy and corresponding DQOs will be developed and presented to NDEP.

5.0 IDENTIFY INFORMATION INPUTS (STEP 3)

Step 3 of the DQO process identifies the information needed to address the goals of the study.

5.1 INFORMATION NEEDS

All information needed to develop and evaluate corrective action alternatives is summarized below. These data have been collected in association with various studies and from modeling that has been conducted to support development of a closure strategy and monitoring programs. Corrective action alternatives in addition to those listed below may be developed; however, the data needs listed below are expected to encompass any additional alternatives that may be developed.

- Closure-in-place data needs
  - CSM in sufficient detail that will allow for all pathways modeling to be completed
  - Understanding of operational history (e.g., waste containerization, waste placement, disposal dates)
  - Waste volumes and inventory (radiological and hazardous)
- Clean-closure data needs
  - Sufficient information regarding waste volumes and inventory (radiological and hazardous) to estimate cost, worker dose, transportation risk, and dose to the public
  - Identification of disposal capacity sufficient for the projected waste streams that will be generated in the event of a clean closure option

5.2 SOURCES OF INFORMATION

Existing information, such as historical documentation, personnel interviews, site process knowledge, site walk-downs, photographs, and previous field screening and analytical results, will be evaluated to determine if it supports the development and evaluation of alternatives. Several types of data will be used to develop corrective action alternatives.

5.2.1 Qualitative Data

Qualitative data identify or describe the characteristics or components of the site. The quality assurance/quality control (QA/QC) requirements are the least rigorous for qualitative data. This measurement of quality is typically assigned to historical information and data where QA/QC may be highly variable or not known. Professional judgment is often used to generate qualitative data.

Qualitative data used to support the development of corrective action alternatives are mainly limited to waste records prior to 1988. However, bounding estimates can be used to adequately account for any uncertainties without adversely affecting the decision-making process. This approach was implemented in the original PA for the Area 5 RWMS, in which bounding assumptions were made regarding the facility performance, and the inventory was evaluated to show compliance with the performance objectives of DOE O 435.1 for a compliance period of 10,000 years. The second addendum to the PA explicitly accounted for uncertainty by employing probabilistic modeling as described in Section 1.3.

5.2.2 Semi-quantitative Data

Semi-quantitative data indirectly measure the quantity or amount of a characteristic or component. Inferences are drawn about the quantity or amount of a characteristic or component because a correlation has been shown to exist between the indirect measurement and the results from a quantitative measurement. The QA/QC requirements on semi-quantitative collection and measurement systems are high but may not be as rigorous as those for quantitative data.

Some semi-quantitative data have been used in various aspects of inventory development. Semi-quantitative data will also be used to estimate costs. Cost models using data from similar sites will be used to develop costs for each corrective action alternative.

5.2.3 Quantitative Data

Quantitative data measure the quantity or amount of a characteristic or component. These data require the highest level of QA/QC in collection and measurement systems because the intended use of the data is to resolve primary decisions and/or to verify that closure standards have been met. Laboratory analytical data are generally considered quantitative.

Quantitative measurements have been collected to support the development of the CSM and, during long-term monitoring, to determine whether contaminant migration has occurred.

6.0 DEFINE THE BOUNDARIES OF THE STUDY (STEP 4)

Step 4 of the DQO process defines the target population of interest, specifies the spatial boundaries and time constraints of that population pertinent for decision making, and determines practical constraints on data collection.

6.1 POPULATION OF INTEREST

The populations of interest for which corrective actions will be developed include the following six units:

- LLW Unit
- CAU 111
- Asbestiform Unit
- Pit 3 MWDU
- TRU GCD Borehole Unit (CAU 207 [currently in CAU 5000])
- TRU Trench Unit

This includes waste inventory, waste constituents, and design parameters of the disposal cells. The population of interest will also include input parameters needed to develop costs and risks for corrective action alternatives, including identification of offsite disposal capacity, routes of transportation to the disposal capacity, definition of likely receptors along the route to disposal, population of potentially exposed workers, cost data, and the parameters described in the CSM.

6.2 TIME CONSTRAINTS

The study data will be evaluated considering the length of time that will be required to develop corrective action alternatives and garner agreement from NDEP on the selection of a correct action alternative. In addition, a further time constraint will be the development of the Corrective Action Decision Document/Corrective Action Plan (CADD/CAP). Furthermore, if classified information must be accessed, additional time may be needed to complete the study.

The schedule will also take into account the time required to complete the closure process and prepare the Closure Report. The certificate of closure for the Pit 3 MWDU is due to NDEP by July 2011; therefore, the Closure Report will be prepared with this due date in mind.

7.0 DEVELOP THE ANALYTIC APPROACH (STEP 5)

Step 5 of the DQO process develops a decision rule statement ("If…, then…") that defines the conditions under which possible alternative actions will be chosen.

7.1 Decision Rules

Decision I:

- If it is determined that closure in place is the most feasible closure option, then a closure design will be developed ensuring that the performance criteria specified in DOE O 435.1 are met. It will be established that these criteria, while designed for radionuclide constituents, are also appropriate for hazardous constituents.

Decision II:

- If it is determined that clean closure is the most feasible closure option, then a closure plan will be prepared outlining the remediation plans that will include the development of an appropriate dose-based remediation standard.

7.2 Action Levels

Action levels for a closure-in-place alternative will be based on the landfill performance standards set forth in the various regulations that cover each of the six areas included in the 92-Acre Area.

The clean-closure alternative will rely upon the preliminary action levels for radiological contaminants. These action levels are based on the National Council on Radiation Protection and Measurements (NCRP)-recommended screening limits for construction, commercial, and industrial land-use scenarios (NCRP, 1999) scaled to 25 mrem/yr dose constraint (Murphy, 2004) and the generic guidelines for residual concentration of radionuclides in DOE O 5400.5 (DOE, 1993). Remaining radiological contamination will be posted per the NV/YMP RadCon Manual (NNSA/NSO, 2004).

7.3 Measurement and Analysis Sensitivity

Historical monitoring data have been of sufficient sensitivity to measure the worker dose and/or potential contaminant migration for the 92-Acre Area. These data were collected under a published DQO process as provided for in the *Routine Radiological Environmental Monitoring Plan* (BN, 2003).

To account for uncertainty in inventory development, bounding assumptions were used in the development of the model, as discussed in Section 1.3 of this document. Care has been taken to ensure these assumptions are reasonable, so as not to skew the evaluation of corrective action alternatives.

8.0 SPECIFY PERFORMANCE OR ACCEPTANCE CRITERIA (STEP 6)

Step 6 of the DQO process specifies performance criteria for the decision rules. Setting tolerable limits on decision errors requires the planning team to weigh the relative effects of threats to human health and the environment, expenditure of resources, and the consequences of an incorrect decision. This section provides an assessment of the possible outcomes of DQO decisions and the impact of those outcomes if the decisions are in error.

In general, confidence in DQO decisions will be established qualitatively by the following:

- Developing CSMs
- Testing the validity of the CSMs based on an analysis of historical data
- Evaluating the quality of the data based on data quality indicator parameters

8.1 DECISION ERRORS

While additional corrective actions may be developed during the CADD/CAP process, the two bounding alternatives are closure in place and clean closure. A corrective action alternative has not been selected; however, to facilitate discussion of decision errors, closure in place will be defined as the baseline condition.

8.1.1 False Rejection

This error would mean deciding that the baseline condition is false when, in fact, it is true. This error means deciding that clean closure is the most advantageous option when closure in place is actually the preferable alternative. The possible consequences of this decision error are increased worker dose during removal, packaging, and transportation of waste; increased short-term risk to the public during transportation of waste; and increased cost. This error will be controlled by having a high degree of confidence in the data inputs such as waste inventory and the CSM. Assumptions that may be required to evaluate this alternative will be bounding, but reasonable enough to ensure the decision process is not adversely affected.

8.1.2 False Acceptance

This error would mean deciding that the baseline condition is true when, in fact, it is false. This error means deciding that closure in place is the most advantageous option when clean closure is actually the preferable alternative. The potential consequence is an increased risk to human health and the environment due to leaving the waste in place. This error will be controlled by having a high degree of confidence in the data inputs such as waste inventory and the CSM. Further, since most of these sites are currently controlled for radiological purposes and there is no proximal public receptor, the impact of this error is minimized.

9.0 DEVELOP THE PLAN FOR OBTAINING DATA (STEP 7)

Step 7 of the DQO process provides the general approach for resolving the decisions. The pool of existing data will be used to resolve the decisions outlined above.

9.1 PROCESS KNOWLEDGE

The historical operations associated with this site are well documented through multiple historical sources. Much of the operational information is based on semi-quantitative, and in some cases, quantitative data.

9.2 WASTE INVENTORY RECORDS

Much of this information has been gathered under compliance assessments of the Area 5 RWMS performed over a 20-year period. The available inventory will be used in the development of corrective action alternatives. Insensitivity of inventory to the results of the facility performance for the 1,000-year post-closure period supports the previous assertion made in Section 1.3 that waste inventory is sufficient to carry out the development of corrective action alternatives.

9.3 CONCEPTUAL SITE MODEL

A large pool of quantitative data has been collected to accurately describe the CSM, thus providing the support needed to adequately quantify the risks and benefits of each of the proposed corrective action alternatives.

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APPENDIX B

COST ESTIMATES

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National Security Technologies, LLC

EST ID: CAU 111 **COST ESTIMATE PROPOSAL DATA SHEET** **Date: 8-Apr-09**

SUBJECT: CADD Alternative Cost Estimates for the 92-Acre Area and CAU 111

ESTIMATOR: Thomas Thiele **REF #:**

	TYPE OF ESTIMATE:				**TYPE OF WORK:**
X	ORDER OF MAGNITUDE		TITLE II		NON-MANUAL ONLY
	PRELIMINARY / PLANNING / STUDY		WORK ORDER		MANUAL ONLY
	CONCEPTUAL / BUDGET		COMPARATIVE	X	MANUAL & NON-MANUAL
	TITLE I		OTHER		OTHER

PROJECT WORK SCOPE IS EXPECTED TO BE PERFORMED BY:

DOE PRIME (LUMP SUM)		SUBCONTRACT	
CONSTRUCTION	X	GPP	
MAINTENANCE		OTHER	

STATEMENT OF WORK

This estimate has been prepared to provide remedial alternative costs for the closure of the 92-Acre Area and Corrective Action Unit (CAU) 111. CAU 111 is an environmental restoration site listed in the *Federal Facility Agreement and Consent Order* ; however, the entire 92-Acre Area will be closed under this plan. Three alternatives have been evaluated for closure of the site: Alternative 1, No Further Action; Alternative 3, Closure in Place with Administrative Controls; and Alternative 4, Closure in Place with Administrative Controls with Removal of TRU Waste from Trench T04A. Alternative 2, Clean Closure, was not evaluated for closure of the site. This estimate will be used to identify the most cost effective alternative for closure of the site while remaining protective of human health and the environment. Cost for project management, plan preparation, project support, and/or other activities are not included herein.

SCOPE:

Provide site closure using the following alternative:
Alternative 1, No Further Action

BASIS:

This site consists of the 92-Acre Area, the southeast quadrant of the Radioactive Waste Management Site, located in Area 5 of the NTS. The 92-Acre Area includes CAU 111, Area 5 WMD Retired Mixed Waste Pits. This alternative includes continuing the current monitoring activities conducted at the 92-Acre Area. Monitoring consists of quarterly direct radiation measurements, air samples for tritium every 2 weeks, monthly air samples for particulates, annual radon flux measurements, groundwater samples every 6 months, meteorology monitoring (precipitation, temperature, humidity, wind speed/direction, and barometric pressure), quarterly moisture probe measurements, quarterly lysimeter measurements, annual soil gas monitoring, and biota samples every 2 years.

ALTERNATIVE SPECIFIC BASIS OF ESTIMATE/ASSUMPTIONS

Alternative 1, No Further Action

- Continuing the following monitoring activities:
  - Quarterly direct radiation measurements
  - Air samples for tritium every 2 weeks and monthly air samples for particulates
  - Annual radon flux measurements
  - Groundwater samples every 6 months
  - Meteorology monitoring (precipitation, temperature, humidity, wind speed/direction, and barometric pressure)
  - Quarterly moisture probe and lysimeter measurements
  - Annual soil gas monitoring
  - Biota samples every 2 years

EST ID: CAU 111

National Security Technologies, LLC

COST ESTIMATE PROPOSAL DATA SHEET

Date: 8-Apr-09

ASSUMPTIONS:

- Equipment will remain operational to support the planned/scheduled completion of each CADD alternative.
- Work to be performed during a "normal" workday (no provision for overtime has been provided). Shifts are based on 10-hour days, 4 days per week.
- This estimate does not include the efficiencies which may be realized if work for similar activities at similar sites can be completed concurrently.
- This estimate does not include costs for preparation of required project plans, permits, reports, mobilization and demobilization, site preparations, or project management.

ESCALATION:

No escalation factors have been applied. All costs are in FY09 Rev. 1 dollars.

CONTINGENCY:

Contingency costs are not included in this estimate.

RATES:

Rates are based on FY09 final rates (Rev. 1) effective 10/01/08 and were applied using the FY09 cost model.

COST ALTERNATIVES SUMMARY:

Alternative 1, No Futher Action

1. Continuing the current monitoring activities

Monitoring Costs: $700,000/year

REVIEW / CONCURRENCE:

Project Manager 7/9/09 Date

Estimator 7/9/09 Date

Project Controls 7/9/09 Date

National Security Technologies, LLC

EST ID: CAU 111 **COST ESTIMATE PROPOSAL DATA SHEET** **Date: 8-Apr-09**

SUBJECT: CADD Alternative Cost Estimates for the 92-Acre Area and CAU 111

ESTIMATOR: Thomas Thiele **REF #:** ____

TYPE OF ESTIMATE:

X ORDER OF MAGNITUDE
____ PRELIMINARY / PLANNING / STUDY
____ CONCEPTUAL / BUDGET
____ TITLE I

____ TITLE II
____ WORK ORDER
____ COMPARATIVE
____ OTHER

TYPE OF WORK:

____ NON-MANUAL ONLY
____ MANUAL ONLY
X MANUAL & NON-MANUAL
____ OTHER

PROJECT WORK SCOPE IS EXPECTED TO BE PERFORMED BY:

DOE PRIME (LUMP SUM) ____
CONSTRUCTION X
MAINTENANCE ____

SUBCONTRACT ____
GPP ____
OTHER ____

STATEMENT OF WORK

This estimate has been prepared to provide remedial alternative costs for the closure of the 92-Acre Area and Corrective Action Unit (CAU) 111. CAU 111 is an environmental restoration site listed in the *Federal Facility Agreement and Consent Order*; however, the entire 92-Acre Area will be closed under this plan. Three alternatives have been evaluated for closure of the site: Alternative 1, No Further Action; Alternative 3, Closure in Place with Administrative Controls; and Alternative 4, Closure in Place with Administrative Controls with Removal of TRU Waste from Trench T04A. Alternative 2, Clean Closure, was not evaluated for closure of the site. This estimate will be used to identify the most cost effective alternative for closure of the site while remaining protective of human health and the environment. Cost for project management, plan preparation, project support, and/or other activities are not included herein.

SCOPE:

Provide site closure using the following alternative:
Alternative 3, Closure in Place with Administrative Controls

BASIS:

This site consists of the 92-Acre Area, the southeast quadrant of the Radioactive Waste Management Site, located in Area 5 of the NTS. The 92-Acre Area includes CAU 111, Area 5 WMD Retired Mixed Waste Pits. This alternative includes construction of a 2.5-m-thick engineered evapotranspiration cover over the 92-Acre Area. With the exception of three active pits, all trenches and pits in the 92-Acre Area have current operational covers approximately 2.4 m thick; therefore, construction of the cover over these units will consist of augmenting the current operational covers to the final thickness, grade, and slope required by the final engineering design. After cover construction activities are complete, the cover will be seeded with a mixture of shallow rooting native plants. Use restriction warning signs and concrete monuments will be installed. Subsidence survey monuments will also be installed.

ALTERNATIVE SPECIFIC BASIS OF ESTIMATE/ASSUMPTIONS

Alternative 3, Closure in Place with Administrative Controls

- Constructing an engineered evapotranspiration cover over the 92-Acre Area
- Installing use restriction warning signs, concrete monuments, and subsidence survey monuments

EST ID: CAU 111

National Security Technologies, LLC
COST ESTIMATE PROPOSAL DATA SHEET

Date: 8-Apr-09

ASSUMPTIONS:

- Equipment will remain operational to support the planned/scheduled completion of each CADD alternative.
- Work to be performed during a "normal" workday (no provision for overtime has been provided). Shifts are based on 10-hour days, 4 days per week.
- This estimate does not include the efficiencies which may be realized if work for similar activities at similar sites can be completed concurrently.
- This estimate does not include costs for preparation of required project plans, permits, reports, mobilization and demobilization, site preparations, or project management.

ESCALATION:

No escalation factors have been applied. All costs are in FY09 Rev. 1 dollars.

CONTINGENCY:

Contingency costs are not included in this estimate.

RATES:

Rates are based on FY09 final rates (Rev. 1) effective 10/01/08 and were applied using the FY09 cost model.

COST ALTERNATIVES SUMMARY:

Alternative 3, Closure in Place with Administrative Controls

1. Constructing an engineered evapotranspiration cover over the 92-Acre Area
2. Installing use restriction warning signs, concrete monuments, and subsidence survey monuments

Construction Costs: $2,640,000
Monitoring Costs: $660,000/year

REVIEW / CONCURRENCE:

7/9/09
Project Manager Date

7/9/09
Estimator Date

7/9/09
Project Controls Date

EST ID: CAU 111

National Security Technologies, LLC
COST ESTIMATE PROPOSAL DATA SHEET

Date: 8-Apr-09

SUBJECT: CADD Alternative Cost Estimates for the 92-Acre Area and CAU 111

ESTIMATOR: Thomas Thiele **REF #:** ____

TYPE OF ESTIMATE:		**TYPE OF WORK:**
X ORDER OF MAGNITUDE	___ TITLE II	___ NON-MANUAL ONLY
___ PRELIMINARY / PLANNING / STUDY	___ WORK ORDER	___ MANUAL ONLY
___ CONCEPTUAL / BUDGET	___ COMPARATIVE	X MANUAL & NON-MANUAL
___ TITLE I	___ OTHER	___ OTHER

PROJECT WORK SCOPE IS EXPECTED TO BE PERFORMED BY:

DOE PRIME (LUMP SUM) ___	SUBCONTRACT ___
CONSTRUCTION X	GPP ___
MAINTENANCE ___	OTHER ___

STATEMENT OF WORK

This estimate has been prepared to provide remedial alternative costs for the closure of the 92-Acre Area and Corrective Action Unit (CAU) 111. CAU 111 is an environmental restoration site listed in the *Federal Facility Agreement and Consent Order*; however, the entire 92-Acre Area will be closed under this plan. Three alternatives have been evaluated for closure of the site: Alternative 1, No Further Action; Alternative 3, Closure in Place with Administrative Controls; and Alternative 4, Closure in Place with Administrative Controls with Removal of TRU Waste from Trench T04A. Alternative 2, Clean Closure, was not evaluated for closure of the site. This estimate will be used to identify the most cost effective alternative for closure of the site while remaining protective of human health and the environment. Cost for project management, plan preparation, project support, and/or other activities are not included herein.

SCOPE:

Provide site closure using the following alternative:
Alternative 4, Closure in Place with Administrative Controls with Removal of TRU Waste from Trench T04A

BASIS:

This site consists of the 92-Acre Area, the southeast quadrant of the Radioactive Waste Management Site, located in Area 5 of the NTS. The 92-Acre Area includes CAU 111, Area 5 WMD Retired Mixed Waste Pits. This alternative includes excavation and disposal of TRU waste that was inadvertently disposed in trench T04A in addition to construction of a 2.5-m-thick engineered evapotranspiration cover over the 92-Acre Area, as described in Alternative III, Closure in Place with Administrative Controls.

ALTERNATIVE SPECIFIC BASIS OF ESTIMATE/ASSUMPTIONS

Alternative 4, Closure in Place with Administrative Controls with Removal of TRU Waste from Trench T04A

- Excavating and disposing TRU waste from trench T04A
- Constructing an engineered evapotranspiration cover over the 92-Acre Area
- Installing use restriction warning signs, concrete monuments, and subsidence survey monuments

ASSUMPTIONS:

- Equipment will remain operational to support the planned/scheduled completion of each CADD alternative.
- Work to be performed during a "normal" workday (no provision for overtime has been provided). Shifts are based on 10-hour days, 4 days per week.
- This estimate does not include the efficiencies which may be realized if work for similar activities at similar sites can be completed concurrently.
- This estimate does not include costs for preparation of required project plans, permits, reports, mobilization and demobilization, site preparations, or project management.

ESCALATION:

No escalation factors have been applied. All costs are in FY09 Rev. 1 dollars.

CONTINGENCY:

Contingency costs are not included in this estimate.

RATES:

Rates are based on FY09 final rates (Rev. 1) effective 10/01/08 and were applied using the FY09 cost model.

COST ALTERNATIVES SUMMARY:

Alternative 4, Closure in Place with Administrative Controls with Removal of TRU Waste from Trench T04A

1. Excavating and disposing TRU waste from trench T04A
2. Constructing an engineered evapotranspiration cover over the 92-Acre Area
3. Installing use restriction warning signs, concrete monuments, and subsidence survey monuments

Construction Costs: $118,640,000
Monitoring Costs: $660,000/year

REVIEW / CONCURRENCE:

Project Manager 7/9/09 Date

Estimator 7/9/09 Date

Project Controls 7/9/09 Date

APPENDIX C

ENGINEERING SPECIFICATION AND DRAWINGS

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NATIONAL NUCLEAR SECURITY ADMINISTRATION

NEVADA SITE OFFICE LAS VEGAS, NEVADA

92 ACRE GRADING AND DRAINAGE AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE

DRAWING INDEX

DRAWING NUMBER		DRAWING TITLE
TITLE		
09068-G-0001	REV 1	TITLE SHEET
09068-G-0002	REV 0	ABBREVIATIONS
09068-G-0003	REV 0	SYMBOLS, NOTES & LEGEND
CIVIL		
09068-C-1001	REV 0	PROJECT LOCATION VICINITY MAPS
09068-C-1002	REV 0	AREA 5 RWMS OVERALL SITE PLAN
09068-C-1003	REV 0	EXISTING SITE & DEMOLITION PLAN - NORTH
09068-C-1004	REV 0	EXISTING SITE & DEMOLITION PLAN - SOUTH
09068-C-1005	REV 0	NEW HORIZONTAL CONTROL PLAN - NORTH
09068-C-1006	REV 0	NEW HORIZONTAL CONTROL PLAN - SOUTH
09068-C-1007	REV 0	NEW SURFACE GRADING PLAN - NORTH
09068-C-1008	REV 0	NEW SURFACE GRADING PLAN - SOUTH
09068-C-1009	REV 0	NORTH DRAINAGE PLAN & PROFILE STA 0+00 TO 23+23
09068-C-1010	REV 0	CENTER DRAINAGE PLAN & PROFILE STA 0+00 TO 18+91
09068-C-1011	REV 0	EAST - SOUTH DRAINAGE PLAN & PROFILE STA 0+00 TO 12+80
09068-C-1012	REV 0	EAST - SOUTH DRAINAGE PLAN & PROFILE STA 12+80 TO 25+58
09068-C-1013	REV 0	EAST HAUL ROAD PLAN & PROFILE STA 0+00 TO 16+50
09068-C-1014	REV 0	EAST HAUL ROAD PLAN & PROFILE STA 16+50 TO 33+00
09068-C-1015	REV 0	WEST HAUL ROAD PLAN & PROFILE STA 0+00 TO 17+50
09068-C-1016	REV 0	WEST HAUL ROAD PLAN & PROFILE STA 17+50 TO 34+89
09068-C-1017	REV 1	NEW MONUMENT PLAN - NORTH
09068-C-1018	REV 1	NEW MONUMENT PLAN - SOUTH
09068-C-3001	REV 0	NEW SURFACE GRADING SECTIONS
09068-C-3002	REV 0	NEW SURFACE GRADING SECTIONS
09068-C-3003	REV 0	NEW SURFACE GRADING SECTIONS
09068-C-3004	REV 0	NEW SURFACE GRADING SECTIONS
09068-C-3005	REV 0	NEW SURFACE GRADING SECTIONS
09068-C-3006	REV 0	NEW SURFACE GRADING SECTIONS
09068-C-4001	REV 0	NEW CULVERT SECTIONS & DETAILS
09068-C-4002	REV 0	NEW CULVERT SECTIONS & DETAILS
09068-C-5001	REV 1	TYPICAL DETAILS
09068-C-5002	REV 1	GUARD RAIL SECTION DETAILS
ELECTRICAL		
09068-E-1001	REV 0	ELECTRICAL SITE PLAN
09068-E-3001	REV 0	TRENCH SECTIONS
09068-E-5001	REV 0	ELECTRICAL DETAIL

△1

SCOPE OF WORK

PROVIDE ADDITIONAL FILL AND GRADING TO COMBINE MULTIPLE EXISTING OPERATIONAL SURFACES INTO 3 FINAL GRADED AREAS AND PROVIDE POSITIVE SURFACE DRAINAGE OFF OF AND AWAY FROM THESE AREAS.

PROVIDE EROSION CONTROL TO MINIMIZE EROSION AND MAINTAINANCE OF THE GRADED AREAS.

RELOCATE EXISTING POLE-MOUNTED ALERT SIREN TO THE FAR EDGE OF THE RWMC SOUTH OF THE STORAGE CONTAINER.

THIS DESIGN DOES NOT IMPACT THE CONTINUED OPERATIONS OF ACTIVE STORAGE PITS LOCATED IN THE AREA 5 RWMS NORTH EXPANSION AREA.

NTS CONSTRUCTION SPECIFICATION INDEX

THE FOLLOWING SPECS SHALL BE FOLLOWED WHEN PERFORMING WORK OUTLINED IN THIS DRAWING PACKAGE:

CONSTRUCTION SPECIFICATION	09068-SPC-G01
014213	ACRONYMS AND ABBREVIATIONS
014216	DEFINITIONS
260500	COMMON WORK RESULTS FOR ELECTRICAL
260526	GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
260543	UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS
311000	SITE CLEARING
312000	EARTH MOVING
312500	EROSION AND SEDIMENTATION CONTROLS
330526	UTILITY LINE SIGNS, MARKERS, AND FLAGS
334100	STORM UTILITY DRAINAGE PIPING

CAUTION NOTE:

INFORMATION SHOWN ON THESE DRAWINGS MIGHT NOT REFLECT CURRENT CONDITIONS OF FACILITY OR STRUCTURE. PERSONNEL SHALL USE CAUTION WHEN PERFORMING WORK BASED ON THE EXISTING INFORMATION SHOWN ON THE DRAWINGS.

7/9/9

[redacted]

Exp 6/30/11

GS

NO	DATE	REVISIONS	DRAWN	PREPARER	CHECKER	PROJ ENGR	APPROVER USER
△1		REVISED MONUMENT PLAN AND DETAILS PER PROJECT MANAGER E-MAIL, DATED 6/11/09	[redacted]				

NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA SITE OFFICE LAS VEGAS, NEVADA

NEVADA TEST SITE — AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

TITLE SHEET

DRAWN DATE | PREPARER DATE | CHECKER DATE | PROJECT ENGINEER DATE | APPROVER / USER DATE
[redacted]

National Security Technologies LLC
Vision • Service • Partnership
NEVADA OPERATIONS
P.O. BOX 98521 LAS VEGAS, NV 89193-8521

ENGINEERING NO. 09068
ORIGINAL SIGNATURES ON FILE
DRAWING NUMBER / WORK ORDER NUMBER 09068-G-0001
REVISION 1

7/1/2009 5:27:36 PM sorolaja

STANDARD ABBREVIATIONS

GENERAL

ABBREVIATION	ABBR
ABOVE FINISH FLOOR	AFF
ABOVE FINISH GRADE	AFG
ADMINISTRATION	ADMIN
AGGREGATE	AGGR
AIR CONDITIONING	A/C
ALTERNATE	ALT
ALUMINUM	AL
AMERICAN NATIONAL STANDARDS INSTITUTE	ANSI
AMERICAN SOCIETY FOR TESTING AND MATERIALS	ASTM
AMERICAN SOCIETY OF SANITARY ENGINEERS	ASSE
AMERICAN WATER WORKS ASSOCIATION	AWWA
ANCHOR BOLT	AB
AND	&
APPROVED	APVD
APPROXIMATE	APPROX
ARCHITECT/ENGINEER	A/E
ASBESTOS CEMENT PIPE	ACP
ASPHALT	ASPH
ASPHALT CEMENT	AC
AT	@
AUTOMATIC	AUTO
AUXILIARY	AUX
AVERAGE	AVG
BEAM	BM
BELOW FINISH GRADE	BFG
BITUMINOUS	BITMUM
BLOCK	BLK
BLOCKING	BLKG
BOREHOLE	BH
BOTTOM	BOT
BRACING	BRCG
BRACKET	BRKT
BUILDING	BLDG
BURIED CABLE	BC
CAST IRON	CI
CARBON STEEL	CS
CATALOG	CAT
CAULKING	CLKG
CEILING	CLG
CEMENT	CEM
CENTER	CTR
CENTER LINE	℄
CENTER TO CENTER	C TO C
CHAIN LINK FENCE	CH LN
CIRCULAR	CIRC
CLEAR	CLR
CODE OF FEDERAL REGULATORS	CFR
COLUMN	COL
COMBINATION	COMB
COMMUNICATIONS	COMM/C
COMPARTMENT	COMPT
CONCRETE	CONC
CONCRETE MASONRY UNITS	CMU
CONNECTION	CONN
CONSTRUCTION	CONSTR
CONSTRUCTION JOINT	CJ
CONSTRUCTION SPECIFICATION	CON SPEC
CONTINUATION/CONTINUOUS	CONT
CONTROL JOINT	CLJ
COPPER	CU
CORNER	COR
CORPORATION	CORP
COUNTERSUNK	CTSK
COUNCIL OF AMERICAN BUILDING OFFICIALS	CABO
CUBIC FOOT	CFT
CUBIC METER	CM
CUBIC YARD	CY
DATED	DTD
DETAIL	DET
DEGREE	DEG
DEPARTMENT OF ENERGY	DOE
DIAGONAL	DIAG
DIAMETER	DIA ∅
DIMENSION	DIM

DOUBLE	DBL
DOWN	DN
DRAWING	DWG
DUCTILE IRON	DI
EACH	EA
EAST	E
ELECTRIC/ELECTRICAL	ELEC
ELECTRIC HEATER	EH
ELECTRIC WATER COOLER	EWC
ELECTRIC WATER HEATER	EWH
ELECTRIC UNIT HEATER	EUH
ELEVATION	EL
EMERGENCY	EMER
ENCLOSURE	ENCL
ENGINEER	ENGR
ENTRANCE	ENTR
EQUAL	EQL
EQUIPMENT	EQPT
EXHAUST	EXH
EXISTING	EXIST
EXPANSION	EXP
EXPANSION JOINT	EXP JT
EXPOSED	EXP
EXTERIOR	EXT
FACILITY	FACIL
FACTORY MUTUAL	FM
FEET	FT
FIBER OPTICS	FO
FIELD	FLD
FINISH	FNSH
FINISH FLOOR	FF
FINISH GRADE	FG
FIRE	F
FIRE ALARM CONTROL PANEL	FACP
FIRE HYDRANT	FHY
FIRE PROTECTION	FP
FIRST	1ST
FITTING	FTG
FIXTURE	FXTR
FLANGE	FLG
FLANGED END	FE
FLOOR	FL
FOOT	FT
FOOTING	FTG
FOUNDATION	FDN
FUTURE	FUT
GAGE OR GAUGE	GA
GALLONS/HOUR	GPH
GALLONS/MINUTE	GPM
GALVANIZED	GALV
GALVANIZED IRON	GALVI
GATE VALVE	GTV
GENERAL	GENL
GOVERNMENT	GOVT
GOVERNMENT FURNISHED EQUIPMENT	GFE
GRADE	GR
GRATING	GRTG
HAND RAIL	HNDRL
HAZARDOUS WASTE	HAZ W
HEATING, VENTILATING AND AIR CONDITIONING	HVAC
HEIGHT	HGT
HELICOPTER LANDING PAD	HELO
HIGH POINT	HPT
HORIZONTAL	HORIZ
HORSEPOWER	HP
HOUR	HR
INCH	IN
INTERNATIONAL BUILDING CODE	IBC
INSIDE DIAMETER	ID
INSULATION	INSUL
INVERT	INVT
JOINT	JT
LAVATORY	LAV

LEFT	LT
LENGTH	LG
LIGHTING	LTG
LINEAR FOOT	LF
LINEAR METER	LM
LIQUEFIED PETROLEUM GAS	LPG
LONG	LG
LOW POINT	LP
MACHINE	MACH
MAGNETIC	MAG
MAINTENANCE	MAINT
MANHOLE	MH
MANUFACTURER	MFR
MANUFACTURING	MFG
MATERIAL	MATL
MAXIMUM	MAX
MECHANICAL	MECH
MECHANICAL JOINT	MJ
MEMBRANE	MEMB
METAL	MET
METER/METRIC	M
METRIC TON	MTON
MEZZANINE	MEZZ
MILE	MI
MILIMETER	MM
MILLION GALLONS PER DAY	MGD
MINIMUM	MIN
MISCELLANEOUS	MISC
MOUNT(ING) (ED)	MT(G)(D)
NATIONAL FIRE PROTECTION ASSOCIATION	NFPA
NATIONAL PIPE THREAD	NPT
NATIONAL SANITATION FOUNDATION	NSF
NEVADA	NV
NEVADA ADMINISTRATIVE CODE	NAC
NEVADA TEST SITE	NTS
NON RISING STEM	NRS
NOMINAL	NOM
NORMAL	NORM
NORTH	N
NOT IN CONTRACT	NICS
NOT TO SCALE	NTS
NUMBER	NO #
OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION	OSHA
ON CENTER	OC
OPENING	OPNG
OPPOSITE	OPP
OUTSIDE DIAMETER	OD
OUTSIDE STEM & YOKE	OS & Y
OVERHEAD	OVHD
PAIR	PR
PAVEMENT	PVMT
PLAIN END	PE
PLATE	PL
POINT	PT
POLE	P
POLYVINYL CHLORIDE (PIPE)	PVC
POUNDS	LBS
POUNDS/SQUARE FOOT	PSF
POUND/SQUARE INCH	PSI
POWER	P
POWER POLE	PP
POWER OVERHEAD	POH
POWER UNDERGROUND	PUG
PREFABRICATED	PREFAB
PRESSURE	PRESS
PRESSURE INDICATOR	PI
PRESSURE REDUCING VALVE	PRV
PRESSURE REDUCING VALVE STATION	PRVS
PROJECT ENGINEER	PE
QUANTITY	QTY
RADIUS	RAD/R
REFERENCE	REF
REGIONAL TRANSPORTATION COMMISSION	RTC
REINFORCED CONCRETE BOX	RCB
REINFORCING	REINF
REQUIRED	REQD
REVISIONS/REVERSE	REV
RIGHT	R
RIGID STEEL	RS
ROAD	RD

ROOF	RF
ROOF DRAIN	RD
ROOF DRAIN OVERFLOW	RDOF
ROOM	RM
ROUGH	RGH
ROUGH OPENING	RO
ROUND	RND
SANITARY SEWER	SS
SCHEDULE	SCH
SECOND	2ND SEC
SECTION	SECT
SHEET METAL	SH MET
SIMILAR	SIM
SOUTH/SEWER	S
SPACE	SPA
SPARE	SPR
SPECIFICATION	SPEC
SPIGOT	SP
SQUARE	SQ
STANDARD	STD
STATION	STA
STEAM	ST
STEEL	STL
SUBGRADE	SG
SUBSTATION	SUBSTA
SYMMETRICAL	SYMM
TANGENT/TELEPHONE	T
THICK	THK
TEMPORARY	TEMP
TOP OF CONCRETE	TOC
TYPICAL	(TYP)
UNDERGROUND	UG
UNDERWRITERS LABORATORIES	UL
UNFINISHED	UNFIN
UNIFORM BUILDING CODE	UBC
UNIFORM PLUMBING CODE	UPC
UNITED STATES	US
UNLESS OTHERWISE NOTED	UON
UNLESS OTHERWISE SPECIFIED	UOS
URINAL	UR
VACUUM	VAC
VENTILATOR	VENT
VERTICAL	VERT
VITRIFIED CLAY PIPE	VCP
VOLUME	VOL
WATER CLOSET	WC
WATERPROOF	WTRPRF
WEATHERPROOF	WP
WEIGHT	WT
WEST/WATER/WASTE	W
WIDTH	WD
WITH	W/
WITHOUT	W/O
YARD	YD

FOR REFERENCE DRAWINGS
SEE 09068-G-0001

CIVIL

CONTROL POINT	CONT PT
CORRUGATED METAL PIPE	CMP
CORRUGATED METAL PIPE ARCH	CMPA
GALVANIZED IRON PIPE	GIP
HIGH POINT OF VERTICAL CURVE	HI
HIGHWAY	HWY
MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES	MUTCD
MIDDLE ORDINATE OF CURVE	MO
NATIONAL SECURITY TECHNOLOGIES	NSTec
NEVADA DEPARTMENT OF TRANSPORTATION	NDOT
POINT OF CURVE	PC
POINT OF INTERSECTION	PI
POINT OF REVERSE CURVE	PRC
POINT OF TANGENCY	PT
POINT OF VERTICAL CURVE	PVC
POINT OF VERTICAL INTERSECTION	PVI
POINT OF VERTICAL REVERSE CURVE	PVRC
POINT OF VERTICAL TANGENCY	PVT
SLOPE	S
SHOULDER	SHLDR
VERTICAL CURVE	VC

6/30/09

GS

NO	DATE	REVISIONS	DRAWN	PREPARER	CHECKER	PROJ ENGR	APPROVER/USER

NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA SITE OFFICE LAS VEGAS, NEVADA

NEVADA TEST SITE — AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

STANDARD ABBREVIATIONS

DRAWN / DATE · PREPARER / DATE · CHECKER / DATE · PROJECT ENGINEER / DATE · APPROVER / USER / DATE

National Security Technologies LLC
Vision • Service • Partnership
NEVADA OPERATIONS
P.O. BOX 98521 LAS VEGAS, NV 89193-8521

ENGINEERING NO. 09068
ORIGINAL SIGNATURES ON FILE
DRAWING NUMBER / WORK ORDER NUMBER 09068-G-0002
REVISION 0

6/2/2009 2:17:38 PM hollanjl
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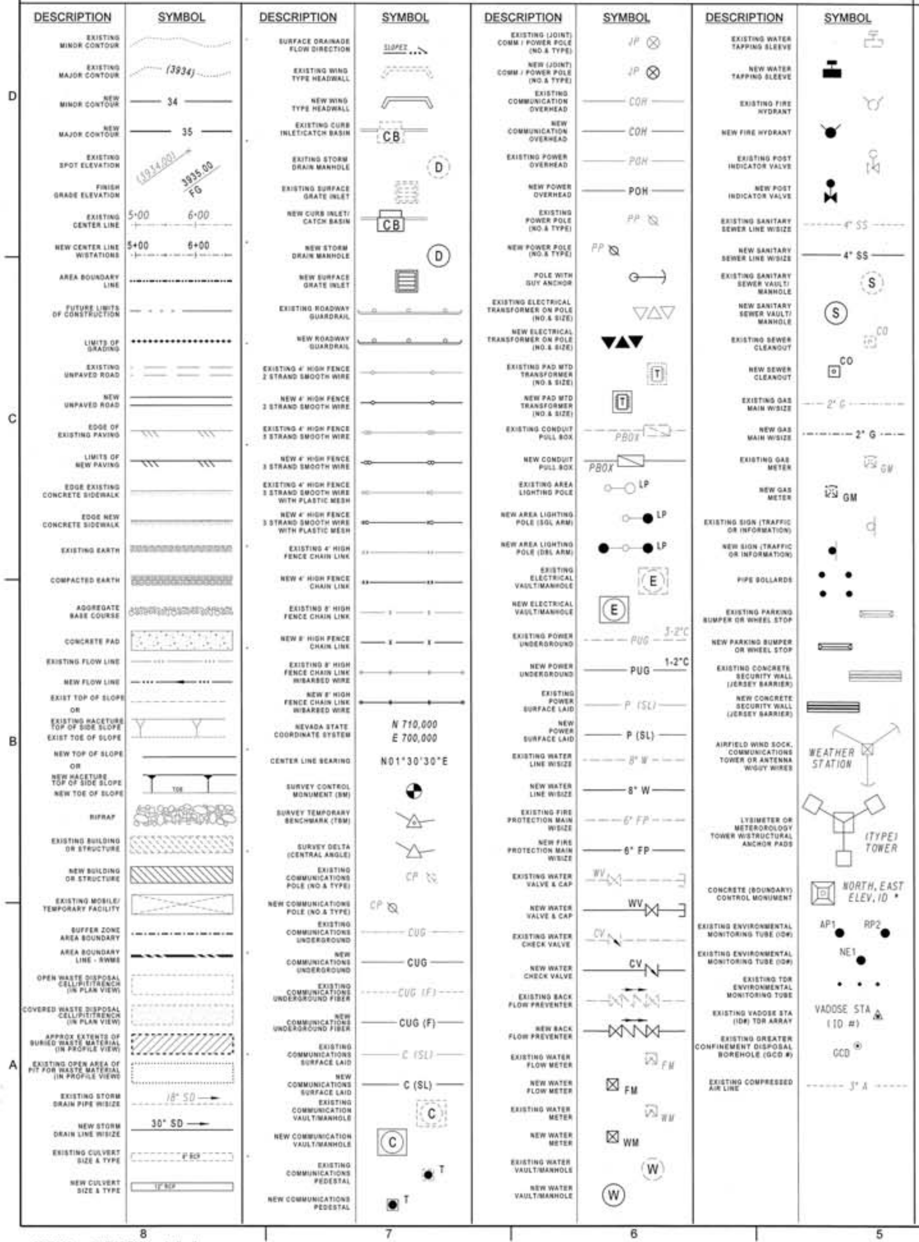
TYPICAL CIVIL SYMBOLS, NOTES & LEGEND

CIVIL SYMBOLS



CIVIL NOTES

GENERAL CIVIL NOTES

1. DO NOT USE ANY SCALE FOR OBTAINING FORMAL DIMENSIONS. THE DIMENSIONS SHOWN ON THE DRAWINGS SHALL TAKE PRECEDENCE.
2. WHERE CONFLICTS EXIST BETWEEN THE REFERENCED SPECIFICATIONS AND THE DRAWINGS, THE PROJECT DRAWINGS SHALL TAKE PRECEDENCE.
3. WHENEVER MATERIALS OR EQUIPMENT ITEMS ARE SPECIFIED BY BRAND NAME AND/OR MODEL NUMBER, OR ARE REQUIRED TO BE UL LISTED OR FM APPROVED, ALTERNATE VENDOR PRODUCTS AND/OR APPROVAL BY ANOTHER NATIONALLY RECOGNIZED AGENCY MAY BE SUBSTITUTED WITH PRIOR APPROVAL OF THE PROJECT ENGINEER.
4. CONSTRUCTOR SHALL CONFIRM ALL EXISTING DIMENSIONS AND ELEVATIONS PRIOR TO COMMENCING WORK AND SHALL REPORT ALL DISCREPANCIES TO THE PROJECT ENGINEER OR DESIGNATED REPRESENTATIVE.

GENERAL CONSTRUCTION NOTES

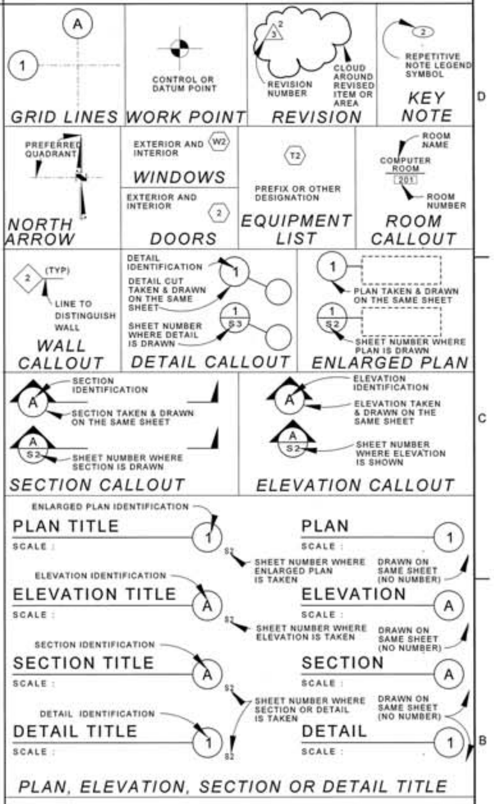
1. BASIS FOR HORIZONTAL CONTROL: NORTH AMERICAN DATUM 1927, NEVADA STATE COORDINATE SYSTEM, CENTRAL ZONE. BASIS FOR VERTICAL CONTROL: NORTH AMERICAN VERTICAL DATUM 1929, NEVADA STATE COORDINATE SYSTEM, CENTRAL ZONE.
2. SURVEY DATA SHALL BE SUBMITTED TO NSTec ENGINEERING IN ASCII FILE FORMAT ALONG WITH COPIES OF FIELD SURVEY SKETCHES. DATA FILES SHALL CONTAIN SUFFICIENT DATA POINTS TO FACILITATE AS-BUILT DRAWINGS.
3. REFER TO CONSTRUCTION SPECIFICATION 09068-SPC-G01.

6/4/09

6/30/09

FOR REFERENCE DRAWINGS SEE 09068-G-0001

DRAFTING LEGEND



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NEVADA SITE OFFICE
LAS VEGAS, NEVADA

NEVADA TEST SITE — AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

TYPICAL CIVIL SYMBOLS, NOTES & LEGEND

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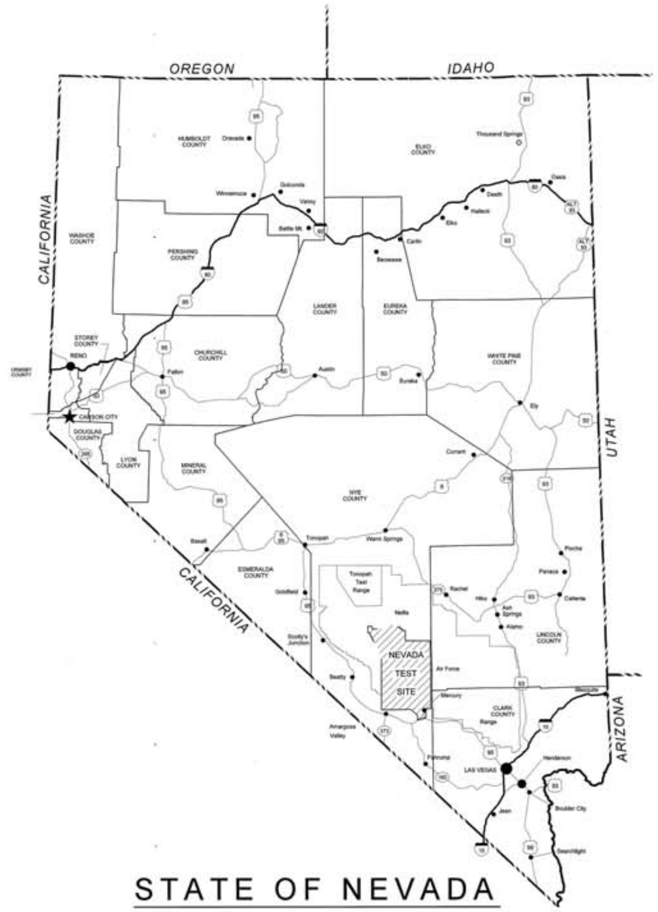
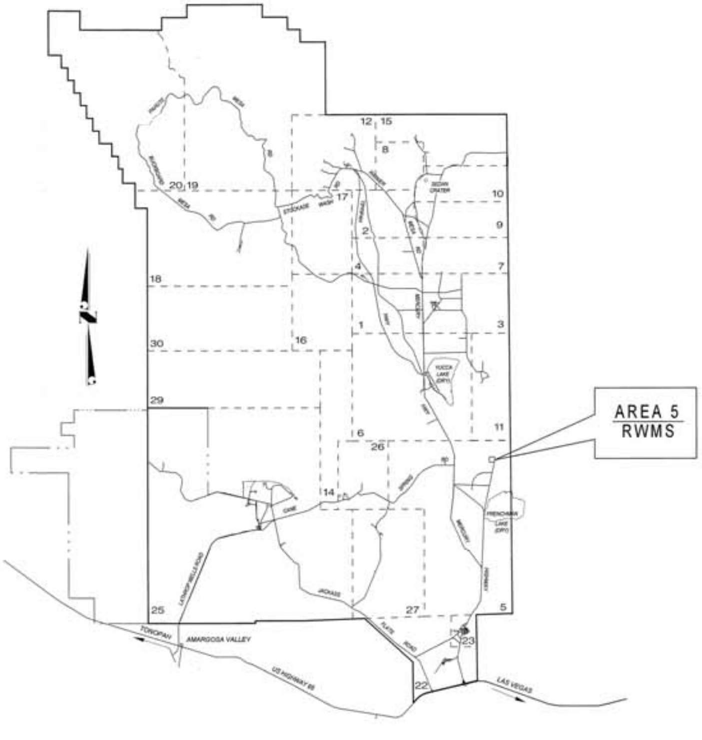


STATE OF NEVADA

SCALE: NONE



NEVADA TEST SITE

SCALE: NONE

FOR REFERENCE DRAWINGS SEE 09068-G-0001

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92 ACRE GRADING AND DRAINAGE

PROJECT LOCATON VICINITY MAPS

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PREPARER
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DRAWING NUMBER / WORK ORDER NUMBER 09068-C-1001
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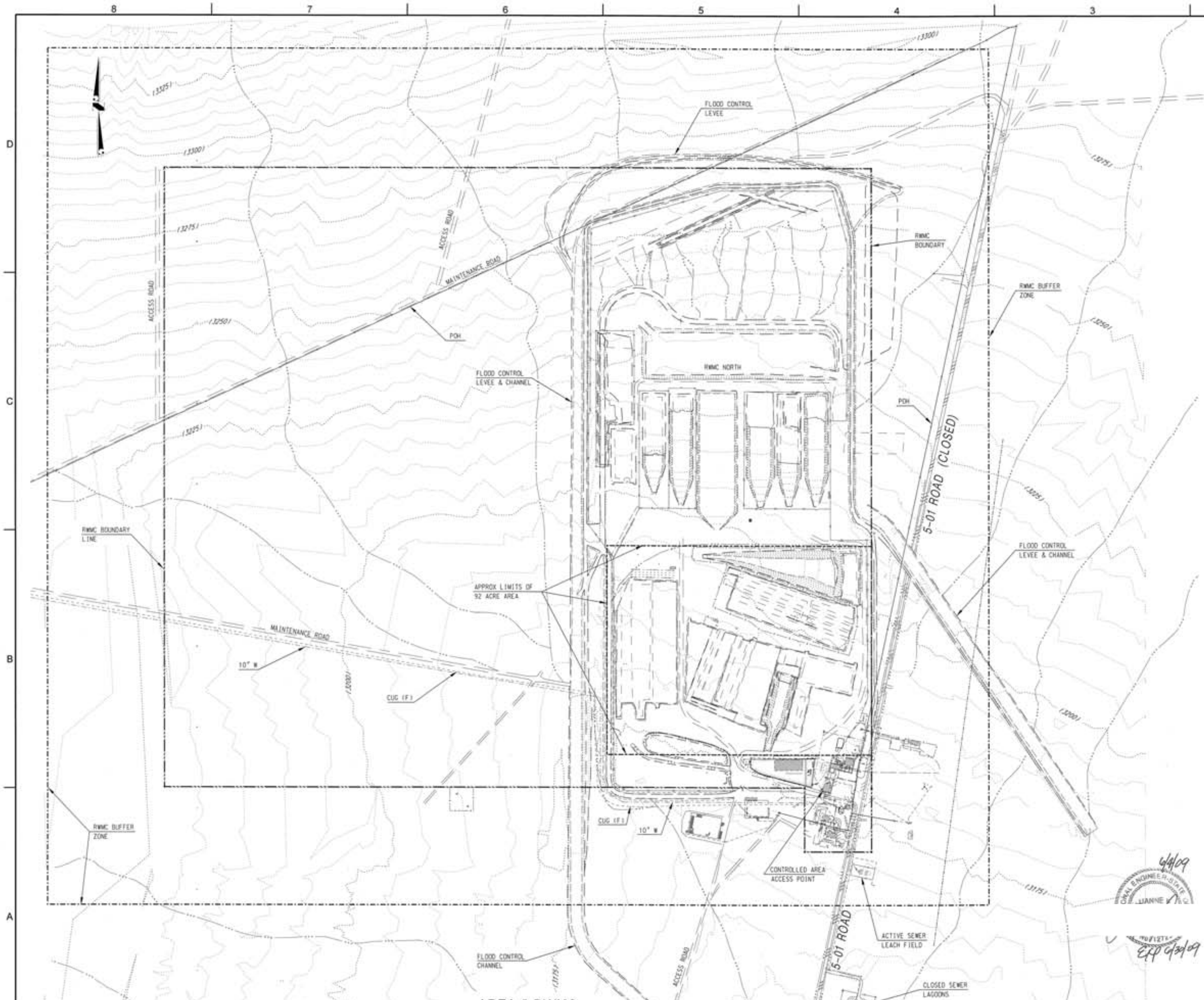

AREA 5 RWMS
OVERALL SITE PLAN
SCALE : 1" = 400'

FOR REFERENCE DRAWINGS SEE 09068-G-0001

GRAPHIC SCALE
0 200 400 800 1200 FEET
1" = 400'
(CONTOUR INTERVAL = 5 FEET)

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92 ACRE GRADING AND DRAINAGE

AREA 5 RWMS OVERALL SITE PLAN

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09068-C-1002
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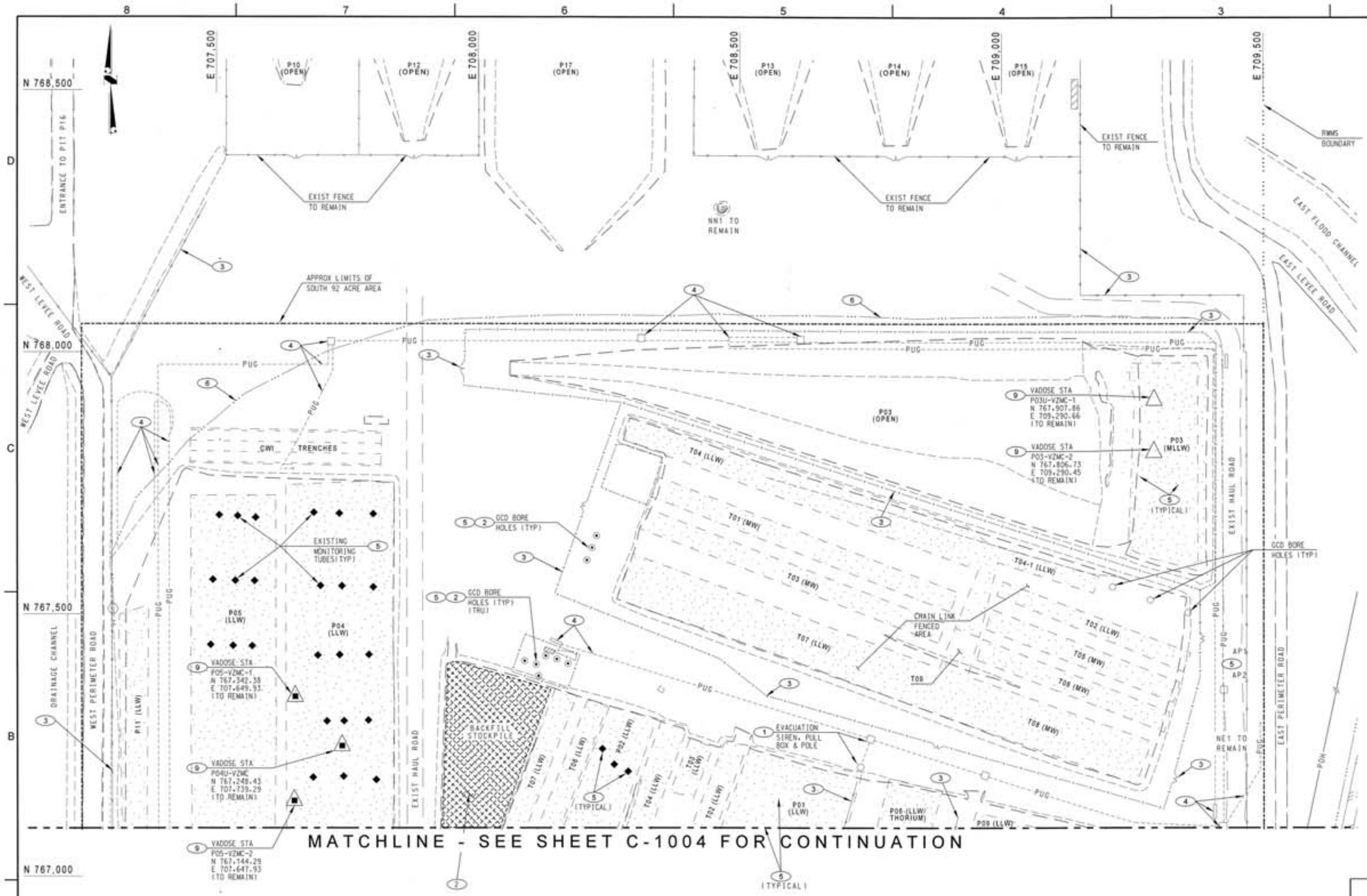

EXISTING SITE & DEMOLITION PLAN-NORTH

SCALE: 1" = 100'

GRAPHIC SCALE

0 50 100 200 300 FEET

1" = 100'

DEMOLITION KEY NOTES

① REMOVE & RELOCATE EXISTING EVACUATION SIREN, PULL BOX AND POLE TO THE NORTH SIDE OF BLDG 5-7 AND WEST OF ELECTRICAL PULL BOX #1 AS SHOWN ON ELECTRICAL DRAWING E-1001.

② THE AREA OUTLINED IN CROSS HATCH EAST OF THE EXISTING CENTER HAUL ROAD AND WEST OF TRENCH T07U IS STOCKPILED CLEAN BACKFILL. THIS SOIL MAY BE USED AS FILL MATERIAL FOR THE NEW GRADED AREAS. SEE GRADING PLAN C-1007.

③ REMOVE AND SALVAGE THE EXISTING CHAIN LINK AND SMOOTH WIRE FENCING INDICATED ON THIS SHEET. DO NOT DISTURB FENCING AT EXISTING BUILDINGS.

④ REMOVE AND SALVAGE ALL EXISTING ABOVE GROUND ELECTRICAL PANELS. MONITORING DEVICES AND/OR JUNCTION BOXES WITHIN THE SOUTH 92 ACRE BOUNDARY EXCEPT AS NOTED. ABANDON ALL BURIED CABLES IN PLACE.

⑤ ALL EXISTING MONITORING TUBES (INCLUDING AP1 AND AP2) SHALL BE CUT OFF 12" BELOW EXISTING GRADE AND BACKFILLED WITH SAND OR SUITABLE COMMON BACKFILL MATERIAL PRIOR TO PLACEMENT OF ANY FINAL SURFACE SOIL. ALL EXISTING GCD BOREHOLES SHALL BE FILLED WITH SUITABLE COMMON BACKFILL MATERIAL PRIOR TO PLACEMENT OF ANY FINAL SURFACE SOIL.

⑥ THE EXISTING EAST-TO-WEST DRAINAGE SWALE, NORTH OF PIT P03U, IS TO BE REGRADED TO INTERSECT THE NEW CMPA CULVERTS SHOWN ON DRAWING C-4002. SEE DRAWING C-5001 FOR DITCH DETAILS.

⑦ PRIOR TO COMMENCING ANY CONSTRUCTION,CONTACT AREA 5 RWMS OPERATIONS MANAGEMENT FOR DISPOSITION AND RELOCATION INSTRUCTIONS CONCERNING ANY REMAINING ABOVE GROUND ITEMS OR PORTABLE STRUCTURES LOCATED WITHIN THE LIMITS OF CONSTRUCTION.

⑧ REMOVE ALL EXISTING CONCRETE MONUMENTS EXCEPT AS NOTED AT THE GCD TEST PIT. SALVAGE AND REUSE FOR SURFACE MONUMENTS IF APPROVED BY THE PROJECT ENGINEER. SEE DRAWING C-5001 FOR NEW MONUMENT FABRICATION AND MARKING DETAILS.

⑨ EXISTING TDR MONITORING CABINETS ARE TO BE RAISED AND REINSTALLED ON NEW SURFACE. NEW SENSOR CABLES ARE TO BE SPLICED WITH EXISTING CABLE AND CONNECTED TO RELOCATED CABINET.

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NEVADA SITE OFFICE LAS VEGAS, NEVADA

NEVADA TEST SITE AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

EXISTING SITE & DEMOLITION PLAN-NORTH

DATE DATE DATE DATE DATE

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FOR REFERENCE DRAWINGS SEE 09068-G-0001

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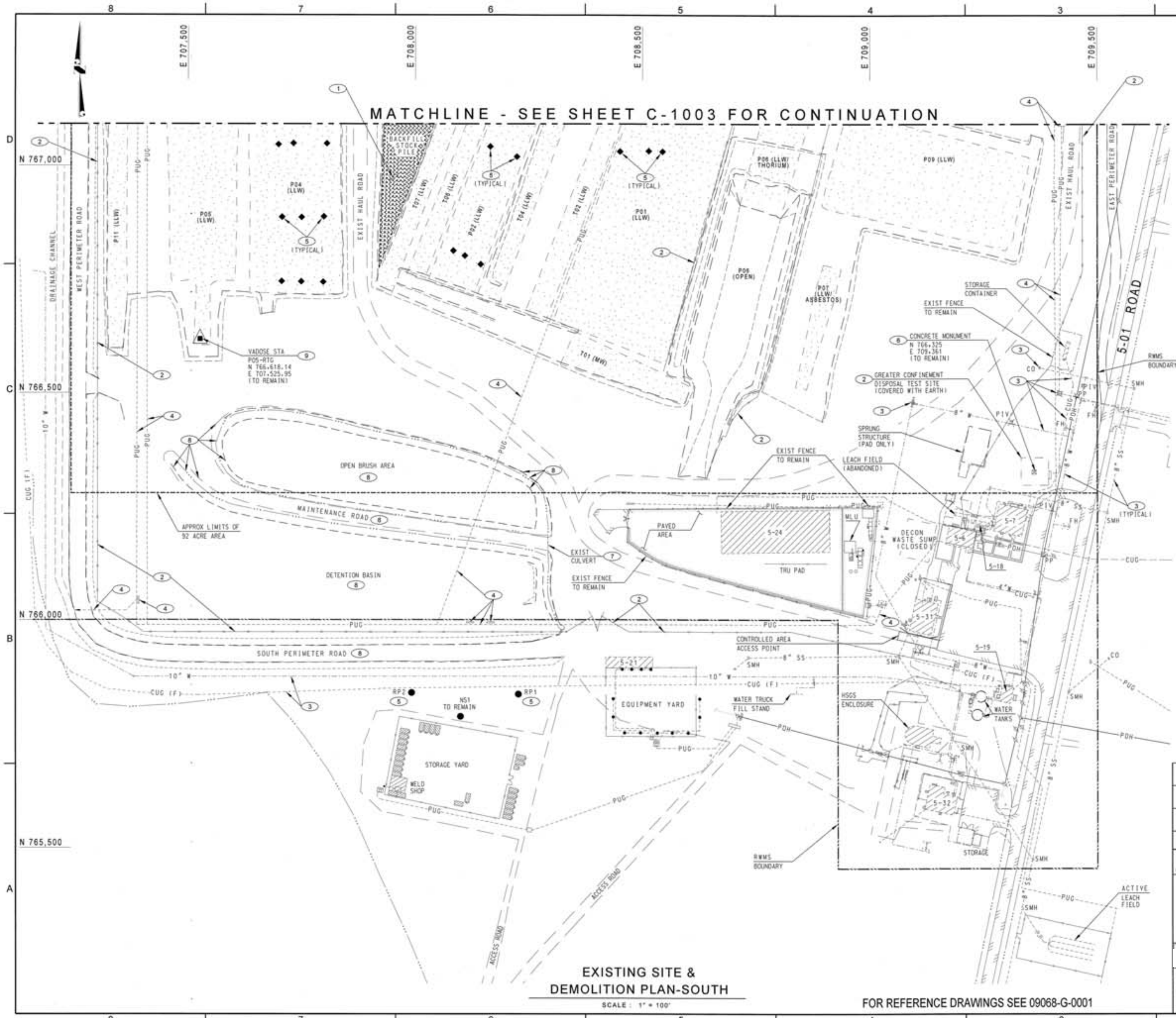

EXISTING SITE &
DEMOLITION PLAN-SOUTH

SCALE : 1" = 100'

FOR REFERENCE DRAWINGS SEE 09068-G-0001

DEMOLITION KEY NOTES

① THE AREA OUTLINED IN CROSS HATCH EAST OF THE EXISTING CENTER HAUL ROAD AND WEST OF TRENCH T07U IS STOCKPILED CLEAN BACKFILL. THIS SOIL MAY BE USED A FILL MATERIAL FOR THE NEW GRADED AREAS. SEE GRADING PLAN C-1008.

② REMOVE AND SALVAGE THE EXISTING CHAIN LINK AND SMOOTH WIRE FENCING INDICATED ON THIS SHEET. DO NOT DISTURB FENCING AT EXISTING BUILDINGS.

③ ALL EXISTING UNDERGROUND WATER, SEWER, AND COMMUNICATIONS LINES, FIXTURES AND APPURTENANCES ARE TO REMAIN IN PLACE. "DO NOT DISTURB". TAKE APPROPRIATE MEASURES AS NEEDED TO PROTECT THESE UTILITIES DURING CONSTRUCTION.

④ REMOVE AND SALVAGE ALL EXISTING ABOVE GROUND ELECTRICAL PANELS, MONITORING DEVICES AND/OR JUNCTION BOXES WITHIN THE SOUTH 92 ACRE BOUNDARY EXCEPT AS NOTED. ABANDON ALL BURIED CABLES IN PLACE.

⑤ ALL EXISTING MONITORING TUBES (INCLUDING AP1, AP2, RP1 AND RP2) SHALL BE CUT OFF 12" BELOW EXISTING GRADE AND BACKFILLED WITH SAND OR SUITABLE COMMON BACKFILL MATERIAL PRIOR TO PLACEMENT OF ANY FINAL SURFACE SOIL. ALL EXISTING GCD BOREHOLES SHALL BE FILLED WITH SUITABLE COMMON BACKFILL MATERIAL PRIOR TO PLACEMENT OF ANY FINAL SURFACE SOIL.

⑥ REMOVE ALL EXISTING CONCRETE MONUMENTS EXCEPT AS NOTED AT THE GCD TEST PIT. SALVAGE AND REUSE FOR SURFACE MONUMENTS IF APPROVED BY THE PROJECT ENGINEER. SEE DRAWING C-5001 FOR NEW MONUMENT FABRICATION AND MARKING DETAILS.

⑦ REMOVE EXISTING DRAIN CULVERT AT THE SOUTH MAINTENANCE ROAD.

⑧ THE EXISTING SOUTH MAINTENANCE ROAD AND DETENTION BASIN AREA ARE TO BE REGRADED AS SHOWN ON DRAWINGS C-1007 & C-1008.

⑨ EXISTING TOR MONITORING CABINETS ARE TO BE RAISED AND REINSTALLED ON SURFACE OF NEW SURFACE. NEW SENSOR CABLES ARE TO BE SPICED WITH EXISTING CABLE AND CONNECTED TO RELOCATED CABINET.

GRAPHIC SCALE
0 50 100 200 300 FEET
1" = 100'

6/4/09

EXP 6/30/09

GS

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NEVADA SITE OFFICE — LAS VEGAS, NEVADA

NEVADA TEST SITE — AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

EXISTING SITE & DEMOLITION PLAN-SOUTH

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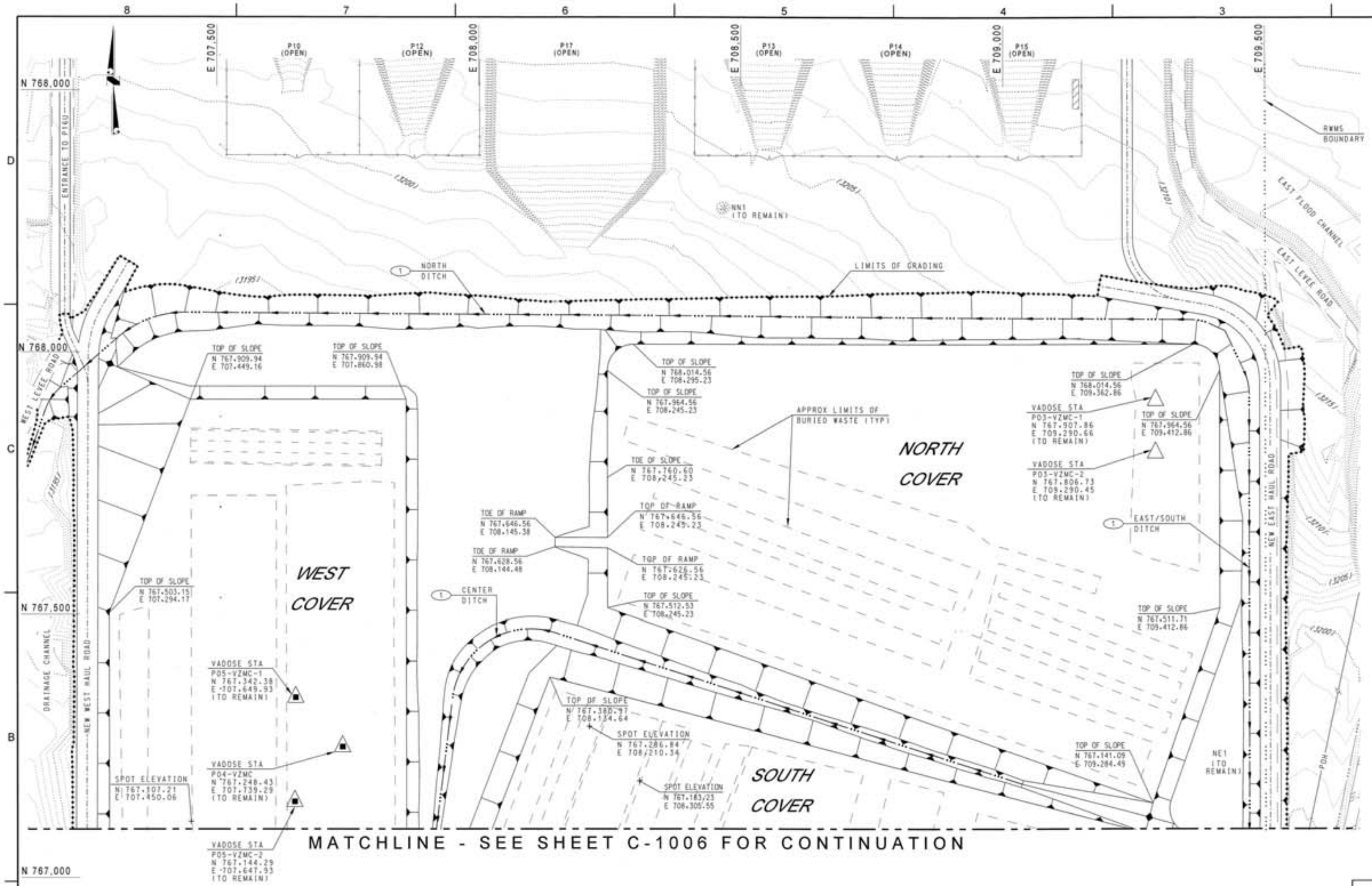

NEW HORIZONTAL
CONTROL PLAN-NORTH
SCALE : 1" = 100'

KEY NOTES

① SEE SHEET 08023-C-1009 (NORTH), C-1010 (CENTER), C-1011 (EAST-SOUTH) FOR LOCATION OF NEW DRAINAGE DITCH FLOW LINE PLANS.

GRAPHIC SCALE
0 50 100 200 300 FEET
1" = 100'
(CONTOUR INTERVALS = 1 FOOT)

6/8/09
No. 12725
Exp 6/30/09

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NEW HORIZONTAL CONTROL PLAN-NORTH

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DRAWING NUMBER / WORK ORDER NUMBER 09068-C-1005
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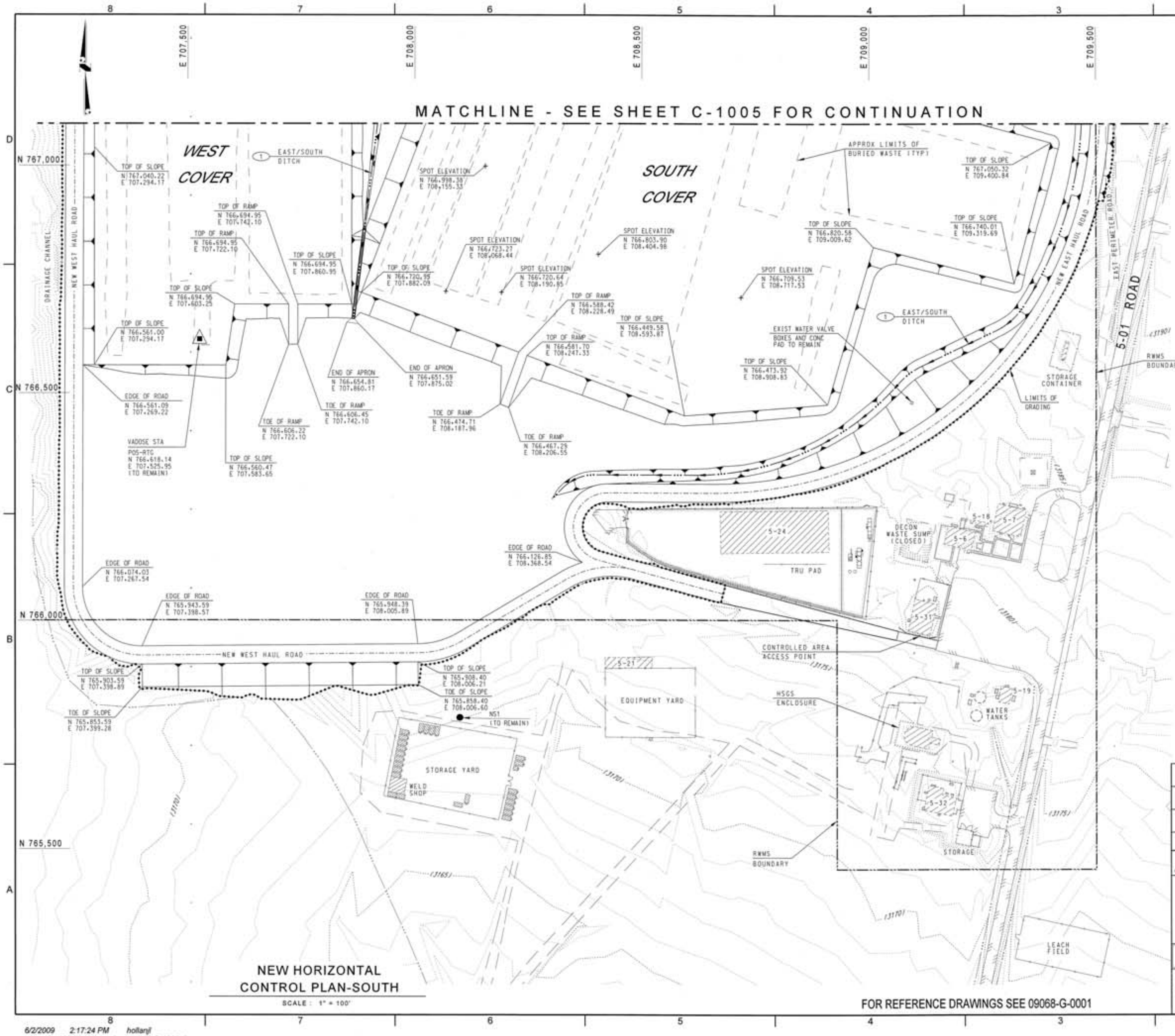
FOR REFERENCE DRAWINGS SEE 09068-G-0001

KEY NOTES

① SEE SHEET C-1010 (CENTER) AND C-1011 (EAST-SOUTH) FOR NEW DRAINAGE DITCH PLANS.



NEW HORIZONTAL CONTROL PLAN-SOUTH

SCALE : 1" = 100'

FOR REFERENCE DRAWINGS SEE 09068-G-0001

GRAPHIC SCALE

0 50 100 200 300 FEE

1" = 100'

(CONTOUR INTERVAL = 1 FOOT)

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NEVADA TEST SITE AREA 05

RADIOACTIVE WASTE MANAGEMENT SITE

92 ACRE GRADING AND DRAINAGE

NEW HORIZONTAL CONTROL PLAN-SOUTH

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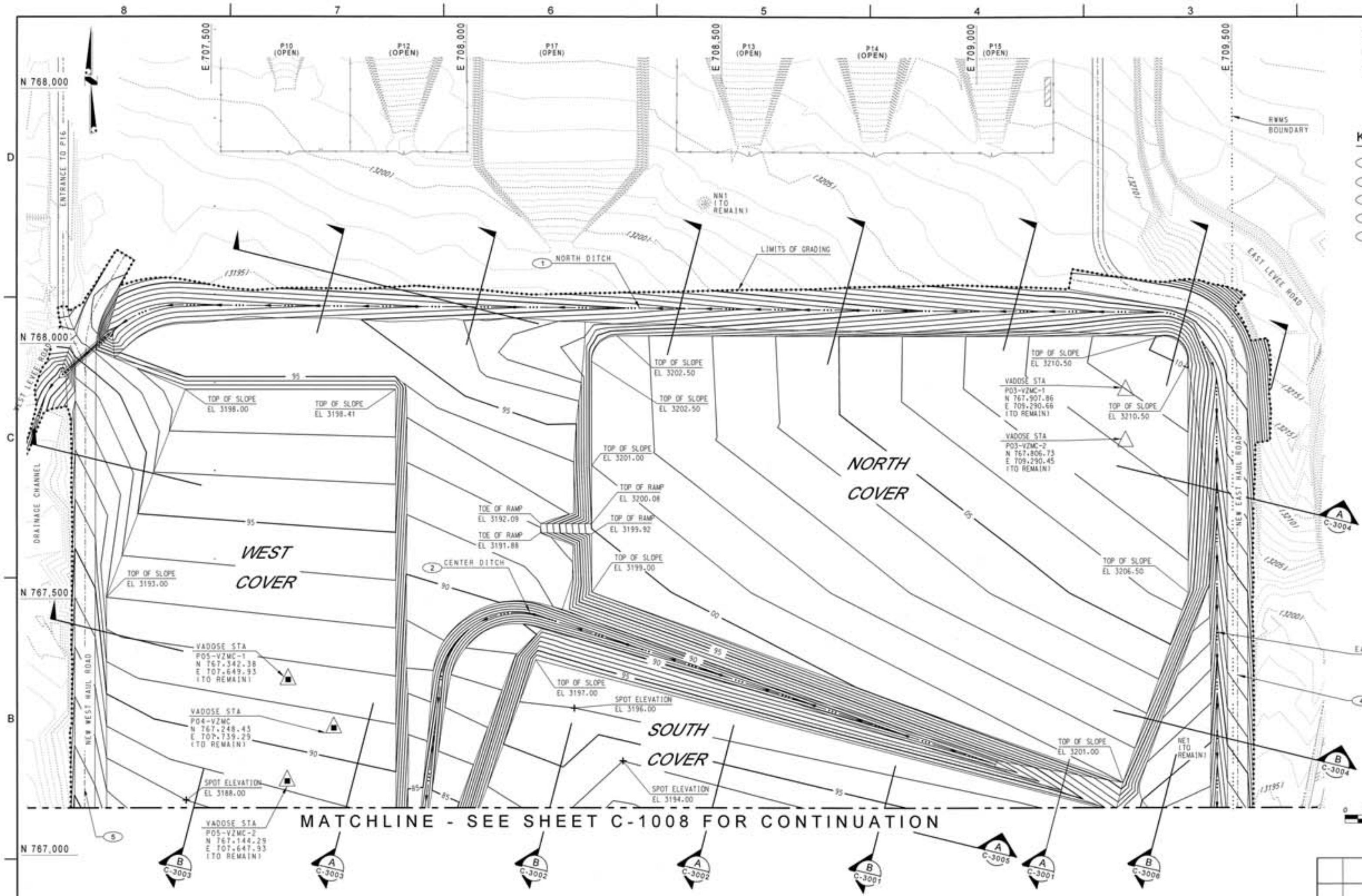

GENERAL NOTES

1. THE TYPICAL SURFACE SIDE SLOPE IS 5:1 UNLESS OTHERWISE NOTED.
2. NEW 40' WIDE UNPAVED HAUL ROADS ARE TO BE GRADED AS SHOWN. SET ℄ AND SHOULDER ELEVATIONS SUCH THAT THE NEW TRAVEL SURFACE PROVIDES POSITIVE DRAINAGE AWAY FROM BLDGS 518C, 5-7, 5-6 & 5-24.AND TOWARDS THE DITCHES.

KEY NOTES

① SEE DRAWING 09068-C-1009 FOR NORTH DRAINAGE DITCH GRADING DETAILS.
② SEE DRAWING 09068-C-1010 FOR CENTER DRAINAGE DITCH GRADING DETAILS.
③ SEE DRAWING 09068-C-1011 & C-1012 FOR EAST-SOUTH DRAINAGE DITCH GRADING DETAILS.
④ SEE DRAWING 09068-C-1013 & C-1014 FOR EAST HAUL ROAD GRADING DETAILS.
⑤ SEE DRAWING 09068-C-1015 & C-1016 FOR WEST HAUL ROAD GRADING DETAILS.

ESTIMATED QUANTITIES

DESCRIPTION	UNIT	QUANITY *
NEW COVER VOLUME FILL	CY	492,164.65
VOLUME REQUIRED TO MATCH EXISTING GRADE PIT P03 OPERATIONAL FILL PIT P06 OPERATIONAL FILL	 CY CY	 -192,726.51* * -43,884.68* *
TOTAL NET FILL REQUIRED	CY	255,553.46*

* NO COMPACTION OR CUT AND FILL FACTORS ARE APPLIED TO PROVIDED QUANTITIES. QUANTITIES PROVIDED ARE FOR NSTec ESTIMATING PURPOSES ONLY.

* * TOTAL VOLUME CALCULATIONS ARE BASED ON FY09 SURVEY DATA AND ASSUME ALL OPEN PITS ARE FILLED TO NATURAL GRADE PRIOR TO BEGINNING CONSTRUCTION.

GRAPHIC SCALE
0 50 100 200 300 FEET
1" = 100'
(CONTOUR INTERVAL = 1 FOOT)

6/4/09

EAP 6/3/09

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92 ACRE GRADING AND DRAINAGE

NEW SURFACE GRADING PLAN-NORTH

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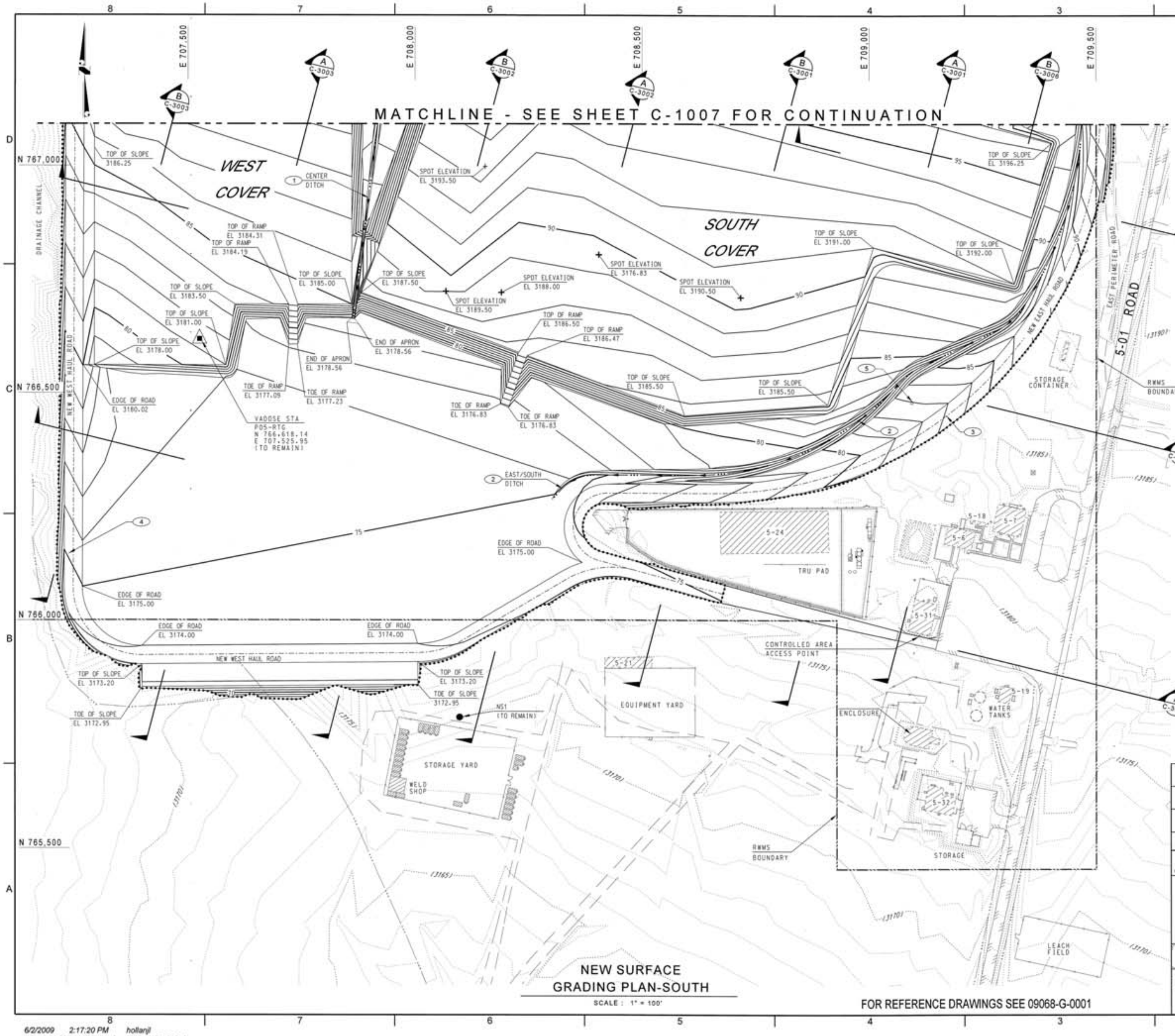

NEW SURFACE
GRADING PLAN-SOUTH
SCALE : 1" = 100'

FOR REFERENCE DRAWINGS SEE 09068-G-0001

GENERAL NOTES

1. THE TYPICAL SURFACE SIDE SLOPE IS 5:1 UNLESS OTHERWISE NOTED.
2. NEW 40' WIDE UNPAVED HAUL ROADS ARE TO BE GRADED AS SHOWN. SET ℄ AND SHOULDER ELEVATIONS SUCH THAT THE NEW TRAVEL SURFACE PROVIDES POSITIVE DRAINAGE AWAY FROM BLDGS 518C, 5-7, 5-6 & 5-24,AND TOWARDS THE DITCHES.

KEY NOTES

① SEE DRAWING 09068-C-1010 FOR CENTER DRAINAGE DITCH GRADING DETAILS.
② SEE DRAWING 09068-C-1011 & C-1012 FOR EAST-SOUTH DRAINAGE DITCH GRADING DETAILS.
③ SEE DRAWING 09068-C-1013 & C-1014 FOR EAST HAUL ROAD GRADING DETAILS.
④ SEE DRAWING 09068-C-1015 & C-1016 FOR WEST HAUL ROAD GRADING DETAILS.
⑤ ALL EXISTING UNDERGROUND WATER, SEWER, AND COMMUNICATIONS LINES, FIXTURES AND APPURTENANCES ARE TO REMAIN IN PLACE. "DO NOT DISTURB." TAKE APPROPRIATE MEASURES AS NEEDED TO PROTECT THESE UTILITIES DURING CONSTRUCTION.

GRAPHIC SCALE
0 50 100 200 300 FEET
1" = 100'
(CONTOUR INTERVAL = 1 FOOT)

6/4/09

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NEVADA SITE OFFICE
LAS VEGAS, NEVADA

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AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

NEW SURFACE GRADING PLAN-SOUTH

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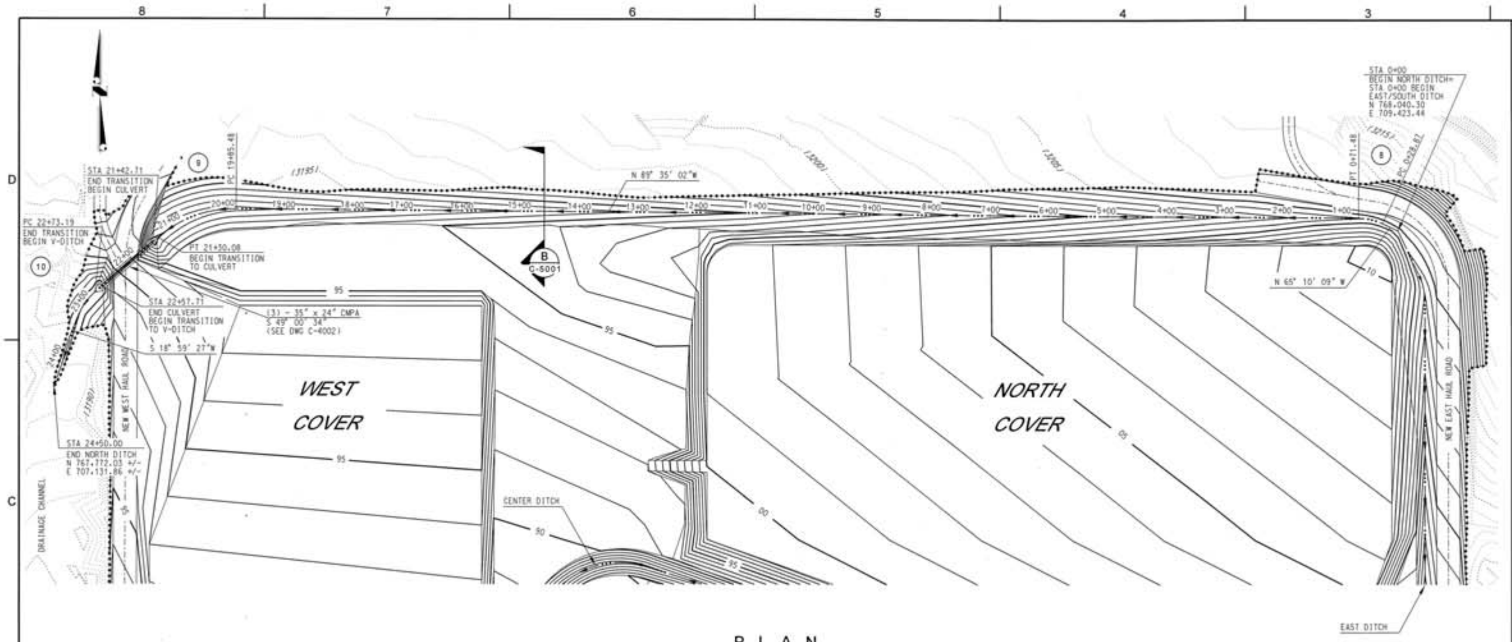
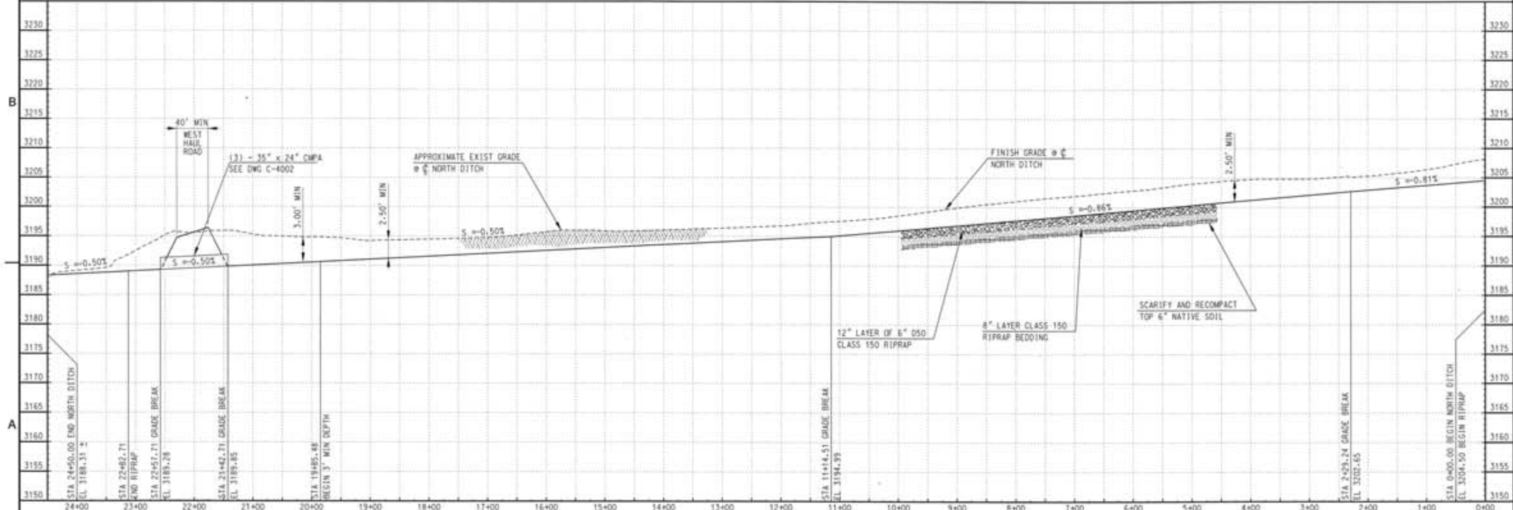


P L A N
SCALE: 1"= 100'



P R O F I L E
SCALE: HORIZ 1"= 100', VERT 1"= 10'

FOR REFERENCE DRAWINGS SEE 09068-G-0001

NORTH DRAINAGE HORIZONTAL CURVE DATA

NO	RP	PC	PT	R	Δ	L	T
⑧	N 767,961.67 E 709,355.24	N 768,052.42 E 709,397.23	N 768,061.67 E 709,355.96	100.00	24°24'53"	42.61'	21.63'
⑨	N 767,875.57 E 707,440.57	N 768,075.57 E 707,442.02	N 768,026.53 E 707,309.39	200.00	41°24'24"	144.54'	75.57'
⑩	N 767,857.14 E 707,266.91	N 767,932.62 E 707,201.31	N 767,889.68 E 707,172.35	100.00	30°01'07"	52.39'	26.81'

GRAPHIC SCALE
0 10 20 30 FEET
1"= 10'

GRAPHIC SCALE
0 50 100 200 300 FEET
1"= 100'
(CONTOUR INTERVAL = 1 FOOT)

6/4/09
6/4/09

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92 ACRE GRADING AND DRAINAGE
NORTH DRAINAGE DITCH
PLAN & PROFILE STA 0+00 - 24+50

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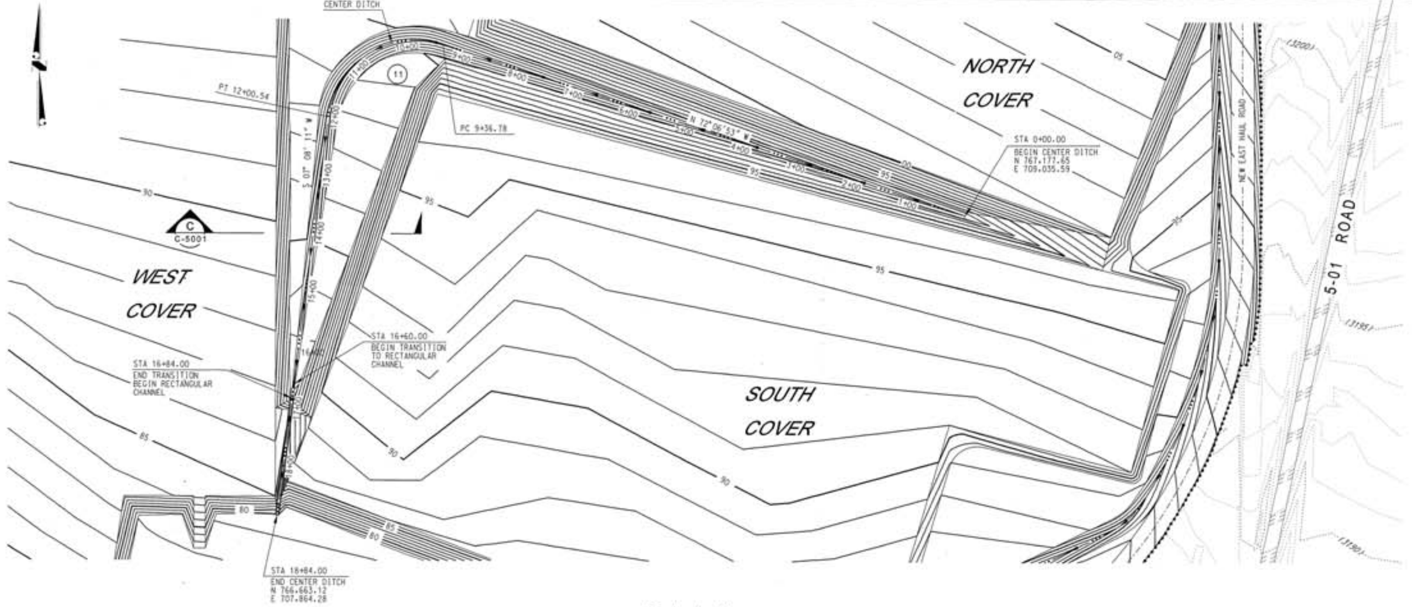
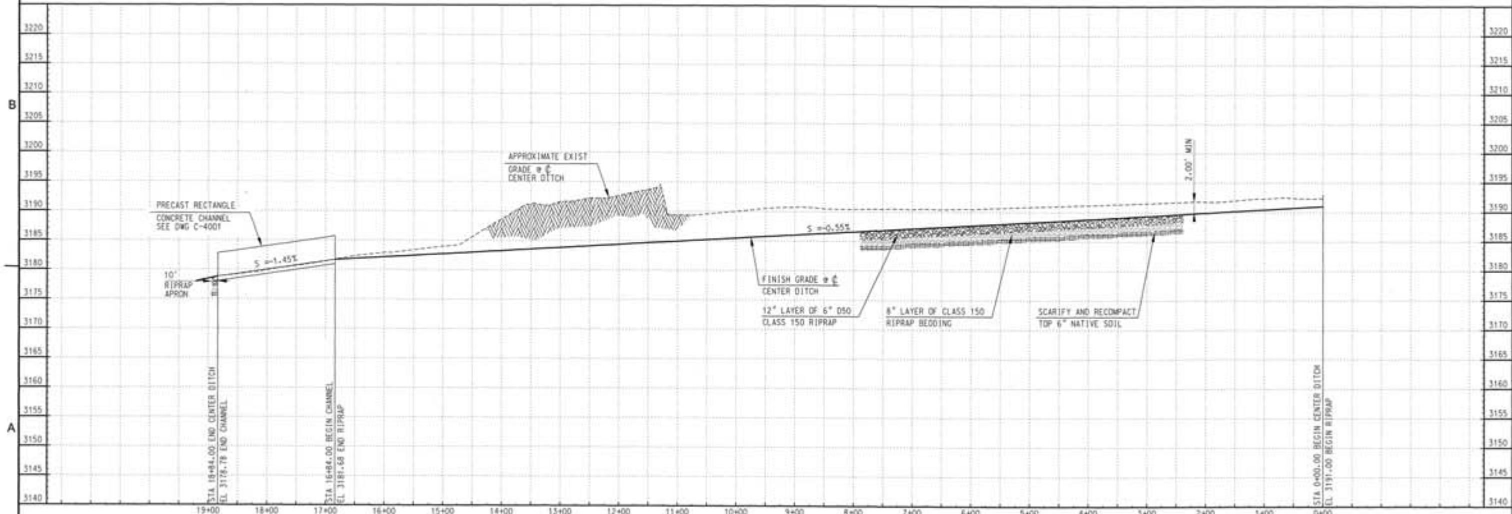


P L A N

SCALE: 1"= 100'

CENTER DRAINAGE HORIZONTAL CURVE DATA							
NO	RP	PC	PT	R	Δ	L	T
(11)	N 767,322.59 E 708,098.02	N 767,465.34 E 708,144.08	N 767,341.23 E 707,949.18	150.00'	100° 44' 57"	263.76'	181.15'



P R O F I L E

SCALE: HORIZ 1"= 100', VERT 1"= 10'

FOR REFERENCE DRAWINGS SEE 09068-G-0001

GRAPHIC SCALE
0 10 20 30 FEET
1"= 10'

GRAPHIC SCALE
0 50 100 200 300 FEET
1"= 100'
(CONTOUR INTERVAL = 1 FOOT)

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NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA SITE OFFICE LAS VEGAS, NEVADA

NEVADA TEST SITE AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE
CENTER DRAINAGE DITCH

PLAN & PROFILE STA 0+00 TO 18+84

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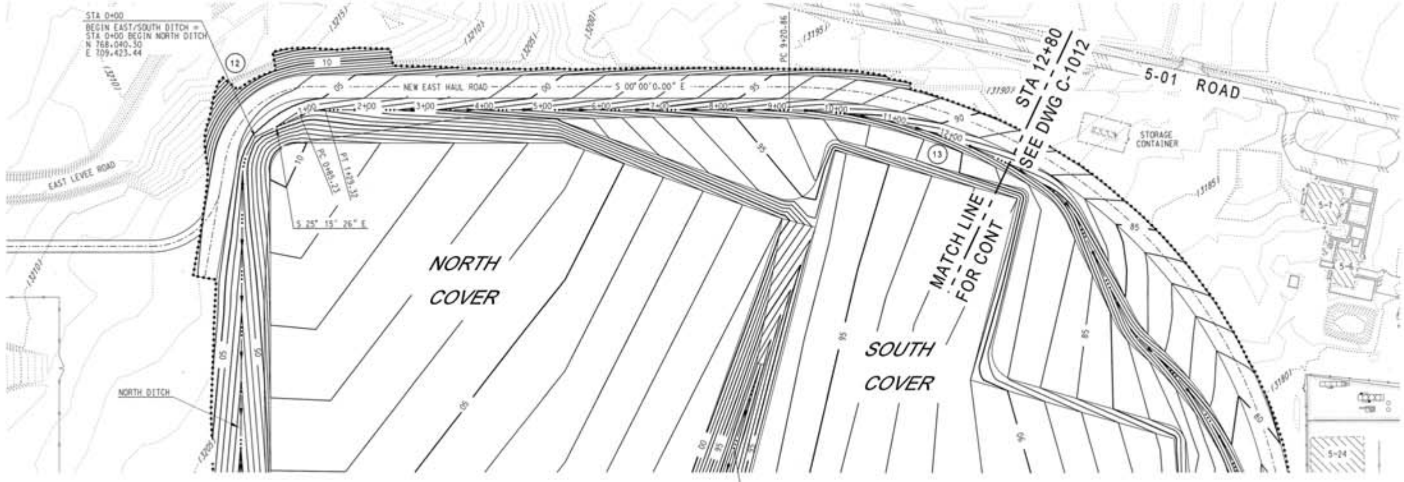
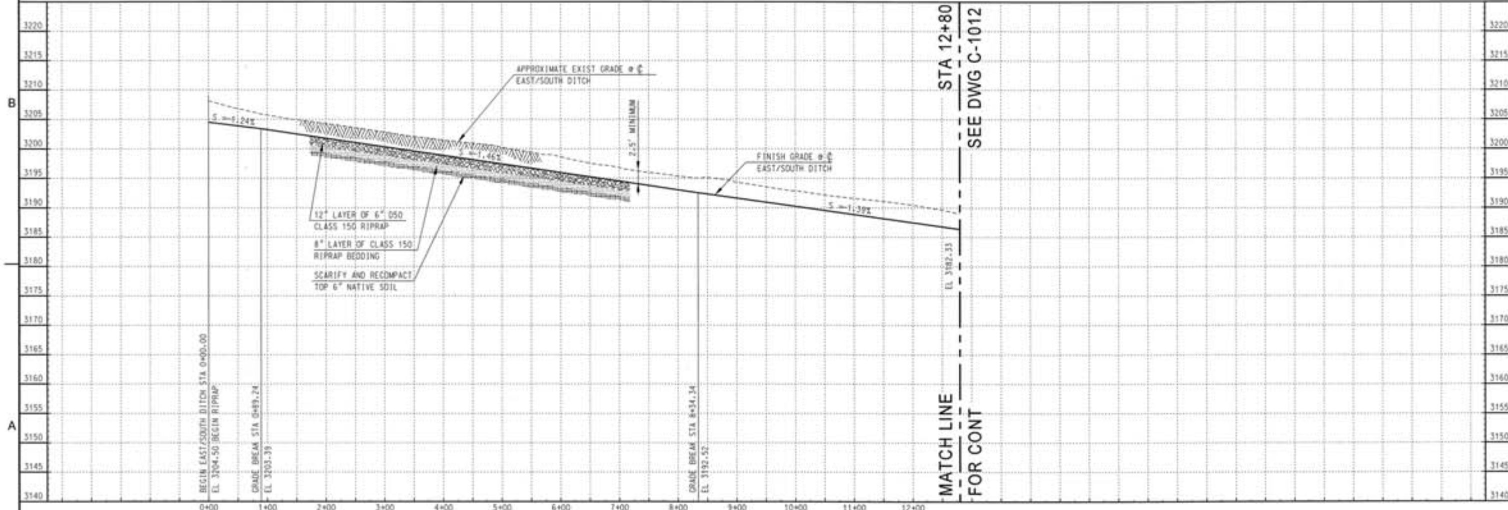


P L A N
SCALE: 1"= 100'



P R O F I L E
SCALE: HORIZ 1"= 100' , VERT 1"= 10'

FOR REFERENCE DRAWINGS SEE 09068-G-0001

EAST SOUTH DRAINAGE HORIZONTAL CURVE DATA

NO	RP	PC	PT	R	Δ	L	T
⑫	N 767,920.54 E 709,369.36	N 767,963.21 E 709,459.80	N 767,920.54 E 709,469.36	100.00	25°15'26"	44.08'	22.41'
⑬	N 767,129.00 E 708,659.36	N 767,129.00 E 709,469.36	N 766,692.52 E 709,340.42	810.00	32°46'28"	463.34	238.20

GRAPHIC SCALE
0 10 20 30 FEET
1"= 10'

GRAPHIC SCALE
0 50 100 200 300 FEET
1"= 100'
(CONTOUR INTERVAL = 1 FOOT)

6/9/09

GS

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NEVADA TEST SITE AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE
EAST - SOUTH DRAINAGE DITCH
PLAN & PROFILE STA 0+00 - 12+80

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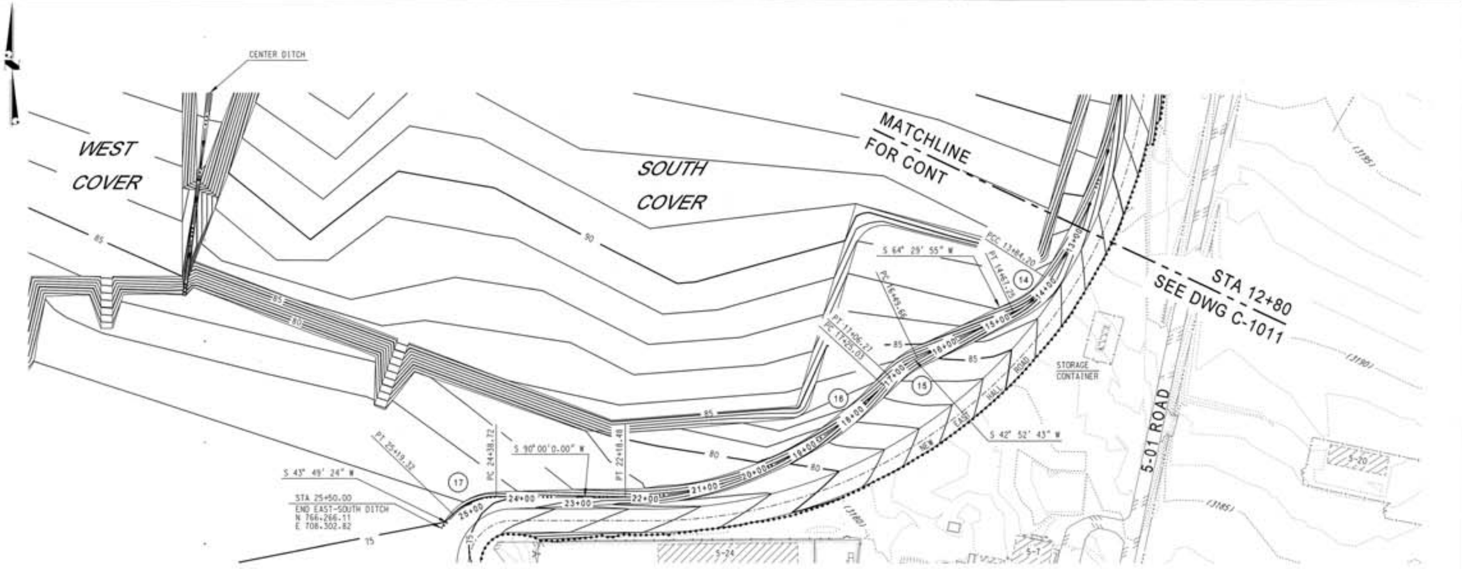
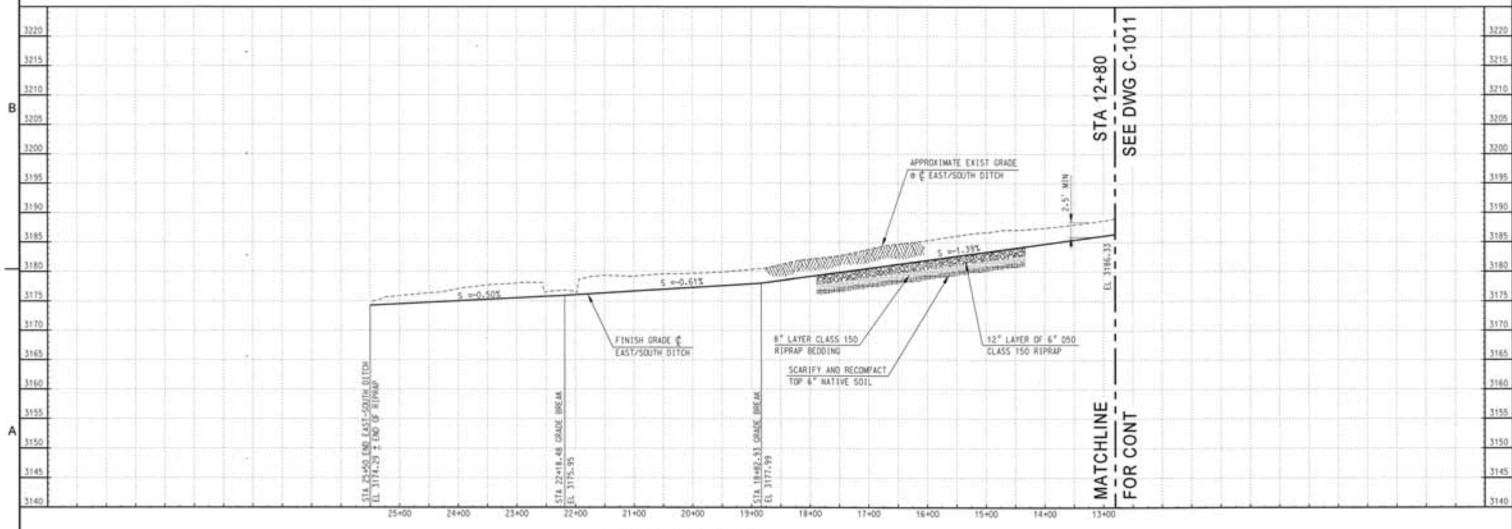


P L A N

SCALE: 1"= 100'



P R O F I L E

SCALE: HORIZ 1"= 100', VERT 1"= 10'

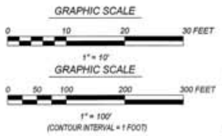
FOR REFERENCE DRAWINGS SEE 09068-G-0001

EAST-SOUTH DRAINAGE HORIZONTAL CURVE DATA

NO	RP	PC	PT	R	Δ	L	T
⑭	N 766,771.72 E 709,214.30	N 766,557.80 E 709,114.24	N 766,636.34 E 709,278.88	150.00'	31° 43' 27"	83.05'	42.62
⑮	N 766,422.41 E 709,178.82	N 766,557.80 E 709,114.24	N 766,524.48 E 709,068.90	150.00'	21° 37' 12"	56.60'	28.64'
⑯	N 766,919.00 E 708,616.45	N 766,510.73 E 709,056.13	N 766,319.00 E 708,616.45	600.00'	47° 07' 17"	493.45'	261.64'
⑰	N 766,219.00 E 708,396.21	N 766,319.00 E 708,396.21	N 766,288.24 E 708,324.06	100.00'	46° 10' 36"	80.59'	42.63'

NOTES

1. SEE SHEET C-1011 FOR CURVE #13 DATA



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NEVADA TEST SITE — AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE
EAST - SOUTH DRAINAGE DITCH
PLAN & PROFILE STA 12+80 - 25+50

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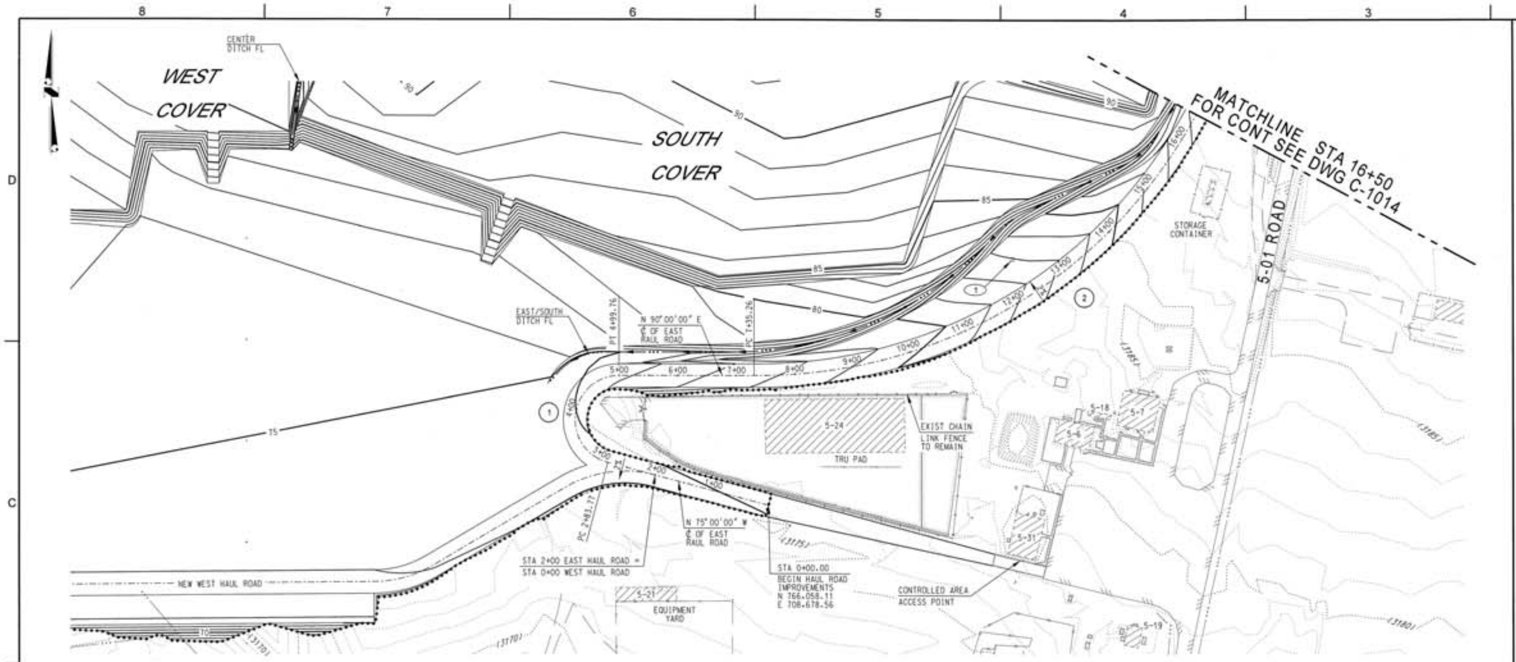
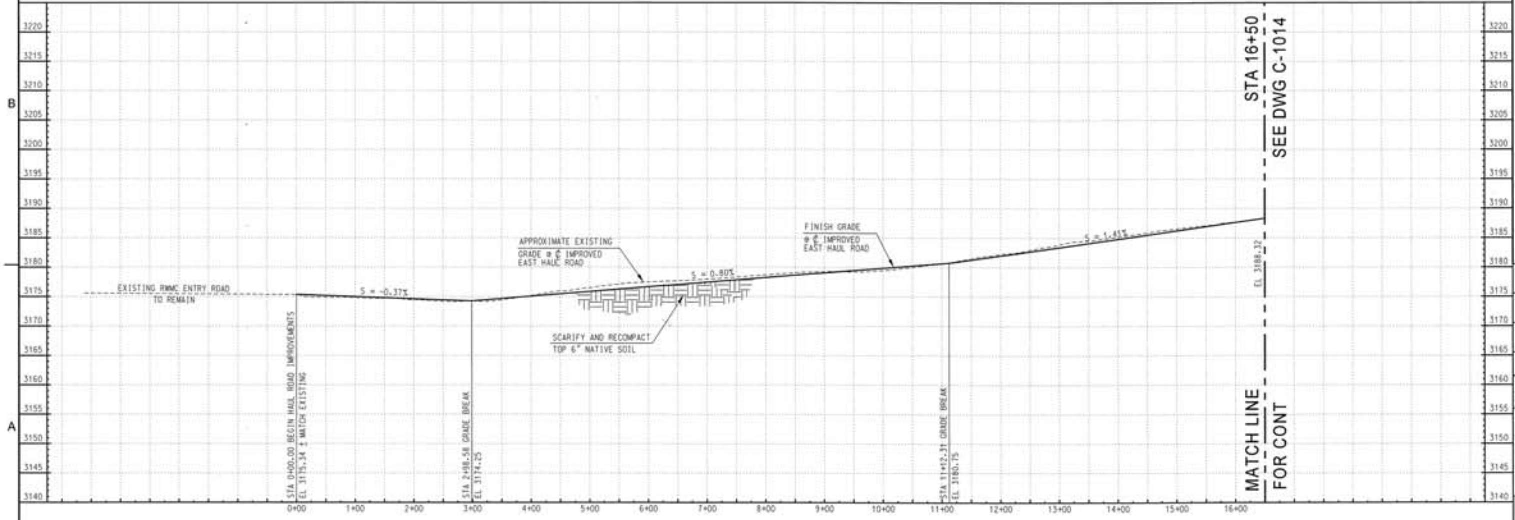


PLAN
SCALE: 1"= 100'



PROFILE
SCALE: HORIZ 1"= 100', VERT 1"= 10'

FOR REFERENCE DRAWINGS SEE 09068-G-0001

KEY NOTES

① CAUTION - EXISTING CONCRETE PAD FOR WATER VALVE BOXES TO REMAIN. TAKE PRECATUIONS TO PROTECT VALVE BOXES AND CONCRETE COVER AS NEEDED DURING CONSTRUCTION.

EAST HAUL ROAD HORIZONTAL CURVE DATA

NO	RP	PC	PT	R	Δ	L	T
①	N 766,204.00 E 708,423.86	N 766,131.56 E 708,404.45	N 766,279.00 E 708,423.86	75.00'	165°00'00"	215.98'	569.68'
②	N 767,129.00 E 708,659.36	N 766,279.00 E 708,659.36	N 767,129.00 E 709,509.36	850.00'	90°00'00"	1335.18'	850.00'

GRAPHIC SCALE
0 10 20 30 FEET
1" = 10'

GRAPHIC SCALE
0 50 100 200 300 FEET
1" = 100'
(CONTOUR INTERVAL = 1 FOOT)

GS

NO	DATE	REVISIONS	DRAWN	PREPARER	CHECKER	PROJ ENGR	APPROVER USER

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NEVADA TEST SITE AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE
EAST HAUL ROAD
PLAN & PROFILE STA 0+00 - 16+50

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DRAWING NUMBER / WORK ORDER NUMBER 09068-C-1013
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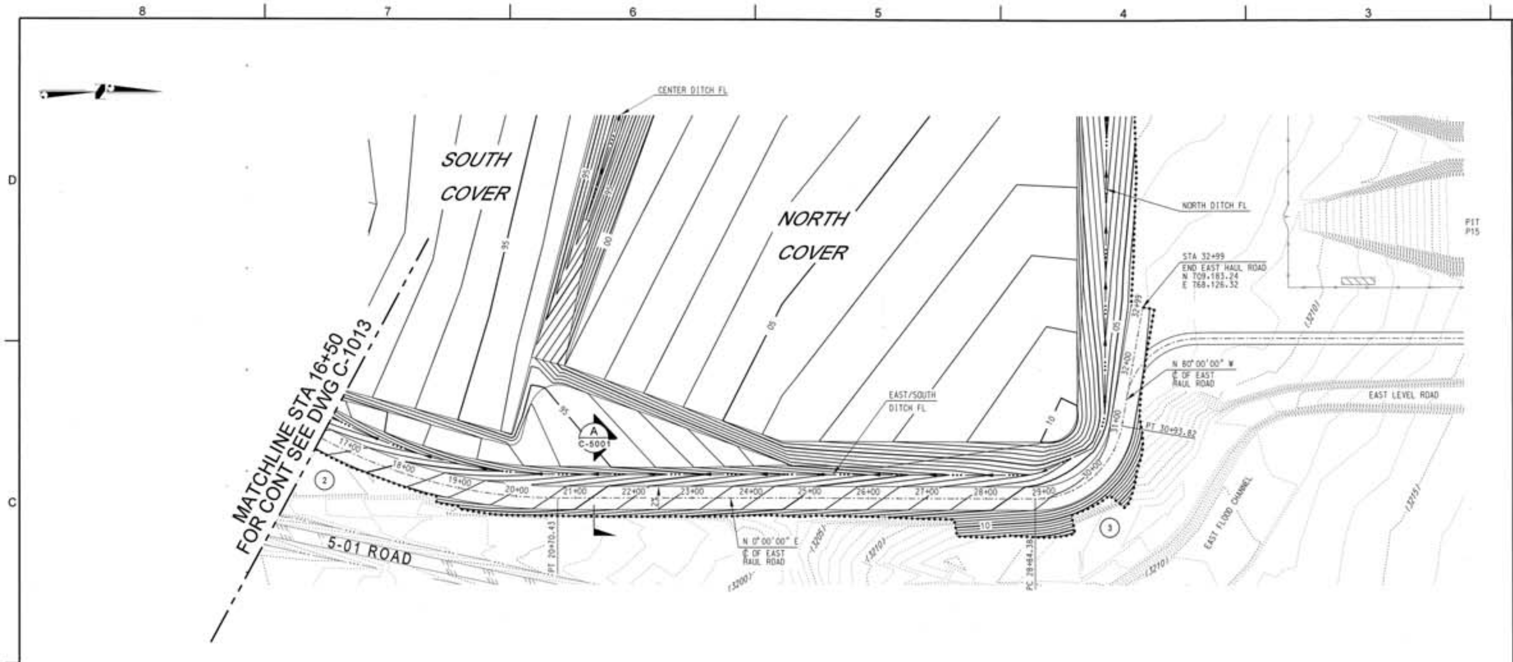
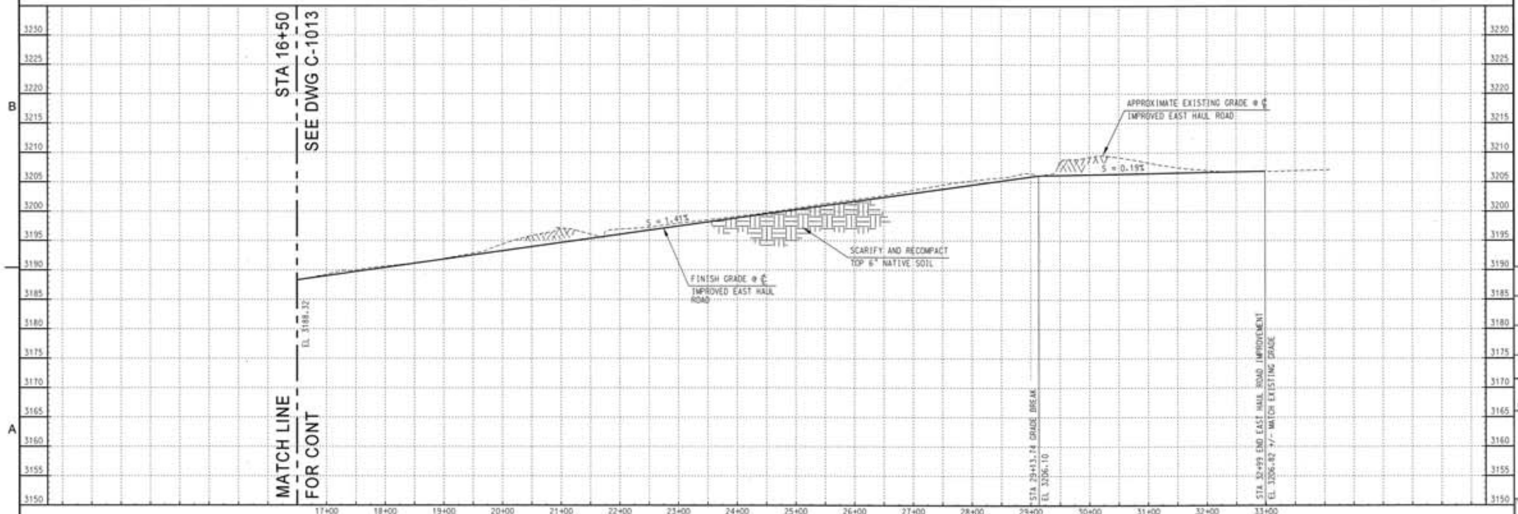


PLAN

SCALE: 1"= 100'



PROFILE

SCALE: HORIZ 1"= 100' , VERT 1"= 10'

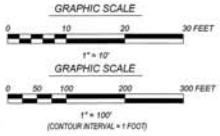
FOR REFERENCE DRAWINGS SEE 09068-G-0001

CENTER DRAINAGE HORIZONTAL CURVE DATA

NO	RP	PC	PT	R	Δ	L	T
③	N 767,942.95 E 709,359.36	N 767,942.95 E 709,509.36	N 768,090.67 E 709,385.41	150.00'	80°00'00"	209.44'	125.86'

NOTES

1. SEE SHEET C-1013 FOR CURVE #2 DATA



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NEVADA TEST SITE — AREA 05
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92 ACRE GRADING AND DRAINAGE
EAST HAUL ROAD
PLAN & PROFILE STA 16+50 - 32+99

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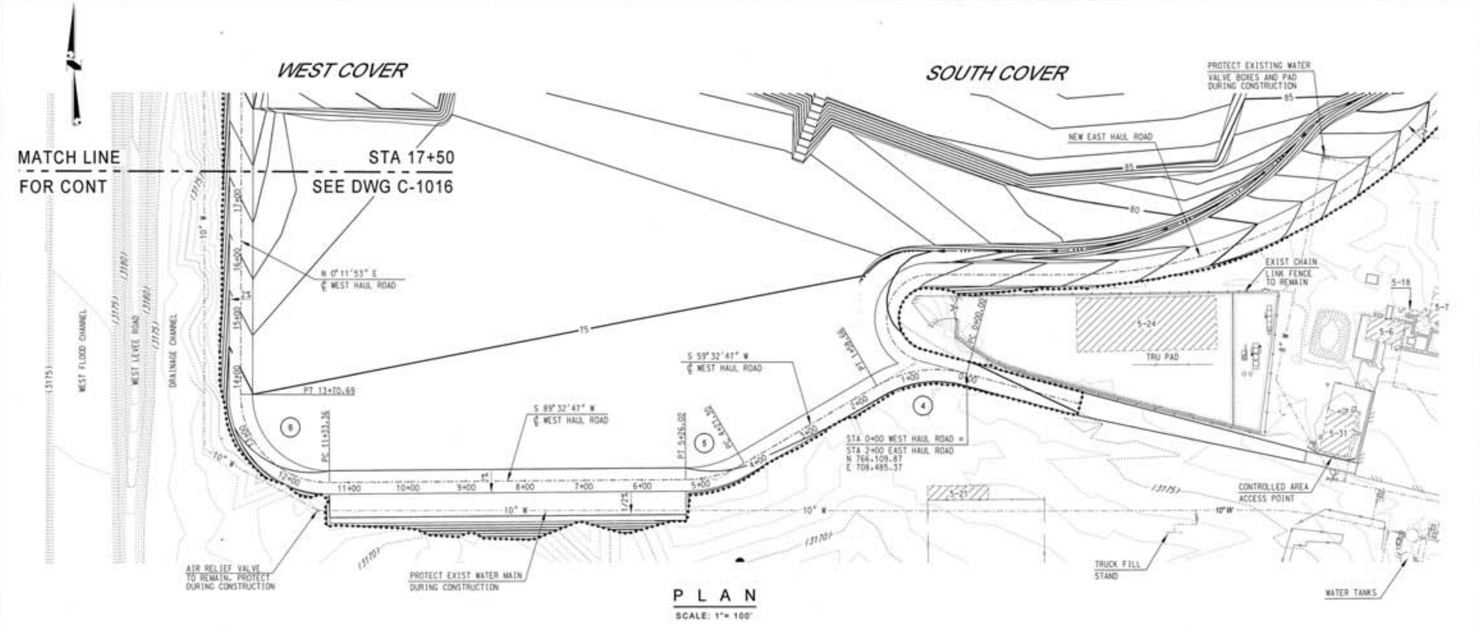
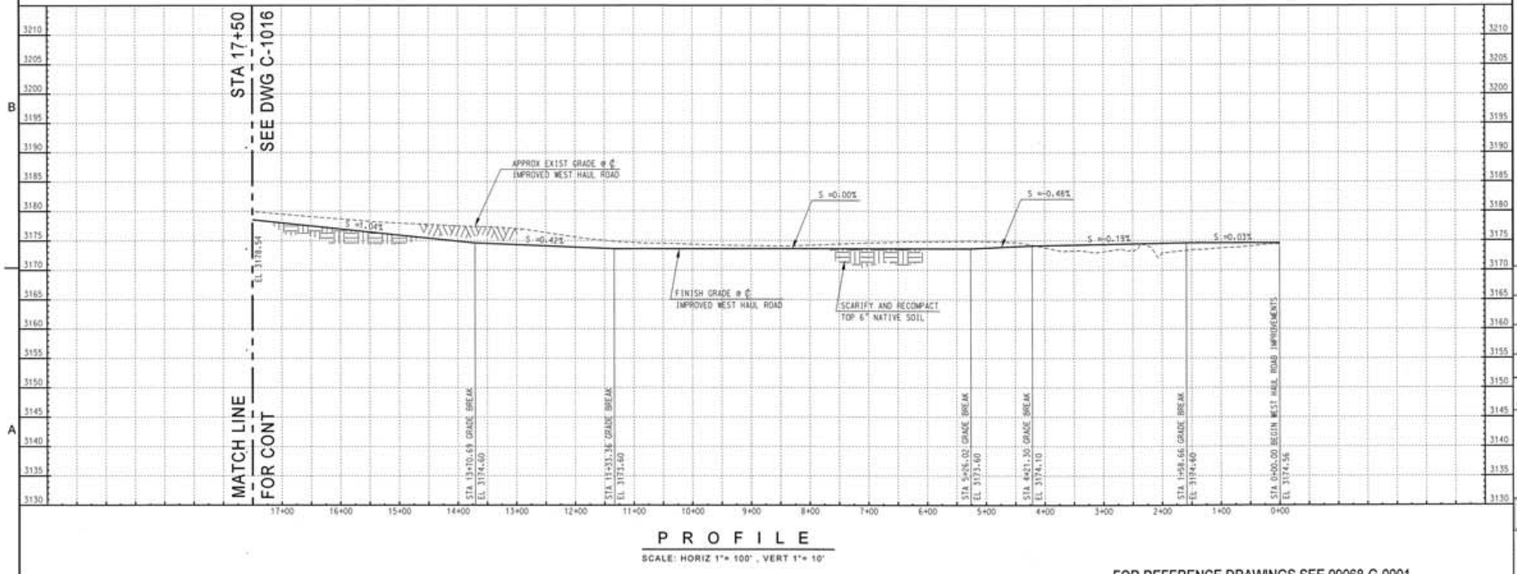


P L A N

SCALE: 1"= 100'

SOUTH DRAINAGE HORIZONTAL CURVE DATA							
NO	RP	PC	PT	R	Δ	L	T
④	N 765,916.69 E 708,433.61	N 766,109.87 E 708,485.37	N 766,089.10 E 708,332.24	200.00'	45°27'13"	158.66'	83.77'
⑤	N 766,128.39 E 708,004.47	N 765,955.98 E 708,105.83	N 765,928.40 E 708,006.05	200.00'	30°00'00"	104.72'	53.59'
⑥	N 766,073.58 E 707,397.54	N 765,923.59 E 707,398.73	N 766,074.10 E 707,247.54	150.00'	90°39'06"	237.33'	151.72'



P R O F I L E

SCALE: HORIZ 1"= 100', VERT 1"= 10'

FOR REFERENCE DRAWINGS SEE 09068-G-0001

GRAPHIC SCALE
0 10 20 30 FEET
1"= 10'

GRAPHIC SCALE
0 50 100 200 300 FEET
1"= 100'
(CONTOUR INTERVAL = 1 FOOT)

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92 ACRE GRADING AND DRAINAGE
WEST HAUL ROAD
PLAN & PROFILE STA 0+00 - 17+50

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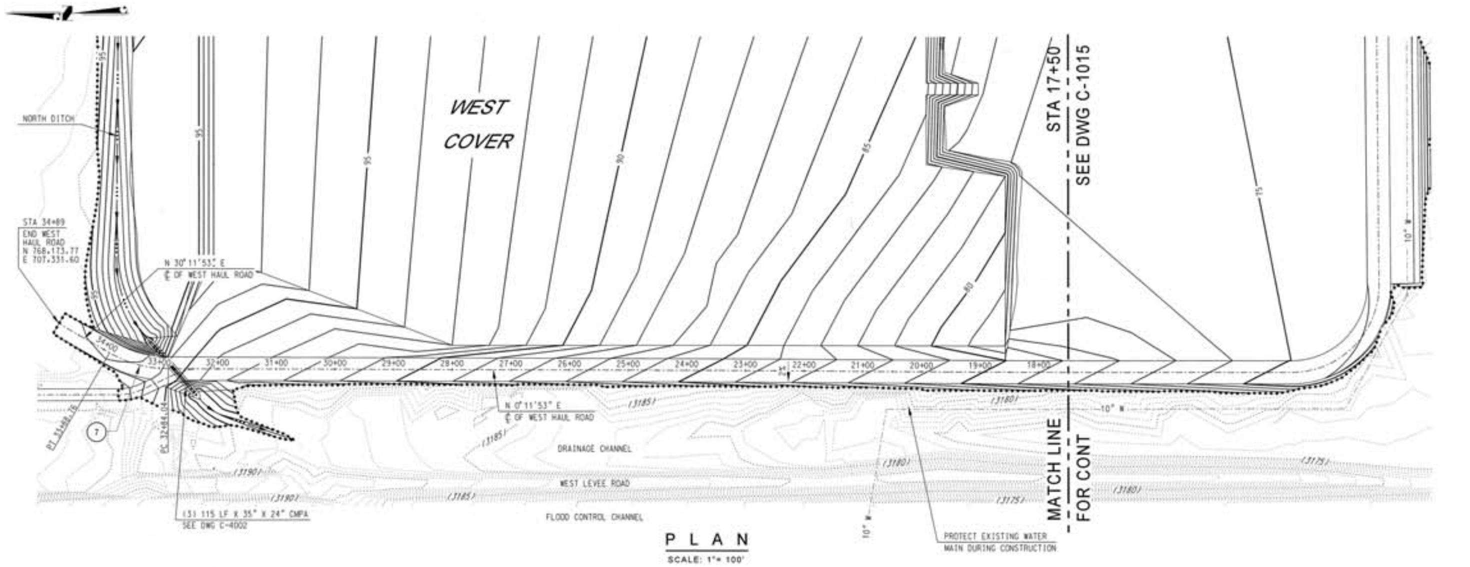
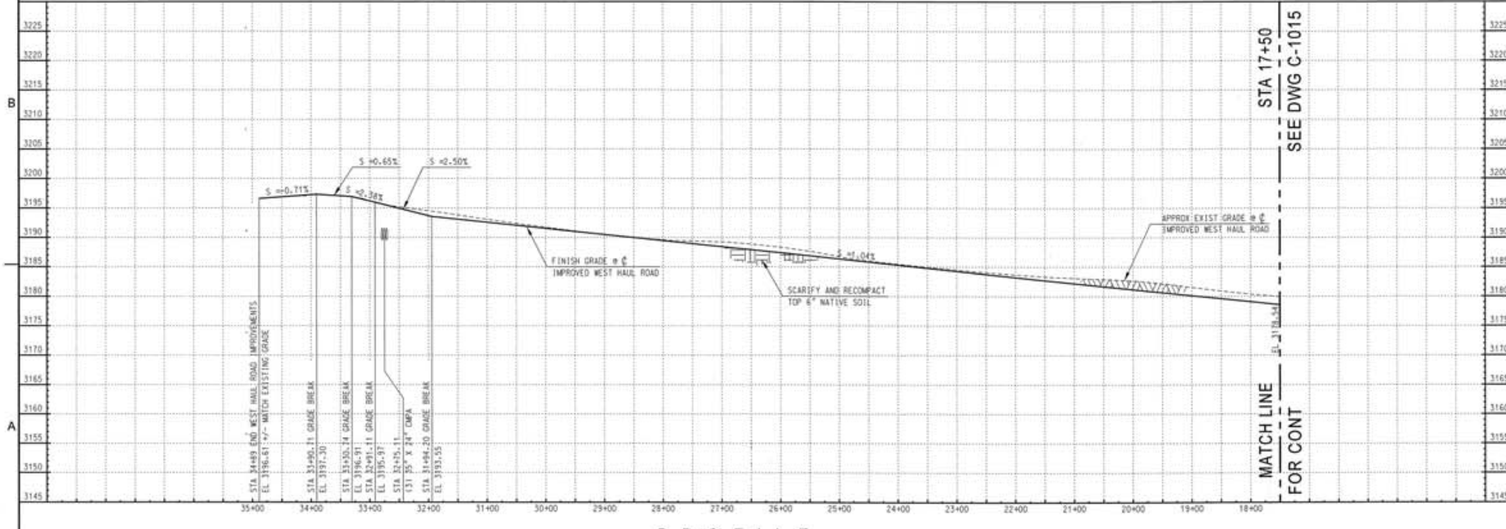


P L A N
SCALE: 1"= 100'



P R O F I L E
SCALE: HORIZ 1"= 100', VERT 1"= 10'

FOR REFERENCE DRAWINGS SEE 09068-G-0001

SOUTH DRAINAGE HORIZONTAL CURVE DATA

NO	RP	PC	PT	R	Δ	L	T
⑦	N 767,986.75 E 707,454.16	N 767,987.44 E 707,254.16	N 768,087.35 E 707,281.30	200.00'	30°00'00"	104.72'	53.59'

GRAPHIC SCALE
0 10 20 30 FEET
1"= 10'

GRAPHIC SCALE
0 50 100 200 300 FEET
1"= 100'
(CONTOUR INTERVAL = 1 FOOT)

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RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE
WEST HAUL ROAD
PLAN & PROFILE STA 17+50 - 34+89

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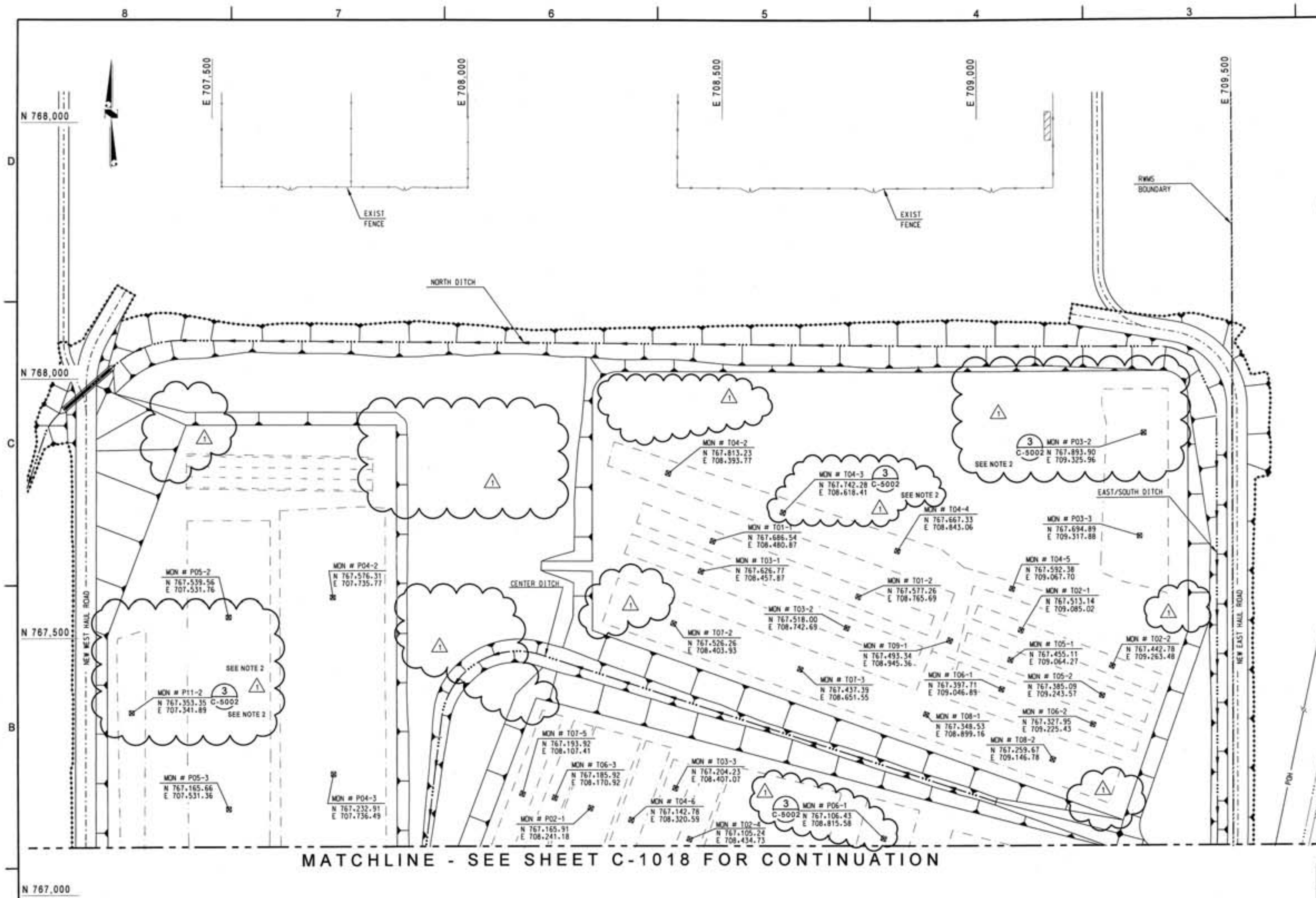
NOTES

1. SEE DRAWING C-5002 FOR MONUMENT FABRICATION AND MARKING DETAILS.
2. USE TYPE 2 CONCRETE MONUMENTS FOR INTERIOR SUBSIDENCE MARKERS (TYPICAL 49 PLACES) △1



MATCHLINE - SEE SHEET C-1018 FOR CONTINUATION

GRAPHIC SCALE
0 50 100 200 300 FEET
1" = 100'

7/9/9

ep 6/30/11

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△1		DELETED BOUNDARY MONUMENTS & ADDED NOTE 2 PER PROJECT MANAGER E-MAIL DATED 06/11/09					
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NEVADA SITE OFFICE LAS VEGAS, NEVADA

NEVADA TEST SITE — AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

NEW MONUMENT PLAN-NORTH

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FOR REFERENCE DRAWINGS SEE 09068-G-0001

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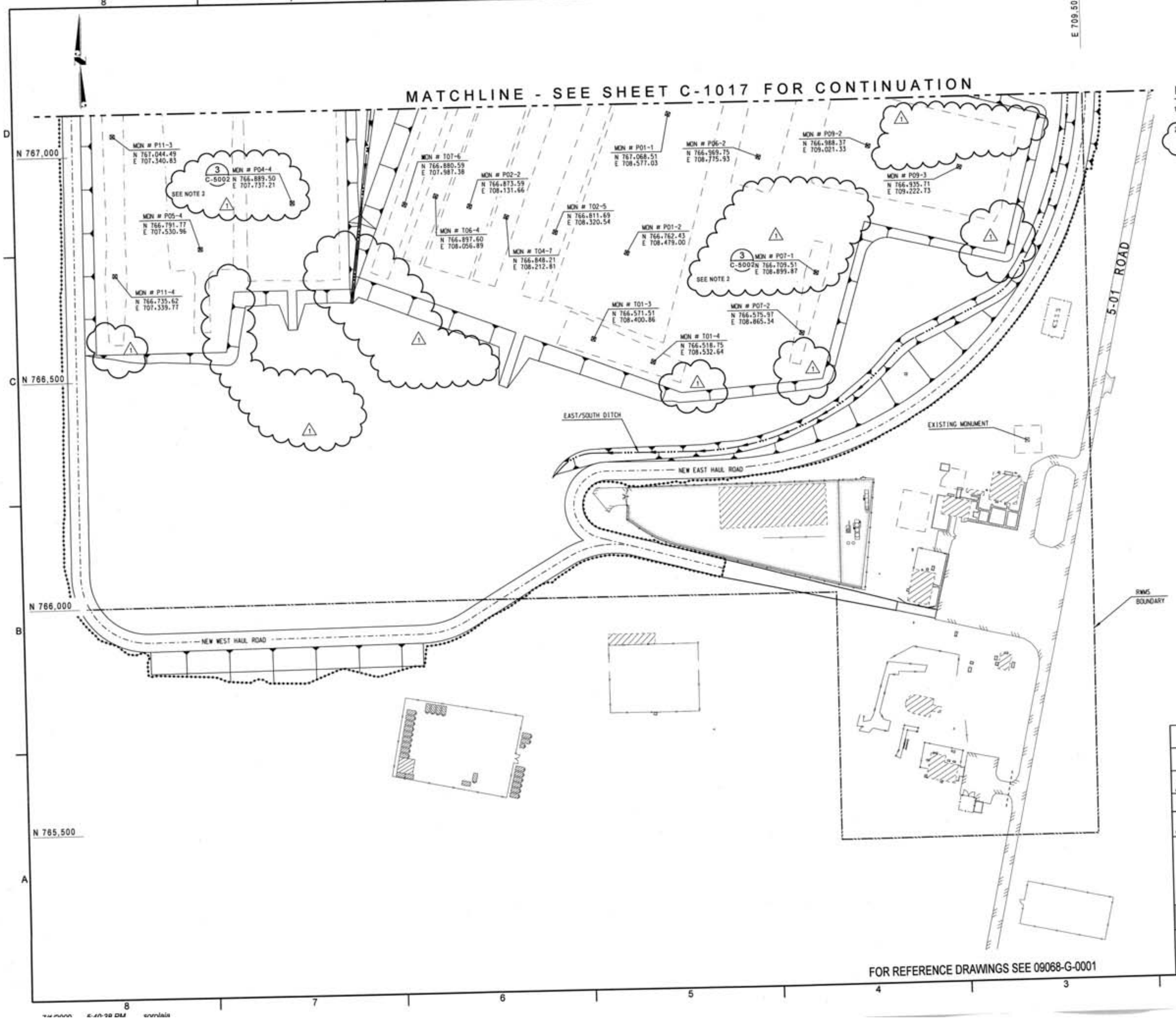

FOR REFERENCE DRAWINGS SEE 09068-G-0001

NOTES

1. SEE DRAWING C-5002 FOR MONUMENT FABRICATION AND MARKING DETAILS.
2. USE TYPE 2 CONCRETE MONUMENTS FOR INTERIOR SUBSIDENCE MARKERS (TYPICAL 49 PLACES) △1

GRAPHIC SCALE
0 50 100 200 300 FEE
1" = 100'

7/9/9

GS

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△1		DELETED BOUNDARY MONUMENTS & ADDED NOTE 2 PER PROJECT MANAGER E-MAIL DATED 06/11/09					

NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA SITE OFFICE
LAS VEGAS, NEVADA

NEVADA TEST SITE — AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

NEW MONUMENT PLAN-SOUTH

PREPARER
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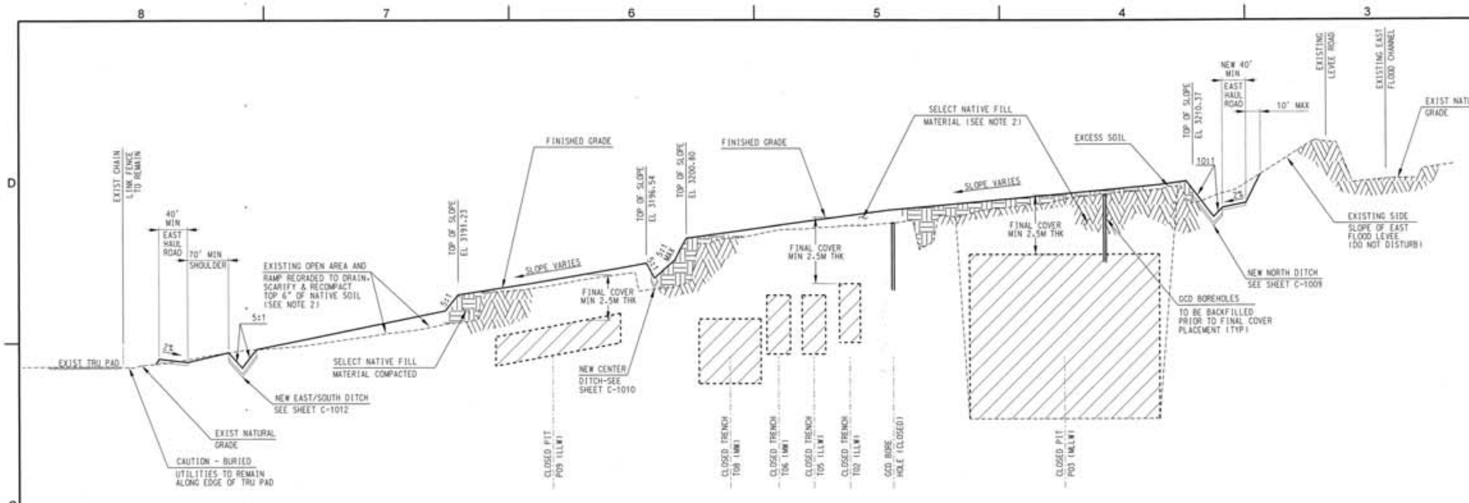


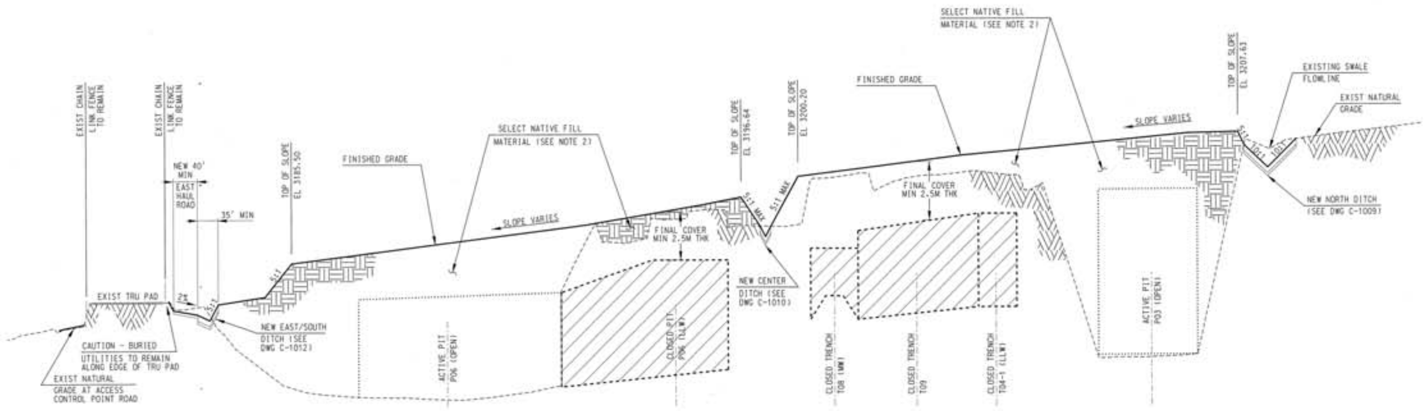
SECTION (SOUTH TO NORTH) Ⓐ

SCALE : HORIZ 1" = 100' VERT 1" = 10' -

C-1007
C-1008

NOTES

1. SEE DRAWINGS C-1009 (NORTH), C-1010 (CENTER), C-1011 AND C-1012 (EAST-SOUTH) FOR DITCH FLOWLINE AND HORIZONTAL LOCATIONS.
2. SEE SPECIFICATION 09068-SPC-G01 FOR SOIL BACKFILL AND COMPACTION REQUIREMENTS.
3. THE BURIED WASTE MATERIAL EXTENTS REPRESENTED ON THIS DRAWING ARE APPROXIMATE, AND ARE BASED ON THE BEST ARCHIVE RECORDS AVAILABLE FROM NTS RWMS SITE OPERATIONS.



SECTION (SOUTH TO NORTH) Ⓑ

SCALE : HORIZ 1" = 100' VERT 1" = 10'

C-1007
C-1008

GRAPHIC SCALE
0 10 20 30 FEET
1" = 10'

GRAPHIC SCALE
0 50 100 200 300 FEET
1" = 100'

6/4/09

EJP 06/24/09

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NEVADA SITE OFFICE — LAS VEGAS, NEVADA

NEVADA TEST SITE — AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

NEW SURFACE GRADING SECTIONS

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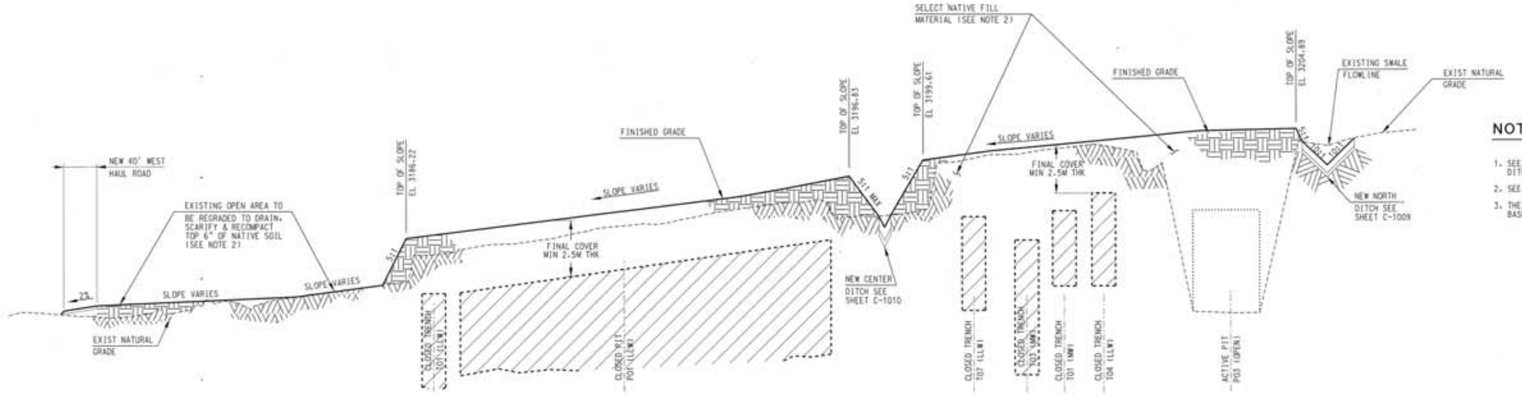


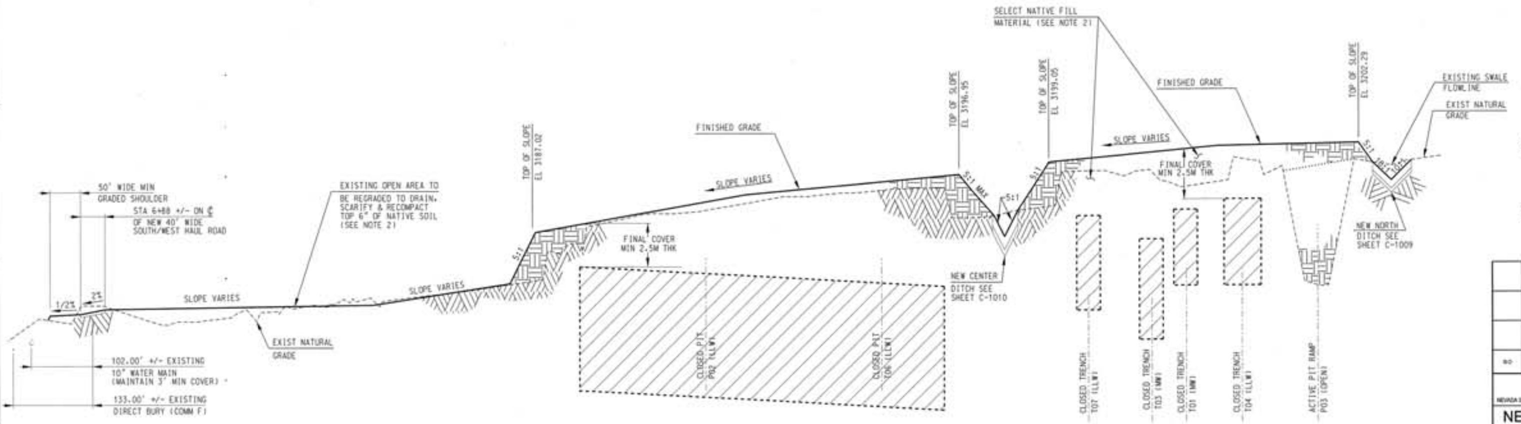
SECTION (SOUTH TO NORTH) Ⓐ

SCALE: HORIZ 1" = 100' VERT 1" = 10'

C-1007
C-1008

NOTES

1. SEE DRAWINGS C-1009 (NORTH), C-1010 (CENTER), C-1011 AND C-1012 (EAST-SOUTH) FOR DITCH FLOWLINE & HORIZONTAL LOCATIONS.
2. SEE SPECIFICATION 09068-SPC-001 FOR SOIL BACKFILL AND COMPACTION REQUIREMENTS.
3. THE BURIED WASTE MATERIAL EXTENTS REPRESENTED ON THIS DRAWING ARE APPROXIMATE, AND ARE BASED ON THE BEST ARCHIVE RECORDS AVAILABLE FROM NTS RWMS SITE OPERATIONS.



SECTION (SOUTH TO NORTH) Ⓑ

SCALE: HORIZ 1" = 100' VERT 1" = 10'

C-1007
C-1008

FOR REFERENCE DRAWINGS SEE 09068-G-0001

GRAPHIC SCALE
0 10 20 30 FEET
1" = 10'

GRAPHIC SCALE
0 50 100 200 300 FEET
1" = 100'

6/4/09
exp 6/30/09

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NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA SITE OFFICE LAS VEGAS, NEVADA

NEVADA TEST SITE — AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

NEW SURFACE GRADING SECTIONS

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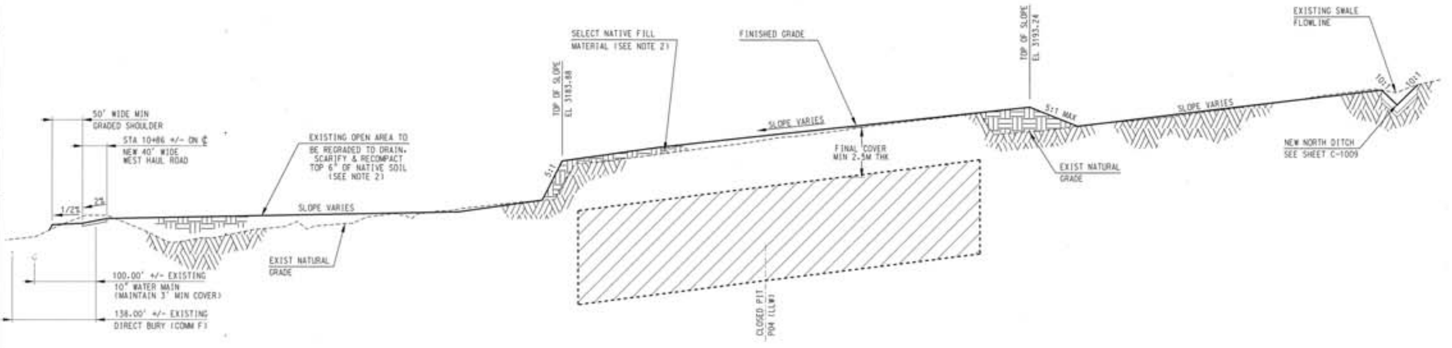
NOTES

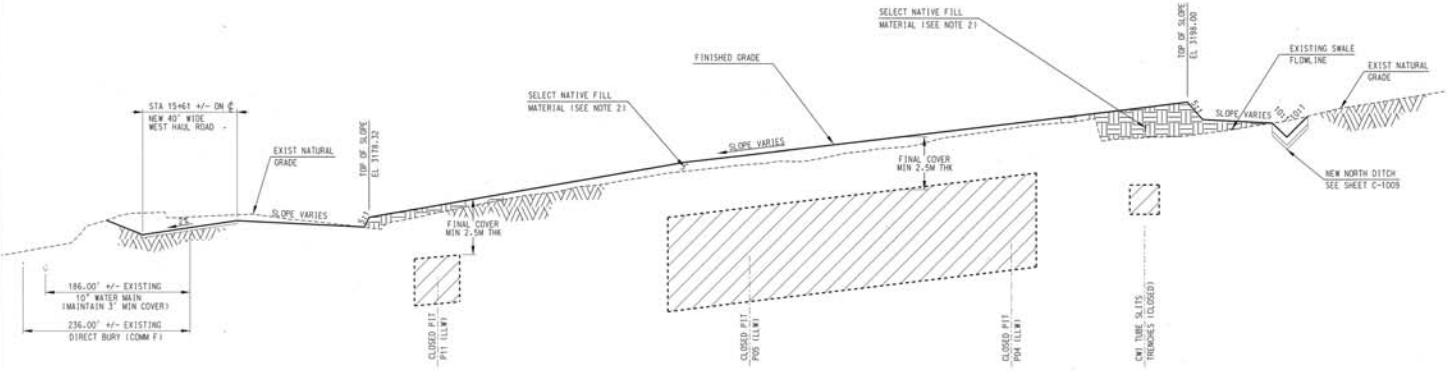
1. SEE DRAWINGS C-1009 (NORTH), C-1010 (CENTER), C-1011 AND C-1012 (EAST-SOUTH) FOR DITCH FLOWLINE & HORIZONTAL LOCATIONS.
2. SEE SPECIFICATION 09068-SPC-001 FOR SOIL BACKFILL AND COMPACTION REQUIREMENTS.
3. THE BURIED WASTE MATERIAL EXTENTS REPRESENTED ON THIS DRAWING ARE APPROXIMATE, AND ARE BASED ON THE BEST ARCHIVE RECORDS AVAILABLE FROM NTS RWMS SITE OPERATIONS.



SECTION (SOUTH TO NORTH) Ⓐ

SCALE : HORIZ 1" = 100' VERT 1" = 10'

C-1007
C-1008



SECTION (SOUTH TO NORTH) Ⓑ

SCALE : HORIZ 1" = 100' VERT 1" = 10'

C-1007
C-1009

GRAPHIC SCALE
0 10 20 30 FEET
1" = 10'

GRAPHIC SCALE
0 50 100 200 300 FEET
1" = 100'

6/4/09

2725

EP 6/3/09

GS

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NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA SITE OFFICE LAS VEGAS, NEVADA

NEVADA TEST SITE AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

NEW SURFACE GRADING SECTIONS

DRAWN PREPARER CHECKER PROJECT ENGINEER APPROVER/USER

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ENGINEERING NO. 09068
ORIGINAL SIGNATURES ON FILE
DRAWING NUMBER / WORK ORDER NUMBER 09068-C-3003
REVISION 0

FOR REFERENCE DRAWINGS SEE 09068-G-0001

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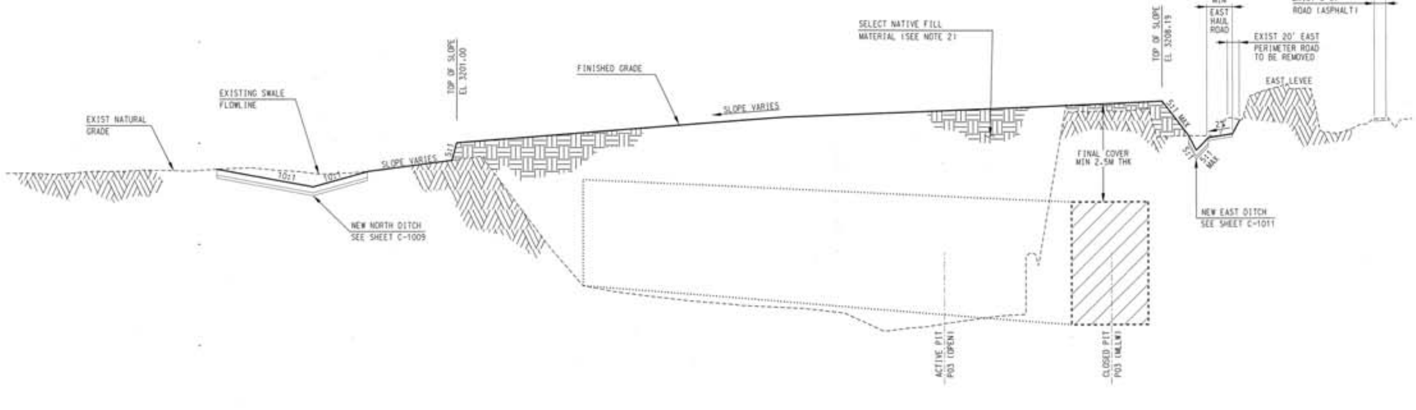
NOTES

1. SEE DRAWINGS C-1009 (NORTH), C-1010 (CENTER), C-1011 AND C-1012 (EAST-SOUTH) FOR DITCH FLOWLINE & HORIZONTAL LOCATIONS.
2. SEE SPECIFICATION 09068-SPC-G01 FOR SOIL BACKFILL AND COMPACTION REQUIREMENTS.
3. THE BURIED WASTE MATERIAL EXTENTS REPRESENTED ON THIS DRAWING ARE APPROXIMATE, AND ARE BASED ON THE BEST ARCHIVE RECORDS AVAILABLE FROM NTS RWMS SITE OPERATIONS.

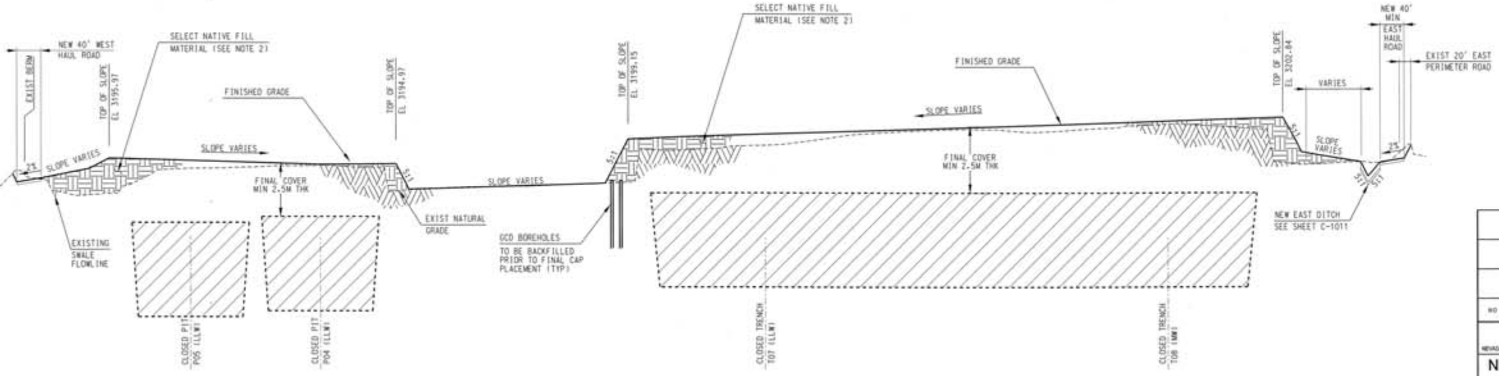


SECTION (WEST TO EAST)

SCALE : HORIZ 1" = 100' VERT 1" = 10'

A

C-1007

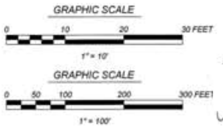


SECTION (WEST TO EAST)

SCALE : HORIZ 1" = 100' VERT 1" = 10'

B

C-1007



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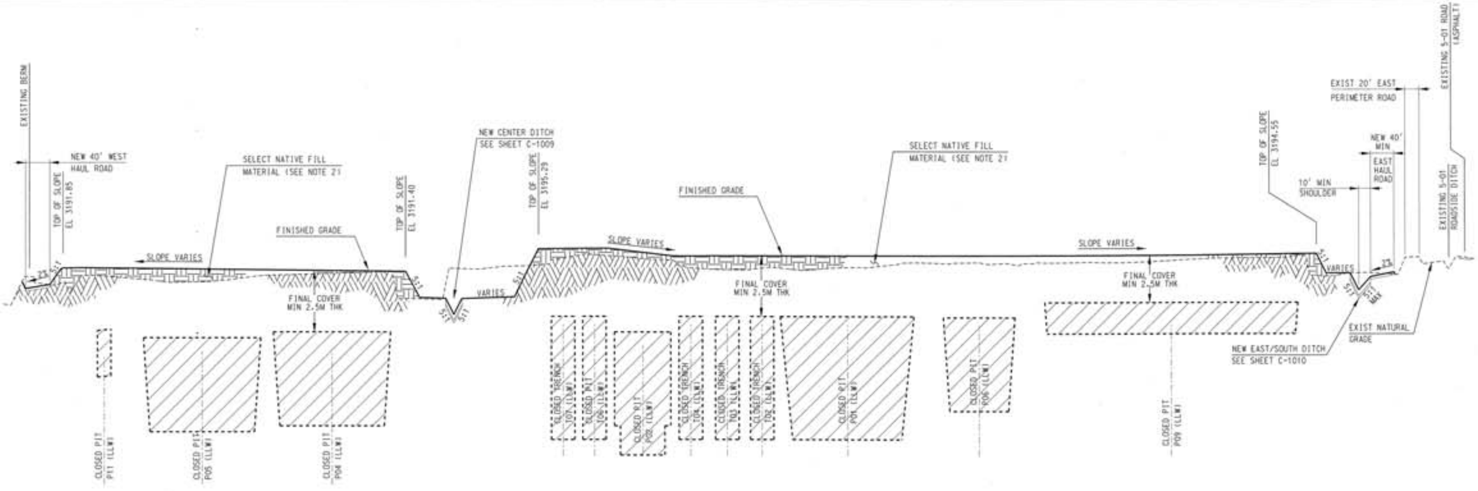


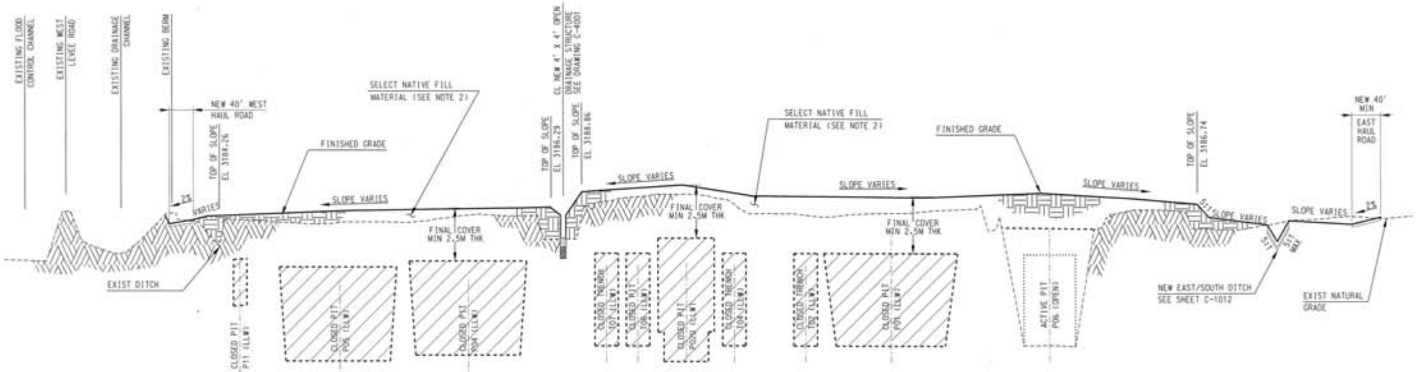
SECTION (WEST TO EAST)

SCALE : HORIZ 1" = 100' VERT 1" = 10'

A
C-1007
C-1008

NOTES

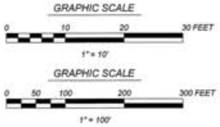
1. SEE DRAWINGS C-1009 (NORTH), C-1010 (CENTER), C-1011 AND C-1012 (EAST-SOUTH) FOR DITCH FLOWLINE & HORIZONTAL LOCATIONS.
2. SEE SPECIFICATION 09068-SPC-G01 FOR SOIL BACKFILL NOTES AND COMPACTION REQUIREMENTS.
3. THE BURIED WASTE MATERIAL EXTENTS REPRESENTED ON THIS DRAWING ARE APPROXIMATE, AND ARE BASED ON THE BEST ARCHIVE RECORDS AVAILABLE FROM NTS RWMS SITE OPERATIONS.



SECTION (WEST TO EAST)

SCALE : HORIZ 1" = 100' VERT 1" = 10'

B
C-1007
C-1008



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EXP 6/30/09

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92 ACRE GRADING AND DRAINAGE

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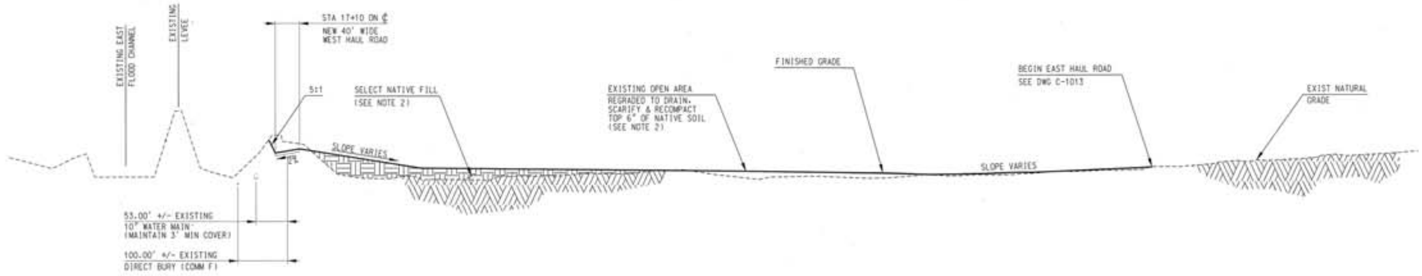
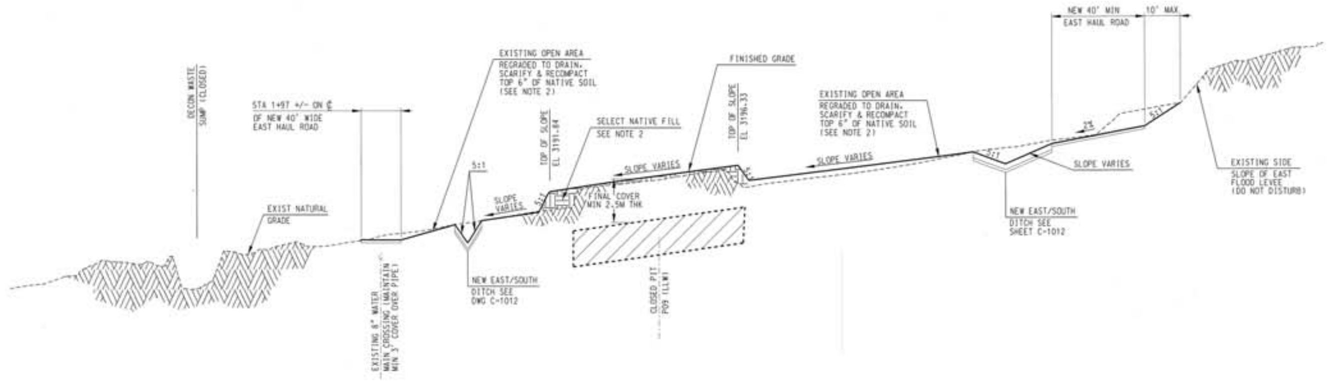


SECTION (SOUTH TO NORTH)

SCALE : HORIZ 1" = 100' VERT 1" = 10'

(A) C-1008



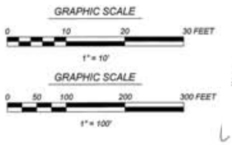
SECTION (SOUTH TO NORTH)

SCALE : HORIZ 1" = 100' VERT 1" = 10'

(B) C-1007 C-1008

NOTES

1. SEE DRAWINGS C-1009 (NORTH), C-1010 (CENTER), C-1011 AND C-1012 (EAST-SOUTH) FOR DITCH FLOWLINE & HORIZONTAL LOCATIONS.
2. SEE SPECIFICATION 09068-SPC-G01 FOR SOIL BACKFILL AND COMPACTION REQUIREMENTS.
3. THE BURIED WASTE MATERIAL EXTENTS REPRESENTED ON THIS DRAWING ARE APPROXIMATE, AND ARE BASED ON THE BEST ARCHIVE RECORDS AVAILABLE FROM NTS RWMS SITE OPERATIONS.



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RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

NEW SURFACE GRADING SECTIONS

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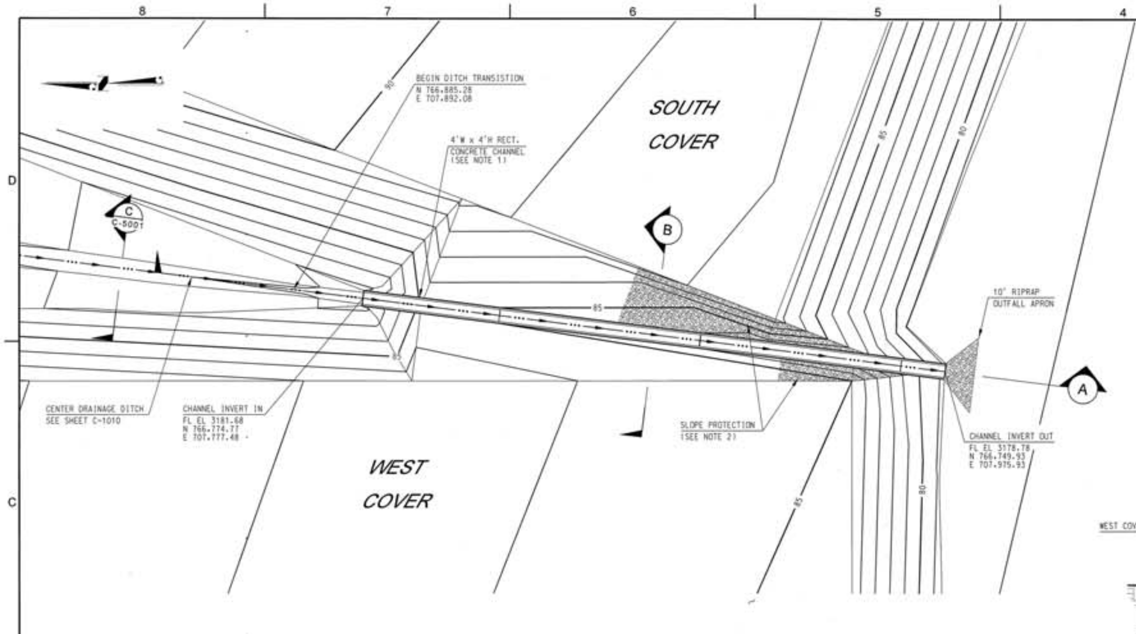
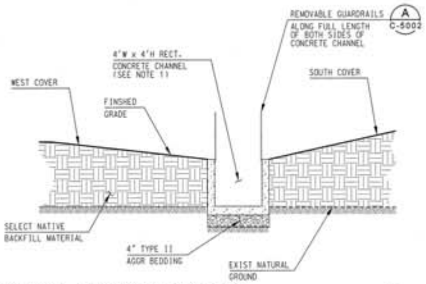


CULVERT PLAN

SCALE : 1" = 20'-0"

DRAINAGE NOTES

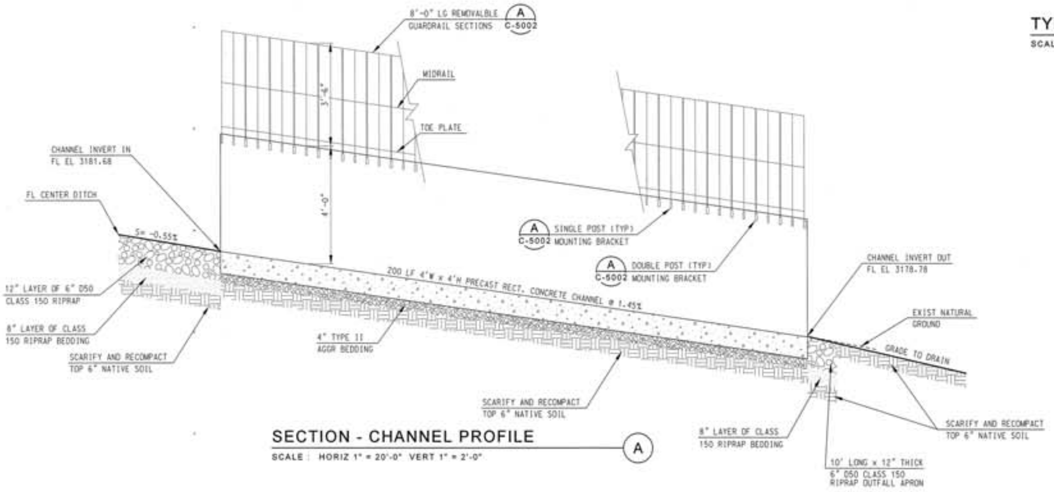
1. INSTALL 4'W X 4'H PRECAST CONCRETE OPEN TOP BOX CULVERTS IN ACCORDANCE WITH PROJECT SPECIFICATION 09068-SPC-G01.
2. PLACE SIZE No. 357 AGGREGATE IN ACCORDANCE WITH SECTION 706 OF THE UNIFORM STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION OFF-SITE IMPROVEMENTS. CLARK COUNTY AREA. NEVADA. ON SIDE SLOPES STEEPER THAN 5:1 ALONG CHANNEL.
3. INSTALL GUARD RAIL ALONG TOP OF CHANNEL WALLS IN ACCORDANCE WITH OSHA 1910.23(e). SEE DRAWING C-5002 FOR FABRICATION DETAILS.



TYPICAL CHANNEL SECTION

B

SCALE : NONE



SECTION - CHANNEL PROFILE

A

SCALE : HORIZ 1" = 20'-0" VERT 1" = 2'-0"

GRAPHIC SCALE

0 1 2 4 6 FEET

1" = 2'

GRAPHIC SCALE

0 10 20 40 60 FEET

1" = 20'

(CONTOUR INTERVAL = 1 FOOT)

6/4/09

6/30/09

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NEVADA SITE OFFICE
LAS VEGAS, NEVADA

NEVADA TEST SITE
AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE
CENTRAL DRAINAGE DITCH
CULVERT SECTION & DETAILS

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09068
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09068-C-4001
REVISION
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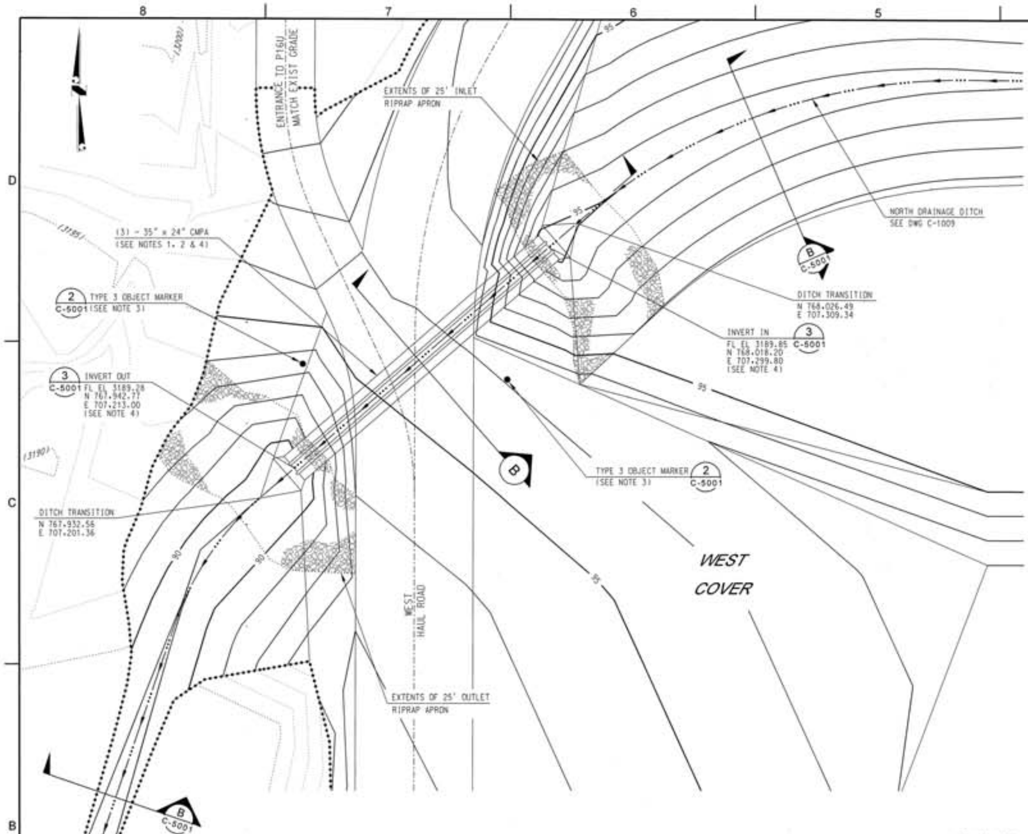
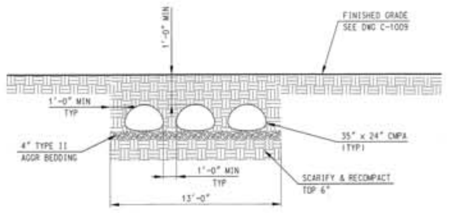


CULVERT PLAN

SCALE : 1" = 20'-0"



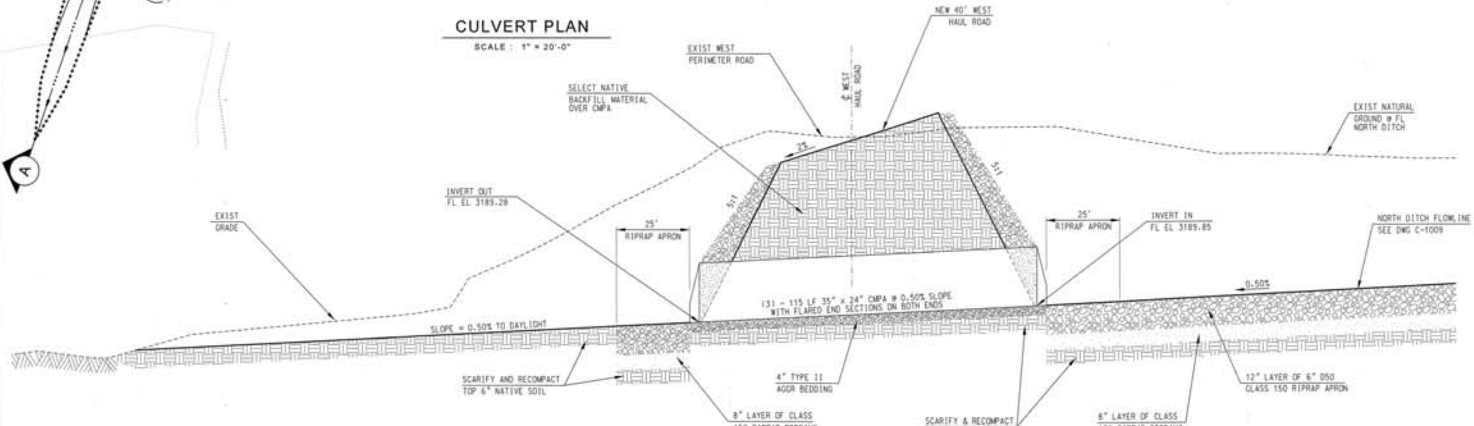
TYPICAL CULVERT SECTION

SCALE : NONE

B

DRAINAGE NOTES

1. INSTALL CORRAGATED METAL PIPE ARCH (CMPA) CULVERTS IN ACCORDANCE WITH NEVADA DEPARTMENT OF TRANSPORTATION (NDOT) STANDARD CONSTRUCTION PLANS B-20.1.8, R-2.6.1, R-2.2.1 AND R-1.3.1.2.
2. CMPA CORRUGATION SHALL BE 2 2/3" x 1/2" AND MINIMUM THICKNESS SHALL BE 0.064 INCHES.
3. INSTALL OBJECT (CULVERT) MARKER SIGNS AS SPECIFIED IN THE MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES, 2003 EDITION.
4. THIS AREA HAS NOT BEEN SURVEYED. THERE MAY BE EXISTING DRAINAGE STRUCTURES UNDER THE WEST PERIMETER ROAD. IF FOUND, THEY ARE TO BE REMOVED OR ABANDONED IN PLACE AS DIRECTED BY RWMC OPERATIONS.



SECTION - PROFILE

SCALE : HORIZ 1" = 20'-0" VERT 1" = 2'-0"

A

FOR REFERENCE DRAWINGS SEE 09068-G-0001

GRAPHIC SCALE
0 1 2 4 6 FEET
1" = 2'

GRAPHIC SCALE
0 10 20 40 60 FEET
1" = 20'
(CONTOUR INTERVAL = 1 FOOT)

6/4/09

GS

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NEVADA SITE OFFICE
LAS VEGAS, NEVADA

NEVADA TEST SITE — AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE
NORTH DRAINAGE DITCH
CULVERT SECTION & DETAILS

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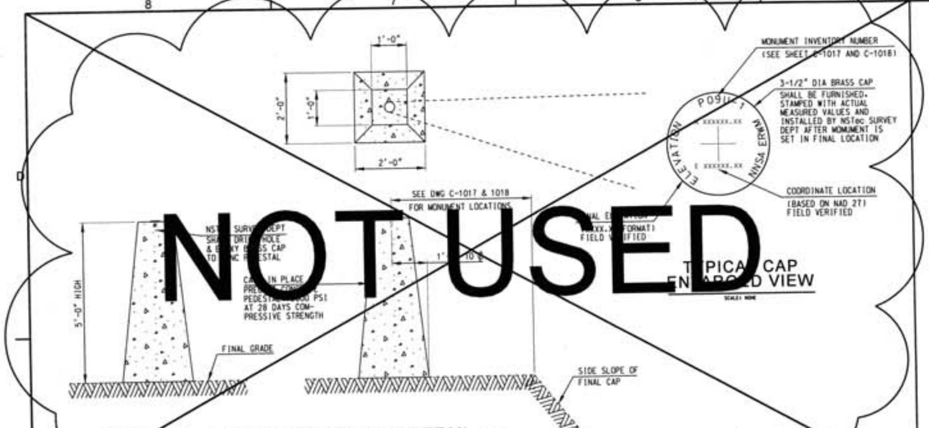
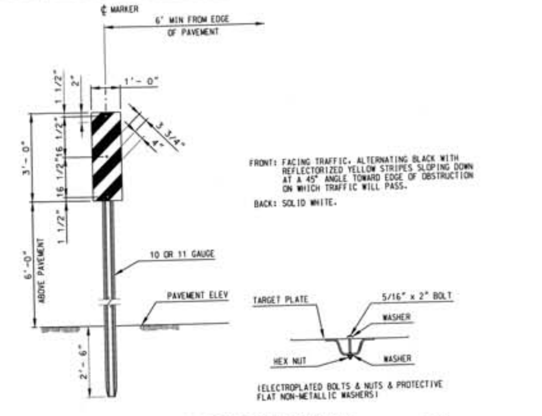


△1 TYPE 1-MONUMENT FABRICATION DETAIL ① C-1017 & C-1018

SCALE: NONE

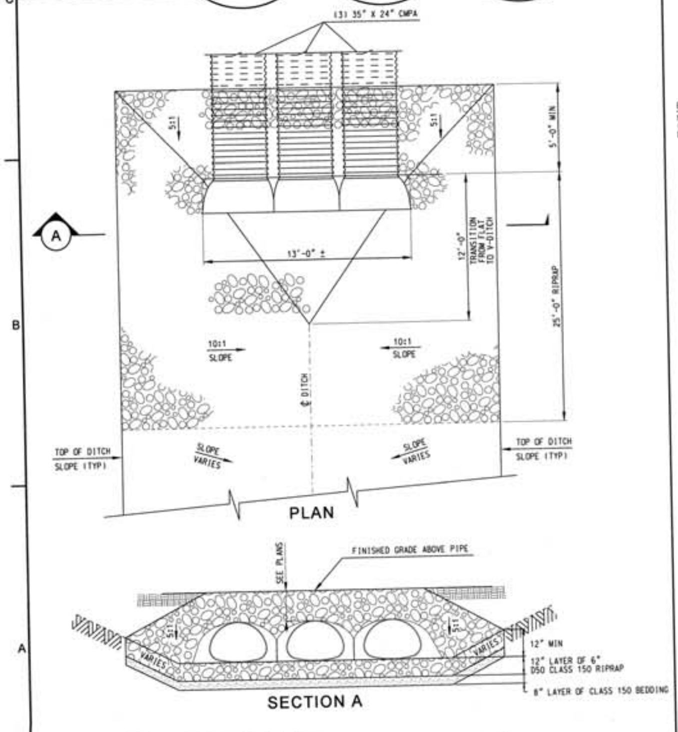


FRONT: FACING TRAFFIC, ALTERNATING BLACK WITH REFLECTORIZED YELLOW STRIPES SLOPING DOWN AT A 45° ANGLE TOWARD EDGE OF OBSTRUCTION ON WHICH TRAFFIC WILL PASS.

BACK: SOLID WHITE.

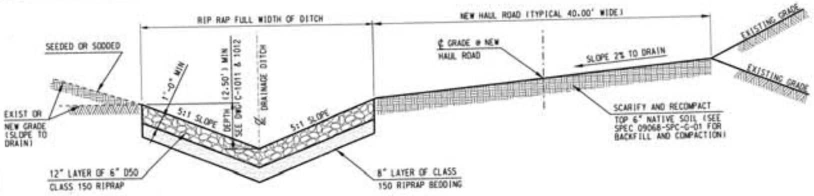
TYPE 3 OBJECT MARKER DETAIL ② C-4002

SCALE: NONE



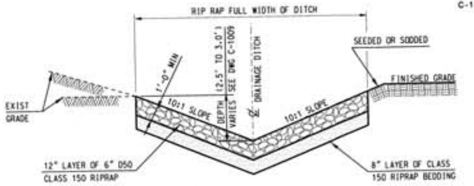
RIPRAP APRON DETAIL ③ C-4002

SCALE: NONE



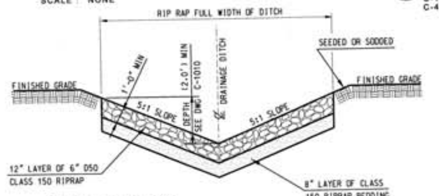
EAST DITCH TYPICAL RIPRAP AND HAUL ROAD SECTION Ⓐ C-1011 C-1012 C-1013 C-1014

SCALE: NONE



NORTH DITCH TYPICAL RIPRAP SECTION Ⓑ C-1009 C-4002

SCALE: NONE



CENTER DITCH TYPICAL RIPRAP SECTION Ⓒ C-1010 C-4001

SCALE: NONE

7/9/9

EXP 6/30/11

FOR REFERENCE DRAWINGS SEE 09068-G-0001

NO	DATE	REVISIONS	DRAWN	PREPARER	CHECKER	PROJ ENGR	APPROVER USER
△1		DETAIL 1 NOT USED PER PROJECT MANAGER E-MAIL DATED 06/11/09					

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NEVADA TEST SITE — AREA 05
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92 ACRE GRADING AND DRAINAGE

TYPICAL DETAILS

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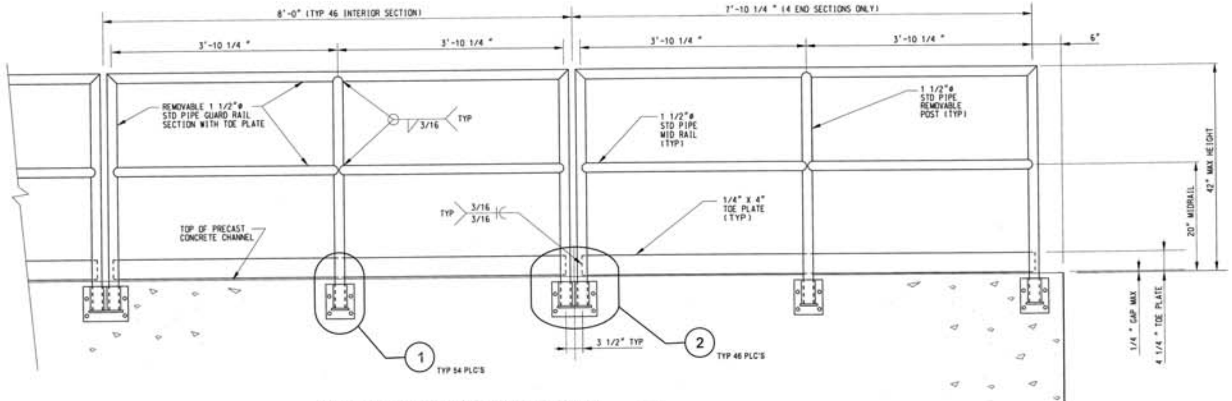
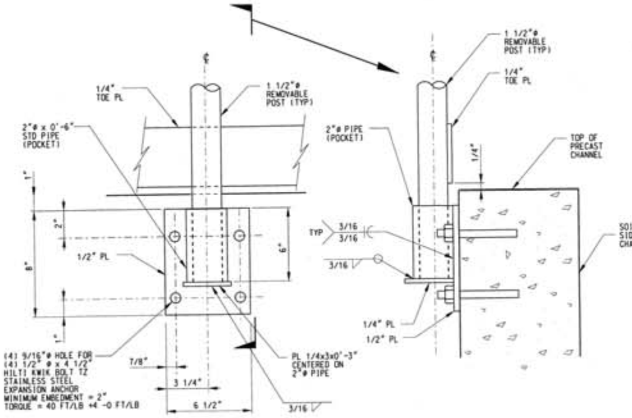


REMOVABLE GUARD RAIL SECTION (A)

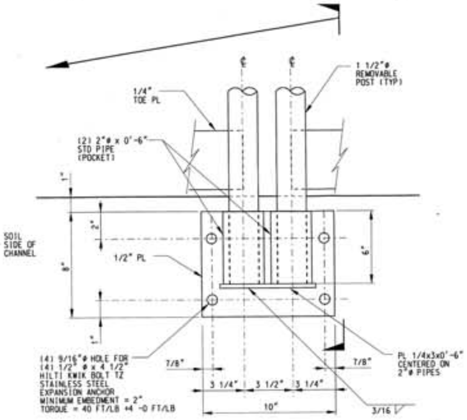
SCALE : 1" = 1'-0"

09068-C4001



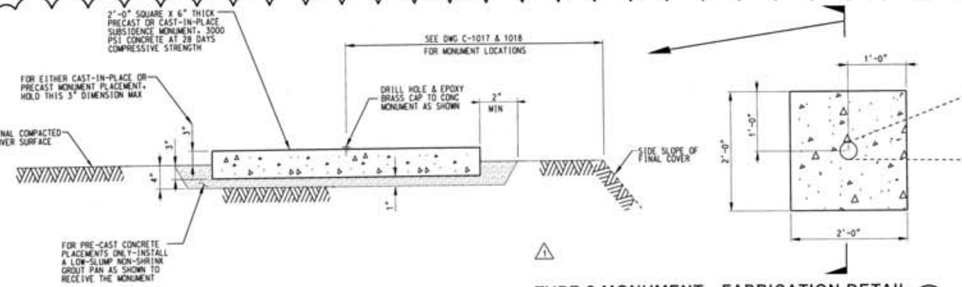
DETAIL (1)

SCALE : NONE



DETAIL (2)

SCALE : NONE



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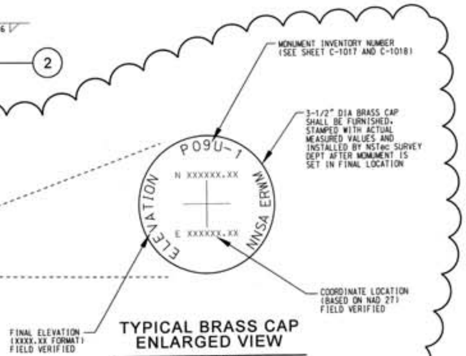
TYPE 2 MONUMENT - FABRICATION DETAIL (3)

SCALE: NONE

C-1017 & C-1018



TYPICAL BRASS CAP ENLARGED VIEW

SCALE: NONE

FOR REFERENCE DRAWINGS SEE 09068-G-0001

7/9/9

EXP 6/30/11

GRAPHIC SCALE

0 1 2 3 FEET

1" = 1'-0"

GS

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⚠1		ADDED DETAIL 3 PER PROJECT MANAGER E-MAIL DATED 06/11/09					

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NATIONAL NUCLEAR SECURITY ADMINISTRATION
LAS VEGAS, NEVADA

NEVADA TEST SITE — AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

GUARD RAIL SECTION & DETAILS

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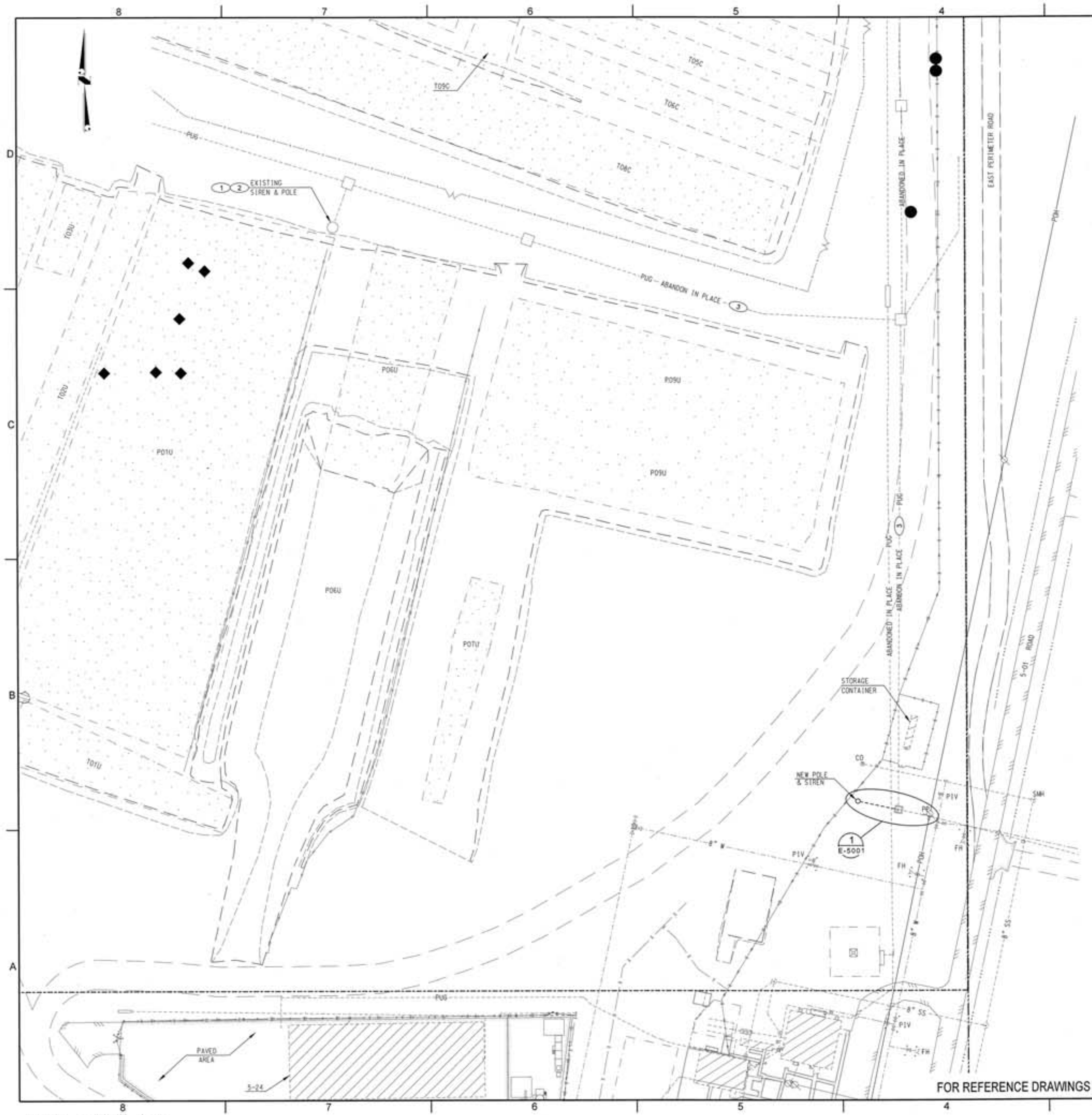
DRAWING NUMBER / WORK ORDER NUMBER 09068-C-5002
REVISION 1



FOR REFERENCE DRAWINGS SEE 09068-G-0001

NOTES

1. DO NOT SCALE DRAWINGS. DIMENSIONS SHOWN ON DRAWING SHALL TAKE PRECEDENCE.
2. REMOVE AND SALVAGE ALL EXISTING ABOVE GROUND ELECTRICAL PANELS, MONITORING DEVICES AND/OR JUNCTION BOXES WITHIN THE SOUTH 92 ACRE BOUNDARY. ALL UNDERGROUND POWER LINES ARE TO BE ABANDONED IN PLACE, EXCEPT AS NOTED. PULL BOXES AND/OR MAN HOLES NOT BEING USED ARE TO BE FILLED IN WITH NATIVE SOIL AND ABANDONED IN PLACE. ALL ABANDONED CONDUITS TO BE CUT AND CAPPED WITH GROUT CEMENT.

KEY NOTES

① REMOVE POLE AND EXISTING EQUIPMENT. RELOCATE EXISTING EVACUATION SIREN, DISCONNECT SWITCH, CONTROL BOX AND ASSOCIATED EQUIPMENT TO WEST OF THE ELECTRICAL PULL BOX #1. SEE SHEET 09068-E-5001 FOR DETAILS.

② FROM THE EXISTING SIREN AND POLE, GOLD-DIKE THE CONTROL WIRES TO FIND THE PATH TO WHERE THEY ARE BEING FED FROM (THE SOURCE). AFTER FINDING THE PATH TO THE SOURCE, CONSULT THE PROJECT ENGINEER AND THE ELECTRICAL DESIGN ENGINEERING TO FIND THE BEST LOCATION TO CUT AND SPLICE NEW CONTROL WIRES INTO THE EXISTING CONTROL WIRES (MATCH EXISTING SIZE, TYPE WIRE AND TERMINATIONM POINTS ON CONTROLLER).

③ REMOVE POWER CABLE AFTER NEW POLE/SIREN IS IN PLACE. CONDUIT AND PULL BOX WILL BE ABANDON IN PLACE

GRAPHIC SCALE
0 30 60 120 180 FEET
1" = 60'

GS

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RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

ELECTRICAL SITE PLAN

DRAWN
PREPARER
CHECKER
PROJECT ENGINEER
APPROVER / USER

National Security Technologies LLC
Vision • Service • Partnership
NEVADA OPERATIONS
P.O. BOX 98521 LAS VEGAS, NV 89193-8521

ENGINEERING NO. 09068
ORIGINAL SIGNATURES ON FILE
DRAWING NUMBER / WORK ORDER NUMBER 09068-E-1001
REVISION 0

6/4/2009 10:47:24 AM henryra
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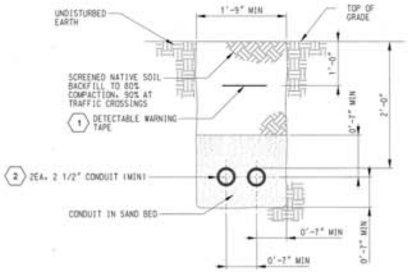
EQUIPMENT LIST

ITEM NO	NO REQD	DESCRIPTION	MFR CAT NO OR APPROVED EQUAL
1	A/R	WARNING TAPE, UNDERGROUND, DETECTABLE, MARKING: RED W/BLACK PRINT "CAUTION-BURIED ELECTRICAL LINE BELOW"	BRADY PART: #91601
2	A/R	CONDUIT 2 1/2" (MIN), SCHEDULE 40 PVC	



TRENCH SECTION

SCALE : NONE

A

E-5001

FOR REFERENCE DRAWINGS SEE 09068-G-0001

GS

NO	DATE	REVISIONS	DRAWN	PREPARER	CHECKER	PROJ ENGR	APPROVED USER

NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA SITE OFFICE
LAS VEGAS, NEVADA

NEVADA TEST SITE — AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

TRENCH SECTION

National Security Technologies LLC
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NEVADA OPERATIONS
P.O. BOX 98521 LAS VEGAS, NV 89193-8521

ENGINEERING NO. 09068
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DRAWING NUMBER / WORK ORDER NUMBER 09068-E-3001
REVISION 0

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NOTES

1. DO NOT SCALE DRAWINGS. DIMENSIONS SHOWN ON DRAWING SHALL TAKE PRECEDENCE.
2. ALL ABANDONED CONDUITS TO BE CUT AND CAPPED WITH GROUT CEMENT.

KEY NOTES

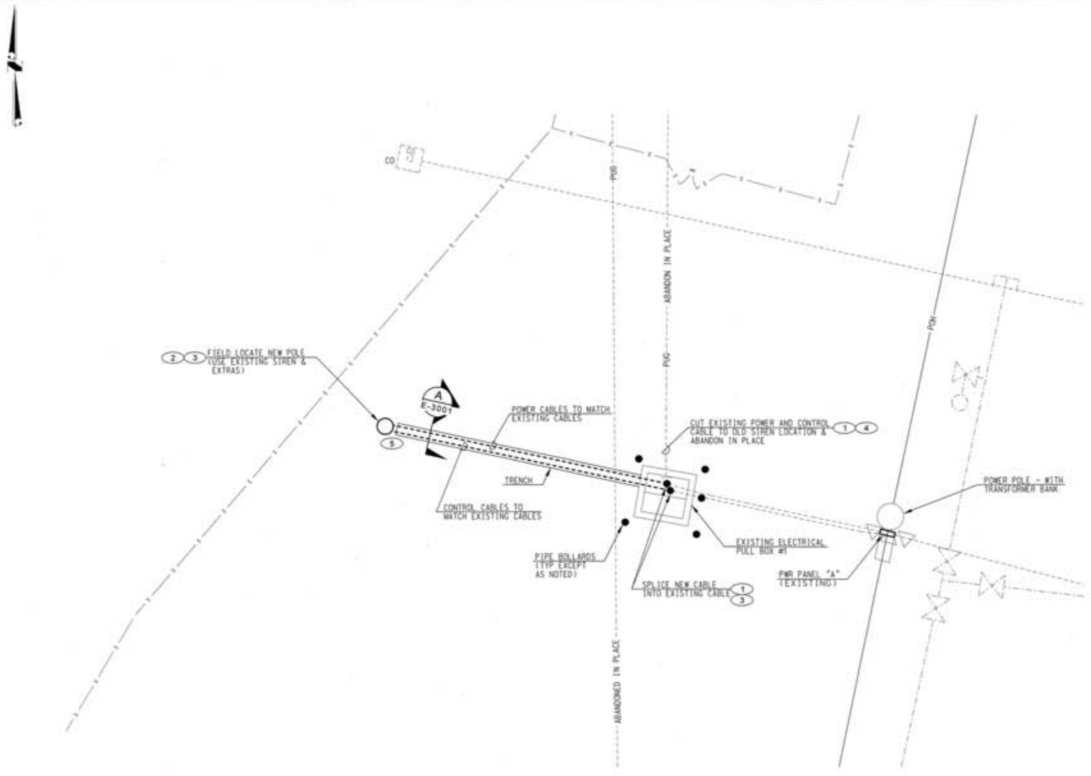
① AFTER LOTO AND DE-ENERGIZING SYSTEM. CUT EXISTING POWER/CONTROL CABLES AND SPLICE IN NEW CABLES GOING TO NEW SIREN POLE (MATCH EXISTING CABLE SIZE AND TYPE). REFER TO EXISTING DRAWING 5-RWMS-S5/E6.1 FOR SIREN POWER SUPPLY. ALL ELECTRICAL REQUIREMENTS AND ONE-LINE DIAGRAM.

② FIELD LOCATE 70FT (MIN) CLASS 3 (MIN) POLE (REUSING EXISTING SIREN, CONTROL BOX, DISCONNECT SWITCH, ETC.). REFER TO EXISTING DRAWING 5-RWMS-S5/E6.1 FOR ALL ELECTRICAL INSTALLATION REQUIREMENTS INCLUDING GROUNDING.

③ CONSULT THE PROJECT ENGINEER AND THE ELECTRICAL DESIGN ENGINEER ON THE BEST LOCATION TO CUT THE EXISTING POWER AND CONTROL CABLES AND SPLICE NEW CABLES INTO THE EXISTING ONES AND THEN CONNECT THE NEW CABLES INTO THE CONTROL AND STARTER BOX RE-LOCATED ONTO THE NEW POLE. THESE CABLES WILL BE PLACED IN A TRENCH FROM THE SPLICE TO THE NEW POLE.

④ UNDERGROUND POWER AND CONTROL CABLES TO BE REMOVED AFTER SPLICING OF NEW CABLE INTO CABLE THAT IS TO REMAIN. CONDUIT IS TO BE ABANDON IN PLACE.

⑤ USE RIGID METALLIC CONDUIT AND ELBOWS TO TRANSITION CONDUIT FROM UNDERGROUND TO ABOVE GROUND. SEE EXISTING DRAWING 5-RWMS-S5/E6.1 FOR ALL ELECTRICAL REQUIREMENTS.



ELECTRICAL DETAIL

SCALE : 1" = 10'-0"

① E-1001

GRAPHIC SCALE

0 10 20 30 FEET

1" = 10'

GS

NO	DATE	REVISIONS	DRAWN	PREPARER	CHECKER	PROJ ENGR	APPROVER USER

NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA SITE OFFICE
LAS VEGAS, NEVADA

NEVADA TEST SITE — AREA 05
RADIOACTIVE WASTE MANAGEMENT SITE
92 ACRE GRADING AND DRAINAGE

ELECTRICAL DETAIL

[redacted]

National Security Technologies LLC
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P.O. BOX 98521 LAS VEGAS, NV 89193-8521

ENGINEERING NO. 09068
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NEVADA TEST SITE

92 Acre Grading and Drainage

CONSTRUCTION SPECIFICATION

Document No. **09068-SPC-G01**

Revision **0**

QG-3

6/4/09

[redacted]

EJP 6/30/09

Preparer: [redacted] Luanne Fairbanks Date: ________ Checker [redacted] Robert Niedringhaus Date: 6-4-09

Preparer: [redacted] Roger Henry Date 6/4/09 Checker ________ Bahman Maccabee Date: 6/4/09

Project Engineer: [redacted] Joseph Depa Date: 6·5·09

Approver: ________ Tom Thiele Date: 6-8-09

TABLE OF CONTENTS

SECTION 014213

ACRONYMS AND ABBREVIATIONS

PART 1 - GENERAL

1.1 ACRONYMS

A

A/E	Architecture/Engineering
AA	Aluminum Association, Inc. (The)
AAADM	American Association of Automatic Door Manufacturers
AABC	Associated Air Balance Council
AAMA	American Architecture Manufacturers Association
AASHTO	American Association of State Highway and Transportation Officials
ABA	Accessibility Guidelines for Buildings and Facilities
ABS	acrylonitrile-butadiene-styrene
AC	Articulation Class
AC	alternating current
ACI	American Concrete Institute
ACPA	American Concrete Pipe Association
ADA	Americans with Disability Act
ADSS	All-dielectric, self-supporting
AFFF	Aqueous Film Forming Foam
AGA	American Gas Association
AGOS	Air Ground Operations Support
AHA	American Hardboard Association
AHJ	Authority Having Jurisdiction
AI	Asphalt Institute
AIA	American Institute of Architects
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ALARA	As Low As Reasonably Achievable
AMCA	Air Movement and Control Association International
ANSI	American National Standards Institute
APA	Architectural Precast Association
API	American Petroleum Institute
ARI	Air-Conditioning & Refrigeration Institute
ARMA	Asphalt Roofing Manufacturers Association
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ASD	allowable stress design
ASJ	all-service jacket
ASME	American Society of Mechanical Engineers International
ASSE	American Society of Sanitary Engineering

ASTM	American Society for Testing and Materials
ATC	Applied Technology Council
ATS	Acceptance Testing Specification
ATS	Automatic Transfer Switch
AT&T	American Telephone and Telegraph
AWG	American Wire Gauge
AWI	Architectural Woodwork Institute
AWPA	American Wood-Preservers' Association
AWS	American Welding Society
AWWA	American Water Works Association

B

BC	bonding conductor
BF	ballast factor
BFP	backflow preventer
BHMA	Builders Hardware Manufacturers Association
BIA	Brick Institute of America
BICSI	Building Industry Consulting Service International
BMS	Building Management System

C

CAC	Ceiling Attenuation Class
CAD	computer-aided design
CADD	computer-aided design and drafting
CBT	Computer Based Training
CDA	Copper Development Association
CDR	Conceptual Design Report
CFC	Chlorofluorocarbons
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CI	cast iron
CISCA	Ceilings & Interior Systems Construction Association
CISPI	Cast Iron Soil Pipe Institute
CLFMI	Chain Link Fence Manufacturers Institute
CLSM	controlled low strength material
CMAA	Crane Manufacturers Association of America
CMPA	corrugated metal pipe arch
CMU	concrete masonry unit
CPA	Composite Panel Association
CPSC	Consumer Product Safety Commission
CPU	central processing unit
CPVC	chlorinated polyvinyl chloride
CQAP	Construction Quality Assurance Plan
CQCP	Construction Quality Control Plan
CRI	color-rendering index
CRSI	Concrete Reinforcing Steel Institute
CSI	Construction Specifications Institute

CTI	Cooling Technology Institute
CU	coefficient of utilization
CWP	cold working pressure
CA	Commissioning Authority

D

DA	Design Authority
DACT	digital alarm communicator transmitter
DACR	digital alarm communicator receiver
DAF	Device Assembly Facility
DBE	design/evaluation basis earthquake
DBF	Design Basis Fire
DC	direct current
DHI	Door and Hardware Institute
DI	ductile iron
DOC	U.S. Department of Commerce
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
DTMF	dual tone multi-frequency

E

EAT	Emergency Action Team
ECN	Engineering Change Notice
EERI	Earthquake Engineering Research Institute
EFRRA	Equivalent Fire Resistance Rated Assembly
EIA	Electronic Industries Alliance
EIFS	Exterior Insulation and Finish Systems
EIMA	EIFS Industry Members Association
EJ	Engineering Judgment
EJMA	Expansion Joint Manufacturers Association, Inc.
EMI	electromagnetic interference
EMT	electrical metallic tubing
ENT	electrical nonmetallic tubing
EOC	Emergency Operations Center
EPA	U.S. Environmental Protection Agency
EPC	electrical polyvinyl chloride conduit
EPDM	ethylene-propylene-diene-monomer
EPDM	ethylene-propylene-diene-terpolymer
EPDM	ethylene-propylene-diene M-class
EPT	Ethylene propylene terpolymer
EQ	Environmental Quality
ERSC	electrical rigid steel conduit
EVO	Efficiency Valuation Organization

F

FACP	Fire Alarm Control Panel
FCC	Federal Communications Commission
FCIA	Firestop Contractors International Association
FCN	Field Change Notice
FCR	Field Change Request
FDA	Food and Drug Administration
FED-STD	Federal Standard
FEMA	Federal Emergency Management Agency
FHA	Fire Hazard Analysis
FM	Factory Mutual Global
FM	Facility Manager
FMC	flexible metal conduit
FMG	Factory Mutual Global
FMH	Fissionable Material Handler
FML	flexible membrane liner
FOB	Freight On Board
FPP	Fire Protection Program
FRO	Fire/Rescue Organization
FRP	Fiber-reinforced polyester
FRPP	fiberglass reinforced plastic pipe
FS	Federal Specification
FSC	Forest Stewardship Council
FSK	foil, scrim, kraft paper
FSP	foil, scrim, polyethylene
FTMS	Federal Test Method Standard

G

GA	Gypsum Association
GCL	geosynthetic clay liner
GFCI	ground-fault circuit interrupter
GFEP	ground-fault equipment protection
GIP	generic implementation procedure
GSA	General Services Administration

H

HCFC	hydrochlorofluorocarbons
HD	heavy duty
HEPA	high-efficiency particulate air
HID	high-intensity discharge
HMIS	hazardous materials identification systems
HMMA	Hollow Metal Manufacturers Association (Part of NAAMM)
HPVA	Hardwood Plywood & Veneer Association
HRR	heat release rate
HVAC	heating, ventilation, and air conditioning
HVAC&R	heating, ventilating, air conditioning, and refrigeration
HWSU	hazardous waste storage unit

I

IAPMO	International Association of Plumbing & Mechanical Officials
IBC	International Building Code
ICBO	International Conference of Building Officials
ICC	International Code Council
ICC-ES	ICC-Evaluation Service, Inc.
ICEA	Insulated Cable Engineers Association
ICP	Inside Cable Plant
ID	inside diameter
IDC	insulation displacement connector
IDF	Intermediate Distribution Frames
IEBC	International Existing Building Code
IECC	International Energy Conservation Code
IEEE	Institute of Electrical and Electronics Engineers
IESNA	Illuminating Engineering Society of North America
IEST	Institute of Environmental Sciences and Technology
IFC	International Fire Code
IGCC	Insulating Glass Certification Council
IGMA	Insulating Glass Manufacturers Alliance
ILI	Indiana Limestone Institute of America
IMC	intermediate metal conduit
IMETCO	Innovative Metals, Co.
ISD	Information Systems Department
ISO	International Organization for Standardization
ITM	inspection, testing, and maintenance
IZC	International Zoning Code

J

JTO	Joint Testing Office

K

Not Applicable

L

LAN	local area network
LED	light emitting diode
LED	Local Emergency Director
LEED	Leadership in Environmental and Engineering Design
LER	luminaire efficacy rating
LFMC	liquidtight flexible metal conduit
LGSEA	Light Gauge Steel Engineers Association
LLW	low-level (radioactive) waste
LLMW	low-level mixed waste

LPI	Lightning Protection Institute
LR	light reflectance coefficient
LSC	Life Safety Code
LVVWD	Las Vegas Valley Water District

M

MBMA	Metal Building Manufacturers Association
MC	metal clad
MCCB	molded-case circuit breakers
MCE	maximum considered earthquake
MCL	maximum containment level
MDF	Main Distribution Frames
MFMA	Metal Framing Manufacturer Association
MHIA	Material Handling Industry of America
MIA	Marble Institute of America
MIA	Masonry Institute of America
MLO	main lug only
MOP	Manual of Practice
MPFL	maximum possible fire loss
MPI	Master Painters Institute
MR	Materials and Resources
MSDS	Material Safety Data Sheets
MSS	Manufactures Standardization Society
MSVD	Magnetron Sputtered Vacuum Disposition
MTS	Maintenance Testing Specifications

N

NAAMM	National Association of Architectural Metal Manufacturers
NACE	National Association of Corrosion Engineers International
NAIMA	North American Insulation Manufacturers Association
NBGQA	National Building Granite Quarries Association, Inc.
NBR	acrylonitrile-butadiene rubber
NC	normally closed
NAC	Nevada Administrative Code
NCMA	National Concrete Masonry Association
NCPI	National Clay Pipe Institute
NDEP	Nevada Department of Environmental Protection
NDOT	Nevada Department of Transportation
NEC	National Electrical Code
NECA	National Electrical Contractors Association
NEHRP	National Earthquake Hazards Reduction Program
NEMA	National Electrical Manufacturers Association
NES	Formerly: National Evaluation Service (See ICC-ES)
NESC	National Electrical Safety Code
NETA	InterNational Electrical Testing Association
NFPA	National Fire Protection Association
NGA	National Glass Association

NHLA	National Hardwood Lumber Association
NICET	National Institute for Certification in Engineering Technologies
NIST	National Institute of Standards and Technology
NNSA	National Nuclear Security Administration
NO	normally open
NPH	natural phenomena hazards
NPS	nominal pipe size
NPTF	National Pipe Taper Female
NPTM	National Pipe Taper Male
NQA	Nuclear Quality Assurance
NRC	noise reduction coefficient
NRC	Nuclear Regulatory Commission
NRCA	National Roofing Contractors Association
NRMCA	National Ready Mix Concrete Association
NRS	nonrising stem
NRTL	Nationally Recognized Testing Laboratories
NSF	National Sanitation Foundation
NSTec	National Security Technologies, LLC
NTS	Nevada Test Site
NVLAP	National Voluntary Laboratory Accreditation Program

O

OCC	Optical Cable Corporation
OD	outside diameter
OI	Organization Instruction
OP	Organization Procedure
OSPDRM	*Outside Plant Design Reference Manual*
OS&Y	outside screw and yoke
OSHA	Occupational Safety and Health Administration
OSP	Outside Cable Plant
OSR	Operational Safety Requirement
OTDR	Optical Time Domain Reflectometer
OUO	Official Use Only

P

PC	performance category
PCA	Portland Cement Association
PCI	Precast/Prestressed Concrete Institute
PDCA	Painting & Decorating Contractors of America
PDI	Plumbing & Drainage Institute
PDSA	Preliminary Documented Safety Analysis
PE	polyethylene plastic
PEX	cross-linked polyethylene
PGI	PVC Geomembrane Institute
PMMA	Poly(methyl methacrylate) or poly(methyl 2-methylpropenoate)
POC	point of contact
POC	point of connection

PQT	Performance Qualification Tests
PSTN	Public Switched Telephone Network
PTFI	Polytetrafluoroethylene. (Seal Tape Material)
PTI	Post-Tensioning Institute
PVC	polyvinyl chloride
PVDC	polyvinylidene chloride
PWS	Public Water System

Q

QA	Quality Assurance
QAPP	Quality Assurance Program Plan
QARD	Quality Assurance Requirements Document
QC	Quality Control

R

RCR	room cavity ratio
RCRA	Resource Conservation and Recovery Act
RCSC	Research Council on Structural Connections
RCT	Radiological Control Technician
RFCI	Resilient Floor Covering Institute
RFI	Request for Information
RFI	radio-frequency interference
RGS	rigid galvinized steel
RMA	Radioactive Material Area
RMC	rigid metal conduit
RMS	root-mean-square
RNC	rigid nonmetallic conduit
RS	rising stem
RSL	Remote Sensing Laboratory
RTCWC	Regional Transportation Commission of Washoe County

S

SAR	Safety Analsis Report
SAM	seismic anchor motion
SC	safety critical
SCTE	Society of Cable Telecommunications Engineers
SD	strength design
SDI	Steel Deck Institute
SDI	Steel Door Institute
SDR	Schedule Dimension Ratio
SEI	Structural Engineering Institute
SF	safety factor
SGCC	Safety Glazing Certification Council
SIA	Security Industry Association
SIGMA	Sealed Insulating Glass Manufacturers Association (Now IGMA)

SJI	Steel Joist Institute
SMACNA	Sheet Metal & Air Conditioning Contractors' National Association
SME	Subject Matter Expert
SMPTE	Society of Motion Pictures & Television Engineering
SNHD	Southern Nevada Health District
SOW	scope of work
SPCC	spill prevention control and countermeasures
SPDT	single-pole, double throw
SPFA	Spray Polyurethane Foam Alliance
SPRI	Single Ply Roofing Industry
SS	sustainable sites
SS	safety significant
SSC	structures, systems and components
SSL	self-sealing lap
SSPC	The Society for Protective Coatings
SSPC-SP	The Society of Protective Coatings – Special Procedure
STD	standard
STI	Steel Tank Institute
STL	Special Technologies Laboratory
STR	Subcontract Technical Representative
SWD	switching duty
SWI	Steel Window Institute
SWP	steam working pressure

T

TBB	Telecommunications Bonding Backbone
TBC	Telecommunications Bonding Conductor
TCA	Tile Council of America
TCNA	Tile Council of North America
TDDM	*Telecommunications Distribution Methods Manual*
TIA	Telecommunications Industry Association
TFE	tetrafluoroethylene
TGB	Telecommunications Grounding Bus
TIA	Telecommunications Industry Association
TMGB	Telecommunications Main Grounding Bus
TIA/EIA	Telecommunications Industry Association/Electronics Industries Alliance
TPOC	Technical Point of Contact
TSR	Technical Safety Requirement
TVOC	total volatile organic compound
TVSS	transient voltage surge suppressor

U

UBC	Uniform Building Code
UDACS	Uniform Design and Construction Standards for Water Distribution Systems
UL	Underwriters Laboratories

UMC	Uniform Mechanical Code
UNS	Unified Numbering Systems
UPC	Uniform Plumbing Code
UPC	Universal Product Code
UPS	uninterruptible power supply
USGBC	U.S. Green Building Council
USGS	United States Geological Survey
USQ	unreviewed safety question
UST	underground storage tanks
UTP	unshielded twisted pair
UV	ultraviolet

V

VAV	Variable Air Volume
VCT	vinyl composition tile
VLT	Visible Light Transmission
VOC	volatile organic compound

W

WASTEC	Waste Equipment Technology Association
WCSC	Window Covering Safety Council
WDMA	Window & Door Manufacturers Association
WH	Warnock Hershey
WPS	Welding Procedure Specification
WRI	Wire Reinforcing Institute

X

Not Applicable

Y

Not Applicable

Z

Not Applicable

1.2 ABBREVIATIONS

A

A	amps or ampere
AC	alternating current

B

Btu/BTU	British thermal unit

C

cfm	cubic foot/feet per minute
cu	cubic
cu ft	cubic foot/feet
cu m	cubic meter
cu yd	cubic yard

D

°C	degrees Celsius
°F	degrees Fahrenheit
dBA	decibel, A-weighted
DC	direct current

E

Not Applicable

F

fc	foot candle
ft	feet/foot
fpm	feet per minute
fps	feet per second

G

g	grams
gal	gallon
g/L	grams per liter
gpm	gallons per minute

H

h	height

hr(s)	hour(s)

I

in.	inch(es)

J

J	Joules

K

K	Kelvin
kA	kilo-Amps
kg/m^2	kilograms per square meter
kHz	kilohertz
kJ	kilojoules
kV	kilovolts
kVA	kilovolt Amp
kW	kilowatt

L

L	liter
lb	pound
lb/ft^2	pounds per square foot
lbf	pound force
lbm	pound mass
lf	linear foot

M

mA	milliamp
mg	milligram
mg/L	milligrams per Liter
MHz	MegaHertz
mHz	MilliHertz
mil	milli-inch
min	minute(s)
MJ/m^2	megajoules per square meter
ml	milliliter
mm	millimeter
mph	miles per hour

N

ηm	nanometer

O

Ω	ohms
o.c.	on center
oz	ounce

P

Φ	phase
perm	permeance
P_H	mean seismic hazard exceedance level
ppb	parts per billion
ppm	parts per million
psf	pounds per square foot
psi	pounds per square inch
psig	pounds per square inch gauge
pt	pint

Q

qt(s)	quart(s)

R

Not Applicable

S

sec	second(s)
sf	square foot/feet
sq ft	square foot/feet
sq in.	square inch/inches

T

Not Applicable

U

μ	micro

V

V	volts
VAC	volts alternating current
VDC	volts direct current

W

W	watts
wg	water gage (or water gauge)

X

Not Applicable

Y

Not Applicable

Z

Not Applicable

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 014213

SECTION 014216

DEFINITIONS

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes definitions for standard terminology used in Divisions 02 through 49 Specifications.

1.2 ACRONYMS AND ABBREVIATIONS

A. Acronyms and abbreviations are defined in Section 014213, *Acronyms and Abbreviations*.

1.3 DEFINITIONS

A

Approve/Approval: Determination of Engineering that Construction's chosen materials or procedures conform to the requirements of the plans and specifications with respect to providing an acceptable and safe project.

B

Backfill: Soil material used to fill an excavation

Borrow Soil: Satisfactory soil imported from off of the construction site fur use as fill or backfill.

C

Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.

Controlled Low Strength Material (CLSM): CLSM is a flowable fill mix material, or slurry material, consisting of cement, fine aggregate, and water.

D

Demolition: Completely remove and legally dispose of off-site.

Demolition Waste: Building and site improvement materials resulting from demolition or selective demolition operations.

E

Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

F

Field Quality Control Testing: Tests and inspections that are performed on-site for installation of the Work and for completed Work.

Fill: Soil materials used to raise existing grades. If under a structure or pavement, this will extend to the bottom of the subbase or base material, as indicated on drawings.

Final Backfill: Backfill placed over initial backfill to fill a trench. If under a structure or pavement, this will extend to the bottom of the subbase or base material, as indicated on drawings.

Flowable Fill (CLSM): Controlled Low Strength Material consisting of cement, fine aggregate, and water.

Furnish: Supply and deliver to Project site, ready for unloading, unpacking, assembly, ready for installation, and similar operations.

G

Not Used

H

Not Used

I

Indicated: Requirements expressed by graphic representations or in written form on Drawings, in Specifications, and in other Contract Documents. Other terms including “shown,” “noted,” “scheduled,” and “specified” have the same meaning as “indicated.”

Initial Backfill: Backfill placed beside and over pipe or conduit in a trench, including haunches to support sides of pipe or conduit.

Installer Qualifications: A firm or individual experienced in installing, erecting, or assembling work similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.

J

Not Used

K

Not Used

L

Lift: Compacted thickness of soil material consisting of 3 at 4 in., 2 at 6 in., 1 at 8 in., or 1 at 12 in. layers.

M

Manufacturer Qualifications: A firm experienced in manufacturing products or systems similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

N

NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.

O

Not Used

P

Pigtail: Short lead used to connect a device to a branch-circuit conductor.

Pipe Zone Bedding Material: Backfill material supporting, surrounding, and extending 1 ft above the top of the pipe.

Product Testing: Tests and inspections that are performed by an NRTL, an NVLAP, or a testing agency qualified to conduct product testing and acceptable to authorities having jurisdiction, to establish product performance and compliance with industry standards.

Project Site: Space available for performing construction activities. The extent of Project site is shown on Drawings.

Provide: Furnish and install, complete and ready for the intended use.

Q

Not Used

R

Regulations: Laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, and rules, conventions, and agreements within the construction industry that control performance of the Work.

Remove: Detach items from existing construction and legally dispose of them off Project site, unless indicated to be removed and salvaged or removed and reinstalled.

S

Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

Subgrade: Surface or elevation remaining after completing excavation.

Submittals: Include, but are not limited to shop drawings, product data, samples, fabrication and installation drawings, erection drawings, lists, graphs, operating instructions, catalog sheets, mix designs, and similar items.

Substitutions: Changes in products, materials, equipment, and methods of construction from those required by the Contract Documents and/or proposed by Contractor. Re-engineering or design modifications may be required to make the substitute item work.

T

Testing Agency: An entity engaged to perform specific tests, inspections, or both. Testing laboratory shall mean the same as testing agency.

Testing Agency Qualifications: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E548; and with additional qualifications specified in individual Sections; and where required by authorities having jurisdiction, that is acceptable to authorities having jurisdiction.

Trench: An excavation in which the depth is greater than the width of the bottom of the excavation.

Trench Backfill Material: Trench backfill is material starting 1 ft above the pipe. All material below this point shall be considered as pipe zone bedding material.

Type 2: All Type 2 material shall be defined as Nevada Department of Transportation (NDOT) Type 2, Class B aggregate base material.

U

Utilities: On-site underground pipes, conduits, ducts, cables, as well as underground services within buildings. Does not include water and sewer.

V

Not Used

W

Not Used

X

Not Used

Y

Not Used

Z

Not Used

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 014216

SECTION 260500

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General electrical requirements
2. Electrical equipment coordination and installation
3. Common electrical installation requirements

B. Related Sections:

1. Section 014213, *Acronyms and Abbreviations*
2. Section 014216, *Definitions*

1.2 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Acronyms and abbreviations are defined in Section 014213, *Acronyms and Abbreviations*.

B. Standard terminology is defined in Section 014216, *Definitions*.

1.3 REFERENCE STANDARDS

A. Use the latest edition of the following codes and standards referenced in this specification, unless otherwise noted:

1. 29 CFR Part 1910, *Occupational Safety and Health Standards*
2. ANSI/IEEE C2, *National Electrical Safety Code* (NESC)
3. NECA 1, *Standard Practices for Good Workmanship in Electrical Contracting*
4. NETA ATS, *Acceptance Testing Specifications for electrical Power Distribution Equipment and Systems*
5. NETA MTS, *Standard for Maintenance Testing Specifications for Electrical Distribution Equipment and Systems*
6. NFPA 70, *National Electrical Code*, 2005 Edition.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: All electrical equipment shall be listed or labeled by a NRTL, as defined by Title 29 CFR Part 1910 (OSHA), when such a category exists. Approved NRTLs include UL and FM.

B. Comply with NFPA 70 and ANSI/IEEE C2.

1.5 COORDINATION

A. Coordinate electrical equipment installation with Design Drawings of other disciplines to avoid potential conflict. Bring any conflicting requirements to the attention of the Project Engineer for resolution.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, and other structural components as they are constructed.

C. Work Sequence: Perform construction in an orderly and efficient sequence.

PART 2 - PRODUCTS

2.1 PRODUCT OPTIONS AND SUBSTITUTIONS

A. Unless otherwise stated, substitutions for equipment in this Specification, and any associated drawings, will be considered if the form, fit, and function of the originally specified equipment is satisfied. Substitutions must be reviewed and approved by Engineering.

PART 3 - EXECUTION

3.1 GENERAL ELECTRICAL REQUIREMENTS

A. Drawings: Electrical drawings are diagrammatic in nature and are meant to indicate the general layout of electrical work.

B. Existing Conditions: Field verify all existing conditions prior to performing electrical work, and notify the Project Engineer if field conditions vary greatly from those shown on the drawings.

C. Workmanship: Workmanship on low voltage (less than 600 V) electrical installations shall be in accordance with NECA 1.

D. Equipment Installation:

   1. Equipment Accessibility: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Changes: Notify the Project Engineer if changes from the original Design Drawings or Specification are necessary.

   1. Secure written approval from the Project Engineer before proceeding with changes or alterations to original design media.

F. Inspection: All electrical work covered by this Division and the Design Drawings shall be inspected by the AHJ, or the designated representative, to ensure compliance with required codes and standards.

G. Testing and Inspection

1. Unless otherwise stated, test low voltage (less than 600 V) electrical installations in accordance with the NETA ATS or MTS, as applicable.
2. Give 24 hours advance notice so that the Project Engineer may be present during the test or inspection.
3. Correct faulty work to the satisfaction of the Project Engineer.

END OF SECTION 260500

FOR NSTec, LLC USE ONLY

This project specification is based on NSTec, LLC Master Guide Specification 260500 Rev. 1, dated February 12, 2009.

SECTION 260526

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment.

B. Related Sections:

1. Section 014213, *Acronyms and Abbreviations*
2. Section 014216, *Definitions*

1.2 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Acronyms and abbreviations are defined in Section 014213, *Acronyms and Abbreviations*.

B. Standard terminology is defined in Section 014216, *Definitions*.

1.3 REFERENCE STANDARDS

A. Use the latest edition of the following codes and standards referenced in this specification, unless otherwise noted:

1. IEEE 81, *IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System Part 1: Normal Measurements*
2. NFPA 70, *National Electrical Code*, 2005 Edition
3. UL 467, *Grounding and Bonding Equipment*

1.4 SUBMITTALS

A. Provide all submittals to Project Engineer for review and/or approval.

B. Product Data: For each type of product indicated.

C. Field quality control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: All electrical equipment shall be listed or labeled by a NRTL, as defined by OSHA, when such a category exists. Approved NRTLs include UL and FM.

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Material shall be as specified on the Design Drawings.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductor Terminations and Connections:

1. The Engineer or designee shall determine locations and methods of making the exothermic- or compression-type connections. Clean bare cable at all connections to a bright surface. Ensure exothermic connections are thoroughly dry.
2. The Engineer or designee shall determine locations of equipment and structural grounds because the location of ground connections, pads, and pigtails are not dimensioned or to scale.
3. Exact location of equipment shall meet NFPA 70 requirements.

B. Conduit hangers are not considered an integral part of the grounding system

3.2 EQUIPMENT GROUNDING

A. General: Provide all electrical apparatus and raceways with equipment grounds in the following manner:

1. Ensure all conduits or raceways contain equipment grounding conductor.

B. Install insulated equipment grounding conductors with all feeders and branch circuits.

C. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits
2. Flexible raceway runs

3.3 INSTALLATION

A. Grounding Conductors

1. Route along shortest and straightest paths possible, unless otherwise indicated.
2. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

3. Unless otherwise noted, all grounding conductors #2 AWG or larger shall be bare, class B stranded, soft-drawn copper wire.
4. Bare grounding conductor #6 AWG shall be solid soft-drawn copper.
5. All insulated grounding conductors shall be Class B stranded with jacket color or identification per NFPA 70, Art. No. 250.119.
6. Grounding conductors to specific electrical equipment are shown on the Design Drawings.
7. Construction is responsible for installing and routing exposed ground cables in accordance with the requirements herein.

B. Bonding Straps and Jumpers

1. Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
2. When bonding to equipment mounted on vibration isolation hangers and supports, install so vibration is not transmitted to rigidly mounted equipment.

C. Grounding Piping and Conduit:

1. Rigid metal conduits for low voltage power system (480 V and below) shall not be considered as providing a ground fault return path. Install equipment grounding conductors in all metallic raceways and conduit.
2. Bond at least one end of all steel conduit extensions to nonmetallic conduit with a grounding bushing and a jumper attached to the grounding system.

D. Other Grounding: Bond all electrical equipment and other structures specified or shown on the Drawings.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system, but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance not less than two full days after last trace of precipitation, and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests with a ground megger using the fall-of-potential method according to IEEE 81.

B. Report measured ground resistances.

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, promptly notify Engineering and include recommendations to reduce ground resistance.

END OF SECTION 260526

FOR NSTec, LLC USE ONLY

This project specification is based on NSTec, LLC Master Guide Specification 260526 Rev. 1, dated February 12, 2009.

SECTION 260543

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes the following:

1. Conduit, ducts, and duct accessories for concrete-encased duct banks, and in single duct runs
2. Handholes and boxes
3. Manholes

B. Related Sections:

1. Section 014213, *Acronyms and Abbreviations*
2. Section 014216, *Definitions*
3. Section 260526, *Grounding and Bonding for Electrical Systems*

1.2 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Acronyms and abbreviations are defined in Section 014213, *Acronyms and Abbreviations*.

B. Standard terminology is defined in Section 014216, *Definitions*.

1.3 REFERENCE STANDARDS

A. All equipment specified herein shall be designed, manufactured, tested, and installed in accordance with the requirements of the latest revision of the following standards, unless otherwise noted:

1. OSHA Standards, 29 CFR 1926.1053, *Ladders*
2. ANSI/IEEE C2, *National Electrical Safety Code (NESC)*
3. NFPA 70, *National Electrical Code*, 2005 Edition
4. NEMA TC 3, *PVC Fittings for Use with Rigid PVC Conduit and Tubing*
5. UL 514B, *Fittings for Conduit and Outlet Boxes*

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70 and ANSI/IEEE C2.

1.5 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Facility Manager/Project Engineer no fewer than seven days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Facility Manager/Project Engineer's permission.

B. Vermin Exclusion: Provide a vermin-proof installation by means of appropriate product selection, careful equipment alignment, and adequate sealing materials.

1.6 COORDINATION

A. Coordinate the requirements of this Specification with the Design Drawings. Bring any conflicting requirements to the attention of the Project Engineer for resolution.

PART 2 - PRODUCTS

2.1 CONDUIT

A. RNC: NEMA TC 2, Type EPC-40-PVC and/or EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation and Backfill: Do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod, if required, immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, and other work.

END OF SECTION 260543

FOR NSTec, LLC USE ONLY

This project specification is based on NSTec, LLC Master Guide Specification 260543 Rev. 1, dated April 6, 2009.

SECTION 311000

SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Clearing and grubbing
2. Removing above- and below-grade site improvements
3. Disconnecting, capping or sealing, and abandoning site utilities in place

B. Related Sections:

1. Section 014213, *Acronyms and Abbreviations*
2. Section 014216, *Definitions*
3. Section 312000, *Earth Moving* for soil materials, excavating, backfilling, and site grading.

1.2 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Acronyms and abbreviations are defined in Section 014213, *Acronyms and Abbreviations*.

B. Standard terminology is defined in Section 014216, *Definitions*.

1.3 MATERIAL OWNERSHIP

A. Remove cleared materials from the project site for disposal.

1.4 SUBMITTALS

A. Provide all submittals to Project Engineer for review and/or approval.

B. Record drawings, identifying and accurately locating capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.5 PROJECT CONDITIONS

A. Utility Locations: Utilities within the project site shall be located and marked prior to beginning site clearing.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. Satisfactory Soil Materials: Requirements for satisfactory soil materials are specified in Section 312000, *Earth Moving*.

1. Obtain approved borrow soil materials off-site when satisfactory soil materials are not available at the project site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as approved by Engineering.

3.2 UTILITIES

A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.

1. Arrange with Site Operations to shut off indicated utilities.
2. Verify that utilities have been disconnected and capped before proceeding with site clearing.

B. Notify Site Operations and Information Services Department (ISD) not less than seven (7) days in advance of proposed utility interrruptions. Do not proceed with utility interruptions without written permission.

C. Notify Facility Manager and Site Utility Power Operation and Maintenance not less than seven (7) days in advance of proposed utility interruptions. Do not proceed with utility interruptions without written permission.

D. Excavate for and remove underground utilities indicated to be removed.

E. Removal of underground utilities is included in Division 26 and Division 33 Sections covering site utilities.

3.3 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
2. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
3. Grind stumps and remove roots, obstructions, and debris extending to a depth of [18 in.] below exposed subgrade.
4. Use only hand methods for grubbing within tree protection zone.
5. Chip removed tree branches and dispose of off-site.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of [12 in.], and compact each layer to a density equal to adjacent original ground.

3.4 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

B. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

3.5 DISPOSAL

A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and dispose of them at the direction of the Environmental Services Department.

END OF SECTION 311000

FOR NSTec, LLC USE ONLY

This project specification is based on NSTec, LLC Master Guide Specification 311000 Rev. 0, dated March 6, 2009.

SECTION 312000

EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes site grading requirements for drainage control structures.

B. Related Sections:

1. Section 014213, *Acronyms and Abbreviations*
2. Section 014216, *Definitions*
3. Section 311000, *Site Clearing*
4. Section 330526, *Utility Line Signs, Markers, and Flags*

1.2 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Acronyms and abbreviations are defined in Section 014213, *Acronyms and Abbreviations*.

B. Standard terminology is defined in Section 014216, *Definitions*.

1.3 REFERENCE STANDARDS

A. Codes and standards referenced in this specification are as follows:

1. ACI 306 R, *Cold-Weather Concreting*
2. ASTM C33, *Standard Specification for Concrete Aggregates*
3. ASTM C150, *Standard Specification for Portland Cement*
4. ASTM C595, *Standard Specification for Blended Hydraulic Cements*
5. ASTM C618, *Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete*
6. ASTM D421, *Standard Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants*
7. ASTM D422, *Standard Test Method for Particle-Size Analysis of Soils*
8. ASTM D448, *Standard Classification for Sizes of Aggregate for Road and Bridge Construction*
9. ASTM D1557, *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 [2,700 kN-m/m3])*
10. ASTM D2487, *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*
11. ASTM D2940, *Standard Specification for Graded Aggregate Material For Bases or Subbases for Highways or Airports*
12. ASTM D4318, *Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils*

13. ASTM D4832, *Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders*
14. ASTM D6103, *Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)*
15. ASTM D6938, *Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).*
16. Nevada Department of Transportation (NDOT), *Standard Specifications for Road and Bridge Construction*

1.4 SUBMITTALS

A. Provide all submittals to Project Engineer for review and/or approval.

B. Submit soil Material Testing Data Sheets

C. Submit CLSM mix design, material certificates, and Material Testing Data Sheets.

1.5 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving occupied facilities.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations. Submit borrow source to Project Engineer for approval.

B. Satisfactory Soils: ASTM D2487, Soil Classification Groups GW, GP, GM, SW, SP, and SM, or a combination of these groups; free of rock or gravel larger than 3 in. in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D2487, or a combination of these groups.

    1. Unsatisfactory soils also include satisfactory soils not maintained within 2% of optimum moisture content at time of compaction.

D. Backfill and fill soils: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand, ASTM D2940. Backfill shall be well graded with a maximum particle size of 3 in. and a maximum of 20% passing the number 200 sieve.

2.2 DETECTABLE WARNING TAPE

A. Provide detectable warning tape according to the requirements in Section 330526, *Utility Line Signs, Markers, and Flags.*

2.3 CLSM BACKFILL

A. Materials

1. Portland cement shall conform to the requirements of ASTM C150, Type V. Cement that becomes partially set or contains lumps of caked cement will be rejected. Do not salvage cement from discarded or used bags.
2. Fine aggregate sand shall conform to the requirements of ASTM C33, except for aggregate gradation. Any aggregate gradation which produces performance characteristics of the CLSM specified herein will be accepted. However, it also must meet the gradation requirements as follows:

Gradation Requirements	
Sieve Size	**Percentage Passing by Weight**
3/4 in.	100
No. 200	0-12

3. Fly ash shall conform to ASTM C618, Class F.

B. CLSM Mix Design

1. Submit a mix design to Engineering including the proportions and source of materials, admixtures, and dry cubic yard batch weights. The mix may be composed of cement, sand, fly ash, and water.
2. The CLSM shall be designed to achieve a minimum 7 day compressive strength of 50 psi and a maximum 7 day compressive strength of 150 psi when tested in accordance with ASTM D4832. Prepare, cure, transport, and test specimens in accordance with ASTM D4832.
3. Flow consistency of the fresh mixture shall be such that the mixture may be placed without segregation.
    a. A desired consistency may be approximated by filling an open-ended 3 in. diameter cylinder, 6 in. high to the top, with the mixture and the cylinder immediately pulled straight up.
    b. The correct consistency of the mixture will produce an approximate 8 in. (± 1 in.) diameter circular-type spread without segregation.
    c. Make adjustments to the proportions of materials to achieve proper solid suspension and flowable characteristic; however the theoretical yield shall be maintained at 1 cu yd for the given batch weights.
4. Flow consistency testing shall be performed per ASTM D6103, at a frequency of one per mix design.
5. Submit test results of proposed mix design to Engineering for approval.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

B. Prepare subgrade for earthwork operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface as specified in Section 311000, *Site Clearing*.

3.2 EXCAVATION

A. Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Excavated materials may include rock, soil materials, and obstructions.

   1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.3 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations as shown on drawings.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 in. higher than top of pipe or conduit per drawings.

   1. Clearance: 8 in. minimum each side of pipe or conduit, or as indicated on the drawings.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

3.4 SUBGRADE PREPARATION

A. Prior to placing backfill or fill materials scarify top 6 inches, moisture condition to ± 2% of the optimum moisture and recompact to 90% of the maximum density as determined per ASTM D1557 in non-traffic areas and 95% in traffic areas, under pavements, and under structures.

B. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities.

3.5 OVER-EXCAVATION

A. Backfill over-excavated areas under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill with 28-day compressive strength of 2,500 psi may be used if approved by Engineering.

1. Backfill over-excavated areas within utility trenches to the required grade with suitable backfill material and compact to 90% of the maximum density determined per ASTM D1557.

3.6 STORAGE OF SOIL MATERIALS

A. Stockpile borrowed soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust. Stockpile soil materials a minimum of 6 feet away from edges of excavations.

B. Stockpile heights shall not exceed 20 ft unless justified by a geotechnical analysis.

3.7 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Backfill trenches to the bottom of any subbase course material, base course material, or drainage course material with backfill soil or CLSM.

C. Install warning tape directly above utilities as indicated on the drawings according to Section 330526, *Utility Line Signs, Markers, and Flags*.

3.8 CLSM BACKFILL CONSTRUCTION METHODS

A. Placement of CLSM Backfill

1. Place CLSM with a mixing unit or other reasonable method. Agitation is required during transportation and waiting time. Place CLSM to avoid displacement of structures from their desired final position and avoid intrusion of CLSM into undesirable areas. Bring the material up uniformly to the minimum depth shown on the Design Drawings.
2. Place CLSM in uniform layers.
    a. Allow each layer to harden to foot traffic.
    b. Each layer should have no visible free water, loose or foreign material on the surface prior to placing successive layers.
3. Do not place CLSM on frozen ground.
    a. Mix and place CLSM when the air temperature is at least 35°F and rising.
    b. At the time of placement, CLSM shall have a temperature of at least 40°F.

B. Curing and Protection of CLSM

1. Maintain the air in contact with the CLSM at temperatures above freezing for a minimum of 72 hrs.

    a. If the anticipated air temperature will be 35°F or less in the 24 hr period following proposed placement, cover the concrete and do not allow it to drop below 40°F.
    b. Refer to ACI 306 R. for cold weather requirements.
    c. CLSM subjected to temperatures below 32°F may be rejected if damage to the material is observed.

2. The CLSM shall not be subject to loads and shall remain undisturbed by construction activities for a period of at least 48 hrs.

3.9 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than one vertical to four horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:

1. Under drainage structures use backfill or fill soil material

3.10 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2% of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace, or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content by 2% and is too wet to compact to specified dry unit weight.

3.11 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 12 in. compacted lift thickness for material compacted by heavy compaction equipment, and not more than 4 in. in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D1557.

1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 in. of existing subgrade and each layer of backfill or fill soil material to 95%.

2. Under lawn or unpaved areas, scarify and recompact top 6 in. below subgrade and compact each layer of backfill or fill soil material to 90%.
3. For utility trenches, compact to 90% in non-traffic areas and 95% in traffic areas, under pavements, under footings, and under structures.

3.12 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Unpaved Areas: ± 1 in.

3.13 FIELD QUALITY CONTROL

A. Perform sieve analysis per ASTM D421 and D422 at a frequency of one test per 1,000 cu yards or fraction thereof of soil materials to be placed per source, and in no case less than one test per day per source.

B. Perform compaction testing during the earthwork phase of this project to verify compaction requirements have been met. Inspect and test subgrades, backfill, and fill layers. Tests shall be conducted near the bottom of every lift placed. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements and have been approved by Engineering.

1. Subgrade testing shall be performed at a frequency of one test per 20,000 sq ft or fraction thereof, and in no case less than three tests.
2. Backfill and fill material testing shall be performed at a frequency of one test per 10,000 sq ft per lift or fraction thereof and in no case less than three tests.

C. Test compaction of soils in place according to ASTM D6938.

D. When subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.

E. CLSM Material Acceptance

1. Acceptance of CLSM delivered and placed as shown on the design drawings shall be based upon mix design approval by Engineering and batch tickets to confirm that the delivered material conforms to the mix design.
2. Perform flow consistency testing per ASTM D6103 at a frequency of one test per truck load of CLSM delivered to the job site. Acceptable result is 8 in. ±1 in.
3. Testing Requirements: ASTM D4832 and ASTM D6103
4. Material Requirements: ASTM C33, ASTM C150, ASTM C618, and ASTM C595

3.14 PROTECTION

A. Protecting Graded Areas During Construction Activities

1. Protect newly graded areas from non-construction traffic, freezing, and erosion.
2. Keep free of trash and debris.

B. Repair and reestablish grades to the specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

C. Where settling occurs, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work.

3.15 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and dispose of it per the direction of the Environmental Services Department.

END OF SECTION 312000

FOR NSTec, LLC USE ONLY

This project specification is based on NSTec, LLC Master Guide Specification 312000 Rev. 0, dated March 6, 2009.

SECTION 312500

EROSION AND SEDIMENTATION CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Furnishing and placing filter fabric, riprap bedding material, and riprap.

B. Related Sections:

1. Section 014213, *Acronyms and Abbreviations*
2. Section 014216, *Definitions*
3. Section 312000, *Earth Moving*

1.2 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Acronyms and abbreviations are defined in Section 014213, *Acronyms and Abbreviations*.

B. Standard terminology is defined in Section 014216, *Definitions*.

1.3 REFERENCE STANDARDS

A. Use the latest edition of the following codes and standards referenced in this specification, unless otherwise noted:

1. AASHTO T85, *Specific Gravity of Coarse Aggregate*
2. AASHTO T96, *Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine*
3. Clark County, *Uniform Standard Specifications for Public Works Construction*
4. NDOT, *Standard Specifications for Road and Bridge Construction*

1.4 SUBMITTALS

A. Provide all submittals to Project Engineer for review and/or approval.

B. Samples: Riprap bedding material and riprap

C. Field Test Reports: Riprap bedding material and riprap. Ensure testing is performed by an approved testing laboratory.

PART 2 - PRODUCTS

2.1 STONES FOR RIPRAP

A. Stones for Riprap: Hard, durable, angular in shape, resistant to weathering and erosion, and free from spoils, cracks and organic matter.

1. The largest dimension of a single riprap stone shall be no larger than 3 times the smallest dimension.
2. Rounded stones or boulders will not be accepted.
3. Shale and stone with shale seams are not acceptable.

B. Gradation Requirements:

Percent Passing By Mass	**Class Designations**					
	150	**300**	**400**	**550**	**700**	**900**
100	250 (10)	500 (20)	750 (30)	1000 (40)	1200 (48)	1500 (60)
70-85	225 (9)	450 (18)	675 (27)	900 (36)	1125 (45)	1350 (54)
35-50	150 (6)	300 (12)	450 (18)	600 (24)	750 (30)	900 (36)
5-15	50 (2)	125 (5)	175 (7)	300 (12)	450 (18)	600 (24)
0	25 (1)	50 (2)	75 (3)	150 (6)	200 (8)	300 (12)

C. Control of gradation will be by visual inspection.

D. Provide a sample of stone at the project site of at least 5 tons meeting the gradation indicated.

1. Locate each sample at the project site near the location where the riprap is to be placed.
2. Ensure the sample riprap is in place and acceptable to Engineering before placing riprap.
3. Maintain the placed riprap until the project is completed and repair any material displaced to the lines and grades indicated on the Design Drawings.

E. Provide riprap test results from an approved testing laboratory.

2.2 RIPRAP BEDDING MATERIAL

A. Aggregate for Riprap Bedding: Hard, durable, angular in shape, resistant to weathering and water action, free from overburden, spoil, shale, and organic material.

B. Gradation Requirements:

Source Requirements Test	**Test Method**	**Requirements**
Percentage of Wear, 500 Rev.	AASHTO T96	45% Max
Specific Gravity	AASHTO T85	2.5 Min

Class 150 Riprap Bedding	
Sieve Size	**Percent Passing by Mass**

1 in.	100
5/8 in.	70-85
3/8 in.	35-50
1/4 in.	5-15
No. 4	0

Class 300/400 Riprap Bedding	
Sieve Size	**Percent Passing by Mass**
6 in.	100
5 in.	70-85
3 in.	35-50
1 in.	5-15
1/2 in.	0

Class 550/700 Riprap Bedding	
Sieve Size	**Percent Passing by Mass**
10 in.	100
9 in.	70-85
6 in.	35-50
2 in.	5-15
1 in.	0

Class 900 Riprap Bedding	
Sieve Size	**Percent Passing by Mass**
20 in.	100
18 in.	70-85
12 in.	35-50
5 in.	5-15
2 in.	0

A. Control of gradation will be by visual inspection.

B. Provide a sample of stone at the construction site of at least 5 tons meeting the gradation indicated.

   1. Locate each sample at the project site near the location where the riprap bedding material is to be placed.
   2. Ensure the sample riprap bedding material is in place and acceptable to Engineering before placing riprap bedding material.

C. Provide riprap bedding material test results from an approved testing laboratory.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Make surfaces to be protected by riprap free of brush, stumps and other objectionable materials and dress to a smooth surface.

B. Remove any soft or spongy material and replace with approved native material.

C. Compact filled areas for embankments and drainage outfalls as specified in Section 312000, *Earth Moving*.

D. Excavation for riprap beds shall conform to Section 312000, *Earth Moving*.

E. Place a bedding layer or filter on the prepared surface as specified on the Design Drawings before the riprap is placed.

3.2 RIPRAP BEDDING PLACEMENT

A. Uniformly place the riprap bedding material on the prepared surface by hand or mechanical means in a manner which produces a well graded mass of material with the minimum practicable percentage of voids.

B. Place the bedding according to the details shown on the Design Drawings.

C. Place riprap bedding to its full course thickness in one operation and in such a manner as to avoid displacement of the underlying material.

D. Do not place riprap bedding in layers, or by dumping into chutes, or by similar methods likely to cause segregation.

E. Produce a fairly compact riprap bedding layer in which all sizes of material are evenly distributed and placed in their proper proportions.

F. Replace any material displaced by any cause to the lines and grades shown on the Design Drawings.

3.3 RIPRAP PLACEMENT

A. Place stone for riprap to produce a well-graded mass of stone with a minimum percentage of voids.

1. Place the entire mass of stone in conformance with the lines, grades, and thicknesses shown on the Design Drawings.
2. Place riprap to its course thickness in one operation and in such a manner as to avoid displacing underlying material.
3. Minimize the height from which the stone is dropped when filter fabric is used under the riprap to avoid fabric damage.
4. Begin placement of stones at the bottom of the slope and proceed upward to the top.

B. Ensure the large stones are well distributed and the entire mass of stones conforms to the gradation specified.

1. Produce a fairly compact riprap course in which all sizes of material are evenly distributed and placed in their proper proportions.
2. Hand placement or rearrangement of individual stones by mechanical equipment may be required to secure the results specified.
3. Do not place riprap in layers, or by dumping into chutes, or by similar methods likely to cause segregation.

END OF SECTION 312500

SECTION 330526

UTILITY LINE SIGNS, MARKERS, AND FLAGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. All materials, equipment, and labor necessary to furnish, mark, and install identification devices for underground utilities using warning tape, color codes, lettering, and related permanent identification devices as required and as specified herein.

B. Related Sections:

1. Section 014213, *Acronyms and Abbreviations*
2. Section *014216*, *Definitions*

1.2 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Acronyms and abbreviations are defined in Section 014213, *Acronyms and Abbreviations*.

B. Standard terminology is defined in Section 014216, *Definitions*.

1.3 SUBMITTALS

A. Provide all submittals to Project Engineer for review and/or approval.

B. Product Data: Product data shall be provided for all products and materials proposed to be used under this Section.

PART 2 - PRODUCTS

2.1 DETECTABLE WARNING TAPE

A. Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 3 in. wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection and detectable by metal detector when tape is buried up to 30 in. deep.

B. Identify utilities using the following color coded warning tape:

1. Red: Electric
2. Yellow: Gas, oil, steam, and dangerous materials
3. Orange: Telephone and other communications

4. Blue: Water systems
5. Green: Sewer systems

PART 3 - EXECUTION

3.1 INSTALLATION OF DETECTABLE WARNING TAPE

A. Detectable warning tape shall be installed over all water mains, and over all service laterals not installed at right angles to the mains.

B. Install detectable warning tape in the pipe trench over entire length of all types, materials, sizes, and locations of water mains.

END OF SECTION 330526

FOR NSTec, LLC USE ONLY

This project specification is based on NSTec, LLC Master Guide Specification 330526 Rev. 0, dated March 6, 2009.

SECTION 334100

STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes gravity-flow, nonpressure storm drainage outside the building.

B. Related Sections:

1. Section 014213, *Acronyms and Abbreviations*
2. Section 014216, *Definitions*
3. Section 312000, *Earth Moving*

1.2 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Acronyms and abbreviations are defined in Section 014213, *Acronyms and Abbreviations*.

B. Standard terminology is defined in Section 014216, *Definitions*.

1.3 REFERENCE STANDARDS

A. Use the latest edition of the following codes and standards referenced in this specification, unless otherwise noted:

1. AASHTO M36, *Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains*
2. ASTM C1433, *Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers.*
3. Nevada Department of Transportation (NDOT), *Standard Specifications for Road and Bridge Construction.*
4. Nevada Department of Transportation (NDOT), *Standard Plans for Road and Bridge Construction.*

1.4 SUBMITTALS

A. Product Data: For the following:

1. Corrugated Metal Pipe Arch (CMPA) for Culverts.
2. Precast Reinforced Concrete Monolithic Box Sections for Culverts and Storm Drains.

B. Shop Drawings: For the following:

1. Corrugated Metal Pipe Arch (CMPA) for Culverts.
2. CMPA Flaired End Sections.

3. Precast Reinforced Concrete Monolithic Box Sections for Culverts and Storm Drains.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect pipe, pipe fittings, and seals from dirt and damage.

PART 2 - PRODUCTS

2.1 CORRUGATED STEEL PIPE

A. Conform to AASHTO M36.

2.2 PRECAST REINFORCED CONCRETE MONLITHIC BOX SECTIONS FOR CULVERTS, STORM DRAINS, AND SEWERS.

A. Conform to ASTM C1433.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Section 312000, *Earth Moving*.

3.2 PIPING APPLICATIONS

A. Pipe couplings and special pipe fittings with pressure ratings at least equal to piping rating may be used.

3.3 PIPING AND CONCRETE BOX INSTALLATION

A. Installations shall conform to NDOT Standard Plans for Road and Bridge Construction, NDOT Standard Specifications for Road and Bridge Construction, and the manufacturer’s specifications.

B. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

C. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and/or couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

3.4 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure drainage piping according to the manufacturer's printed instructions.

3.5 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 in. of backfill is in place, and again at completion of project.

1. Submit separate reports for each system inspection.
2. Defects requiring correction include the following:
    a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5% of piping diameter.
    c. Crushed, broken, cracked, or otherwise damaged piping.
    d. Infiltration: Water leakage into piping.
    e. Exfiltration: Water leakage from or around piping.
3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Re-inspect and repeat procedure until results are satisfactory.

3.6 CLEANING

A. Clean interior of piping of dirt and superfluous materials.

END OF SECTION 334100

1. **Calculation No.:** 08023-CAL-C -001	2. **Revision No.:** 1	3. **Date:** 6-4-09	4. **Project No.:** 08023	5. **Pages** 9

6. **Calculation Title:** Area 5 RWMS 92-Acre Area WEQ	7. **Project Title:** 92 Acre Grading and Drainage

8. **Calculation Type:** ☐ Preliminary ☒ Final ☐ Voided/ Superseded	9. **Quality Grade** ☐ QG-1 ☒ QG-3 ☐ QG-2 ☐ QG-4	10. **Performance Category** ☒ PC-1 ☐ PC-2 ☐ PC-3	11. Superseded by Calculation No.: N/A 12. Supersedes Calculation No.: N/A

Original and Revised Calculation/Analysis Approval (Signature/Date)

13.	**Revision 1**	**Revision**	**Revision**
14. Preparer:	Luanne Fairbanks	1	6/4/09 Date
15. Checker:	Robert Niedringhaus	1	6-4-09 Date
16. Peer Reviewer:	N/A		Date
17. Discipline Section Supervisor:	Steven Goold	1	6-8-09 Date

Affected Documents

Document No.	**Document Title**	**Revision No**	**Responsible Discipline Lead Initials**

Record of Revision

Revision No.	**Reason for Revision**
0	Original
1	Editorial changes per new project scope

Attachments

Attachment No.	**Title**	**Total Pages**
A.	Wind erodibility groups and wind erodibility index	1
B.	Agronomy Technical Note 69 – Wind Erosion Equation	4
C.	(E) * Soil Loss From Wind Erosion in Tons per Acre per Year	4
	6/4/09	
	LUANNE E **Total Calculation Page Count**	18

V No. 12725 Exp 6/30/09

1 Introduction

This calculation was generated to estimate the magnitude of soil loss due to wind erosion for the proposed final graded areas within the Area 5 RWMS 92-acre area. The graded areas will be seeded with native vegetation. The site is located within the Area 5 Radioactive Waste Management Site (RWMS). Annual soil loss estimates are made using the Wind Erosion Equation (WEQ).

2 Basis

Calculations are performed to support grading and drainage design.

2.1 Design Inputs

- Soil particle size data were obtained from boreholes drilled in Area 5 (Shott et al 1998).
- Wind speed, temperature and precipitation data required to calculate the local climate factor (C) were obtained from Soule, 2006. These data are from the Well 5B meteorological station located approximately 3.5 miles from the proposed location. Values used in calculations are based on averages of over 17 years of data.
- Unsheltered distances and surface slopes for the graded surfaces and sideslopes were obtained from design drawings completed by the Civil Engineering Design group.

2.2 Criteria

Compute annual average soil loss due to wind erosion.

2.3 Assumptions

- The final surface slope is less than 3%.
- Sideslopes will vary between 10-20%.
- The finished elevation of the graded areas will be approximately 4 ft above existing grade.

3 References

Coduto, D. *Geotechnical Engineering: Principles and Practices.* Prentice-Hall Inc Upper Saddle River, New Jersey, 1999.

Natural Resources Conservation Service (NRCS). *National Agronomy Manual*, 190-V-NAM, 3rd

Edition October 2002.

National Security Technologies (NSTec), LLC. *Nevada Test Site 2006 Waste Management Monitoring Report Area 3 and Area 5 Radioactive Waste Management Sites*, June 2007.

Soule, D. 2006. *Climatology of the Nevada Test Site*. SORD Technical Memorandum SORD 2006-3, Air Resources Laboratory, Silver Spring, Maryland 165pp.

Shott GJ, Barker LE, Rawlinson SE, Sully MJ, and BA Moore. *Performance Assessment for the Area 5 Radioactive Waste Management Site*, Nye County, Nevada. Las Vegas, NV: Bechtel Nevada, DOE/NV/11718—176; 1998.

Turner FB and DC Randall. *Net Production By Shrubs And Winter Annuals In Southern Nevada*. Journal of Arid Environments (1989) 17, 23-36.

Microsoft Excel 2002 SP3

U.S. Department of Agriculture, Soil Conservation Service, Western Technical Services Center – Portland Oregeon. Agronomy Technical Note 69 – *Wind Erosion Equation (Annual Method) on Rangeland*, May 2004.

Webb, R. H., M. B. Murov, T. C. Esque, D. E. Boyer, L. A. DeFalco, D. F. Haines, D. Oldershaw, S. J. Scoles, K. A. Thomas, J. B. Blainey, and P. A. Medica. 2003. *Perennial Vegetation Data from Permanent Plots on the Nevada Test Site, Nye County, Nevada*. Open-File Report 03-336, U.S. Geological Survey, Tuscon, AZ

Personal communication with project plant ecologist David Anderson.

Personal communication with Mike Sporcic, Wind Erosion Specialist, Natural Resources Conservation Service, National Technology Support Center-Central.

4 Methods

- Wind erosion loss is calculated using the Wind Erosion Equation (WEQ).

5 Results and Conclusions

The calculated annual soil loss for the graded areas, due to wind erosion, is presented below.

Calculated Annual Soil Loss

Surface	Wind Erosion (tons/acre/year)
Sideslopes	194 (10H:1V), 162 (5H:1V)
Graded Area	115

Important limitations of this method should be recognized when interpreting these results. Limitations include the equation does not account for deposition of incoming soil particles or the changes in the soil surface over time which may reduce the amount of erosion. This is of particular importance at the project site due to the high percentage of coarse fragments (~ 25%) present in the site soils. Therefore these calculations should be considered very conservative. Additionally, little erosion has been observed at the U-3ax/bl landfill at the Nevada Test Site which was constructed in 2001 and has similar climatic, soil and vegetation conditions.

6 Calculations and Analyses

The Wind Erosion Equation (WEQ) (NRCS, 2002) was used to calculate potential wind erosion.

$$E = f\,(IKCLV)$$

where:

E = estimated average annual soil loss (tons/acre)
f = indicates the relationships that are not straight-line mathematical functions
I = soil erodibility index
K = soil surface roughness
C = climatic factor
L = the unsheltered distance (feet)
V = the re-vegetative graded areas (small grain equivalent residue in pounds per acre)

Soil Grain-Size Data - Mean Percent Passing Indicated Size

3/4 in	3/8 in	#4	#6	#10	#16	#40	#70	#140	#200
19.0 mm	9.52 mm	4.75 mm	3.35 mm	2.0 mm	1.18 mm	0.425 mm	0.212 mm	0.106 mm	0.075 mm
96.0%	91.3%	85.1%	80.3%	74.7%	65.5%	51.3%	31.8%	12.9%	8.4%

(Shott et al, 1998)

Soil Grain Size Data (minus 2.0 mm fraction only)

#10	#16	#40	#70	#140	#200
2.0 mm	1.18 mm	0.425 mm	0.212 mm	0.106 mm	0.075 mm
100%	91.7	68.7	42.6	17.3	11.2

The United States Department of Agriculture (USDA) soil classification system is used to determine the Soil Erodibility Index (p 502-22, NRCS 2002) for the WEQ. The USDA classification system does not include coarse (>2.0 mm) fragments in the classification procedure (Coduto, 1999). The USDA size range for silt is 0.05 – 0.002 mm. The smallest sieve size data available is minus 0.075mm. For the purpose of determining soil texture, the minus #200 percentage is assumed to be silt. Hydrometer analysis indicates the minus #200 fraction is primarily silt rather than clay (Shott et al 1998). Using the presented soil grain-size data (the minus 2mm fraction only), and the NRCS soil texture calculator http://soils.usda.gov/technical/aids/investigations/texture/ , the soil texture is classified as coarse sand.

From footnote 5 (p 502-22 NRCS 2002) – the soil erodibility index (I) for coarse sand is 160 ton/acre/yr.

The soil roughness coefficient (K) is a function of ridge (Krd) and random roughness (Krr).

K =Krd * Krr

The graded areas will be constructed without ridges, therefore Krd = 1. The random roughness factor Krr for I factors greater than 134 is equal to 1. Therefore K = 1

The climatic factor (C) equation is expressed as :

$$C = 34.48 \times \frac{V^3}{(PE)^2}$$

where:

C = annual climatic factor
V = average annual wind velocity (mi/hour)
PE = precipitation-effectiveness index of Thornthwaite
34.48 = constant used to adjust local values to a common base (Garden City, Kansas)

$$PE = \sum_{Jan}^{Dec} 115 \times \left[\frac{P}{T - 10} \right]^{10/9}$$

where:

PE = the annual precipitation effectiveness index
P = average monthly precipitation (in) (minimum of 0.5)
T = average monthly temperature (F)

W5B Meteorological Data

Month	Average precipitation (in)	Average temperature (ºF)
January	0.61	39.7
February	0.68	44.7
March	0.54	50.7
April	0.32	57.2
May	0.26	66.5
June	0.16	74.9
July	0.47	81.7
August	0.47	80.0
September	0.36	71.5
October	0.23	60.0
November	0.36	46.6
December	0.45	38.9

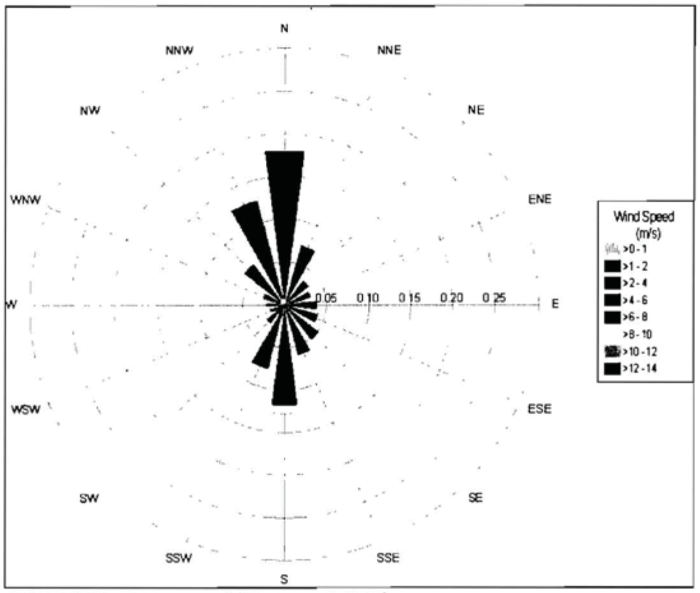
Soule, 2006 pages 9 and 38

V = 6.4 mi/hr (Soule 2006 p. 21)

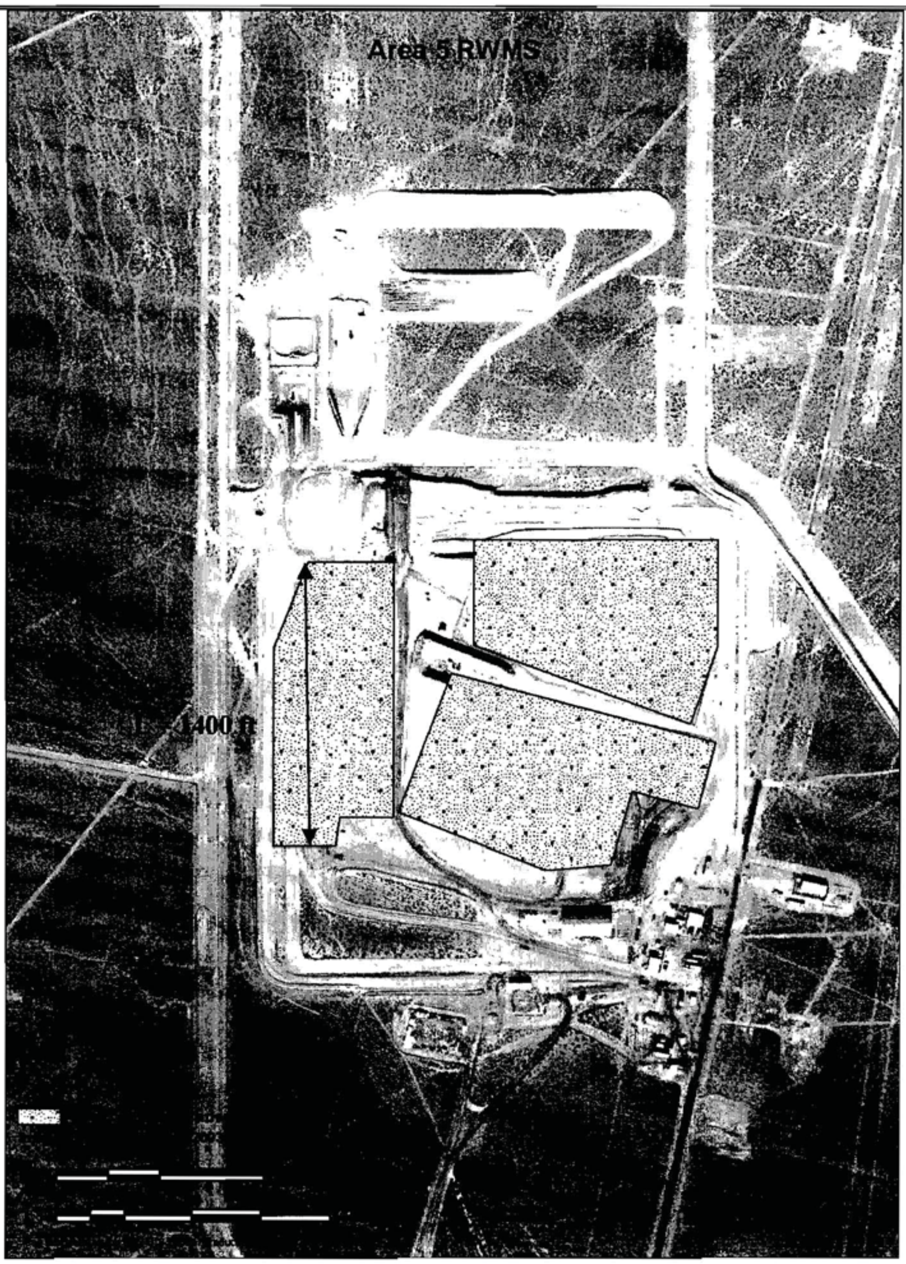
The calculated climatic factor (C) = 87

The prevailing wind erosion direction is estimated from the annual wind rose presented in NSTec (2007). These data are collected from the meteorological tower located on-site.

From the estimated extent of the graded areas, L = 1400 ft. The estimated soil loss is relatively insensitive to unsheltered distance as L approaches 1000 ft.



2006 Wind Rose (NSTec, 2007)



Overview of 92-acre Graded Areas

The re-vegetative graded areas factor (in small grain equivalent) was estimated using the aboveground net production (ANP) equations (Eqs. 3 and 4) presented in Turner and Randall (1989). W5B precipitation data was used.

For annuals:

$$\log(ANP) = 1.976\log(PPTSM - 26.2) - 2.746$$

where:

PPTSM is the precipitation from September through March in millimeters.
ANP in grams/m^2

For perennials:

$$ANP = 0.297(PPTOS) - 6.12$$

where:

PPTOS is the precipitation from October through September in millimeters.
ANP in grams/m^2

Annual Net Production

Annuals ANP (pounds/acre)	Perrenials ANP (pounds/acre)
45	275.9

Annual net production values (ANP) must be converted in small grain equivalent (sge) values for use in the WEQ. The sge is calculated using the below equation. The coefficients for the sge equations were taken from the WEQ Annual Method West spreadsheet obtained from Mike Sporcic wind erosion specialist from the NRCS.

$$sge = a * (species\, lbs / acre)^{b}$$

Perrenial Small Grain Equivalents

Total lbs/acre (perennial)	**275.9**				
species	**% abundance**	**lbs / acre**	**a**	**b**	**sge**
Low sagebrush	47	129.65	0.078687	1.643208	233.16
Greasewood	14	38.62	0.014532	1.828419	11.58
Tall/low rabbitbrush	1	2.76	0.026389	1.775753	0.16
shadscale	4	11.03	0.040087	1.663769	2.18
Creosote bush	33	91.03	0.049122	1.569699	58.43
Winterfat	1	2.76	0.077278	1.566006	0.38
				total	**305.89**

Percent abundance values were taken from Webb et al, 2003 with interpretation from David Anderson (project plant ecologist) to categorize into species presented in Agronomy Technical Note 69.

The annuals species found at the project site are not listed in Agronomy Technical Note 69. Annuals are therefore assumed to have a 1:1 ratio of ANP to small grain equivalent (sge).

The vegetative factor (V) for use in the WEQ is 350 (the sum of the annuals and perennial sge's).

Using the calculated WEQ parameters and interpolation of tables in Attachment C, the calculated wind erosion for the final graded areas is 115 tons/acre/yr.

Sideslopes
With the exception of the unsheltered length and the erodidibility index, the WEQ parameters for the sideslopes are the same as those calculated for the graded areas.

Due to the greater than 3% slope of the graded area sideslopes, a knoll erodibility adjustment is applied to the I factor (NRCS, 2002, p. 502). From Table 502- (NRCS, 2002) the Knoll erodibility factor is 3.6 for slope changes >= 10%, this results in an I factor of 576 for the sideslopes. Tabulated values for the climatic factor (C) do not exceed 310, therefore an I value of 310 is assumed for the sideslope erosion calculation. The top of the graded areas is assumed to be completed approximately 4 ft above grade.

WEQ Parameter Summary

Surface	I (tons/acre/yr)	K	C	L (ft)	V (sge lbs/acre)	E (tons/acre/yr)
Graded Areas	160	1.0	87	1400	350	115
10H:1V Sideslopes	310	1.0	87	60	350	194
5H:1V Sideslopes	310	1.0	87	30	350	162

Assuming a 1.6 g/cm^3 bulk density of graded area soil material, the calculation indicates over 30 years the graded areas will have eroded 1.6 ft.

Attachment A
Wind Erodibility Groups and Wind Erodibility Index

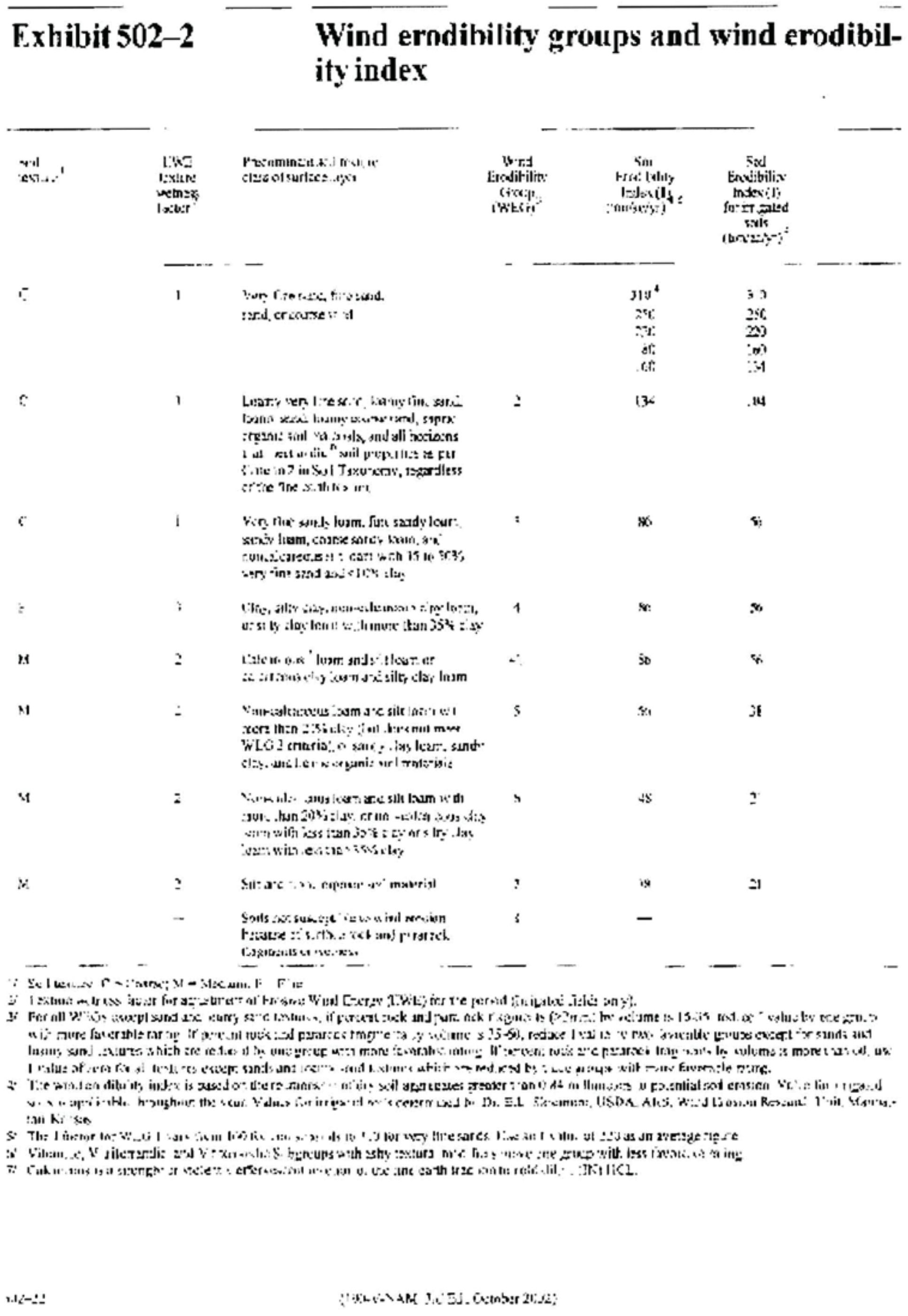


Exhibit 502–2 Wind erodibility groups and wind erodibility index

Soil texture[1]	EWE texture wetness factor[2]	Predominant soil texture class of surface layer	Wind Erodibility Group (WEG)[3]	Soil Erodibility Index (I)[4],[5] (tons/acre/yr)	Soil Erodibility Index (I) for irrigated soils (tons/acre/yr)[4]
C	1	Very fine sand, fine sand, sand, or coarse sand		310[4] 250 220 180 160	310 250 220 160 134
C	1	Loamy very fine sand, loamy fine sand, loamy sand, loamy coarse sand, sapric organic soil materials, and all horizons that meet andic[6] soil properties as per Criteria 2 in Soil Taxonomy, regardless of the fine earth fraction	2	134	104
C	1	Very fine sandy loam, fine sandy loam, sandy loam, coarse sandy loam, and noncalcareous silt loam with 35 to 50% very fine sand and <10% clay	3	86	56
F	3	Clay, silty clay, noncalcareous clay loam, or silty clay loam with more than 35% clay	4	86	56
M	2	Calcareous[7] loam and silt loam or calcareous clay loam and silty clay loam	4L	86	56
M	2	Noncalcareous loam and silt loam with more than 20% clay (that does not meet WEG 2 criteria), or sandy clay loam, sandy clay, and hemic organic soil materials	5	56	38
M	2	Noncalcareous loam and silt loam with more than 20% clay, or noncalcareous clay loam with less than 35% clay, or silty clay loam with less than 35% clay	6	48	27
M	2	Silt and fibric organic soil material	7	38	21
	—	Soils not susceptible to wind erosion because of surface rock and pararock fragments or wetness	8	—	

1/ Soil texture: C = Coarse; M = Medium; F = Fine

2/ Texture wetness factor for adjustment of Erosive Wind Energy (EWE) for the period (irrigated fields only).

3/ For all WEGs except sand and loamy sand textures, if percent rock and pararock fragments (>2mm) by volume is 15-35, reduce I value by one group with more favorable rating. If percent rock and pararock fragments by volume is 35-60, reduce I value by two favorable groups except for sands and loamy sand textures which are reduced by one group with more favorable rating. If percent rock and pararock fragments by volume is more than 60, use I value of zero for all textures except sands and loamy sand textures which are reduced by three groups with more favorable rating.

4/ The wind erodibility index is based on the percentage of dry soil aggregates greater than 0.84 millimeters to potential soil erosion. Value for irrigated soils is applicable throughout the year. Values for irrigated soils determined by Dr. E.L. Skidmore, USDA, ARS, Wind Erosion Research Unit, Manhattan, Kansas.

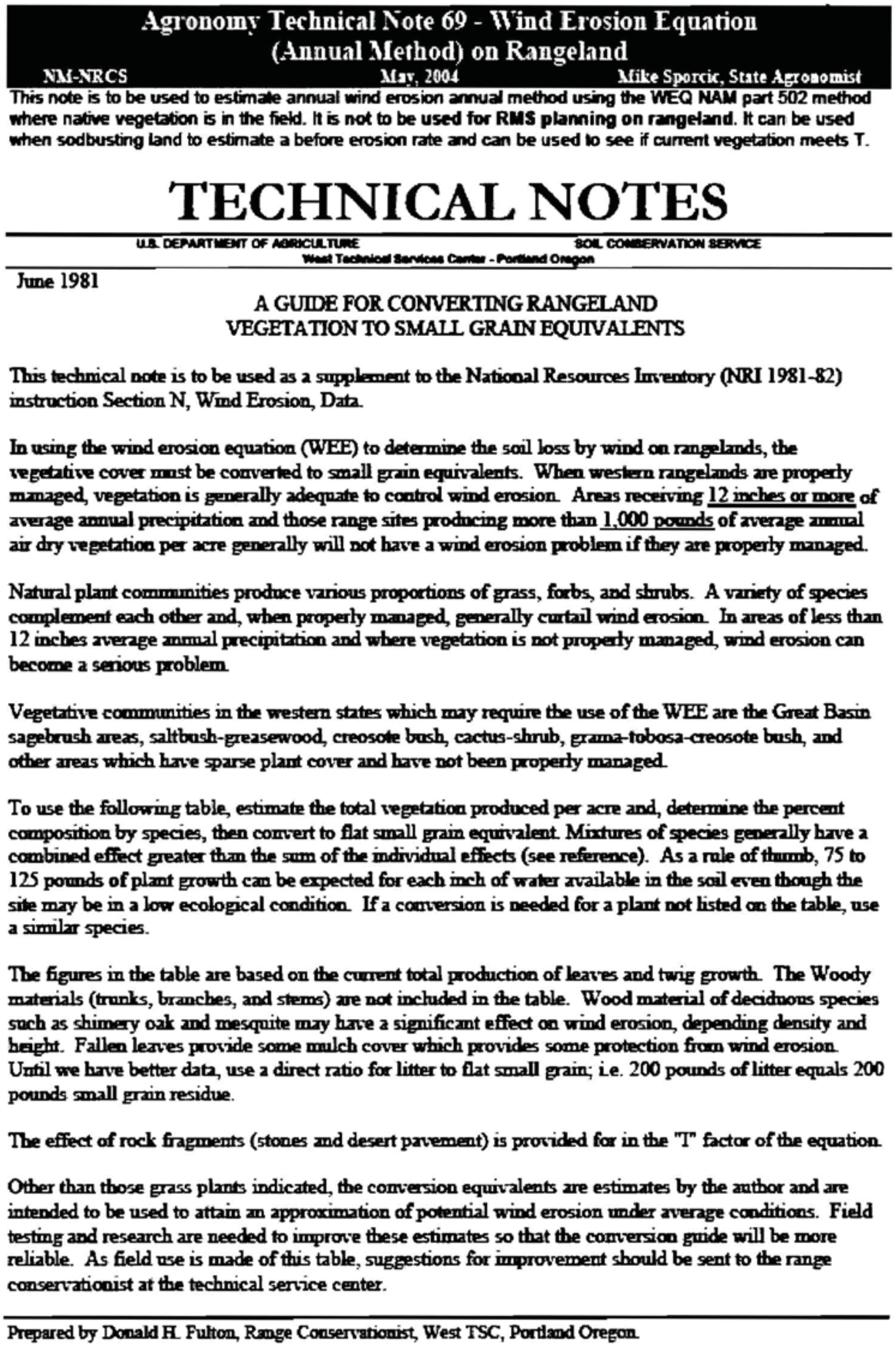
5/ The I factor for WEG 1 varies from 160 for coarse sands to 310 for very fine sands. Use an I value of 220 as an average figure.

6/ Vitrandic, Vitritorrandic, and Vitrixerandic Subgroups with ashy textures move one group with less favorable rating.

7/ Calcareous is a strong or violent effervescence of the fine earth fraction to cold dilute (1N) HCl.

502–22 (190-V-NAM, 3rd Ed., October 2002)

Attachment B
Agronomy Technical Note 69 – Wind Erosion Equation



Agronomy Technical Note 69 - Wind Erosion Equation (Annual Method) on Rangeland

NM-NRCS May, 2004 Mike Sporcic, State Agronomist

This note is to be used to estimate annual wind erosion annual method using the WEQ NAM part 502 method where native vegetation is in the field. It is not to be used for RMS planning on rangeland. It can be used when sodbusting land to estimate a before erosion rate and can be used to see if current vegetation meets T.

TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE
West Technical Services Center - Portland Oregon

June 1981

A GUIDE FOR CONVERTING RANGELAND VEGETATION TO SMALL GRAIN EQUIVALENTS

This technical note is to be used as a supplement to the National Resources Inventory (NRI 1981-82) instruction Section N, Wind Erosion, Data.

In using the wind erosion equation (WEE) to determine the soil loss by wind on rangelands, the vegetative cover must be converted to small grain equivalents. When western rangelands are properly managed, vegetation is generally adequate to control wind erosion. Areas receiving 12 inches or more of average annual precipitation and those range sites producing more than 1,000 pounds of average annual air dry vegetation per acre generally will not have a wind erosion problem if they are properly managed.

Natural plant communities produce various proportions of grass, forbs, and shrubs. A variety of species complement each other and, when properly managed, generally curtail wind erosion. In areas of less than 12 inches average annual precipitation and where vegetation is not properly managed, wind erosion can become a serious problem.

Vegetative communities in the western states which may require the use of the WEE are the Great Basin sagebrush areas, saltbush-greasewood, creosote bush, cactus-shrub, grama-tobosa-creosote bush, and other areas which have sparse plant cover and have not been properly managed.

To use the following table, estimate the total vegetation produced per acre and, determine the percent composition by species, then convert to flat small grain equivalent. Mixtures of species generally have a combined effect greater than the sum of the individual effects (see reference). As a rule of thumb, 75 to 125 pounds of plant growth can be expected for each inch of water available in the soil even though the site may be in a low ecological condition. If a conversion is needed for a plant not listed on the table, use a similar species.

The figures in the table are based on the current total production of leaves and twig growth. The Woody materials (trunks, branches, and stems) are not included in the table. Wood material of deciduous species such as shimery oak and mesquite may have a significant effect on wind erosion, depending density and height. Fallen leaves provide some mulch cover which provides some protection from wind erosion. Until we have better data, use a direct ratio for litter to flat small grain; i.e. 200 pounds of litter equals 200 pounds small grain residue.

The effect of rock fragments (stones and desert pavement) is provided for in the "I" factor of the equation.

Other than those grass plants indicated, the conversion equivalents are estimates by the author and are intended to be used to attain an approximation of potential wind erosion under average conditions. Field testing and research are needed to improve these estimates so that the conversion guide will be more reliable. As field use is made of this table, suggestions for improvement should be sent to the range conservationist at the technical service center.

Prepared by Donald H. Fulton, Range Conservationist, West TSC, Portland Oregon.

Guide for Converting Range Vegetation to Equivalent Quantity of Flat Small Grain Residue

		Pounds per acre of Range Vegetation										
	Grass Plants	50	100	200	300	400	500	600	700	800	900	1000
1	*Buffalograss, burrograss Inland saltgrass	320	720	1630	2630							
2	*Big bluestem	45	110	280	480	705	950	1215	1495	1785	2090	2410
3	*Western wheatgrass, creeping wildrye & sideoats grama	155	245	775	1240	1740	2260	2795	3345			
4	*Little bluestem	45	110	285	495	735	995	1280	1580	1900	2230	2575
5	*Blue grams, threadleaf sedge & perennial threeawn	110	235	490	760	1040	1325	1610	1905			
6	Galleta & tobosa	150	300	800	1200	1700	2600					
7	Bottlebrush squirreltail, needleandthread, & thurber needlegrass	70	150	300	600	800	1200					
8	Alkali sacaton	60	150	400	800	1400	2200	2800	3600			
9	Bluebunch wheatgrasa	50	120	300	550	850	1150	1500	1900	2300	2600	3000
10	Idaho fescue	100	200	400	900	1500	2300					
11	Indian ricegrass	100	175	300	600	900	1400					
12	Crested wheatgrass	130	300	600	900	1300	1800	2400	3100	4000		
13	Cheatgrass	100	200	300	600	800	1000	1200	1600	2000	2500	3000

*Lyles Leon and Bruce E. Allison, "Range Grasses and Their Small Grain Equivalents for Wind Erosion Control," Journal of Range Management, Vol. 33 No. 2, March 1980, pp. 143-146.

NOTE: Other grass species equivalents were estimated by comparing the growth characteristics with the tested species.

Pounds per acre of Range Vegetation [1/]

	Forbs	**50**	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**
1	Perennial forbs	50	100	300	500							
2	Annual forbs	50	100	200	300	500	800	1000				
	Shrubs											
1	Big sagebrush	30	70	300	750	1100	1500	2000	2600	3200	4000	
2	Low sagebrush	50	150	450	900	1600	2200	2900	3600			
3	Greasewood & 4-wing saltbush	20	60	250	450	800	1250	1800	2400	3000		
4	Tall and low rabbitbrush	30	70	350	800	1200	1700	2200	2800	3400		
5	Shadscale	30	70	300	500	850	1300					
6	Creosote bush	20	70	250	400	600	800	1000				
7	Mesquite	20	80	200	300	500	700	800	1000	1500	2000	3000
8	Juniper	40	90	180	300	450	800	950	1300	2000	2700	36050
9	Cholla 2/	0	50	100	250	350	500	700	950	1300		
10	Yucca 2/	0	70	150	250	400	600	750	000	1400	1800	
11	Winterfat	40	100	300	500	800	1400	1800	2300	3000		
12	Litter 3/	50	100	200	300	400	509	600	700	300	900	1000

[1/] Total leaf and twig growth-air dry weight. Woody production not included in these weight figures,

[2/] Include all leaf and fibrous material.

[3/] Litter should, include leaves, twigs and seems up to 1/2 inch in diameter.

For deciduous shrub" estimate foliage production at time of wind erosion hazard.

The forb and shrub small grain equivalents are personal judgment only. No research data is available to support these figures.

-

Examples of determining "v" for use in the wind erosion equation.

Range site: Loamy – 8-10" p.z. fair condition

Bluebunch wheatgrass	-	50#/acre	=	80	
Cheatgrass	-	100#/acre	=	200	
Annual forbs	-	50#/acre	=	50	
Big sagebrush	-	500#/acre	=	1500	
Litter	-	300#/acre	=	300	
		v	=	2130	

Range site: Basalt hills 2-7"" p.z. fair condition

Perennial threeawn	-	20#/acre	=	28	
Sixweeks grama	-	80#/acre	=	160	(use cheatgrass)
Annual forbs	-	20#/acre	=	20	
Creosote bush*	-	250#/acre	=	325	
Litter	-	50#/acre	=	50	
		v	=	583	

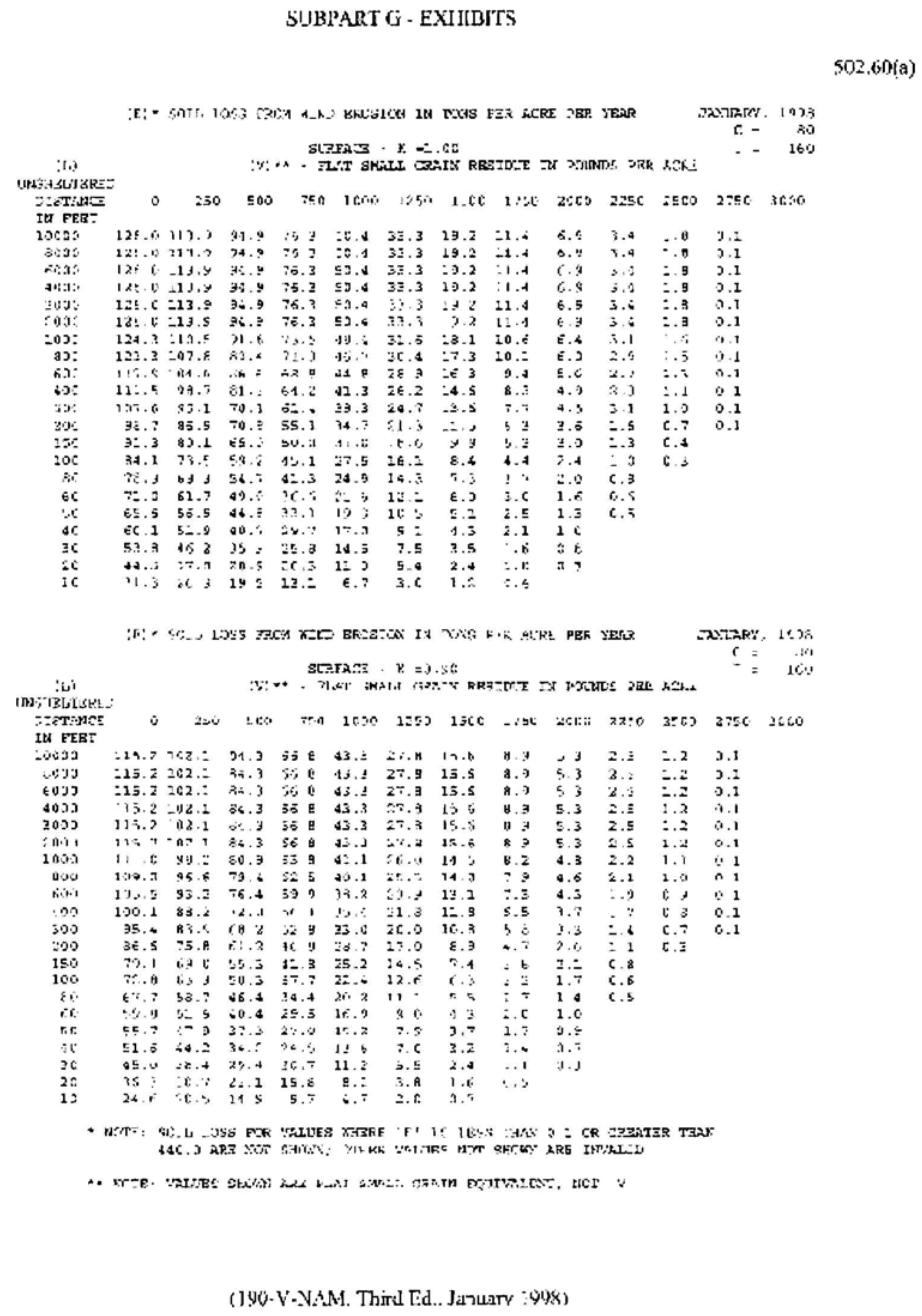
*current and accumulated production

Range site: Loamy 12-16" p.z. [1/] poor condition

Cheatgrass	-	300#/acre	=	600
Big sagebrush	-	700#/acre	=	2600
Litter	-	400#/acre	=	400
		v	=	3600

[1/] Little if any wind erosion should occur on this site.

Attachment C
(E) * Soil Loss From Wind Erosion in Tons per Acre per Year



SUBPART G - EXHIBITS

502.60(a)

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR JANUARY, 1998
C = 80
I = 160

SURFACE - K =1.00
(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	126.0	113.9	94.9	76.3	50.4	33.3	19.2	11.4	6.9	3.4	1.8	0.1	
8000	126.0	113.9	94.9	76.3	50.4	33.3	19.2	11.4	6.9	3.4	1.8	0.1	
6000	126.0	113.9	94.9	76.3	50.4	33.3	19.2	11.4	6.9	3.6	1.8	0.1	
4000	126.0	113.9	94.9	76.3	50.4	33.3	19.2	11.4	6.9	3.6	1.8	0.1	
3000	126.0	113.9	94.9	76.3	50.4	33.3	19.2	11.4	6.9	3.6	1.8	0.1	
2000	126.0	113.9	94.9	76.3	50.4	33.3	19.2	11.4	6.9	3.6	1.8	0.1	
1000	124.3	110.5	91.6	73.5	48.4	31.6	18.1	10.6	6.4	3.1	1.6	0.1	
800	123.3	107.8	89.4	71.0	46.9	30.4	17.3	10.1	6.0	2.9	1.5	0.1	
600	115.9	104.6	86.2	68.9	44.8	28.9	16.3	9.4	5.6	2.7	1.3	0.1	
400	111.5	98.7	81.2	64.2	41.3	26.2	14.5	8.3	4.9	2.3	1.1	0.1	
300	107.6	93.1	76.1	61.4	38.3	24.7	13.5	7.7	4.5	2.1	1.0	0.1	
200	98.7	85.5	70.9	55.1	34.7	21.5	11.9	6.2	3.6	1.6	0.7	0.1	
150	91.3	80.1	65.5	50.8	31.8	19.6	9.9	5.2	3.0	1.3	0.4		
100	84.1	73.5	59.2	45.1	27.5	16.2	8.4	4.4	2.4	1.0	0.3		
80	78.3	69.3	54.7	41.3	24.9	14.3	7.3	3.5	2.0	0.8			
60	72.0	61.7	49.5	36.9	21.6	12.1	6.0	3.0	1.6	0.6			
50	65.5	56.5	44.8	33.1	19.3	10.5	5.2	2.5	1.3	0.5			
40	60.1	51.9	40.5	29.7	17.0	9.1	4.3	2.1	1.0				
30	53.8	46.2	35.5	25.8	14.5	7.5	3.5	1.6	0.6				
20	44.5	37.8	28.5	20.3	11.0	5.4	2.4	1.0	0.3				
10	31.3	26.3	19.5	12.1	6.7	3.0	1.2	0.4					

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR JANUARY, 1998
C = 80
I = 160

SURFACE - K =0.90
(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	115.2	102.1	84.3	56.8	43.3	27.8	15.6	8.9	5.3	2.5	1.2	0.1	
8000	115.2	102.1	84.3	56.8	43.3	27.8	15.5	8.9	5.3	2.5	1.2	0.1	
6000	115.2	102.1	84.3	56.8	43.3	27.8	15.5	8.9	5.3	2.5	1.2	0.1	
4000	115.2	102.1	84.3	56.8	43.3	27.8	15.6	8.9	5.3	2.5	1.2	0.1	
3000	115.2	102.1	84.3	56.8	43.3	27.8	15.6	8.9	5.3	2.5	1.2	0.1	
2000	115.2	102.1	84.3	56.8	43.3	27.8	15.6	8.9	5.3	2.5	1.2	0.1	
1000	111.0	98.2	80.9	53.9	41.1	26.0	14.5	8.2	4.8	2.2	1.1	0.1	
800	109.3	95.6	79.4	52.5	40.1	25.5	14.0	7.9	4.6	2.1	1.0	0.1	
600	105.5	93.2	76.4	50.9	38.2	23.9	13.1	7.3	4.3	1.9	0.9	0.1	
400	100.1	88.2	72.3	47.1	35.6	21.8	11.9	5.5	3.7	1.7	0.8	0.1	
300	95.4	83.5	68.2	43.9	33.0	20.0	10.8	5.6	3.3	1.4	0.7	0.1	
200	86.5	75.8	61.2	46.9	28.7	17.0	8.9	4.7	2.6	1.1	0.3		
150	79.1	69.0	55.3	41.3	25.2	14.5	7.4	3.6	2.1	0.8			
100	72.8	63.3	50.3	37.7	22.4	12.6	6.3	2.8	1.7	0.6			
80	67.7	58.7	46.4	34.4	20.2	11.1	5.5	2.7	1.4	0.5			
60	59.9	52.5	40.4	29.5	16.9	9.0	4.3	2.0	1.0				
50	55.7	47.9	37.3	27.0	15.2	7.9	3.7	1.7	0.9				
40	51.6	44.2	34.5	24.6	13.6	7.0	3.2	1.4	0.7				
30	45.0	38.4	29.4	20.7	11.2	5.5	2.4	1.1	0.3				
20	35.3	30.7	22.1	15.8	8.2	3.8	1.6	0.5					
10	24.6	20.5	14.5	9.7	4.7	2.0	0.7						

* NOTE: SOIL LOSS FOR VALUES WHERE (E) IS LESS THAN 0.1 OR GREATER THAN 440.0 ARE NOT SHOWN; THESE VALUES NOT SHOWN ARE INVALID

** NOTE: VALUES SHOWN ARE FLAT SMALL GRAIN EQUIVALENT, NOT V

(190-V-NAM, Third Ed., January 1998)

SUBPART G - EXHIBITS

502.60(a)

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR

JANUARY, 1998
C - 90
I - 160

SURFACE - K =1.00

(L)
UNSHELTERED DISTANCE IN FEET

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	144.0	128.8	108.4	88.3	59.8	40.8	24.2	14.8	9.3	4.9	2.6	0.2	
8000	144.0	128.8	108.4	88.3	59.8	40.8	24.2	14.8	9.3	4.9	2.6	0.2	
6000	144.0	128.8	108.4	88.3	59.8	40.8	24.2	14.8	9.3	4.9	2.6	0.2	
4000	144.0	128.8	108.4	88.3	59.8	40.8	24.2	14.8	9.3	4.9	2.6	0.2	
3000	144.0	128.8	108.4	88.3	59.8	40.8	24.2	14.8	9.3	4.8	2.6	0.2	
2000	144.0	128.8	108.4	88.3	59.8	40.8	24.2	14.8	9.3	4.8	2.6	0.2	
1000	140.7	125.7	105.3	85.8	57.8	39.5	23.1	14.1	8.8	4.5	2.4	0.2	
800	137.9	123.1	103.2	83.7	56.2	37.6	22.2	13.4	8.3	4.2	2.2	0.2	
600	[illegible]	[illegible]	[illegible]	81.0	54.1	36.2	21.1	12.7	7.6	3.9	2.0	0.2	
400	127.0	113.0	94.1	75.5	49.9	32.9	18.0	11.2	6.6	3.3	1.7	0.1	
300	121.2	106.2	89.8	71.7	47.0	30.6	17.4	10.3	6.1	3.0	1.5	0.1	
200	110.6	97.8	80.6	63.6	40.0	25.9	14.4	8.2	4.8	2.2	1.1	0.1	
150	103.8	91.6	75.0	58.7	[illegible]	[illegible]	12.7	7.1	4.1	1.9	0.9	0.1	
100	96.9	85.2	70.4	53.6	33.0	20.6	11.1	6.0	3.4	1.6	0.5	0.1	
80	90.6	79.5	64.4	49.5	30.6	18.2	9.7	5.2	2.9	1.3	0.4		
60	81.7	71.4	57.3	43.5	26.4	15.3	7.9	4.1	2.3	0.9	0.3		
50	76.4	66.5	53.1	40.0	24.0	13.7	5.9	3.5	1.9	0.7			
40	71.4	[illegible]	49.3	36.8	21.8	12.2	5.1	3.0	1.6	0.6			
30	65.0	51.5	42.8	31.5	18.2	9.8	4.5	2.5	1.2				
20	55.0	45.5	35.0	25.3	14.2	[illegible]	3.4	1.5	0.8				
10	37.8	32.0	24.2	15.6	8.6	4.1	1.7	0.6					

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR

JANUARY, 1998
C - 90
I - 160

SURFACE - K =0.90

(L)
UNSHELTERED DISTANCE IN FEET

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	129.5	115.4	96.3	77.1	51.4	34.0	19.7	11.7	7.1	3.5	1.8	0.2	
8000	129.5	115.4	96.3	77.4	51.4	34.0	19.7	11.7	7.1	3.5	1.8	0.2	
6000	129.5	115.4	96.3	77.4	51.4	34.0	19.7	11.7	7.1	3.5	1.8	0.2	
4000	129.5	115.4	96.3	77.4	51.4	34.0	19.7	11.7	7.1	3.5	1.8	0.2	
3000	129.5	115.4	96.3	77.4	51.4	34.0	19.7	11.7	7.1	3.5	1.8	0.2	
2000	129.5	115.4	96.3	77.4	51.4	34.0	19.7	11.7	7.1	3.5	1.8	0.2	
1000	124.8	111.0	92.5	73.9	48.5	31.9	18.3	10.7	6.5	3.2	1.6	0.1	
800	122.5	108.8	90.8	72.3	47.3	30.9	17.6	10.3	6.1	3.0	1.5	0.1	
600	117.5	104.2	86.2	68.5	44.5	28.7	16.6	9.6	5.6	2.7	1.3	0.1	
400	110.7	97.9	80.6	63.6	40.9	25.8	14.9	8.2	4.8	2.2	1.1	0.1	
300	106.3	92.9	77.1	60.5	38.5	24.2	13.3	7.5	4.3	2.0	1.0	0.1	
200	98.1	86.4	72.4	54.7	34.1	21.1	11.4	6.2	3.6	1.7	0.7	0.1	
150	90.2	79.1	64.1	49.2	30.5	18.2	9.6	5.1	2.9	1.2	0.4		
100	82.5	72.1	57.5	44.0	26.3	15.5	8.1	4.2	2.3	0.9	0.3		
80	77.2	67.2	53.8	40.6	24.4	13.9	7.1	3.5	1.8	0.7			
60	69.9	60.5	48.1	35.8	21.1	11.7	5.8	2.9	1.5	0.6			
50	64.4	55.7	43.5	32.2	19.3	10.2	4.5	2.4	1.2				
40	59.1	51.0	39.5	29.1	16.4	8.9	4.2	2.0	1.0				
30	52.6	45.2	35.1	25.2	14.1	7.2	3.3	1.5	0.8				
20	43.2	35.6	28.1	19.7	10.6	5.1	2.3	1.0	0.5				
10	30.8	25.9	19.2	12.9	6.5	2.9	1.2	0.4					

* NOTE: SOIL LOSS FOR VALUES WHERE 'E' IS LESS THAN 0.1 OR GREATER THAN 400.0 ARE NOT SHOWN; OTHER VALUES NOT SHOWN ARE INVALID

** NOTE: VALUES SHOWN ARE FLAT SMALL GRAIN EQUIVALENT, NOT (V)

SUBPART G - EXHIBITS

502.60(a)

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR   JANUARY, 1998
C = 30
SURFACE - K =1.00   I = 310

(V)** FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	248.0	227.1	199.7	174.4	131.4	104.6	70.9	51.0	36.4	23.6	15.5	4.1	2.8
8000	248.0	227.1	199.7	174.4	131.4	104.6	70.9	51.0	36.4	23.6	15.5	4.1	2.8
6000	248.0	227.1	199.7	174.4	131.4	104.6	70.9	51.0	36.4	23.6	15.5	4.1	2.8
4000	248.0	227.1	199.7	174.4	131.4	104.6	70.9	51.0	36.4	23.6	15.5	4.1	2.8
3000	248.0	227.1	199.7	174.4	131.4	104.6	70.9	51.0	36.4	23.6	15.5	4.1	2.8
2000	248.0	227.1	199.7	174.4	131.4	104.6	70.9	51.0	36.4	23.6	15.5	4.1	2.8
1000	248.0	227.1	199.7	174.4	131.4	104.6	70.9	51.0	36.4	23.6	15.5	4.1	2.8
800	248.0	227.1	199.7	174.4	131.4	104.6	70.9	51.0	36.4	23.6	15.5	4.1	2.8
600	248.0	227.1	199.7	174.4	131.4	104.6	70.9	51.0	36.4	23.6	15.5	4.1	2.8
400	248.0	227.1	199.7	174.4	131.4	104.6	70.9	51.0	36.4	23.6	15.5	4.1	2.8
300	245.5	224.7	197.4	172.8	129.5	102.5	69.5	49.8	35.5	22.9	15.0	4.0	2.7
200	238.0	217.5	190.7	166.6	123.8	97.4	65.3	46.6	32.8	20.9	13.5	3.5	2.4
150	230.5	210.4	183.9	159.1	118.1	92.1	61.3	43.2	30.3	19.9	12.2	3.1	2.1
100	223.0	203.7	177.3	152.7	112.5	87.0	57.5	40.0	27.8	17.3	10.9	2.8	1.8
80	215.5	196.1	170.5	146.3	107.2	83.0	53.7	37.0	25.6	15.6	9.7	2.4	1.5
60	203.0	184.3	159.4	135.7	98.3	75.5	47.7	32.3	22.0	13.1	8.0	1.9	1.3
50	193.4	175.4	151.2	127.9	91.9	68.1	43.5	29.0	19.5	11.4	6.8	1.6	1.0
40	185.5	168.0	144.3	121.5	86.4	63.6	40.1	26.4	17.6	10.2	5.0	1.1	0.7
30	173.3	153.5	132.0	105.1	76.5	54.6	33.8	21.5	14.2	7.9	4.5	1.0	0.5
20	148.7	133.2	112.4	91.9	58.6	43.1	25.8	15.9	10.1	5.3	2.9	0.6	
10	117.1	103.9	85.9	68.2	44.4	25.5	16.1	8.1	5.5	2.6	1.3	0.1	

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR   JANUARY, 1998
C = 60
SURFACE K =0.90   I = 310

(V)** FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	223.2	203.4	177.4	152.8	112.8	67.1	57.6	40.1	27.9	17.3	10.9	2.8	1.8
8000	223.2	203.4	177.4	152.8	112.8	87.1	57.6	40.1	27.9	17.3	10.9	2.8	1.8
6000	223.2	203.4	177.4	152.8	112.8	87.1	57.6	40.1	27.9	17.3	10.9	2.8	1.8
4000	223.2	203.4	177.4	152.8	112.8	87.1	57.6	40.1	27.9	17.3	10.9	2.8	1.8
3000	223.2	203.4	177.4	152.8	112.8	87.1	57.6	40.1	27.9	17.3	10.9	2.8	1.8
2000	223.2	203.4	177.4	152.8	112.8	87.1	57.6	40.1	27.9	17.3	10.9	2.8	1.8
1000	223.2	203.4	177.4	152.8	112.8	87.1	57.6	40.1	27.9	17.3	10.9	2.8	1.8
800	223.2	203.4	177.4	152.8	112.8	87.1	57.6	40.1	27.9	17.3	10.9	2.8	1.8
600	223.2	203.4	177.4	152.8	112.8	87.1	57.6	40.1	27.9	17.3	10.9	2.8	1.8
400	220.4	200.8	174.9	150.5	110.8	85.3	55.2	39.0	27.1	16.7	10.5	2.6	1.6
300	215.6	196.2	170.6	146.4	107.3	83.1	53.6	37.1	25.5	15.7	9.8	2.4	1.5
200	207.5	188.7	163.8	139.8	101.7	77.1	50.0	34.1	23.4	14.1	8.7	2.1	1.4
150	197.6	179.2	154.7	131.7	94.1	70.6	45.3	30.4	20.6	12.1	7.3	1.7	1.1
100	187.5	165.6	145.8	122.9	87.6	64.5	40.8	27.0	18.3	10.4	6.2	1.4	0.9
80	181.7	154.5	140.8	119.3	83.7	61.0	38.4	25.7	16.7	9.5	5.6	1.4	0.7
60	168.0	151.3	128.9	107.1	74.7	53.3	32.8	21.6	13.7	7.5	4.3	0.9	0.5
50	159.5	143.0	121.6	100.7	69.2	48.7	29.5	19.7	12.0	6.5	3.6	0.8	0.4
40	147.2	133.8	112.9	92.5	63.0	43.5	26.0	15.1	10.2	5.3	2.9	0.5	
30	134.4	125.6	100.9	84.0	56.4	38.5	23.4	13.5	8.4	4.4	2.2	0.2	
20	120.1	105.7	88.4	70.5	46.0	29.6	16.3	9.8	5.9	2.8	1.4	0.1	
10	94.4	83.0	67.4	52.1	32.5	19.7	10.5	5.7	3.2	1.4	0.4		

* NOTE: SOIL LOSS FOR VALUES WHERE (E) IS LESS THAN 0.1 OR GREATER THAN 300.0 ARE NOT SHOWN; OTHER VALUES NOT SHOWN ARE INVALID

** NOTE VALUES SHOWN ARE FLAT SMALL GRAIN EQUIVALENT, ACT (V)

(190-V-NAM, Third Ed., January 1998)

SUBPART G - EXHIBITS

502.60(a)

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR JANUARY, 1998
C = 90
SURFACE - K =1.00
I = 310
(L) (V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	279.0	256.8	228.0	202.1	155.9	128.3	89.4	65.6	48.5	33.2	22.8	6.4	4.5
8000	279.0	256.8	228.0	202.1	155.9	128.3	89.4	65.6	48.9	33.2	22.8	6.4	4.5
6000	279.0	256.8	228.0	202.1	155.9	128.3	89.4	65.6	48.9	33.3	22.8	6.4	4.5
4000	279.0	256.8	228.0	202.1	155.9	128.3	89.4	65.6	48.9	33.3	22.8	6.4	4.5
3000	279.0	256.8	228.0	202.1	155.9	128.3	89.4	65.6	48.9	33.2	22.8	6.4	4.5
2000	279.0	256.8	228.0	202.1	155.9	128.3	89.4	65.6	48.9	33.2	22.8	6.4	4.5
1000	279.0	256.8	228.0	202.1	155.9	128.3	89.4	65.6	48.9	33.3	22.8	6.4	4.5
800	279.0	256.8	228.0	202.1	155.9	128.3	89.4	65.6	48.9	33.3	22.8	6.4	4.5
600	279.0	256.8	228.0	202.1	155.9	128.3	89.4	65.6	48.9	33.3	22.8	6.4	4.5
400	279.0	256.8	228.0	202.1	155.9	128.3	89.4	65.6	48.9	33.3	22.8	6.4	4.5
300	279.3	255.1	225.5	199.5	153.6	126.1	87.9	65.1	47.7	32.7	22.1	6.2	4.3
200	265.2	246.3	218.0	192.2	147.1	120.8	83.7	63.0	44.3	29.6	20.0	5.5	3.8
150	260.6	239.1	211.2	185.9	141.2	116.0	78.2	57.6	41.3	27.2	18.2	5.0	3.4
100	252.1	231.9	204.3	178.5	135.0	108.4	75.8	53.4	38.3	25.0	16.6	4.4	3.0
80	247.6	224.6	197.5	172.3	129.5	102.9	69.5	49.8	35.5	22.9	15.0	4.0	2.9
60	233.1	212.8	186.3	161.4	120.1	94.3	63.7	41.0	31.1	19.7	12.6	3.3	2.2
50	221.3	204.5	176.4	153.8	113.6	87.9	58.2	40.6	26.5	17.5	11.1	2.8	1.9
40	213.6	195.2	170.5	146.6	107.2	[illegible]	53.8	37.1	25.6	15.5	9.8	2.4	1.6
30	197.9	179.4	154.9	132.5	94.2	70.7	45.4	30.5	20.6	12.2	7.4	1.7	1.1
20	[illegible]	158.1	135.7	113.0	79.5	57.4	35.7	23.2	14.2	8.5	5.2	1.1	0.6
10	134.6	123.8	103.5	84.3	56.5	38.2	22.5	13.6	6.4	4.3	2.3	0.2	

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR JANUARY, 1998
C = 90
SURFACE - K =0.90
I = 310
(L) (V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	251.1	230.3	202.5	177.1	132.8	105.9	72.6	52.4	37.5	24.4	16.1	4.3	3.0
8000	251.1	230.3	202.5	177.1	132.8	105.9	72.6	52.4	37.5	24.4	16.1	4.3	3.0
6000	251.1	230.3	202.5	177.1	132.8	105.9	72.6	52.4	37.5	24.4	16.1	4.3	3.0
4000	251.1	230.3	202.5	177.1	132.8	105.9	72.6	52.4	37.5	24.4	16.1	4.3	3.0
3000	251.1	230.3	202.5	177.1	132.8	105.9	72.6	52.4	37.5	24.4	16.1	4.3	3.0
2000	251.1	230.3	202.5	177.1	132.8	105.9	72.6	52.4	37.5	24.4	16.1	4.3	3.0
1000	251.1	230.3	202.5	177.1	132.8	105.9	72.6	52.4	37.5	24.4	16.1	4.3	3.0
800	251.1	230.3	202.5	177.1	132.8	105.9	72.6	52.4	37.5	24.4	16.1	4.3	3.0
600	251.1	230.3	202.5	177.1	132.8	105.9	72.6	52.4	37.5	24.4	16.1	4.3	3.0
400	248.3	227.4	200.0	175.7	131.6	104.5	71.1	51.1	36.5	23.7	15.5	4.1	2.9
300	243.6	222.8	195.7	170.5	128.0	101.4	68.4	48.9	34.0	22.3	14.5	3.8	2.7
200	235.8	215.4	190.7	163.7	122.1	95.9	64.2	45.4	32.0	20.7	13.1	3.4	2.3
150	225.6	205.8	179.7	155.0	114.6	88.9	59.5	41.2	28.7	17.5	11.4	2.9	1.9
100	215.7	196.3	172.7	146.4	107.2	82.1	53.8	37.1	25.5	15.7	9.8	2.4	1.7
80	205.2	189.1	164.0	140.1	101.9	76.2	50.2	34.2	23.4	14.1	8.7	2.1	1.4
60	192.1	174.0	149.8	125.7	90.7	65.2	42.8	28.3	19.1	11.2	6.7	1.5	1.0
50	183.4	165.7	142.2	119.5	84.6	60.0	39.1	25.7	17.0	9.9	5.7	1.3	0.8
40	174.2	157.1	134.2	112.1	[illegible]	56.7	35.3	22.8	15.0	8.4	4.9	1.1	0.6
30	155.5	144.2	122.4	101.7	69.5	49.2	30.0	19.6	12.2	6.5	3.7	0.9	0.4
20	140.4	125.8	[illegible]	85.6	57.7	39.1	23.0	14.0	8.7	4.5	2.4	0.2	
10	130.3	95.8	[illegible]	63.6	40.2	25.3	14.1	7.9	4.6	2.1	1.0	0.1	

* NOTE: SOIL LOSS FOR VALUES WHERE 'E' IS LESS THAN 0.1 OR GREATER THAN 300.0 ARE NOT SHOWN; OTHER VALUES NOT SHOWN ARE INVALID

** NOTE: VALUES SHOWN ARE FLAT SMALL GRAIN EQUIVALENT, NOT [illegible]

(190-V-NAM, Third Ed., January 1998)

1. **Calculation No.:** 08023-CAL-C-002	2. **Revision No.:** 1	3. **Date:** 6-4-09	4. **Project No.:** 08023	5. **Pages** 5

6. **Calculation Title:** Area 5 RWMS Internal Drainage Hydrology	7. **Project Title:** 92 Acre Grading and Drainage

8. **Calculation Type:** ☐ Preliminary ☒ Final ☐ Voided/ Superseded	**9. Quality Grade** ☐ QG-1 ☒ QG-3 ☐ QG-2 ☐ QG-4	**10. Performance Category** ☒ PC-1 ☐ PC-2 ☐ PC-3	11. Superseded by Calculation No.: N/A 12. Supersedes Calculation No.: N/A

Original and Revised Calculation/Analysis Approval (Signature/Date)

13.	**Revision 1**	**Revision**	**Revision**
14. Preparer:	Luanne Fairbanks	1	6/4/09 Date
15. Checker:	Robert Niedringhaus	1	6-4-09 Date
16. Peer Reviewer:	N/A		Date
17. Discipline Section Supervisor:	Steven Goold	1	6-8-09 Date

Affected Documents

Document No.	**Document Title**	**Revision No**	**Responsible Discipline Lead Initials**

Record of Revision

Revision No.	**Reason for Revision**
0	Original
1	Removed channel and culvert hydraulic calculations from 08023-CAL-C-002. Included revised calculations for final design in 09068-CAL-C01 Rev 0.

Attachments

Attachment No.	**Title**	**Total Pages**
A.	Site Map and Subbasin Delineation	3
B.	Point Precipitation Frequency Estimates From NOAA Atlas 14	5
C.	HEC-HMS Basin Schematic and Summary Output	2
D.	HEC-HMS Input Files	3
E.	Travel Time Velocity	1
	Total Calculation Page Count	19

6/4/09

LUANNE

No 12725

6/30/09

1 Introduction

This calculation was generated to determine the 25-YR 24-HR flood flows impacting the proposed final graded areas for the 92-acre area within the Area 5 Radioactive Waste Management Site (RWMS).

This calculation addresses drainage within the berm/channel system protecting the Area 5 RWMS from offsite flooding. The drainage area is split into two basic subbasins (see Attachment A, Figure A-1): (1) the "expansion area" and (2) the 92-acre area. The expansion area is an area of active waste disposal. Once a disposal cell is filled, the cell is operationally closed with a bare soil cover. Flow from the expansion area will be diverted to the west of the 92-acre area. Flows were also calculated from two partial areas within the 92-acre area to size an internal diversion channel and calculate required sideslope riprap (see Attachment A, Figure A-2).

2 Basis

The 25-YR 24-HR design storm level and location of the final graded areas was given by Waste Management grading and drainage project personnel.

2.1 Design Inputs

- Basin losses were modeled using the SCS curve number approach, curve numbers were assigned to areas based on engineering judgment and tabulated values given in Table 604 of CCRFCD, 2008.
- Site location information was derived from aerial photographs and the NSTec engineering CADD database. Attachment A contains site maps.
- Watersheds were delineated from interpretation of site topographic maps, orthophotos and field reconnaissance. Watershed areas were derived using aerial photographs and preliminary graded area designs. The watersheds drain to the south/southwest with a maximum slope of 2%, based on graded area designs and site topographic information.
- Approximate location of the final graded area is E 593,130, N 4,079,388, UTM zone 11 NAD 83, meters.
- Design storm precipitation data was obtained from NOAA, 2006 and is presented as Attachment B.

2.2 Criteria

Compute flood flows impacting the proposed final graded areas for the 92-acre within the Area 5 Radioactive Waste Management Site (RWMS) from a 25-YR 24-HR design storm.

2.3 Assumptions

- The precipitation design event has a 5 minute maximum intensity, 50% peak center.
- The 92-acre disposal area will be closed with a monolayer evapotranspiration type final graded area using native alluvium and vegetated with native plant species. The maximum cover slope is 2%.
- The entire expansion area has only a bare soil cover and a 2% slope.
- The 92-acre area final graded areas will have established native vegetation with a curve number (CN) of 63, the expansion area has a CN of 72, urban area CN = 98 (Table 604 CCRFCD, 2008). Assume AMC II conditions.

3 References

National Oceanic and Atmospheric Administration (NOAA), *Precipitation-Frequency Atlas of the United States*, NOAA Atlas 14, Volume 1, Version 4, National Weather Service Silver Spring, Maryland, 2006, accessed January 23, 2008 http://www.nws.noaa.gov/ohd/hdsc/.

Clark County Regional Flood Control District (CCRFCD), *Hydrologic Criteria and Drainage Design Manual*, Las Vegas, Nevada. Adopted August 12,1999, including all current revisions.

U.S. Army Corps of Engineers, 2003. *Hydrologic Modeling System HEC-HMS* (HEC-HMS computer program version 2.2.2), Davis California. May 2003.

Mays, Larry W., *Water Resources Engineering*. John Wiley & Sons, Inc, Hoboken NJ, 2001.

Microsoft Excel 2002 SP3

4 Methods

- Runoff flows for all basins were calculated with the SCS synthetic unit hydrograph model and curve number method to represent basin losses.
- The frequency storm option within HEC-HMS was used for the meteorologic model.

5 Results and Conclusions

The below table summarizes the calculated flows impacting the graded areas for a 25-YR 24-HR design storm event.

HEC-HMS Summary Table

Subbasin	Area (mi^2)	Total precipitation (in)	Peak discharge (cfs)	Total volume of discharge (acre-ft)
Expansion area	0.26	2.17	38.0	5.1
92 acre area	0.19	2.17	17.9	2.8
Zone 1 plus swale	0.044	2.17	2.6	0.47
West section	0.026	2.17	0.85	0.2

The HEC-HMS basin model schematic and summary output is presented as Attachment C.

The following three (3) HEC-HMS generated files presenting model input and topology and are included as Attachment D.

C:\hmsproj\A5_RWMS_internal\Basin_1.basin
C:\hmsproj\A5_RWMS_internal\Met_1.met
C:\hmsproj\A5_RWMS_internal\Control_1.control

6 Calculations and Analyses

All rainfall-runoff calculations were performed with HEC-HMS using the SCS curve number method to account for basin losses and the SCS synthetic unit hydrograph approach for transformation of rainfall into runoff.

The time of concentration for each subbasin is calculated using Equation 601 from CCRFCD, 2008.

$$t_c = t_i + t_t$$

where:

t_c = time of concentration (min)
t_i = initial or overland flow time (min)
t_t = travel time in the ditch, channel, gutter, storm sewer, gully etc. (min)

from CCRFCD, 2008 Equation 602:

$$t_i = \frac{1.8(1.1-K)L_o^{0.5}}{S^{1/3}}$$

where:

t_i = initial or overland flow time (min)
K = flow resistance coefficient
L_o = length of overland flow (500 ft maximum)
S = average basin slope (%)

from CCRFCD, 2008 Equation 603:

$$K = 0.0132CN - 0.39$$

where:

CN = SCS curve number

The gully flow velocity (V_g) is obtained from Figure 602 (CCRFCD, 2008) (included as Attachment E). The length of gully flow is obtained from the below equation.

$$L_g = L_b - L_o$$

where:

L_g = length of gully flow (ft)
L_b = length of the subbasin (ft)
L_o = length of overland flow (500 ft maximum)

The gully flow travel time (t_t) is obtained from the below equation:

$$t_t = L_g \frac{1}{V_g} \frac{1\min}{60s}$$

where:

t_t = travel time in the ditch, channel, gutter, storm sewer, gully etc. (min)
L_g = length of gully flow (ft)
V_g = gully flow velocity (ft/s)

The lag time (t_{lag}) for each subbasin is calculated using the SCS relationship to time of concentration shown below (Equation 612 from CCRFCD, 2008):

$$t_{lag} = 0.6t_c$$

Subbasin Curve Number Summary

Subbasin	% Vegetative Cover	% Bare Cover	% Urban	Weighted CN
expansion area	0	100	0	72
92 acre area	46	50	4	69
Zone 1 plus swale	70	30	0	65.7
West section	100	0	0	63

Subbasin Physical Parameter Summary

Subbasin	Area (mi^2)	CN	L_b (ft)	L_o (ft)	L_g (ft)	Slope (%)	K
expansion area	0.26	72	3165	500	2665	2	0.56
92 acre area	0.19	69	2600	500	2100	1.5	0.52
Zone 1 plus swale	0.04	65.7	1250	500	750	1.5	0.48
West section	0.026	63	1400	500	900	2	0.44

Subbasin Lag Time Parameter Summary

Subbasin	t_i (min)	V_g (ft/s)	t_t (min)	t_c (min)	t_{lag} (min)
expansion area	17.2	2.8	15.9	33.1	19.9
92 acre area	20.4	2.5	14.0	34.4	20.6
Zone 1 plus swale	21.9	2.5	5.0	26.9	16.1
West section	21.0	2.8	5.4	26.4	15.8

6/8/09

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Attachment A
Site Map and Subbasin Delineation

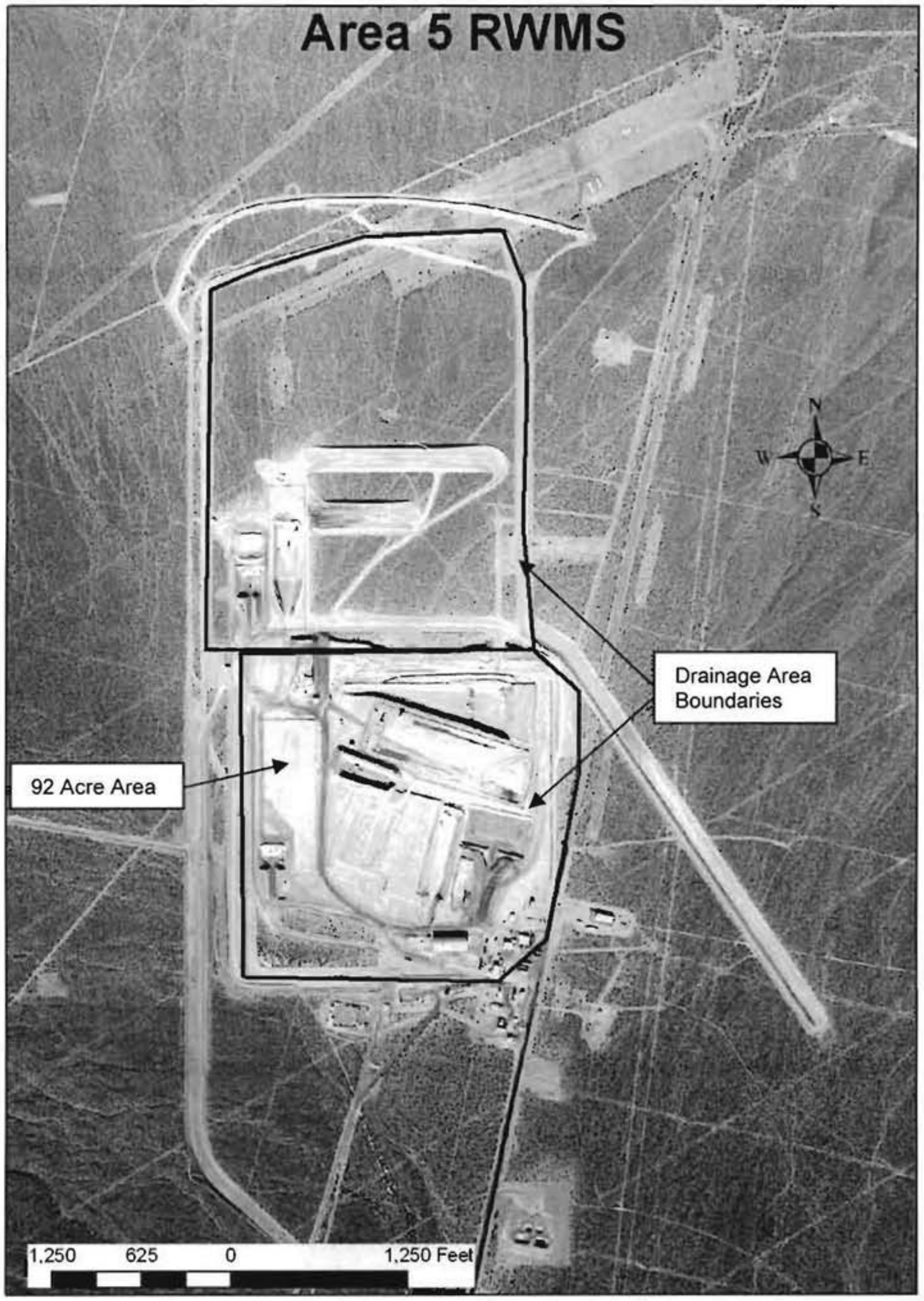


Figure A-1 : Expansion Area and 92-Acre Area Subbasin Delineation

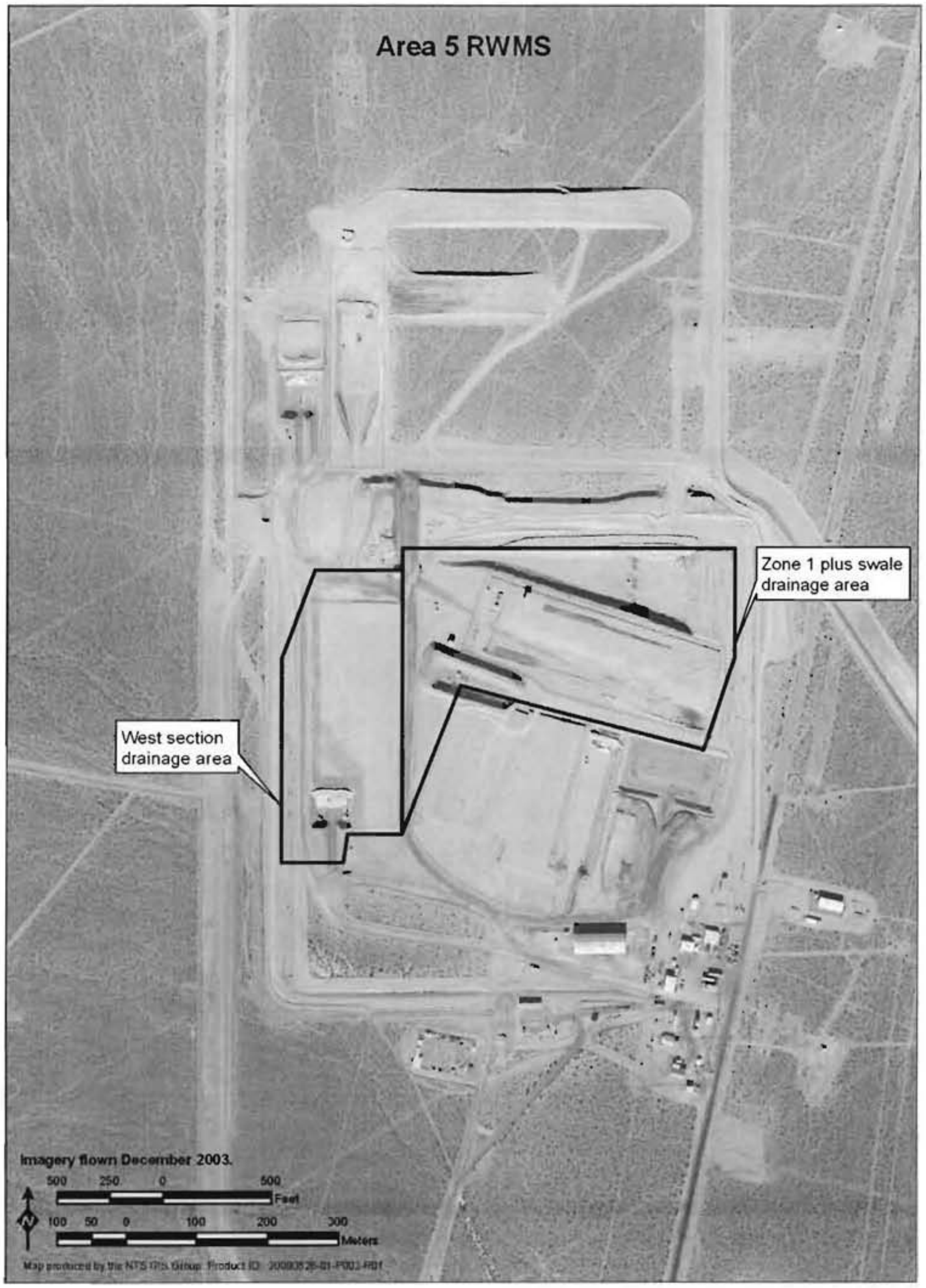


Figure A-2: Drainage Areas

Prepare 6/8/09

Checker: 6/8/09

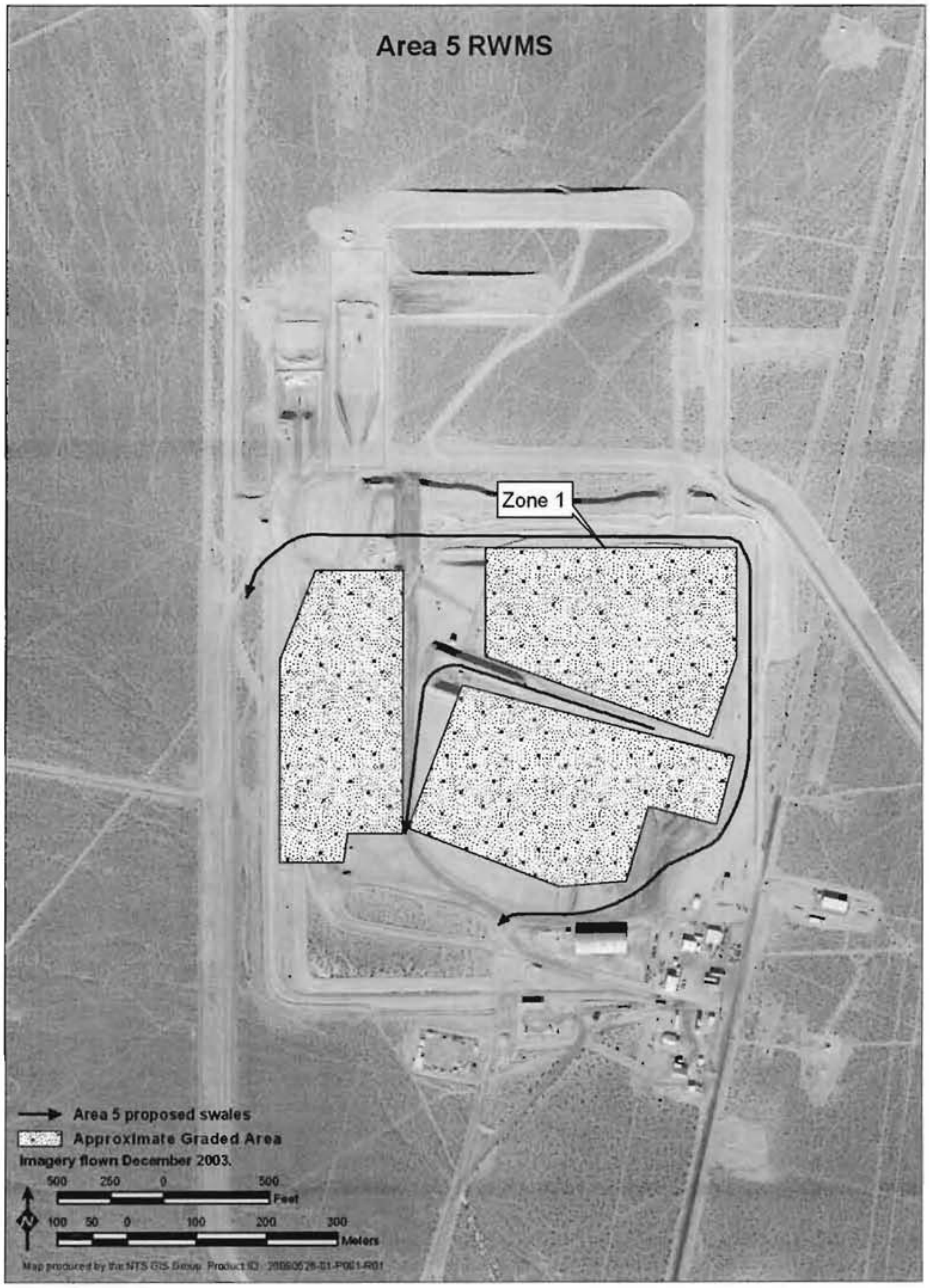
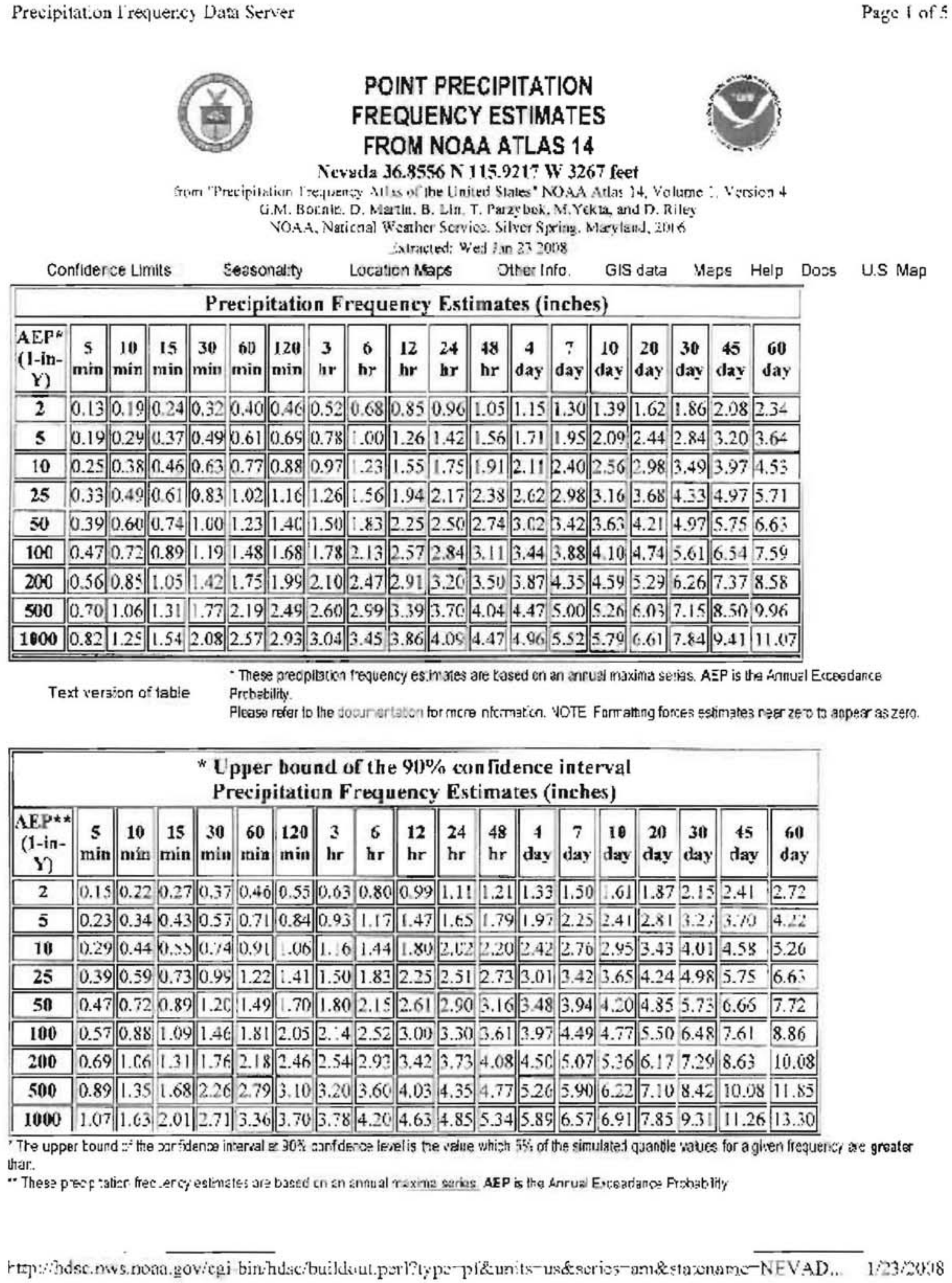


Figure A-3: Swale Areas

Preparer: /8/09

Checker 6/8/09

Attachment B
Point Precipitation Frequency Estimates from NOAA Atlas 14



POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Nevada 36.8556 N 115.9217 W 3267 feet

from "Precipitation Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006
Extracted: Wed Jan 23 2008

Confidence Limits Seasonality Location Maps Other Info. GIS data Maps Help Docs U.S Map

Precipitation Frequency Estimates (inches)

AEP* (1-in-Y)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.13	0.19	0.24	0.32	0.40	0.46	0.52	0.68	0.85	0.96	1.05	1.15	1.30	1.39	1.62	1.86	2.08	2.34
5	0.19	0.29	0.37	0.49	0.61	0.69	0.78	1.00	1.26	1.42	1.56	1.71	1.95	2.09	2.44	2.84	3.20	3.64
10	0.25	0.38	0.46	0.63	0.77	0.88	0.97	1.23	1.55	1.75	1.91	2.11	2.40	2.56	2.98	3.49	3.97	4.53
25	0.33	0.49	0.61	0.83	1.02	1.16	1.26	1.56	1.94	2.17	2.38	2.62	2.98	3.16	3.68	4.33	4.97	5.71
50	0.39	0.60	0.74	1.00	1.23	1.40	1.50	1.83	2.25	2.50	2.74	3.02	3.42	3.63	4.21	4.97	5.75	6.63
100	0.47	0.72	0.89	1.19	1.48	1.68	1.78	2.13	2.57	2.84	3.11	3.44	3.88	4.10	4.74	5.61	6.54	7.59
200	0.56	0.85	1.05	1.42	1.75	1.99	2.10	2.47	2.91	3.20	3.50	3.87	4.35	4.59	5.29	6.26	7.37	8.58
500	0.70	1.06	1.31	1.77	2.19	2.49	2.60	2.99	3.39	3.70	4.04	4.47	5.00	5.26	6.03	7.15	8.50	9.96
1000	0.82	1.25	1.54	2.08	2.57	2.93	3.04	3.45	3.86	4.09	4.47	4.96	5.52	5.79	6.61	7.84	9.41	11.07

Text version of table

* These precipitation frequency estimates are based on an annual maxima series. AEP is the Annual Exceedance Probability.
Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.

*** Upper bound of the 90% confidence interval**
Precipitation Frequency Estimates (inches)

AEP** (1-in-Y)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.15	0.22	0.27	0.37	0.46	0.55	0.63	0.80	0.99	1.11	1.21	1.33	1.50	1.61	1.87	2.15	2.41	2.72
5	0.23	0.34	0.43	0.57	0.71	0.84	0.93	1.17	1.47	1.65	1.79	1.97	2.25	2.41	2.81	3.27	3.70	4.22
10	0.29	0.44	0.55	0.74	0.91	1.06	1.16	1.44	1.80	2.02	2.20	2.42	2.76	2.95	3.43	4.01	4.58	5.26
25	0.39	0.59	0.73	0.99	1.22	1.41	1.50	1.83	2.25	2.51	2.73	3.01	3.42	3.65	4.24	4.98	5.75	6.63
50	0.47	0.72	0.89	1.20	1.49	1.70	1.80	2.15	2.61	2.90	3.16	3.48	3.94	4.20	4.85	5.73	6.66	7.72
100	0.57	0.88	1.09	1.46	1.81	2.05	2.14	2.52	3.00	3.30	3.61	3.97	4.49	4.77	5.50	6.48	7.61	8.86
200	0.69	1.06	1.31	1.76	2.18	2.46	2.54	2.93	3.42	3.73	4.08	4.50	5.07	5.36	6.17	7.29	8.63	10.08
500	0.89	1.35	1.68	2.26	2.79	3.10	3.20	3.60	4.03	4.35	4.77	5.26	5.90	6.22	7.10	8.42	10.08	11.85
1000	1.07	1.63	2.01	2.71	3.36	3.70	3.78	4.20	4.63	4.85	5.34	5.89	6.57	6.91	7.85	9.31	11.26	13.30

* The upper bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are greater than.
** These precipitation frequency estimates are based on an annual maxima series. AEP is the Annual Exceedance Probability

Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

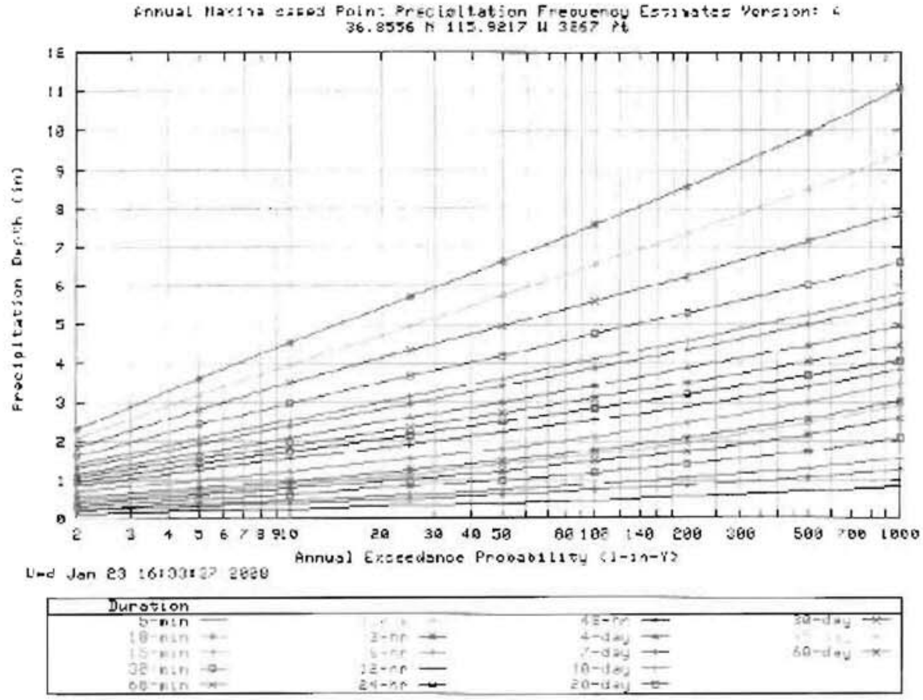
*** Lower bound of the 90% confidence interval**
Precipitation Frequency Estimates (inches)

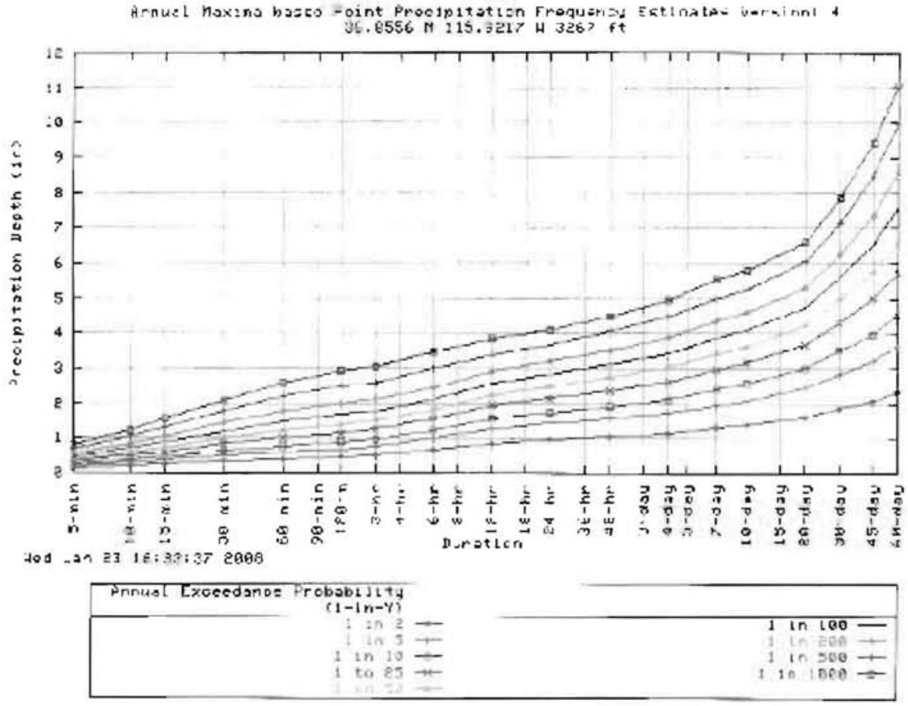
AEP** (1-in-Y)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.10	0.15	0.19	0.25	0.31	0.38	0.45	0.58	0.74	0.83	0.91	0.99	1.12	1.20	1.39	1.60	1.78	1.99
5	0.15	0.23	0.29	0.39	0.48	0.58	0.66	0.85	1.09	1.23	1.35	1.48	1.68	1.80	2.10	2.43	2.73	3.09
10	0.19	0.30	0.37	0.49	0.61	0.73	0.82	1.05	1.33	1.50	1.65	1.80	2.05	2.19	2.55	2.98	3.39	3.84
25	0.26	0.39	0.49	0.65	0.81	0.94	1.04	1.31	1.66	1.85	2.03	2.23	2.53	2.69	3.14	3.68	4.21	4.81
50	0.31	0.47	0.58	0.78	0.97	1.12	1.23	1.52	1.90	2.12	2.32	2.54	2.88	3.06	3.56	4.18	4.83	5.54
100	0.36	0.55	0.69	0.92	1.14	1.32	1.43	1.75	2.15	2.38	2.60	2.86	3.23	3.43	3.98	4.69	5.44	6.28
200	0.42	0.64	0.80	1.07	1.33	1.53	1.65	1.99	2.40	2.64	2.88	3.18	3.58	3.79	4.38	5.19	6.06	7.01
500	0.52	0.78	0.97	1.31	1.62	1.86	1.98	2.36	2.74	3.00	3.26	3.60	4.04	4.26	4.91	5.83	6.86	7.97
1000	0.59	0.90	1.12	1.51	1.86	2.12	2.26	2.66	3.07	3.27	3.54	3.92	4.39	4.62	5.30	6.32	7.47	8.72

* The lower bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are less than

** These precipitation frequency estimates are based on an annual maxima series. AEP is the Annual Exceedance Probability.

Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

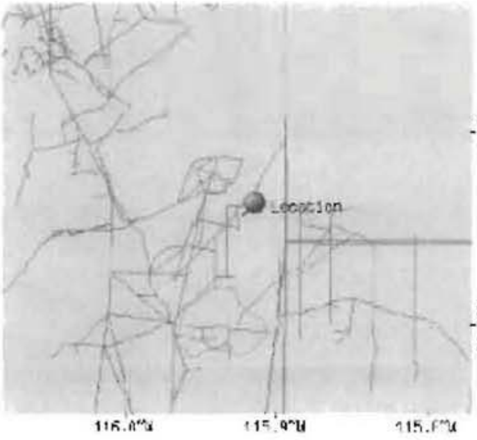




Maps -

These maps were produced using a direct map request from the U.S. Census Bureau Mapping and Cartographic Resources Tiger Map Server

Please read disclaimer for more information.



Other Maps/Photographs -

View USGS digital orthophoto quadrangle (DOQ) covering this location from TerraServer; **USGS Aerial Photograph** may also be available
from this site. A DOQ is a computer-generated image of an aerial photograph in which image displacement caused by terrain relief and camera tilts has been removed. It combines the image characteristics of a photograph with the geometric qualities of a map. Visit the USGS for more information.

Watershed/Stream Flow Information -

Find the Watershed for this location using the U.S. Environmental Protection Agency's site.

Climate Data Sources -

Precipitation frequency results are based on data from a variety of sources, but largely NCDC. The following links provide general information
about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study,
please refer to our documentation.

Using the **National Climatic Data Center's (NCDC)** station search engine, locate other climate stations within:

+/-30 minutes ...OR... +/-1 degree of this location (36.8556/-115.9217). Digital ASCII data can be obtained directly from NCDC.

Find Natural Resources Conservation Service (NRCS) SNOTEL (SNOwpack TELemetry) stations by visiting the **Western Regional Climate Center's state-specific SNOTEL station maps.**

Hydrometeorological Design Studies Center
DOC/NOAA/National Weather Service
1325 East-West Highway
Silver Spring, MD 20910

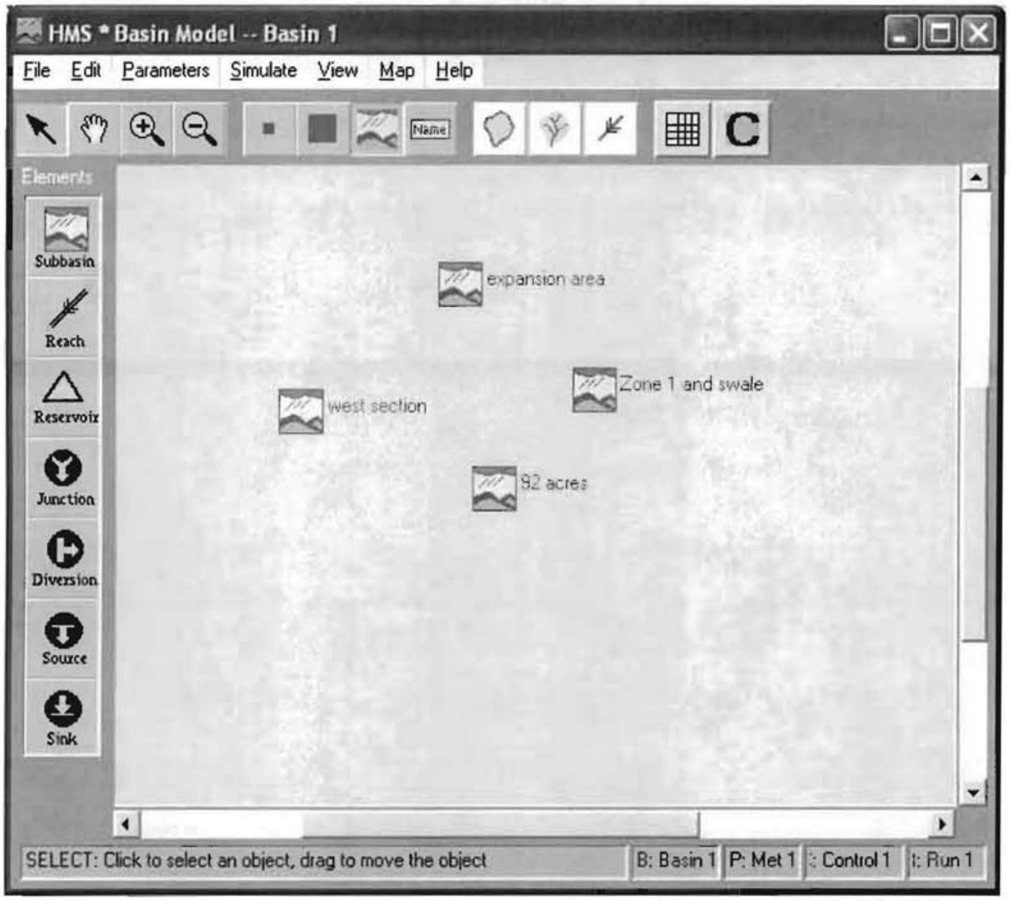
6/8/09

6/8/09

(301) 713-1669
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Attachment C
HEC-HMS Basin Schematic and Summary Output



SELECT: Click to select an object, drag to move the object

Figure C-1: HEC-HMS Basin Model Schematic

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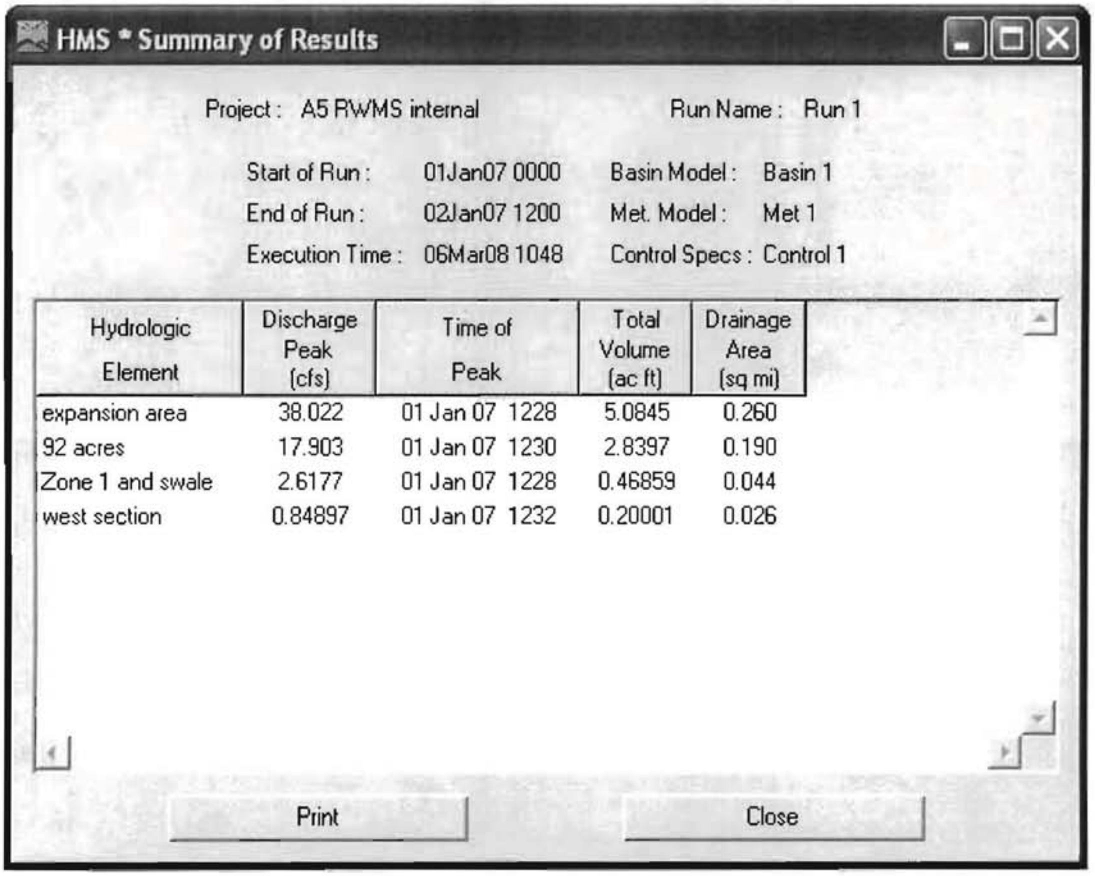


Project : A5 RWMS internal   Run Name : Run 1

Start of Run : 01Jan07 0000   Basin Model : Basin 1
End of Run : 02Jan07 1200   Met. Model : Met 1
Execution Time : 06Mar08 1048   Control Specs : Control 1

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Total Volume (ac ft)	Drainage Area (sq mi)
expansion area	38.022	01 Jan 07 1228	5.0845	0.260
92 acres	17.903	01 Jan 07 1230	2.8397	0.190
Zone 1 and swale	2.6177	01 Jan 07 1228	0.46859	0.044
west section	0.84897	01 Jan 07 1232	0.20001	0.026

Figure C-2: HEC-HMS Results Summary

Attachment D
HEC-HMS Input Files

C:\hmsproj\A5_RWMS_internal\Basin_1.basin

```
Basin: Basin 1
   Last Modified Date: 6 March 2008
   Last Modified Time: 10:48:20
   Version: 2.2.2
   Default DSS File Name: C:\hmsproj\A5_RWMS_internal\A5_RWMS_internal.dss
   Unit System: English
End:

Subbasin: expansion area
   Canvas X: -329.835
   Canvas Y: 1329.034
   Label X: 16
   Label Y: 0
   Area: 0.26

   LossRate: SCS
   Percent Impervious Area: 0.0
   Curve Number: 72

   Transform: SCS
   Lag: 19.900000

   Baseflow: None
End:

Subbasin: 92 acres
   Canvas X: -329.834
   Canvas Y: 1329.027
   Label X: 16
   Label Y: 0
   Area: 0.19

   LossRate: SCS
   Percent Impervious Area: 0.0
   Curve Number: 69

   Transform: SCS
   Lag: 20.600000

   Baseflow: None
End:

Subbasin: Zone 1 and swale
   Canvas X: -329.830
   Canvas Y: 1329.030
   Label X: 16
   Label Y: 0
   Area: 0.044

   LossRate: SCS
```

```
     Percent Impervious Area: 0.0
     Curve Number: 65.7

     Transform: SCS
     Lag: 16.100000

     Baseflow: None
End:

Subbasin: west section
     Canvas X: -329.840
     Canvas Y: 1329.029
     Label X: 16
     Label Y: 0
     Area: 0.026

     LossRate: SCS
     Percent Impervious Area: 0.0
     Curve Number: 63

     Transform: SCS
     Lag: 15.800000

     Baseflow: None
End:

Default Attributes:
     Default Basin Unit System: English
     Default Meteorology Unit System: SI
     Default Loss Rate: Initial+Constant
     Default Transform: Modified Clark
     Default Baseflow: Recession
     Default Route: Muskingum
     Enable Flow Ratio: No
     Enable Evapotranspiration: No
     Compute Local Flow At Junctions: No
     Missing Flow To Zero: No
End:
```

C:\hmsproj\A5_RWMS_internal\Met_1.met

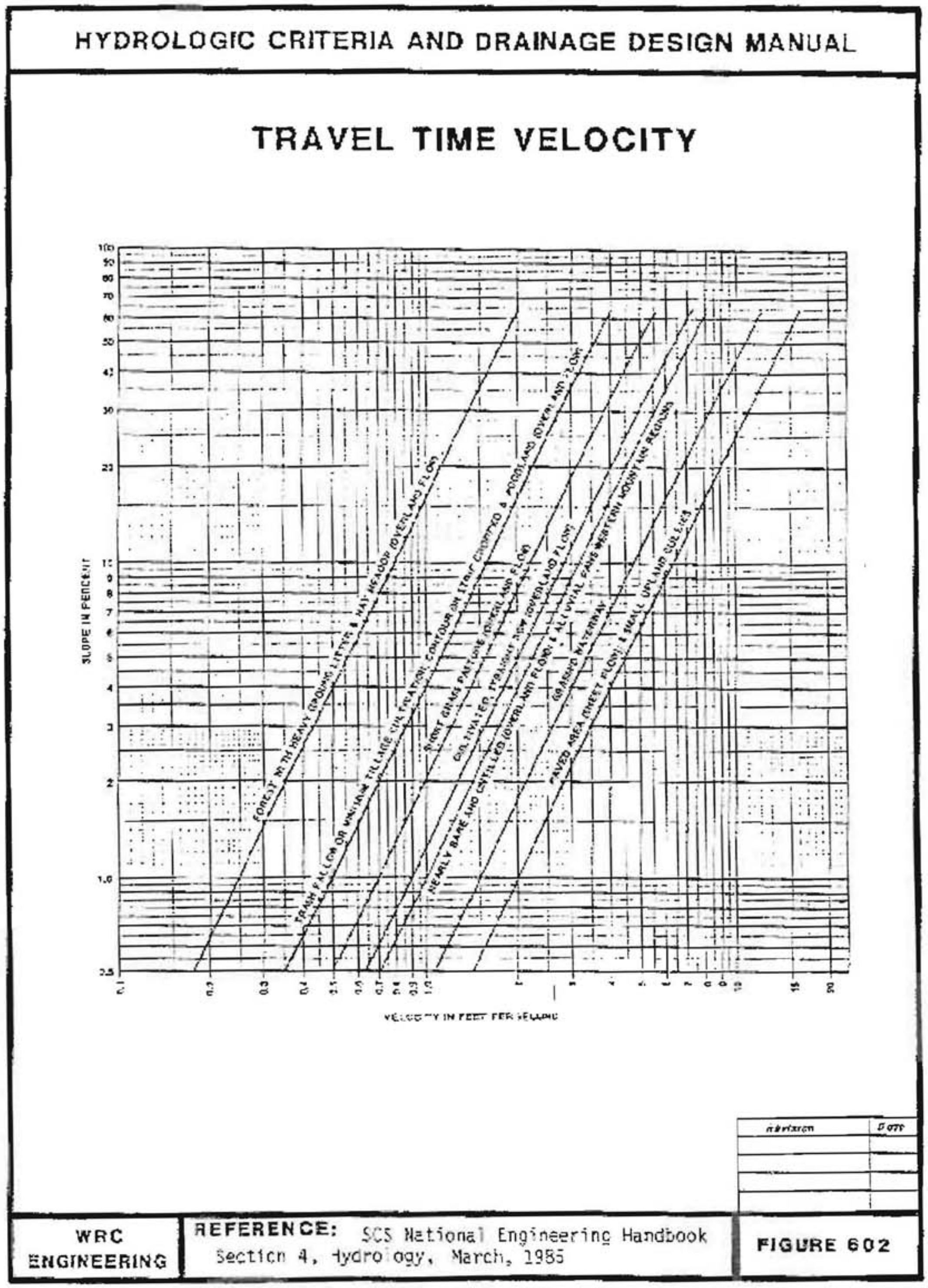
```
Precip: Met 1
     Last Modified Date: 27 February 2008
     Last Modified Time: 13:09:17
     Version: 2.2.2
     Default DSS File Name: C:\hmsproj\A5_RWMS_internal\A5_RWMS_internal.dss
     Unit System: English
     Enable Evapotranspiration: No
     Precipitation Method: Frequency Based Hypothetical
End:

Method Parameters: Frequency Based Hypothetical
     Exceedence Frequency: 4
     Single Hypothetical Storm Size: Yes
     Convert to Annual Series: Yes
     Storm Size:
```

```
     Total Duration: 1440
     Time Interval: 5
     Percent of Duration Before Peak Rainfall: 50
     Depth: 0.33
     Depth: 0.61
     Depth: 1.02
     Depth: 1.16
     Depth: 1.26
     Depth: 1.56
     Depth: 1.94
     Depth: 2.17
End:

Subbasin: classified area
End:

Subbasin: expansion area
End:

Subbasin: Subbasin-1
End:

Subbasin: expansion with SCS
End:
```

C:\hmsproj\A5_RWMS_internal\Control_1.control

```
Control: Control 1
     Last Modified Date: 21 February 2008
     Last Modified Time: 14:44:11
     Start Date: 1 January 2007
     Start Time: 00:00
     End Date: 2 January 2007
     End Time: 12:00
     Time Interval: 2
End:
```

Attachment E
Travel Time Velocity



HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

TRAVEL TIME VELOCITY

REVISION	DATE

WRC ENGINEERING	REFERENCE: SCS National Engineering Handbook Section 4, Hydrology, March, 1985	FIGURE 602

Figure E-1: Travel Time Velocity

Preparer: 6/8/09

Checker: 6/8/09

1. **Calculation No.:** 08023-CAL-C-003	2. **Revision No.:** 1	3. **Date:** 6-4-09	4. **Project No.:** 08023	5. **Pages** 7

6. **Calculation Title:** Area 5 RWMS Water Erosion	7. **Project Title:** 92 Acre Grading and Drainage

8. **Calculation Type:** ☐ Preliminary ☒ Final ☐ Voided/ Superseded	9. **Quality Grade** ☐ QG-1 ☒ QG-3 ☐ QG-2 ☐ QG-4	10. **Performance Category** ☒ PC-1 ☐ PC-2 ☐ PC-3	11. Superseded by Calculation No.: N/A 12. Supersedes Calculation No.: N/A

Original and Revised Calculation/Analysis Approval (Signature/Date)

13.	Revision 1	Revision	Revision
14. **Preparer:**	Luanne Fairbanks	1	6/4/09 Date
15. **Checker:**	Robert Niedringhaus	1	6-4-09 Date
16. **Peer Reviewer:**	N/A		Date
17. **Discipline Section Supervisor:**	Steven Goold	1	6-8-09 Date

Affected Documents

Document No.	Document Title	Revision No	Responsible Discipline Lead Initials

Record of Revision

Revision No.	Reason for Revision
0	Original
1	Editorial changes per new project scope

Attachments

Attachment No.	Title	Total Pages
A.	RUSLE R-factor map	1
	Total Calculation Page Count	8

6/4/09

LUANNE E FAIRBANKS
No 12725

EP 6/30/09

1 Introduction

This calculation was generated to evaluate potential waterborne erosion of the proposed final graded areas for the 92-acre area within the Area 5 Radioactive Waste Management Site (RWMS). Calculations include: average annual soil loss from the final grading areas using the Revised Universal Soil Loss Equation (RUSLE) and riprap requirements for the grading area sideslopes.

2 Basis

Calculations are performed to support grading area design. The design 25-year 24-hour storm level and location of the final grading areas was given by Waste Management grading and drainage project personnel.

2.1 Design Inputs

- The graded area surfaces will have a maximum of 2% slope, sideslopes are 5H:1V.
- Site location information was derived from aerial photographs and the NSTec engineering CADD database.
- Approximate location of the final graded area is E 593,130, N 4,079,388, UTM zone 11 NAD 83, meters.
- Design storm flows used for the sideslope riprap calculation are taken from 08023-CAL-C-003.
- Soil texture information for the graded area material is taken from Shott et al 1998.

2.2 Criteria

Compute annual average of soil loss due to water erosion of the final graded areas. Compute sideslope armoring requirements from flood flows impacting the proposed final graded areas for the 92-acres within the Area 5 Radioactive Waste Management Site (RWMS) from a 25-YR 24-HR design storm.

2.3 Assumptions

The 92-acre disposal area will be closed with a monolayer evapotranspiration type final graded area using native alluvium and vegetated with native plant species.

3 References

Nelson J.D., S.R Abt, R.L. Volpe, D. van Zyl, N.E. Hinkle and W.P. Staub. *Methodologies for*

Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments. NUREG/CR—4620, TI86 007859.

Haan C.T., B.J. Barfield and J.C. Hayes. *Design Hydrology and Sedimentology for Small Catchments.* Academic Press. 1994.

Microsoft Excel 2002 SP3

Shott GJ, Barker LE, Rawlinson SE, Sully MJ, and BA Moore. *Performance Assessment for the Area 5 Radioactive Waste Management Site*, Nye County, Nevada. Las Vegas, NV: Bechtel Nevada, DOE/NV/11718—176; 1998.

08023-CAL-C-003 (Area 5 drainage calc)

EPA. *Design and Construction of RCRA/CERCLA Final Covers.* EPA/625/4-91/025. May 1991

4 Methods

- Annual potential soil loss from the final graded areas was determined using the Revised Universal Soil Loss Equation (Haan et al. 1994).
- Sideslope armoring was estimated using the Stephenson Method (Nelson et at. 1986).

5 Results and Conclusions

The calculated average soil loss from the final graded areas is 0.56 tons/acre/year. This is below the EPA guidance of 2 tons/acre/yr (EPA, 1991 p.3). Over 30 years, 0.1 inches of the graded areas will have potentially eroded.

Riprap armoring of the graded area sideslopes is not warranted. The calculated rock size required is very small (d_{50}< 0.25 inches). Any repairs needed due to erosion can be accommodated through the maintenance program.

6 Calculations and Analyses

Graded Areas Erosion

Graded areas erosion is calculated using the Revised Universal Soil Loss Equation:

$$A = R\,K\,L\,S\,C\,P$$

where:

A = the average soil loss per unit of area, expressed in units selected for K and the time period specified by R.
R = the rainfall/runoff factor, which is the number of rainfall units for rainfall energy and runoff plus a factor from snowmelt.

K = the soil erodibility factor, which is the rate of soil loss per unit of R (erosion index units) for a given soil under continuous fallow with up and downhill cultivation on a slope of 9 percent with a slope length of 72.6 ft.

L = the slope length factor, which is the ratio of soil loss from a defined slope length relative to that from a slope length of 72.6 ft.

S = the slope steepness factor, which is the ratio of soil loss from a slope with a given steepness relative to that from a 9 percent slope.

C = the cover management factor, which is the ratio of soil loss from an area with a specified cover and management to soil loss from an identical area in continuous fallow.

P = the supporting conservation practice factor, which is the ratio of soil loss from a field with a conservation support practice (such as contouring) relative to that with straight row farming up and downhill.

R value is based on geographic location (Haan et al 1994, see Attachment A)

K value is obtained from Haan et al 1994 p. 255 for sand texture (texture obtained from Shott et al 1998).

NOTE: using the equation 8.36 on p. 255 of Haan et al 1994 yields and unreasonably low K value. Therefore a K value is select from the Haan et al Table 8.4 based on the texture class of sand.

Soil Grain-Size Data - Mean Percent Passing Indicated Size

3/4 in	3/8 in	#4	#6	#10	#16	#40	#70	#140	#200
19.0 mm	9.52 mm	4.75 mm	3.35 mm	2.0 mm	1.18 mm	0.425 mm	0.212 mm	0.106 mm	0.075 mm
96.0%	91.3%	85.1%	80.3%	74.7%	65.5%	51.3%	31.8%	12.9%	8.4%

(Shott et al, 1998)

Maximum slope = 2% design criteria

The L factor is calculated using the following equation from Haan et al 1994:

$$L = \left[\frac{\lambda}{72.6}\right]^m$$

where:

λ is the horizontal length of the graded area (1400 ft from design drawings)
m = 0.14

NOTE: m is a variable slope exponent obtained from Table 8.6 Haan et al 1994 assuming a low rill to interrill erosion ratio as suggested by Haan et al 1994 for rangeland soils.

The calculated L = 1.51

The S factor is calculated using the following equation from Hann et al 1994:

$$S = 10.8\sin\theta + 0.03$$

where:

θ is the slope angle (the eq. is valid only for sin θ < 0.09)
θ = 1.15 degrees

The calculated S = 0.24

C assume conservative factor of 1 (bare soil)

P assume conservative factor of 1 (no conservation practices)

RUSLE Parameters

Parameters	Value
R	10
K	0.15
LS	0.37
C	1
P	1

A = (10)(0.15)(0.37)(1)(1) = 0.56 tons/acre/year

Assuming a bulk density of 1.6 g/cm^3 for the graded area material, over 30 years 0.1 inches of the graded area surface will have eroded.

Sideslope Riprap

A representative sideslope armouring calculation is performed for western section of the (see below figure) proposed final graded area. This section has the longest overland flow lengths. From 08023-CAL-C-002, the peak discharge from this area is 0.85 cfs. Due to the relatively long watercourse lengths (>1000 ft) of this area, there is a potential for overland to concentrate. Assuming a concentration factor of 3, the design discharge for this area is 2.55 cfs. Assuming a flow width of 580 ft, the maximum flow rate per unit width is 0.0044 cfs/ft. Graded area sideslopes are assumed to be 5H:1V. The Stephenson Method (from Nelson et al 1986) is used to calculate the required stone size for a stable slope.

$$d_{50} = \left[\frac{q\left(\tan\theta\right)^{\frac{7}{6}} n^{\frac{1}{6}}}{C\, g^{0.5}\left[(1-n)(S-1)\cos\theta\left(\tan\phi-\tan\theta\right)\right]^{\frac{5}{3}}} \right]^{\frac{2}{3}}$$

where:

d50 is the representative diameter at which rock movement is expected for unit discharge q (ft)
q is the maximum flow rate per unit width (cfs/ft)
n is the rockfill porosity (dimensionless)
g is the acceleration constant (ft/s2)
θ is the angle of the sideslope (degrees)
Φ is the angle of internal friction (degrees)
C is an empirical factor (varies from 0.22 for gravel and pebbles to 0.27 for crushed granite)
S is the relative density of the rock

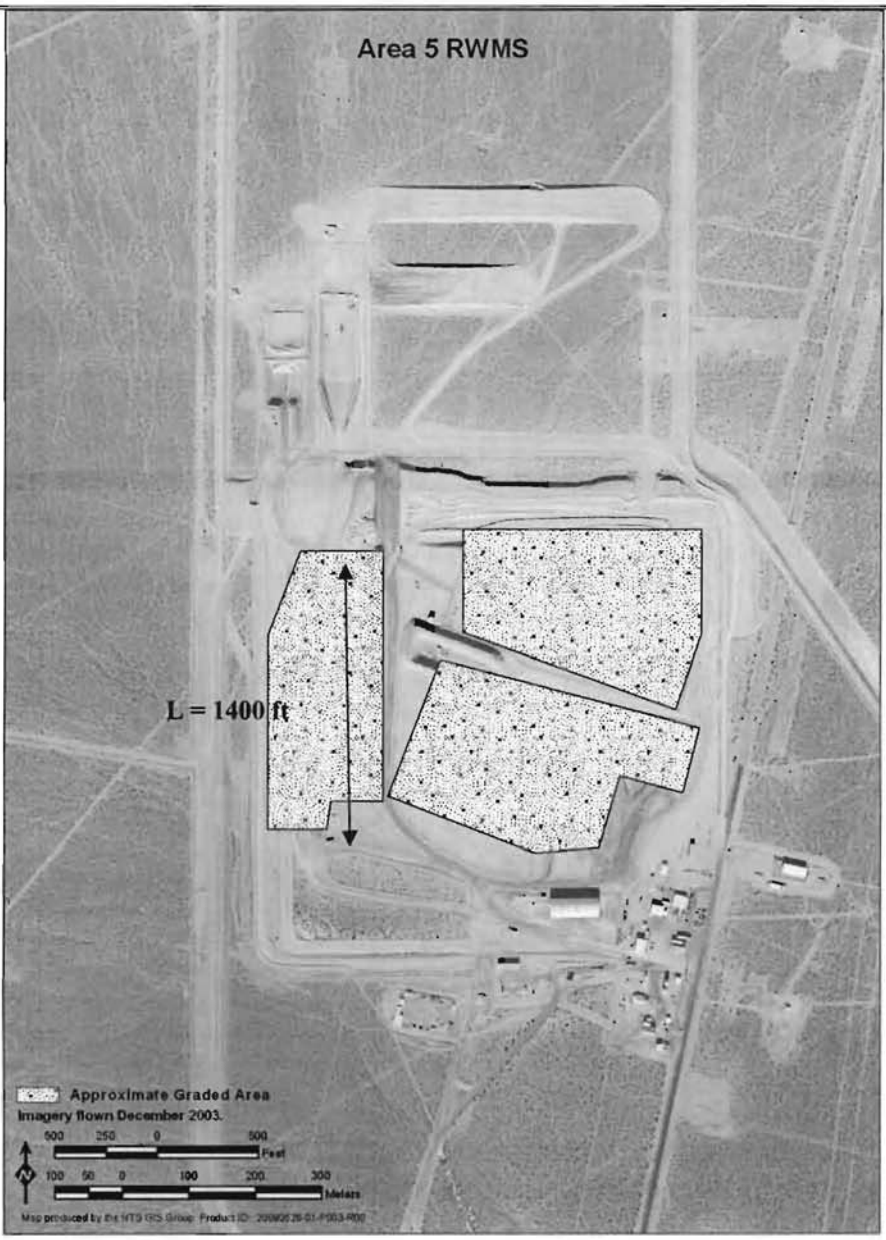
Parameter	Value
q	0.0044
n	0.35
g	32.2
θ	11.3
Φ	35
C	0.22
S	2.6

The calculated median rock diameter is then multiplied by Olivier's constant to ensure stability (1.2 for gravel). Design rock size = 1.2* 0.15 (in) = 0.18 in.

d_{50} design = 0.18 in

Due to the small size of the calculated rock, infrequent runoff producing rainfall events at the project site and an already required graded area maintenance period, it is recommended not to armor the sideslopes. Maintenance/repair of significant erosion of the sideslopes is recommended.

Graded area sideslopes of 4H:1V yield a d_{50} design = 0.24 in



Expansion Area and 92-Acre Subbasin Delineation

6/8/09

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Attachment A
RUSLE R factor map

530 Appendix 8A

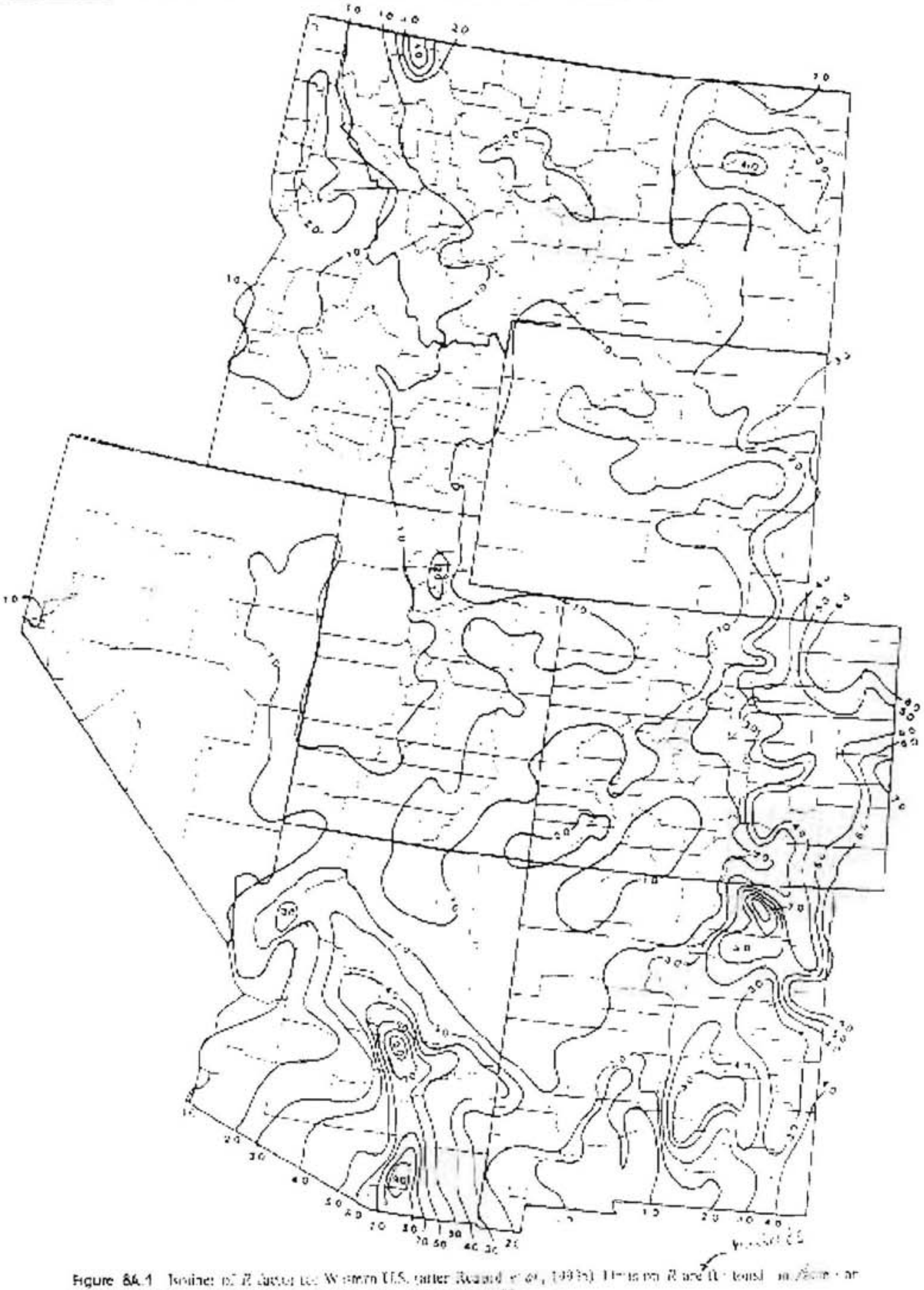

Figure 8A.1 Isolines of R factor for Western U.S. (after Renard et al., 1993a). Units on R are ft · tonsf · in./acre · hr · year. To convert to metric, MJ · mm/ha · h · year, multiply by 17.02.

1. Calculation No.: **09068-CAL-C01**	**2. Revision No.: 0**	**3. Date:** **6/4/2009**	**4. Project No.:** **09068**	**5. Pages** **1** of **11**

6. Calculation Title:
Drainage Channels, Culverts, and Riprap

7. Project Title:
92 Acre Grading and Drainage

8. Purpose of Calculation or Revision: This calculation supercedes a portion of Calculation 08023-CAL-C-002, Revision 0 to include updated hydraulic analysis of drainage channels, culverts, and riprap sizing.

9. Calculation Type:
☐ Scoping
☐ Preliminary
☒ Final
☐ Void

10. Quality Grade
☐ QG-1
☐ QG-2
☒ QG-3

11. Performance Category
☒ PC-1
☐ PC-2
☐ PC-3
☐ N/A

12. Functional Classification
☐ SC ☐ SS
☒ GS ☐ Other____

13. Authorized Derivative Classifier Review and Stamp (if required)

ENGINEER
[redacted]
No. 12725
6/4/09
Exp 6/30/09

Calculation/Analysis Signoffs and Approval

14. Preparer:	**Sign**	[redacted]	/ Date: 6/4/09
	Print	**Luanne Fairbanks**	
15. Checker: **("N/A" if Peer Review is Required)**	**Sign**	[redacted]	/ Date: 6-4-09
	Print	**Robert Niedringhaus**	
16. Peer Reviewer: **(Required for NPH and also provides calculation checker function)**	**Sign**		/ Date:
	Print		
17. Approver:	**Sign**	[redacted]	/ Date: 6-8-09
	Print	**Steven Goold**	

18. Affected Documents

Document No.	**Document Title**

19. Record of Revision

Revision	**Reason for Revision**	**Date**	**Preparer**	**Checker**	**Approver**

20. Attachments

Attachment No.	**Title**	**Total Pages**

A.	Flow Master Output Sheets - North	11
B.	Flow Master Output Sheets - East	18
C.	Flow Master Output Sheets - Center	11
D.	Culvert Master Output Sheets	5
E.	Sieve Analysis Data Sheets	27
	Total Calculation Page Count	83

8/8/09

8/8/09

Drainage Channels, Culverts, and Riprap

1. Purpose and Objective

The purpose of this calculation is to determine the hydraulic adequacy of new drainage channels, culverts, and the size of riprap required to protect 3 graded areas within a 92 acre area of the Area 5 Radioactive Waste Management Complex (RWMC).

2. Basis

2.1 Design Inputs

1. North channel flow capacity is 40 cfs (cubic feet per second). See Reference 3.
2. Center channel flow capacity is 3 cfs. See Reference 3.
3. East channel flow capacity is 10 cfs. See Reference 3.

2.2 Criteria

1. Sub-Critical Flow Regime – Froude Number < 1 (Reference 1, Chapter 702.1)
2. Critical Flow Regime – Froude Number = 1 (Reference 1, Chapter 702.1)
3. Super-Critical Flow Regime – Froude Number > 1 (Reference 1, Chapter 702.1)
4. For Stable Flow: (Reference 1, page 709)

Flow Regime	Froude Number	Flow Depth
Sub-critical	< 0.86	> $1.1d_c$
Super-Critical	> 1.13	< $0.9d_c$

5. Manning's n value = 0.025 for newly constructed channel (Reference 2, Table 4-8, item C.a.3. and Reference 2, Table 702, maximum value for constructed channels with earth bottom and sides).
6. Manning's n value = 0.065 for 6" D_{50} (particle diameter for which 50 percent of particles are smaller). This is the default value for 6" D_{50} riprap within the Flowmaster software program.
7. Minimum freeboard required for sub-critical flow is 0.5 ft + $V^2/2g$ (Reference 1, Equation 741). At bends an additional 0.5 foot shall be added (Reference 1, Paragraph 706.1.3).
8. Minimum freeboard required for super-critical flow is $1.0 + 0.025(V)(d)^{1/3}$ (Reference 1, Equation 747). At bends an additional freeboard equal to $[(1.0)(V^2)(T_w)]/[(g)(r)]$ (Reference 1, Equation 748).
9. The minimum angle of repose for the native, partially cemented soils is 37 degrees (Reference 4, page 3).
10. The specific gravity of the native soils is 2.5 (conservative value after review of Reference 3). The minimum specific gravity for riprap is 2.5 (Reference 1, page 747).

2.3 Assumptions

1. Maximum allowable clear water depth of flow is 2 foot.
2. Flow is uniform.

3. References

1. *Hydrologic Criteria and Drainage Design Manual*, Clark County Regional Flood Control District, Las Vegas, Nevada. Adopted August 12,1999, including all current revisions.
2. *Open-Channel Hydraulics*, Richard H. French, 1985.

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3. *Calculation 08023-CAL-C-002, Revision 1*, National Security Technologies, LLC.
4. *Geotechnical Evaluation for Shallow Land Disposal Facility Nevada Test Site, Area 5 Mercury, Nevada*, Western Technologies, December 1994.
5. *Drawings 09068-C-1009 thru 09068-C-1012, Revision 0,* National Security Technologies, LLC, 2009.

4. Methods

1. Bentley FlowMaster software, Service Pack 3, 2005, was used to calculate the hydraulic properties of each drainage channel.
2. Bentley CulvertMaster software, Version 3.1, Service Pack 1, was used to determine the number and size of culverts required to drain the flow in the north channel under the access road.
3. The required flow, longitudinal slope, and side slopes for each reach (section) of each channel was input into Bentley FlowMaster using an n value of 0.025 to determine the hydraulic properties of the newly constructed channels.
4. The flow depth and Froude Number determined in Step 3 were compared with criteria 1-4 to determine the flow regime and whether the flow is stable or unstable.
5. The hydraulic properties determined in Step 3 were used to calculate the tractive stress and maximum, soil, particle size that will move in each channel (erode). Available particle size distribution data was compared to these calculated values to determine if riprap is required.
6. The D_{50} (size for which 50 percent of particles are smaller) particle size for riprap was determined for each reach of each channel and the worst case size selected.
7. The required flow, longitudinal slope, and side slopes for each reach (section) of each channel was input into Bentley FlowMaster using a n value of 0.069 to determine the hydraulic properties of the channels with worst case, D_{50} size riprap.
8. The flow depth and Froude Number determined in Step 7 were compared with criteria 1-4 to determine the flow regime and whether the flow is stable or unstable.
9. The hydraulic properties determined in Step 7 were used to calculate the required freeboard and total depth of channel.

5. Results and Conclusions

1. The largest particle size (worst case) for which motion will occur is approximately 1 inch. Attachment E contains particle size data taken at various times and locations for the near surface soils in and around the Radioactive Waste Management Complex. These data sheets indicate that less than 10 percent of the soil particles are larger than 1 inch. Therefore, the channels will erode.
2. The worst case 50_{th} percentile (D_{50}) particle size required for stable slopes is 6 inches. It is recommended that Nevada Department of Transportation, Class 150 riprap gradation and Class 150 riprap bedding be used throughout all reaches of the channels.
3. The Froude Number for all reaches with riprap is less than 1. Therefore all flow for these reaches is sub-critical. The Froude Number for flow within the precast, concrete, split box drainage structure is greater than 1 so the flow is super-critical. With 6 inch D_{50} riprap, the flow in all reaches is stable. Without the riprap, there is unstable flow in the channels.
4. The required design depth for the north channel is 3 foot. The required design depth for the east channel is 2.5 foot. The required design depth for the center channel is 2.0 foot.
5. A riprap apron is recommended at the outlet of the precast, concrete split box culvert as the flow will change from super-critical to sub-critical resulting in a hydraulic jump. It is recommended that the apron extend a minimum of 10 foot past the outlet, be 6 foot wide at the outlet and flare at 45 degrees to account for spreading of the flow.
6. 3 – 35 x 24 CMPA's are adequate to convey the required flow within the north channel under the access road.
7. The extent of required riprap protection at the outlet of the CMPA's is 25 feet.

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6. Calculations and Analyses

Attachment A contains the FlowMaster output sheets for the north channel.

Attachment B contains the FlowMaster output sheets for the east channel.

Attachment C contains the FlowMaster output sheets for the center channel.

Attachment D contains the CulvertMaster output sheets for the north culverts.

The calculated hydraulic parameters for each channel, newly constructed, are summarized below:

Table 6.1

North Channel Hydraulic Parameters:

	Design slope (ft/ft)	Design Q (flow) (cfs)	Flow Area (ft^2)	Wetted Perimeter (ft)	Velocity (ft/s)	Flow Depth (ft)	Critical Depth (ft)	Froude Number (dimensionless)	Stable Flow (Yes/No)
Reach 1	0.0081	40.00	11.40	21.46	3.51	1.07	1.00	0.85	NO
Reach 2	0.0086	40.00	11.15	21.22	3.59	1.06	1.00	0.87	NO
Reach 3	0.0050	40.00	13.66	23.49	2.93	1.17	1.00	0.68	Yes

Table 6.2

East Channel Hydraulic Parameters:

	Design slope (ft/ft)	Design Q (flow) (cfs)	Flow Area (ft^2)	Wetted Perimeter (ft)	Velocity (ft/s)	Flow Depth (ft)	Critical Depth (ft)	Froude Number (dimensionless)	Stable Flow (Yes/No)
Reach 1	0.0124	10.00	2.91	7.78	3.44	0.76	0.76	0.98	NO
Reach 2	0.0146	10.00	2.74	7.55	3.65	0.74	0.76	1.06	NO
Reach 3	0.0139	10.00	2.79	7.61	3.59	0.75	0.76	1.04	NO
Reach 4	0.0061	10.00	3.80	8.89	2.63	0.87	0.76	0.70	Yes
Reach 5	0.0050	10.00	4.09	9.22	2.45	0.90	0.76	0.64	Yes

Table 6.3

Center Channel Hydraulic Parameters:

	Design slope (ft/ft)	Design Q (flow) (cfs)	Flow Area (ft^2)	Wetted Perimeter (ft)	Velocity (ft/s)	Flow Depth (ft)	Critical Depth (ft)	Froude Number (dimensionless)	Stable Flow (Yes/No)
Reach 1	0.0055	3.00	1.60	5.77	1.87	0.57	0.47	0.62	Yes
Reach 2*	0.0145	3.00	0.72	4.36	4.15	0.18	0.26	1.72	Yes
Reach 3**	0.0145	3.00	1.09	4.54	2.76	0.27	0.26	0.93	No

* Precast Concrete Split Box Drainage Structure

** Just past outlet of concrete structure prior to spreading of flow

The tractive stress (bed shear stress) is calculated using Equation 727 from Reference 1.

$\tau_0 = \gamma RS$

In which, τ_o = Shear Stress, in lb/ft^2

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γ = Specific Weight of Water (62.4 pounds/cubic foot)

R = Hydraulic Radius (Flow Area / Wetted Perimeter), in ft

S = Energy Slope (equals the channel slope in uniform flow), in ft/ft

The maximum particle size for which motion will occur is calculated using Equation 728 from Reference 1.

$$D = \tau_o / [(0.047)(S_s - 1)(\gamma)]$$

In which, D = Largest diameter of the sediment, in ft

S_s = Specific gravity of the sediment = 2.5

0.047 = Recommended value of the Shield's Parameter (constant)

γ = Specific Weight of Water (62.4 pounds/cubic foot)

The tractive stress and maximum particle size for which motion occurs for each channel is summarized below:

North Channel Tractive Stress and Maximum Particle Size for which Motion Occurs:

Table 6.4

	Tractive Stress (lbs/ft^2)	Particle Diameter (inches)
Reach 1	0.2680	0.73
Reach 2	0.2820	0.77
Reach 3	0.1820	0.50

East Channel Tractive Stress and Maximum Particle Size for which Motion Occurs:

Table 6.5

	Tractive Stress (lbs/ft^2)	Particle Diameter (inches)
Reach 1	0.2894	0.79
Reach 2	0.3306	0.90
Reach 3	0.3180	0.87
Reach 4	0.1627	0.44
Reach 5	0.1384	0.38

Center Channel Tractive Stress and Maximum Particle Size for which Motion Occurs:

Table 6.6

	Tractive Stress (lbs/ft^2)	Particle Diameter (inches)
Reach 1	0.0952	0.26
Reach 3	0.2172	0.59

The largest particle size (worst case) for which motion will occur is approximately 1 inch. Attachment E contains particle size data taken at various times and locations for the near surface soils in and around the Radioactive Waste Management Complex. These data sheets indicate that less than 10 percent of the soil particles are larger than 1 inch. Therefore, the channels will erode.

The 50_{th} percentile (D_{50}) particle size required for stable slopes is calculated using Equation 736 from Reference 1.

$D_{50} = (14.2)(F_s)(Y_{max})(S_e/K_1)$

In which, F_s = Stability Factor

= 1.0 – 1.2 for Straight or Mildly Curving Reach (value of 1.1 used as reaches are straight with mild curves and no impact from floating debris)

Y_{max} = Maximum Channel Depth (used maximum allowable clear water depth of 2 foot)

S_e = Average Energy Slope (equals the channel slope in uniform flow), in ft/ft

K_1 = Bank Angle Modification Factor

$= [1 - (\sin^2\phi / \sin^2\theta)]^{0.5}$

ϕ = Bank Angle with Horizontal, in degrees

θ = Riprap Angle of Repose, in degrees

The riprap angle of repose was taken to be 37 degrees for 3 inch D_{50} rounded rock which is conservative. This angle of repose is also the lower value reported in Reference 4 for excavated slopes in the native material.

The 50_{th} percentile (D_{50}) particle size required for stable slopes for each channel are summarized below:

Table 6.7

North Channel 50th Percentile (D_{50}) Particle Size for Stable Slopes:

	Max. Allow. depth (ft)	Stability Factor (dimensionless)	Energy Slope (ft/ft)	Bank Angle (degrees)	Angle of Repose (degrees)	Bank Angle Modification Factor	D_{50} (inches)
Reach 1	2.0	1.1	0.0081	5.71	37.00	0.9862	3.08
Reach 2	2.0	1.1	0.0086	5.71	37.00	0.9862	3.27
Reach 3	2.0	1.1	0.0050	5.71	37.00	0.9862	1.90

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Table 6.8

East Channel 50th Percentile (D_{50}) Particle Size for Stable Slopes:

	Max. Allow. depth (ft)	Stability Factor (dimensionless)	Energy Slope (ft/ft)	Bank Angle (degrees)	Angle of Repose (degrees)	Bank Angle Modification Factor	D_{50} (inches)
Reach 1	2.0	1.1	0.0124	11.30	37.00	0.9455	4.92
Reach 2	2.0	1.1	0.0146	11.30	37.00	0.9455	5.79
Reach 3	2.0	1.1	0.0139	11.30	37.00	0.9455	5.51
Reach 4	2.0	1.1	0.0061	11.30	37.00	0.9455	2.42
Reach 5	2.0	1.1	0.0050	11.30	37.00	0.9455	1.98

Table 6.9

Center Channel 50th Percentile (D50) Particle Size for Stable Slopes:

	Max. Allow. depth (ft)	Stability Factor (dimensionless)	Energy Slope (ft/ft)	Bank Angle (degrees)	Angle of Repose (degrees)	Bank Angle Modification Factor	D_{50} (inches)
Reach 1	2.0	1.1	0.0055	11.30	37.00	0.9455	2.18
Reach 3	2.0	1.1	0.0145	11.30	37.00	0.9455	5.75

The worst case D_{50} particle size is 6 inches. It is recommended that Nevada Department of Transportation, Class 150 riprap gradation and Class 150 riprap bedding be used throughout all reaches of the channels for consistency.

The calculated hydraulic parameters for each channel surfaced with 6 inch D_{50} riprap are summarized below:

Table 6.10

North Channel Hydraulic Parameters with Riprap:

	Design slope (ft/ft)	Design Q (flow) (cfs)	Flow Area (ft^2)	Wetted Perimeter (ft)	Velocity (ft/s)	Flow Depth (ft)	Critical Depth (ft)	Froude Number (dimensionless)	Stable Flow (Yes/No)
Reach 1	0.0081	40.00	24.41	31.40	1.64	1.56	1.00	0.33	Yes
Reach 2	0.0086	40.00	23.87	31.05	1.68	1.54	1.00	0.34	Yes
Reach 3	0.0050	40.00	29.26	34.38	1.37	1.71	1.00	0.26	Yes

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Table 6.11

East Channel Hydraulic Parameters with Riprap:

	Design slope (ft/ft)	Design Q (flow) (cfs)	Flow Area (ft^2)	Wetted Perimeter (ft)	Velocity (ft/s)	Flow Depth (ft)	Critical Depth (ft)	Froude Number (dimensionless)	Stable Flow (Yes/No)
Reach 1	0.0124	10.00	6.23	11.39	1.60	1.12	0.76	0.38	Yes
Reach 2	0.0146	10.00	5.86	11.04	1.71	1.09	0.76	0.41	Yes
Reach 3	0.0139	10.00	5.97	11.14	1.67	1.09	0.76	0.40	Yes
Reach 4	0.0061	10.00	8.13	13.01	1.23	1.28	0.76	0.27	Yes
Reach 5	0.0050	10.00	8.76	13.50	1.14	1.32	0.76	0.25	Yes

Table 6.12

Center Channel Hydraulic Parameters with Riprap:

	Design slope (ft/ft)	Design Q (flow) (cfs)	Flow Area (ft^2)	Wetted Perimeter (ft)	Velocity (ft/s)	Flow Depth (ft)	Critical Depth (ft)	Froude Number (dimensionless)	Stable Flow (Yes/No)
Reach 1	0.0055	3.00	3.43	8.44	0.88	0.83	0.47	0.24	Yes
Reach 3	0.0145	3.00	2.09	5.04	1.44	0.52	0.26	0.35	Yes

The Froude Number for all reaches with riprap is less than 1. Therefore all flow for these reaches is sub-critical. The Froude Number for flow within the precast, concrete, split box drainage structure is greater than 1 so the flow is super-critical (see reach 2, Table 6.3). With 6 inch D_{50} riprap, the flow in all reaches is stable.

Using criteria 7 and 8, the required total depth for each channel is summarized below:

Table 6.13

North Channel Required Freeboard and Total Depth:

	Freeboard (ft)	Bend (Y/N)	Total Depth (ft)
Reach 1	0.5418	Y	2.60
Reach 2	0.5438	N	2.08
Reach 3	0.5291	Y	2.74

Table 6.14

East Channel Required Freeboard and Total Depth:

	Freeboard (ft)	Bend (Y/N)	Total Depth (ft)
Reach 1	0.5398	Y	2.16
Reach 2	0.5454	Y	2.14
Reach 3	0.5433	Y	2.13
Reach 4	0.5235	Y	2.30
Reach 5	0.5202	Y	2.34

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Table 6.15

Center Channel Required Freeboard and Total Depth:

	Freeboard (ft)	Bend (Y/N)	Total Depth (ft)
Reach 1	0.5120	Y	1.84
Reach 2	1.0589	N	1.24

Reach 3 of the center channel is the finish grade at the outfall of the precast concrete, split box, culvert and is not a channel. Therefore it does not require a freeboard and total depth calculation.

The required design depth for the north channel is 3 foot. The required design depth for the east channel is 2.5 foot. The required design depth for the center channel is 2.0 foot.

The extent of riprap needed at the outlet of the concrete structure is calculated using Equation 764 from Reference 1.

$$L = (1/(2\tan\theta))(A_t / Y_t - W)$$

In which, L = Length of Protection, in ft

W = Width of the Rectangular Culvert, in ft = 4

Y_t = Tailwater Depth at Outlet, in ft = 0.27

Q = Design Discharge, in cubic feet per second (cfs) = 3

V = Allowable non-eroding velocity in the channel, in feet per second (fps)

A_t = Design Discharge / Allowable Non-eroding Flow Velocity, in ft^2

θ = The Expansion Angle of the Culvert Flow, in degrees

From Table 703 of Reference 1, for a sandy loam soil the maximum permissible velocity is 1.75 fps.

Therefore, $A_t = Q/V = 3/1.75 = 1.71$ ft^2

Using Figure 715 from Reference 1 with the following;

$$Q/WH^{1.5} = 3/(4*4^{1.5}) = 0.0938 \text{ and}$$

$$Y_t / H = 0.27 / 4 = 0.0675$$

$$1/(2\tan\theta) = 0.6, \text{ therefore}$$

$$L = 0.6*(1.71/0.27 - 4) = 1.4 \text{ ft}$$

Even though the above equation yields a very small result, a riprap apron is recommended at the outlet as the flow will change from super-critical to sub-critical resulting in a hydraulic jump. It is recommended that the apron extend a minimum of 10 foot past the outlet, be 6 foot wide at the outlet and flare at 45 degrees to account for the spreading out of the flow.

Attachment D contains the CulvertMaster output sheets for 4 – 24 inch diameter, 3 – 30 inch diameter, 4 – 30 inch diameter corrugated metal pipes (CMP), and 3 – 35 x 24 corrugated metal pipe arches (CMPA).

The 4 – 24 inch CMP resulted in headwater depths greater than the allowable depth of 2 foot. The 4 – 30 inch CMP option resulted in acceptable headwater depth but the depth of cover was not sufficient. Depth of cover for a conduit height of 24 inches is sufficient. Therefore, the 3 – 35 x 24 CMPA option was tried as 1 – 35 x 24 CMPA is hydraulically equivalent to 1 – 30 inch CMP and the 24 inch height will allow sufficient cover. Additionally, CMPA's are more efficient at conveying flow than CMP's which result in fewer pipes being required.

The 3 – 35 x 24 CMPA's are adequate to convey the required flow within the north channel.

The extent of riprap protection at the outlet should be 25 feet which is 10 times the equivalent diameter (30 inches) of a 35 x 24 CMPA which is the maximum required by Section 707.4.3 of Reference 1.

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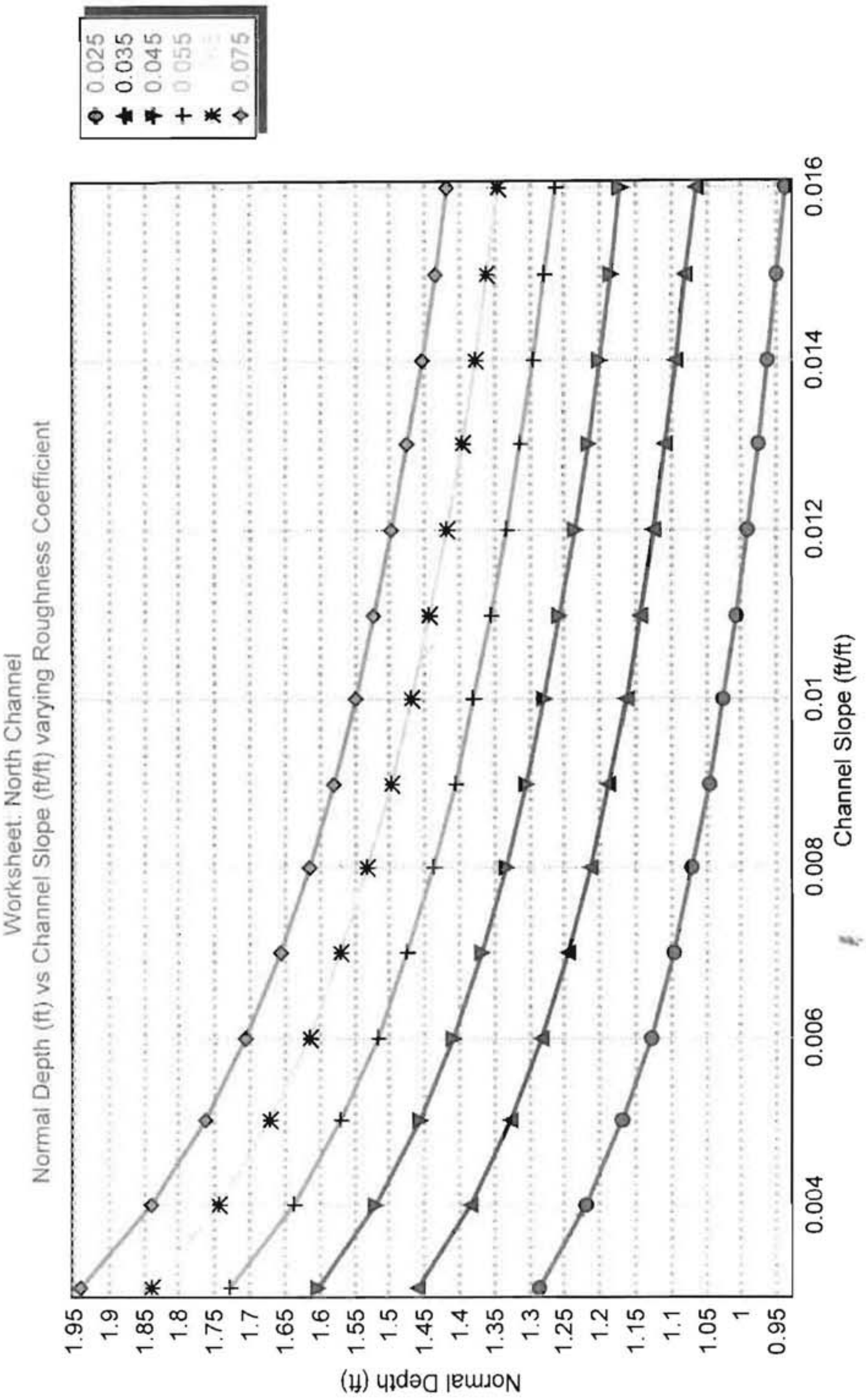
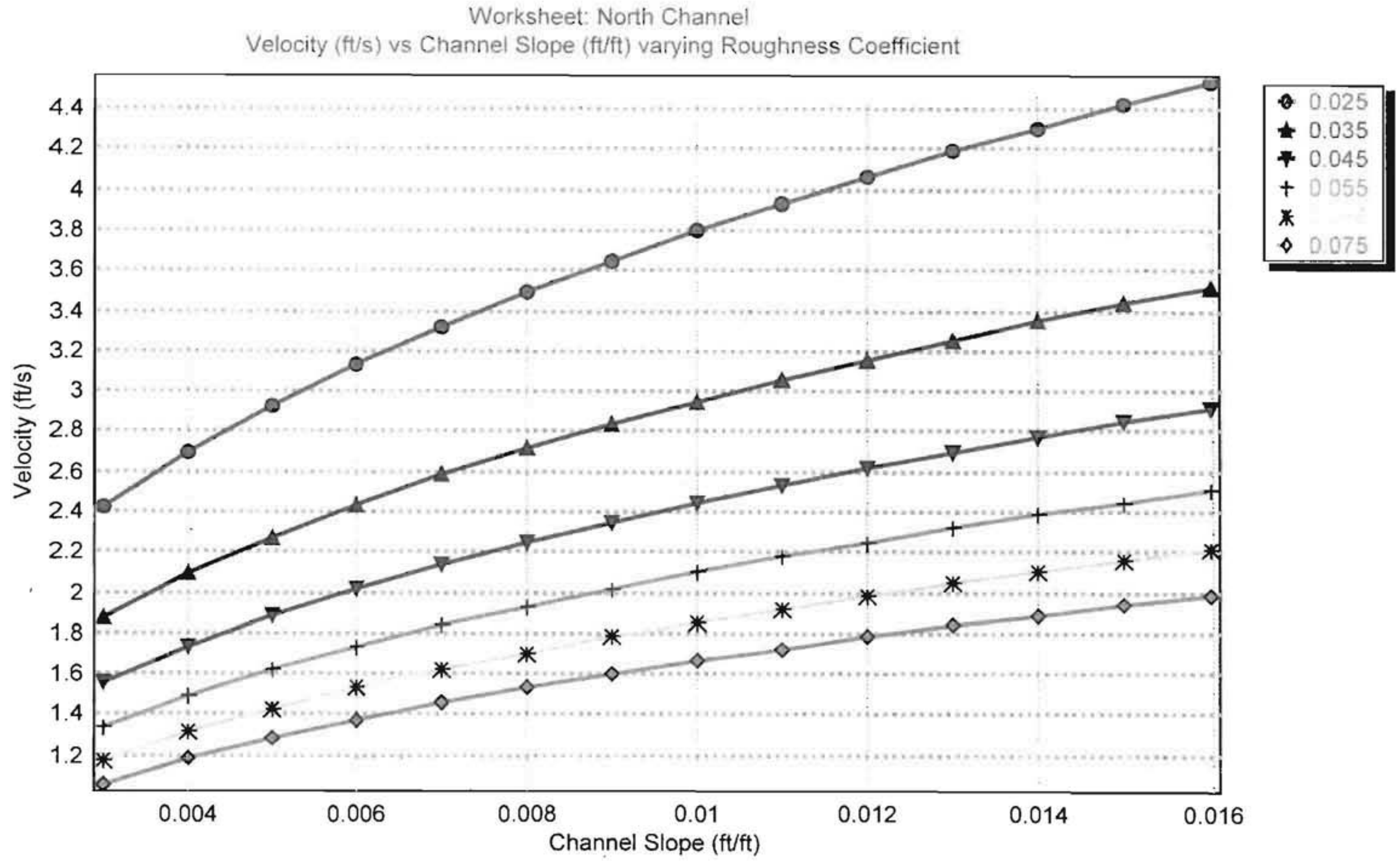
Attachment A

Flow Master Output Sheets - North

Attachment A
Flow Master Output Sheets - North



Attachment A
Flow Master Output Sheets – North (cont.)



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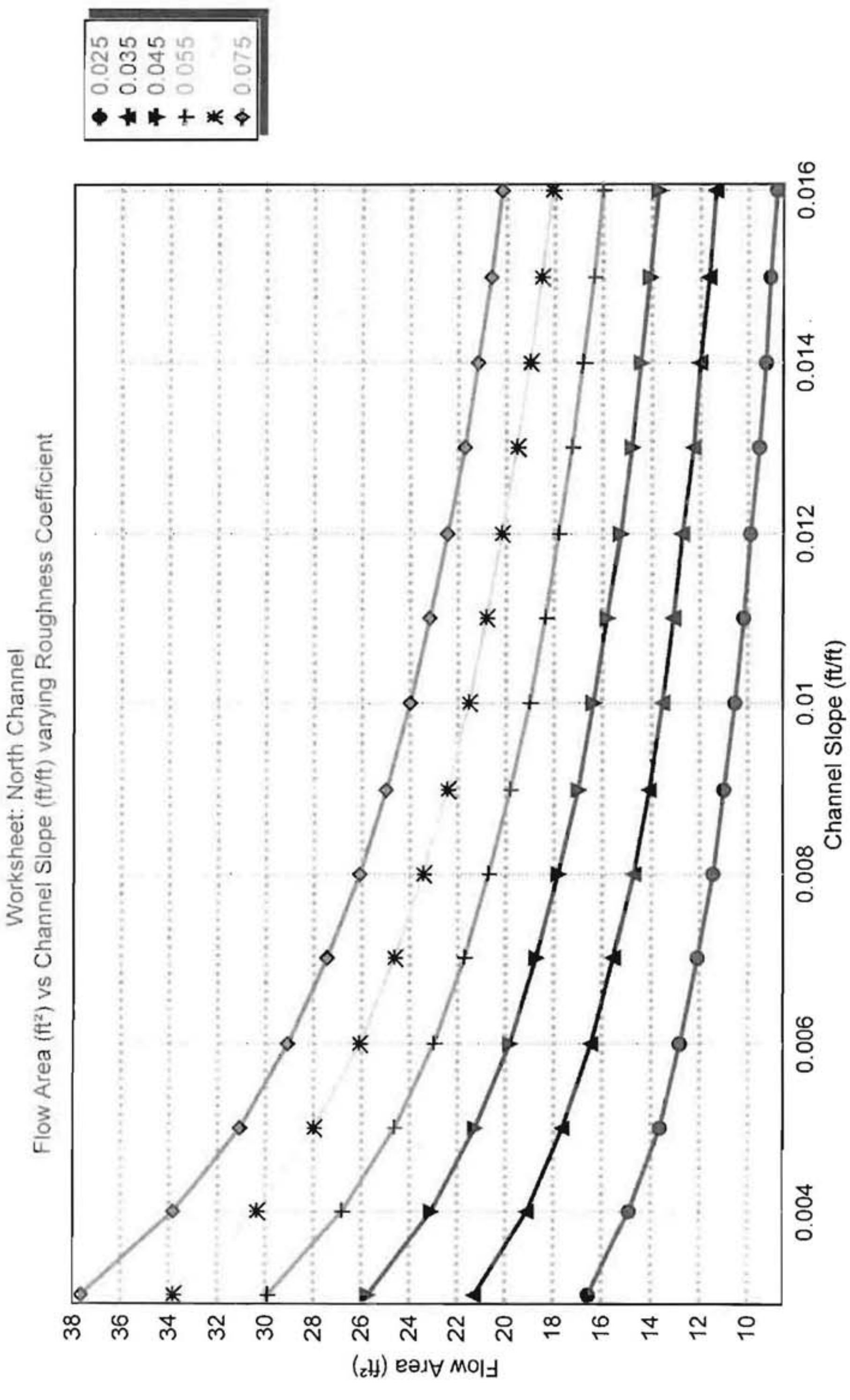
Attachment A
Flow Master Output Sheets – North (cont.)



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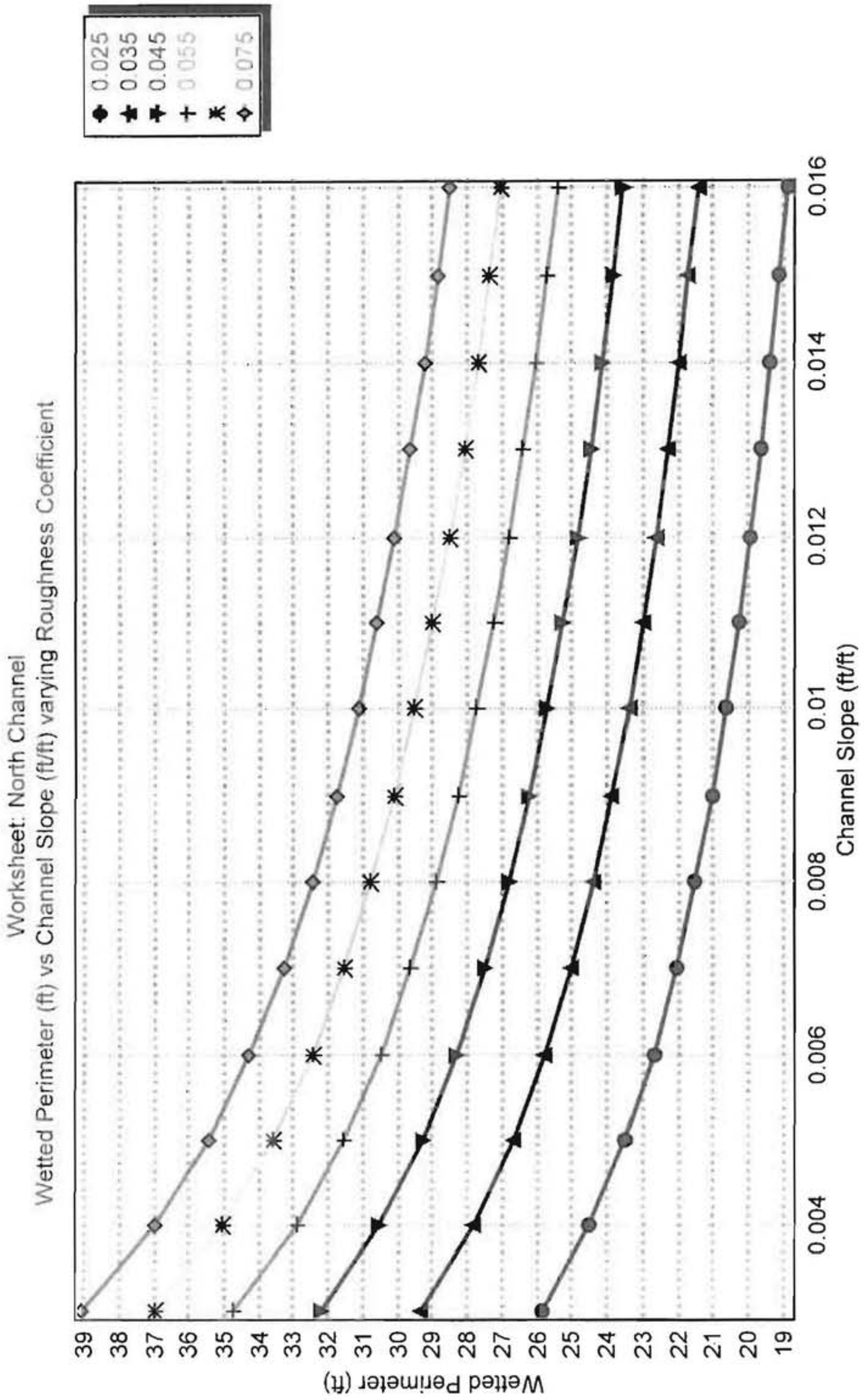
Attachment A
Flow Master Output Sheets – North (cont.)



Attachment A
Flow Master Output Sheets – North (cont.)

Worksheet for North Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.025	
Channel Slope	0.00810	ft/ft
Left Side Slope	10.00	ft/ft (H:V)
Right Side Slope	10.00	ft/ft (H:V)
Discharge	40.00	ft³/s

Results

Normal Depth		1.07	ft	≯ 1.1dc
Flow Area		11.40	ft²	
Wetted Perimeter		21.46	ft	
Top Width		21.35	ft	
Critical Depth		1.00	ft	
Critical Slope		0.01156	ft/ft	
Velocity		3.51	ft/s	
Velocity Head		0.19	ft	
Specific Energy		1.26	ft	
Froude Number		0.85		<0.56
Flow Type	Subcritical			UNSTABLE FLOW

Reqd Freeboard

$F_B = .5 + \frac{3.51^2}{64.4}$

$= .69$ Ft

total depth =
$1.07 + .69 = 1.76$ Ft

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.07	ft
Critical Depth	1.00	ft
Channel Slope	0.00810	ft/ft
Critical Slope	0.01156	ft/ft

NSTec

5/22/2009 4:45:06 PM
Bentley Systems, Inc. Haestad Methods Solution Center
27 Siemons Company Drive Suite 200 W Watertown, CT 06795 USA +1-203-755-1666
Bentley FlowMaster [08.01.071.00]
Page 1 of 1

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Attachment A
Flow Master Output Sheets – North (cont.)

Worksheet for North Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.069	
Channel Slope	0.00810	ft/ft
Left Side Slope	10.00	ft/ft (H:V)
Right Side Slope	10.00	ft/ft (H:V)
Discharge	40.00	ft³/s

Results

Normal Depth		1.56	ft	$>1.1 d_c$ $F_b = .5 + \frac{1.64^2}{64.4}$
Flow Area		24.41	ft²	$= .54$ Ft
Wetted Perimeter		31.40	ft	
Top Width		31.25	ft	total Depth $= 1.56 + .54$
Critical Depth	$1.1 d_c = 1.1$	1.00	ft	$= 2.1$ Ft
Critical Slope		0.08802	ft/ft	
Velocity		1.64	ft/s	
Velocity Head		0.04	ft	
Specific Energy		1.60	ft	
Froude Number		0.33	<0.86	
Flow Type	Subcritical	Stable Flow		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.56	ft
Critical Depth	1.00	ft
Channel Slope	0.00810	ft/ft
Critical Slope	0.08802	ft/ft

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5/26/2009 6:39:02 PM 27 Siemons Company Drive Suite 200 W Watertown, CT 06795 USA +1-203-755-1666 Page 1 of 1

Attachment A
Flow Master Output Sheets – North (cont.)

Worksheet for North Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.025	
Channel Slope	0.00860	ft/ft
Left Side Slope	10.00	ft/ft (H:V)
Right Side Slope	10.00	ft/ft (H:V)
Discharge	40.00	ft³/s

Results

Normal Depth	1.06	ft	$\overline{\approx} 1.1 d_c$
Flow Area	11.15	ft²	
Wetted Perimeter	21.22	ft	
Top Width	21.12	ft	
Critical Depth	1.00	ft	
Critical Slope	0.01156	ft/ft	
Velocity	3.59	ft/s	
Velocity Head	0.20	ft	
Specific Energy	1.26	ft	
Froude Number	0.87		> 0.86
Flow Type	Subcritical		UNSTABLE FLOW

Req'd Freeboard

$F_b = .5 + \frac{3.59^2}{64.4}$

$= .70$ Ft

total Depth $= 1.06 + .70$

$= 1.76$ Ft

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.06	ft
Critical Depth	1.00	ft
Channel Slope	0.00860	ft/ft
Critical Slope	0.01156	ft/ft

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Attachment A
Flow Master Output Sheets – North (cont.)

Worksheet for North Channel

Project Description

Friction Method	Manning Formula		
Solve For	Normal Depth		

Input Data

Roughness Coefficient	0.069	
Channel Slope	0.00860	ft/ft
Left Side Slope	10.00	ft/ft (H:V)
Right Side Slope	10.00	ft/ft (H:V)
Discharge	40.00	ft³/s

Results

Normal Depth		1.54	ft	>1.1dc
Flow Area		23.87	ft²	
Wetted Perimeter		31.05	ft	
Top Width		30.90	ft	
Critical Depth		1.00	ft	
Critical Slope		0.08802	ft/ft	
Velocity		1.68	ft/s	
Velocity Head		0.04	ft	
Specific Energy		1.59	ft	
Froude Number		0.34		< 0.56
Flow Type	Subcritical			Stable Flow

$F_b = .5 + \frac{1.68^2}{64.4}$

$= .54 \text{ Ft}$

total Depth $= 1.54 + .54$

$= 2.08 \text{ Ft}$

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.54	ft
Critical Depth	1.00	ft
Channel Slope	0.00860	ft/ft
Critical Slope	0.08802	ft/ft

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Attachment A
Flow Master Output Sheets – North (cont.)

Worksheet for North Channel

Project Description

Friction Method	Manning Formula		
Solve For	Normal Depth		

Input Data

Roughness Coefficient	0.025	
Channel Slope	0.00500	ft/ft
Left Side Slope	10.00	ft/ft (H:V)
Right Side Slope	10.00	ft/ft (H:V)
Discharge	40.00	ft³/s

Results

Normal Depth		1.17	ft	$> 1.1 d_c$
Flow Area		13.66	ft²	
Wetted Perimeter		23.49	ft	
Top Width		23.38	ft	
Critical Depth (d_c)		1.00	ft	
Critical Slope		0.01156	ft/ft	
Velocity		2.93	ft/s	
Velocity Head		0.13	ft	
Specific Energy		1.30	ft	
Froude Number		0.68		< 0.86
Flow Type	Subcritical			Stable Flow

Req'd Freeboard.

$F_b = .5 + \frac{V^2}{2g}$

$= .5 + \frac{2.93^2}{69.4}$

$= .63$ Ft

total Depth = 1.17 + .63
= 1.8 Ft

@ Bend depth =
1.8 + .5 = 2.3 Ft

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.17	ft
Critical Depth	1.00	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01156	ft/ft

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Attachment A
Flow Master Output Sheets – North (cont.)

Worksheet for North Channel

Project Description

Friction Method	Manning Formula		
Solve For	Normal Depth		

Input Data

Roughness Coefficient	0.069		
Channel Slope	0.00500	ft/ft	
Left Side Slope	10.00	ft/ft (H:V)	
Right Side Slope	10.00	ft/ft (H:V)	
Discharge	40.00	ft³/s	

Results

Normal Depth	1.71	ft	>1.1dc
Flow Area	29.26	ft²	
Wetted Perimeter	34.38	ft	
Top Width	34.21	ft	
Critical Depth	1.00	ft	
Critical Slope	0.08803	ft/ft	
Velocity	1.37	ft/s	
Velocity Head	0.03	ft	
Specific Energy	1.74	ft	
Froude Number	0.28	<0.86	
Flow Type	Subcritical	Stable Flow	

$F_G = .5 + \frac{1.37^2}{64.4}$
$= .53$ Ft

total Depth $= 1.71 + .53$
$= 2.24$ Ft

@ Bend into Culvert =
$2.24 + .5 = 2.74$ Ft

GVF Input Data

Downstream Depth	0.00	ft	
Length	0.00	ft	
Number Of Steps	0		

GVF Output Data

Upstream Depth	0.00	ft	
Profile Description			
Profile Headloss	0.00	ft	
Downstream Velocity	Infinity	ft/s	
Upstream Velocity	Infinity	ft/s	
Normal Depth	1.71	ft	
Critical Depth	1.00	ft	
Channel Slope	0.00500	ft/ft	
Critical Slope	0.08803	ft/ft	

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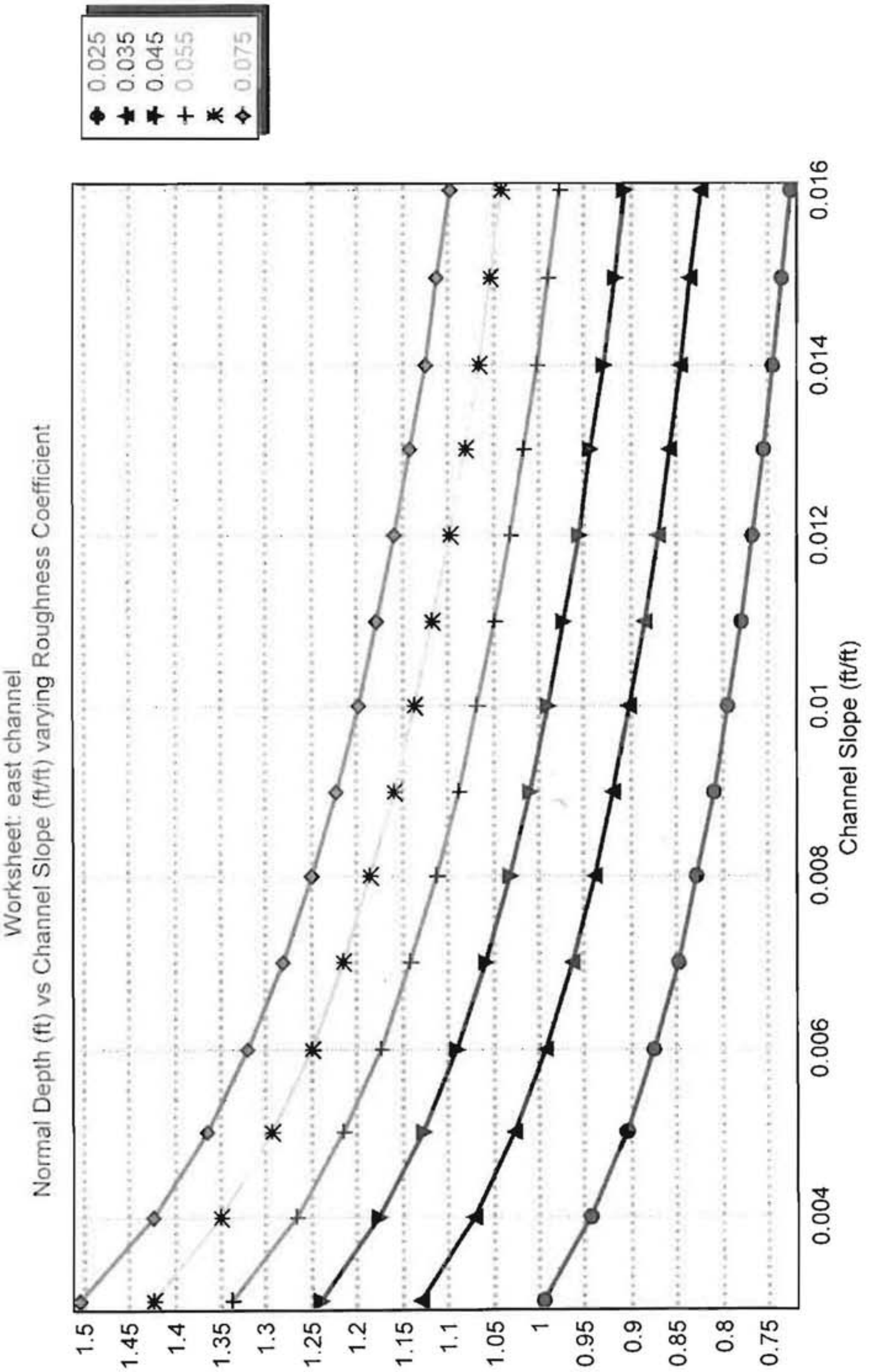
Attachment B

Flow Master Output Sheets - East

Attachment B
Flow Master Output Sheets - East



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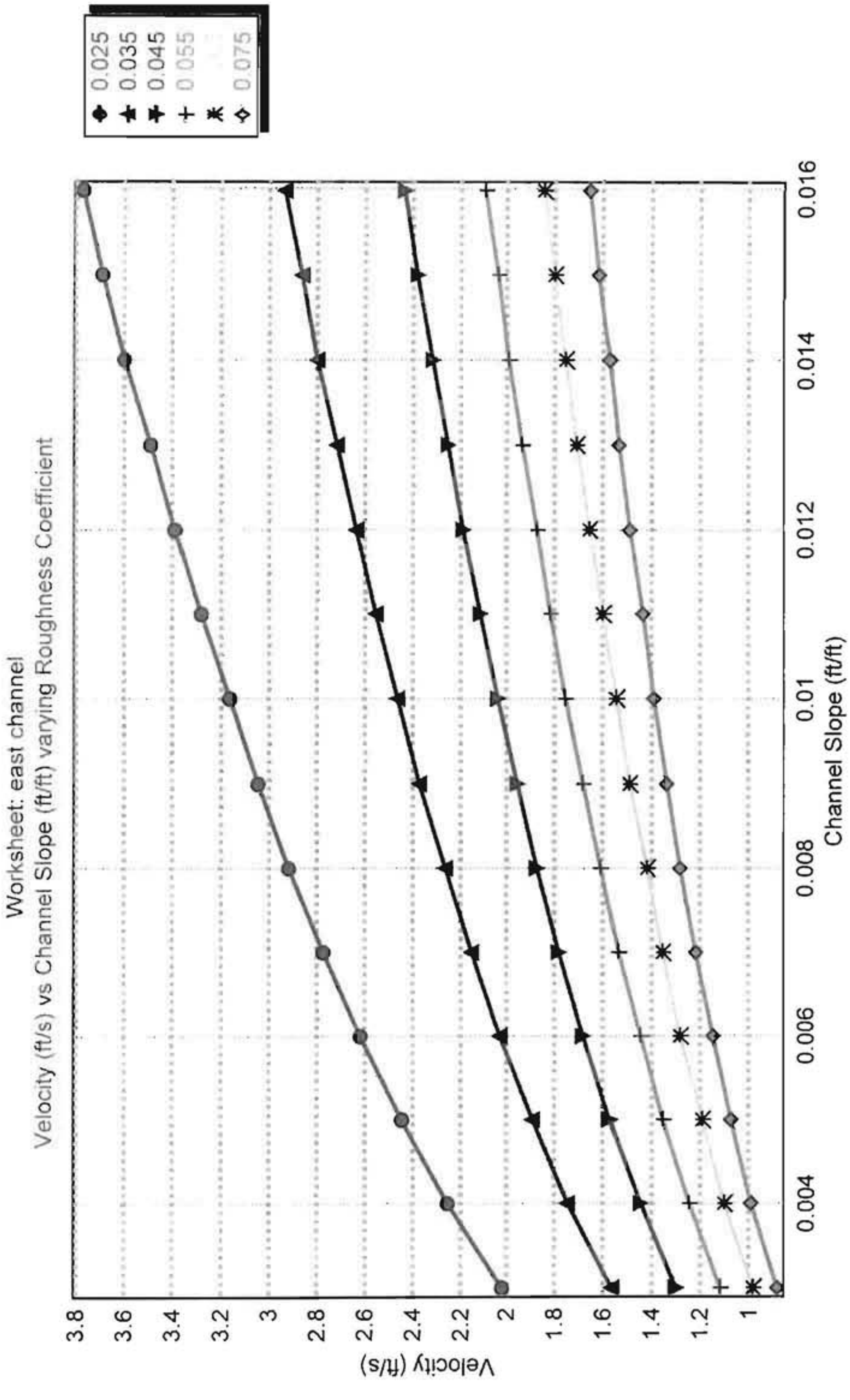
Attachment B
Flow Master Output Sheets – East (cont.)



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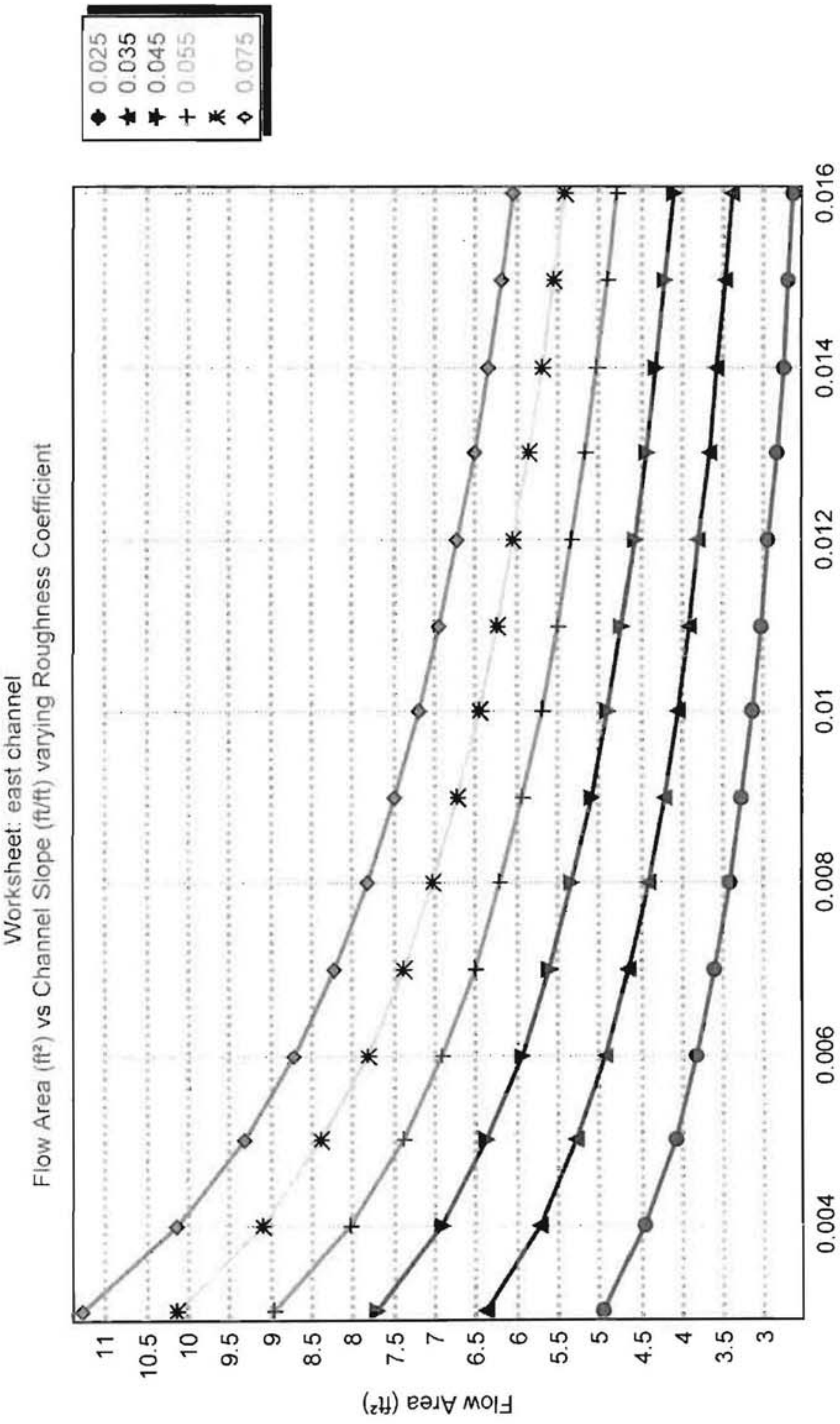
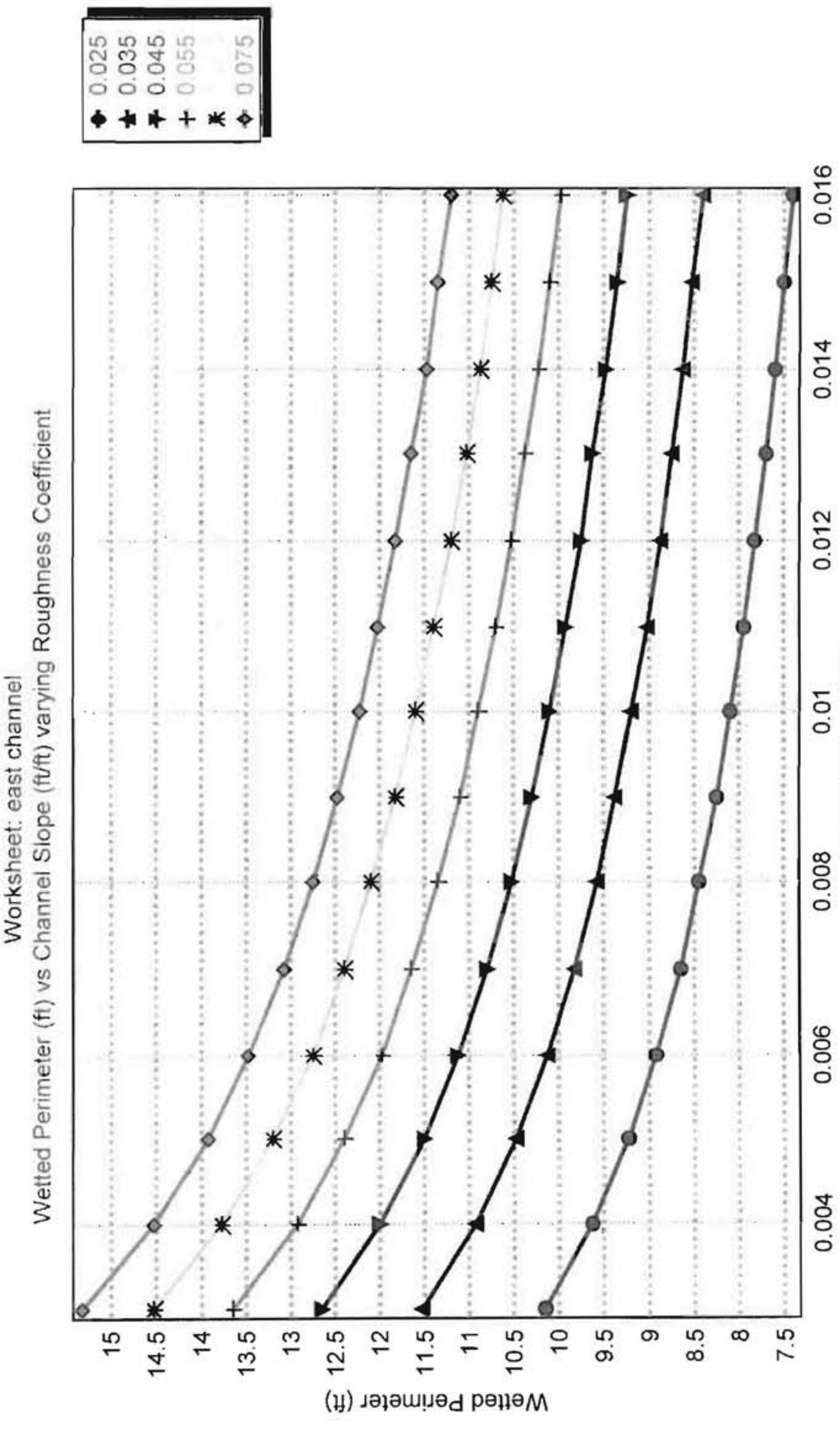
Attachment B
Flow Master Output Sheets – East (cont.)



Attachment B
Flow Master Output Sheets – East (cont.)



Attachment B
Flow Master Output Sheets – East (cont.)

Worksheet for east channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.025	
Channel Slope	0.01240	ft/ft
Left Side Slope	5.00	ft/ft (H:V)
Right Side Slope	5.00	ft/ft (H:V)
Discharge	10.00	ft³/s

Results

Normal Depth		0.76	ft	< 1.1dc
Flow Area		2.91	ft²	
Wetted Perimeter		7.78	ft	
Top Width		7.63	ft	
Critical Depth		0.76	ft	1.1dc = .84 Ft
Critical Slope		0.01292	ft/ft	
Velocity		3.44	ft/s	
Velocity Head		0.18	ft	
Specific Energy		0.95	ft	
Froude Number		0.98		> 0.86
Flow Type	Subcritical			UNSTABLE FLOW

Req'd Freeboard

$F_b = .5 + \frac{3.44^2}{64.4}$

$= .68$ Ft

total Depth =

$.76 + .68 = 1.44$ Ft

Bend: 1

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.76	ft
Critical Depth	0.76	ft
Channel Slope	0.01240	ft/ft
Critical Slope	0.01292	ft/ft

Preparer: 6/8/09 Checker: 6/8/09

Attachment B
Flow Master Output Sheets – East (cont.)

Worksheet for east channel

Project Description				
Friction Method	Manning Formula			
Solve For	Normal Depth			
Input Data				
Roughness Coefficient		0.069		
Channel Slope		0.01240	ft/ft	
Left Side Slope		5.00	ft/ft (H:V)	
Right Side Slope		5.00	ft/ft (H:V)	
Discharge		10.00	ft³/s	
Results				
Normal Depth		1.12	ft	$>1.1d_c$
Flow Area		6.23	ft²	
Wetted Perimeter		11.39	ft	
Top Width		11.16	ft	
Critical Depth	$1.1d_c = .84$ Ft	0.76	ft	
Critical Slope		0.09844	ft/ft	
Velocity		1.60	ft/s	
Velocity Head		0.04	ft	
Specific Energy		1.16	ft	
Froude Number		0.38	<0.86	
Flow Type	Subcritical	STABLE FLOW		
GVF Input Data				
Downstream Depth		0.00	ft	
Length		0.00	ft	
Number Of Steps		0		
GVF Output Data				
Upstream Depth		0.00	ft	
Profile Description				
Profile Headloss		0.00	ft	
Downstream Velocity		Infinity	ft/s	
Upstream Velocity		Infinity	ft/s	
Normal Depth		1.12	ft	
Critical Depth		0.76	ft	
Channel Slope		0.01240	ft/ft	
Critical Slope		0.09844	ft/ft	

$F_b = .5 + \frac{1.6^2}{64.4}$
$= .5$ Ft

total Depth $= 1.12 + .5$
$\doteq 1.62$ Ft

@ Bend $= 1.62 + .5$
$= 2.12$ Ft

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Attachment B
Flow Master Output Sheets – East (cont.)

Worksheet for east channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient		0.025	
Channel Slope		0.01390	ft/ft
Left Side Slope		5.00	ft/ft (H:V)
Right Side Slope		5.00	ft/ft (H:V)
Discharge		10.00	ft³/s

Results

Normal Depth		0.75	ft	$>.9d_c$
Flow Area		2.79	ft²	
Wetted Perimeter		7.61	ft	
Top Width		7.47	ft	
Critical Depth		0.76	ft	
Critical Slope		0.01292	ft/ft	
Velocity		3.59	ft/s	
Velocity Head		0.20	ft	
Specific Energy		0.95	ft	
Froude Number		1.04		<1.13
Flow Type	Supercritical			UNSTABLE FLOW

Req'd Freeboard

$F_b = 1 + .025(3.59)(.75)^{1/3}$

$= 1.05\ Ft$

Bends: 2, 3, 4, 5

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.75	ft
Critical Depth	0.76	ft
Channel Slope	0.01390	ft/ft
Critical Slope	0.01292	ft/ft

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Preparer: 6/8/09 Checker: 3/8/09

Attachment B
Flow Master Output Sheets – East (cont.)

Worksheet for east channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.069	
Channel Slope	0.01390	ft/ft
Left Side Slope	5.00	ft/ft (H:V)
Right Side Slope	5.00	ft/ft (H:V)
Discharge	10.00	ft³/s

Results

Normal Depth	1.09	ft	>1.1dc
Flow Area	5.97	ft²	
Wetted Perimeter	11.14	ft	
Top Width	10.93	ft	
Critical Depth	0.76	ft	
Critical Slope	0.09845	ft/ft	
Velocity	1.67	ft/s	
Velocity Head	0.04	ft	
Specific Energy	1.14	ft	
Froude Number	0.40	<0.86	
Flow Type	Subcritical		

$F_G = .5 + \frac{1.67^2}{64.4}$

$= .54$ Ft

total Depth $= 1.09 + .54$

$= 1.63$ Ft

@Bends $= 1.63 + .5$

$= 2.13$ Ft

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.09	ft
Critical Depth	0.76	ft
Channel Slope	0.01390	ft/ft
Critical Slope	0.09845	ft/ft

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Attachment B
Flow Master Output Sheets – East (cont.)

Worksheet for east channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.025	
Channel Slope	0.01390	ft/ft
Left Side Slope	5.00	ft/ft (H:V)
Right Side Slope	5.00	ft/ft (H:V)
Discharge	10.00	ft³/s

Results

Normal Depth		0.75	ft >.9dc
Flow Area		2.79	ft²
Wetted Perimeter		7.61	ft
Top Width		7.47	ft
Critical Depth		0.76	ft
Critical Slope		0.01292	ft/ft
Velocity		3.59	ft/s
Velocity Head		0.20	ft
Specific Energy		0.95	ft
Froude Number		1.04	<1.13
Flow Type	Supercritical	UNSTABLE FLOW	

Req'd Freeboard

$F_b = 1+.025(3.59)(.75)^{1/3}$

$= 1.08$ Ft

Bends: 2, 3, 4, 5

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.75	ft
Critical Depth	0.76	ft
Channel Slope	0.01390	ft/ft
Critical Slope	0.01292	ft/ft

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Preparer: 6/8/09 Checker: 6/8/09

Attachment B
Flow Master Output Sheets – East (cont.)

Worksheet for east channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.069	
Channel Slope	0.01390	ft/ft
Left Side Slope	5.00	ft/ft (H:V)
Right Side Slope	5.00	ft/ft (H:V)
Discharge	10.00	ft³/s

Results

Normal Depth	1.09	ft >1.1dc
Flow Area	5.97	ft²
Wetted Perimeter	11.14	ft
Top Width	10.93	ft
Critical Depth	0.76	ft
Critical Slope	0.09845	ft/ft
Velocity	1.67	ft/s
Velocity Head	0.04	ft
Specific Energy	1.14	ft
Froude Number	0.40	<0.86
Flow Type	Subcritical	

$F_b = .5 + \frac{1.67^2}{64.4}$

$= .54$ Ft

total Depth = 1.09 + .54

= 1.63 Ft

@Bends = 1.63 + .5

= 2.13 Ft

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.09	ft
Critical Depth	0.76	ft
Channel Slope	0.01390	ft/ft
Critical Slope	0.09845	ft/ft

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Attachment B
Flow Master Output Sheets – East (cont.)

Worksheet for east channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.025	
Channel Slope	0.00610	ft/ft
Left Side Slope	5.00	ft/ft (H:V)
Right Side Slope	5.00	ft/ft (H:V)
Discharge	10.00	ft³/s

Results

Normal Depth	0.87	ft	>1.1dc
Flow Area	3.80	ft²	
Wetted Perimeter	8.89	ft	
Top Width	8.71	ft	
Critical Depth	1.1dc = .84 0.76	ft	
Critical Slope	0.01292	ft/ft	
Velocity	2.63	ft/s	
Velocity Head	0.11	ft	
Specific Energy	0.98	ft	
Froude Number	0.70	<0.86	
Flow Type	Subcritical	Stable Flow	

Req'd Freeboard
$F_b = .5 + \frac{2.63^2}{64.4}$
$= .61$ Ft

Bend : 5

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.87	ft
Critical Depth	0.76	ft
Channel Slope	0.00610	ft/ft
Critical Slope	0.01292	ft/ft

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Attachment B
Flow Master Output Sheets – East (cont.)

Worksheet for east channel

Project Description				
Friction Method	Manning Formula			
Solve For	Normal Depth			
Input Data				
Roughness Coefficient		0.069		
Channel Slope		0.00610	ft/ft	
Left Side Slope		5.00	ft/ft (H:V)	
Right Side Slope		5.00	ft/ft (H:V)	
Discharge		10.00	ft³/s	
Results				
Normal Depth		1.28	ft	>1.1dc
Flow Area		8.13	ft²	
Wetted Perimeter		13.01	ft	
Top Width		12.75	ft	
Critical Depth		0.76	ft	
Critical Slope		0.09845	ft/ft	
Velocity		1.23	ft/s	
Velocity Head		0.02	ft	
Specific Energy		1.30	ft	
Froude Number		0.27		<0.86
Flow Type	Subcritical			Stable Flow
GVF Input Data				
Downstream Depth		0.00	ft	
Length		0.00	ft	
Number Of Steps		0		
GVF Output Data				
Upstream Depth		0.00	ft	
Profile Description				
Profile Headloss		0.00	ft	
Downstream Velocity		Infinity	ft/s	
Upstream Velocity		Infinity	ft/s	
Normal Depth		1.28	ft	
Critical Depth		0.76	ft	
Channel Slope		0.00610	ft/ft	
Critical Slope		0.09845	ft/ft	

$F_b = .5 + \frac{1.23^2}{64.4}$
$= .52$ Ft

total Depth $= 1.28 + .52$
$= 1.80$ Ft

@ Bends $= 1.80 + .50$
$= 2.3$ Ft

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Page 1 of 1

Attachment B
Flow Master Output Sheets – East (cont.)

Worksheet for east channel

Project Description

Friction Method	Manning Formula		
Solve For	Normal Depth		

Input Data

Roughness Coefficient	0.025		
Channel Slope	0.00500	ft/ft	
Left Side Slope	5.00	ft/ft (H:V)	
Right Side Slope	5.00	ft/ft (H:V)	
Discharge	10.00	ft³/s	

Results

Normal Depth		0.90	ft	$>1.1d_c$ Req'd Freeboard
Flow Area		4.09	ft²	$F_b = .5 + \frac{2.45^2}{64.4}$
Wetted Perimeter		9.22	ft	$= .59$ Ft
Top Width		9.04	ft	
Critical Depth		0.76	ft	Bend : 6
Critical Slope		0.01292	ft/ft	
Velocity		2.45	ft/s	
Velocity Head		0.09	ft	
Specific Energy		1.00	ft	
Froude Number		0.64		<0.86
Flow Type	Subcritical	Stable Flow		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.90	ft
Critical Depth	0.76	ft
Channel Slope	0.00500	ft/ft
Critical Slope	0.01292	ft/ft

NSTec

5/22/2009 4:46:27 PM Bentley Systems, Inc. Haestad Methods Solution Center 27 Siemons Company Drive Suite 200 W Watertown, CT 06795 USA +1-203-755-1666 Bentley FlowMaster [08.01.071.00] Page 1 of 1

Preparer: 6/8/09 Checker: 6/8/09

Attachment B
Flow Master Output Sheets – East (cont.)

Worksheet for east channel

Project Description

Friction Method	Manning Formula		
Solve For	Normal Depth		

Input Data

Roughness Coefficient		0.069	
Channel Slope		0.00500	ft/ft
Left Side Slope		5.00	ft/ft (H:V)
Right Side Slope		5.00	ft/ft (H:V)
Discharge		10.00	ft³/s

Results

Normal Depth		1.32	ft	>1.1dc
Flow Area		8.76	ft²	
Wetted Perimeter		13.50	ft	
Top Width		13.24	ft	
Critical Depth		0.76	ft	
Critical Slope		0.09845	ft/ft	
Velocity		1.14	ft/s	
Velocity Head		0.02	ft	
Specific Energy		1.34	ft	
Froude Number		0.25		<0.86
Flow Type	Subcritical			Stable Flow

$F_b = .5 + \frac{1.14^2}{64.4}$
$= .52$ Ft

total Depth = 1.32 + .52
= 1.84 Ft

@ Bend = 1.84 + .5
= 2.34 Ft

GVF Input Data

Downstream Depth		0.00	ft
Length		0.00	ft
Number Of Steps		0	

GVF Output Data

Upstream Depth		0.00	ft
Profile Description			
Profile Headloss		0.00	ft
Downstream Velocity		Infinity	ft/s
Upstream Velocity		Infinity	ft/s
Normal Depth		1.32	ft
Critical Depth		0.76	ft
Channel Slope		0.00500	ft/ft
Critical Slope		0.09845	ft/ft

NSTec

Bentley Systems, Inc. Haestad Methods Solution Center Bentley FlowMaster [08.01.071.00]
5/26/2009 6:42:24 PM 27 Siemons Company Drive Suite 200 W Watertown, CT 06795 USA +1-203-755-1666 Page 1 of 1

Preparer: 6/8/09 Checker: 6/8/09

Attachment B
Flow Master Output Sheets – East (cont.)

```
             Project Name: drainage
              Description: Ditches
Horizontal Alignment Name: east
              Description:
                    Style: Default
                                         STATION        NORTHING        EASTING

Element: Linear
             POB   (         )           0+00.00       768040.30      709423.44
             PC    (         )           0+85.23       767963.21      709459.80
        Tangent Direction:       S 25^15'26.26" E
          Tangent Length:               85.23455

Element: Circular
             PC    (         )           0+85.23       767963.21      709459.80
             PI    (         )           1+07.64       767942.95      709469.36
             CC    (         )                         767920.54      709369.36
             PT    (         )           1+29.32       767920.54      709469.36
                   Radius:             100.00000
                    Delta:          25^15'26.26" Right   ① Mostly a SuperCritical
  Degree of Curvature(Arc):          57^17'44.81"           Flow PVI @ 0+89.24
                   Length:              44.08230
                  Tangent:              22.40515
                    Chord:              43.72623
          Middle Ordinate:               2.41924
                 External:               2.47922
        Tangent Direction:       S 25^15'26.26" E
         Radial Direction:       S 64^44'33.74" W
          Chord Direction:       S 12^37'43.13" E
         Radial Direction:       S 90^00'00.00" W
        Tangent Direction:       S  0^00'00.00" E

Element: Linear
             PT    (         )           1+29.32       767920.54      709469.36
             PC    (         )           9+20.86       767129.00      709469.36
        Tangent Direction:       S  0^00'00.00" E
          Tangent Length:              791.54361

Element: Circular
             PC    (         )           9+20.86       767129.00      709469.36
             PI    (         )          11+59.06       766890.80      709469.36
             CC    (         )                         767129.00      708659.36
             PCC   (         )          13+84.20       766690.52      709340.42
                   Radius:             810.00000
                    Delta:          32^46'27.70" Right
  Degree of Curvature(Arc):           7^04'24.79"
                   Length:             463.33662      ② SuperCritical
                  Tangent:             238.19905
                    Chord:             457.04544
          Middle Ordinate:              32.90453
                 External:              34.29781
        Tangent Direction:       S  0^00'00.00" E
         Radial Direction:       S 90^00'00.00" W
          Chord Direction:       S 16^23'13.85" W
         Radial Direction:       N 57^13'32.30" W
        Tangent Direction:       S 32^46'27.70" W

Element: Circular
             PCC   (         )          13+84.20       766690.52      709340.42
             PI    (         )          14+26.82       766654.69      709317.35
             CC    (         )                         766771.72      709214.30
             PT    (         )          14+67.25       766636.34      709278.88
                   Radius:             150.00000
                    Delta:          31^43'27.10" Right
  Degree of Curvature(Arc):          38^11'49.87"
                   Length:              83.05375
                  Tangent:              42.62136    ③ SuperCritical
                    Chord:              81.99688
          Middle Ordinate:               5.71165
                 External:               5.93775
        Tangent Direction:       S 32^46'27.70" W
         Radial Direction:       N 57^13'32.30" W
          Chord Direction:       S 48^38'11.25" W
         Radial Direction:       N 25^30'05.20" W
        Tangent Direction:       S 64^29'54.80" W
```

Preparer: 6/8/09 Checker: 6/8/09

Attachment B
Flow Master Output Sheets – East (cont.)

```
Element: Linear
        PT   (         )           14+67.25     766636.34      709278.88
        PC   (         )           16+49.66     766557.80      709114.24
    Tangent Direction:    S 64^29'54.80" W
      Tangent Length:            182.41338

Element: Circular
        PC   (         )           16+49.66     766557.80      709114.24
        PI   (         )           16+78.31     766545.47      709088.39
        CC   (         )                        766422.41      709178.82
        PT   (         )           17+06.27     766524.48      709068.90
               Radius:           150.00000
                Delta:        21^37'12.05"  Left
  Degree of Curvature(Arc):   38^11'49.87"
               Length:            56.60106
              Tangent:            28.64118
                Chord:            56.26586
      Middle Ordinate:             2.66182
             External:             2.70991
    Tangent Direction:    S 64^29'54.80" W
     Radial Direction:    N 25^30'05.20" W
      Chord Direction:    S 53^41'18.78" W
     Radial Direction:    N 47^07'17.25" W
    Tangent Direction:    S 42^52'42.75" W
```

④ Super Critical

```
Element: Linear
        PT   (         )           17+06.27     766524.48      709068.90
        PC   (         )           17+25.03     766510.73      709056.13
    Tangent Direction:    S 42^52'42.75" W
      Tangent Length:             18.76133

Element: Circular
        PC   (         )           17+25.03     766510.73      709056.13
        PI   (         )           19+86.67     766319.00      708878.10
        CC   (         )                        766919.00      708616.45
        PT   (         )           22+18.48     766319.00      708616.45
               Radius:           600.00000
                Delta:        47^07'17.25"  Right
  Degree of Curvature(Arc):    9^32'57.47"
               Length:           493.45475
              Tangent:           261.64396
                Chord:           479.66502
      Middle Ordinate:            50.01785
             External:            54.56670
    Tangent Direction:    S 42^52'42.75" W
     Radial Direction:    N 47^07'17.25" W
      Chord Direction:    S 66^26'21.38" W
     Radial Direction:    N  0^00'00.00" E
    Tangent Direction:    S 90^00'00.00" W
```

⑤ SuperCritical-In 1.39%
Subcritical - Out .61%

```
Element: Linear
        PT   (         )           22+18.48     766319.00      708616.45
        PC   (         )           24+38.72     766319.00      708396.21
    Tangent Direction:    S 90^00'00.00" W
      Tangent Length:            220.24253

Element: Circular
        PC   (         )           24+38.72     766319.00      708396.21
        PI   (         )           24+81.35     766319.00      708353.58
        CC   (         )                        766219.00      708396.21
        PT   (         )           25+19.32     766288.24      708324.06
               Radius:           100.00000
                Delta:        46^10'36.19"  Left
  Degree of Curvature(Arc):   57^17'44.81"
               Length:            80.59358
              Tangent:            42.62961
                Chord:            78.43005
      Middle Ordinate:             8.00988
             External:             8.70733
    Tangent Direction:    S 90^00'00.00" W
     Radial Direction:    N  0^00'00.00" E
      Chord Direction:    S 66^54'41.90" W
     Radial Direction:    N 46^10'36.19" W
    Tangent Direction:    S 43^49'23.81" W
```

⑥ Subcritical

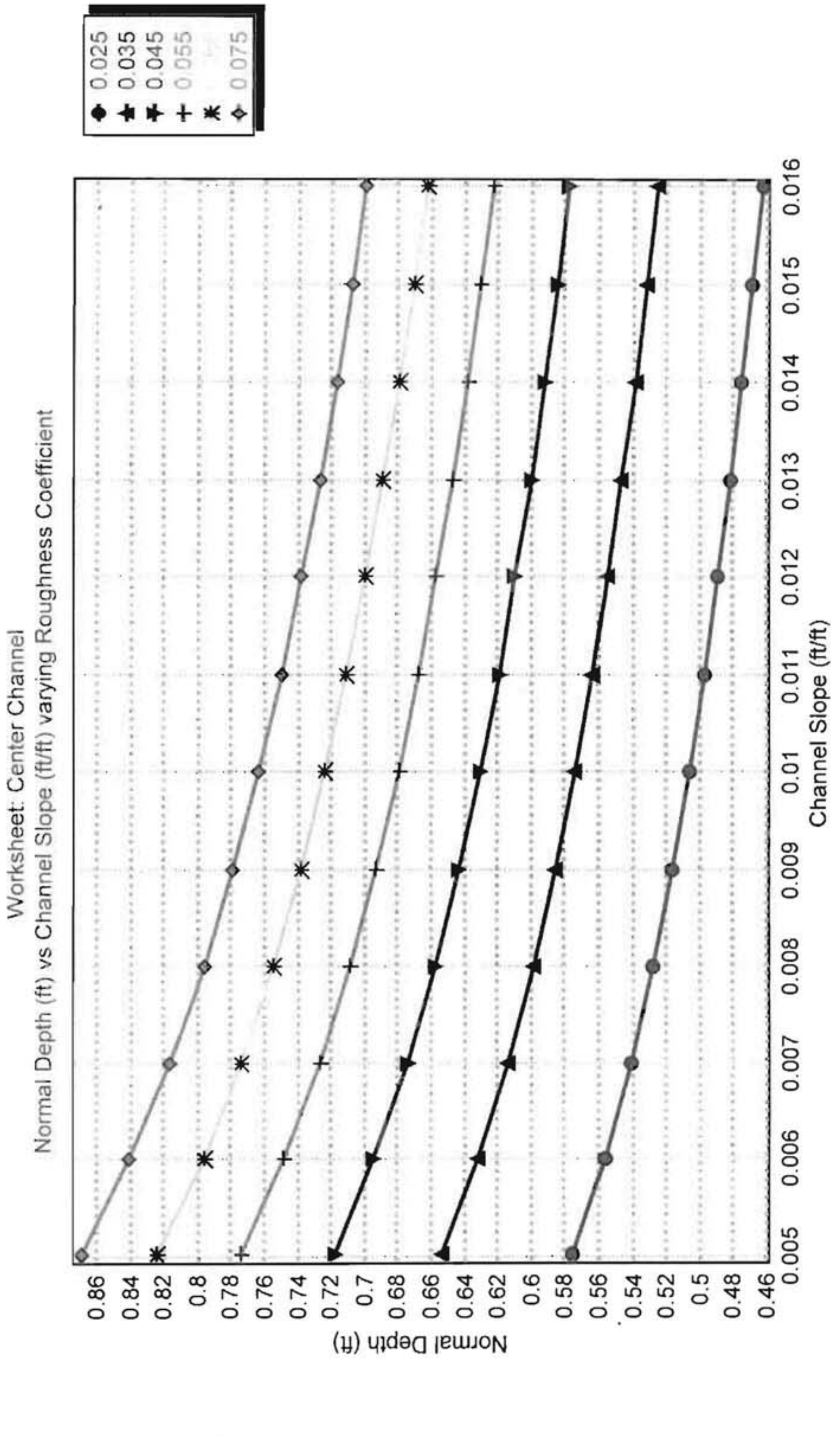
Attachment B
Flow Master Output Sheets – East (cont.)

```
Element: Linear
         PT   (         )          25+19.32      766288.24      708324.06
        POE   (         )          25+50.00      766266.11      708302.82
      Tangent Direction:   S 43^49'23.81" W
         Tangent Length:           30.67868
```

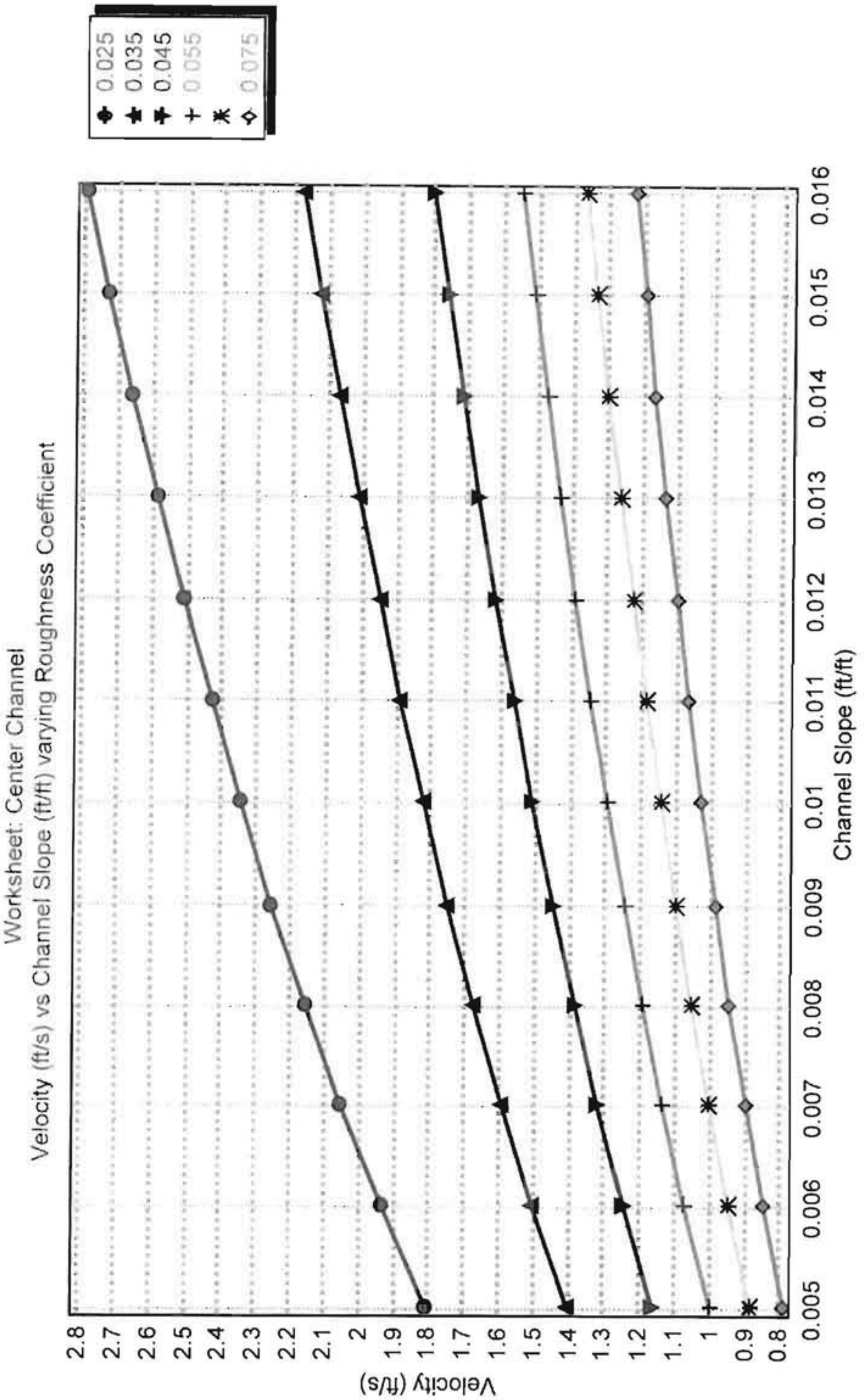
Attachment C

Flow Master Output Sheets - Center

Attachment C
Flow Master Output Sheets – Center

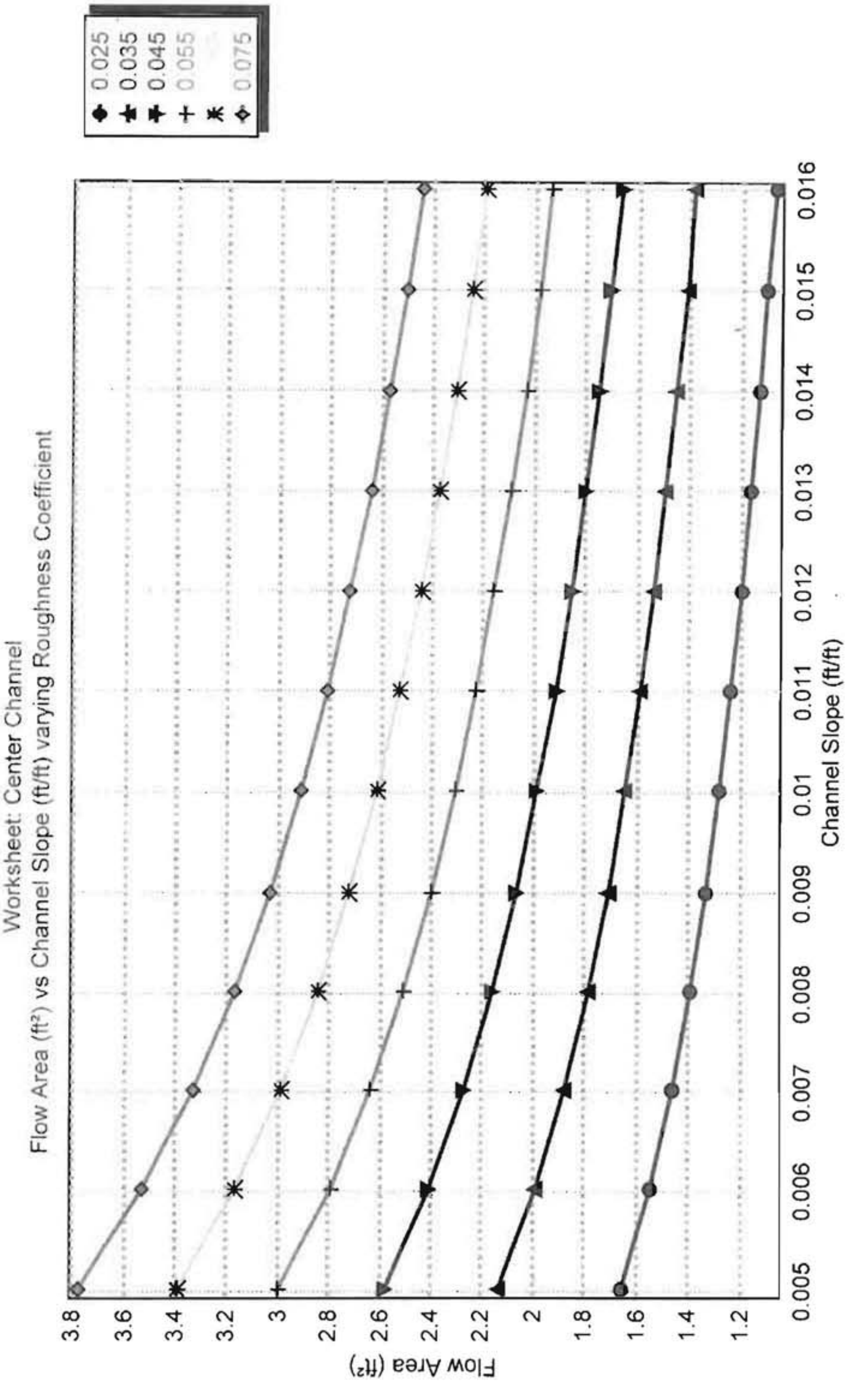


Attachment C
Flow Master Output Sheets – Center (cont.)



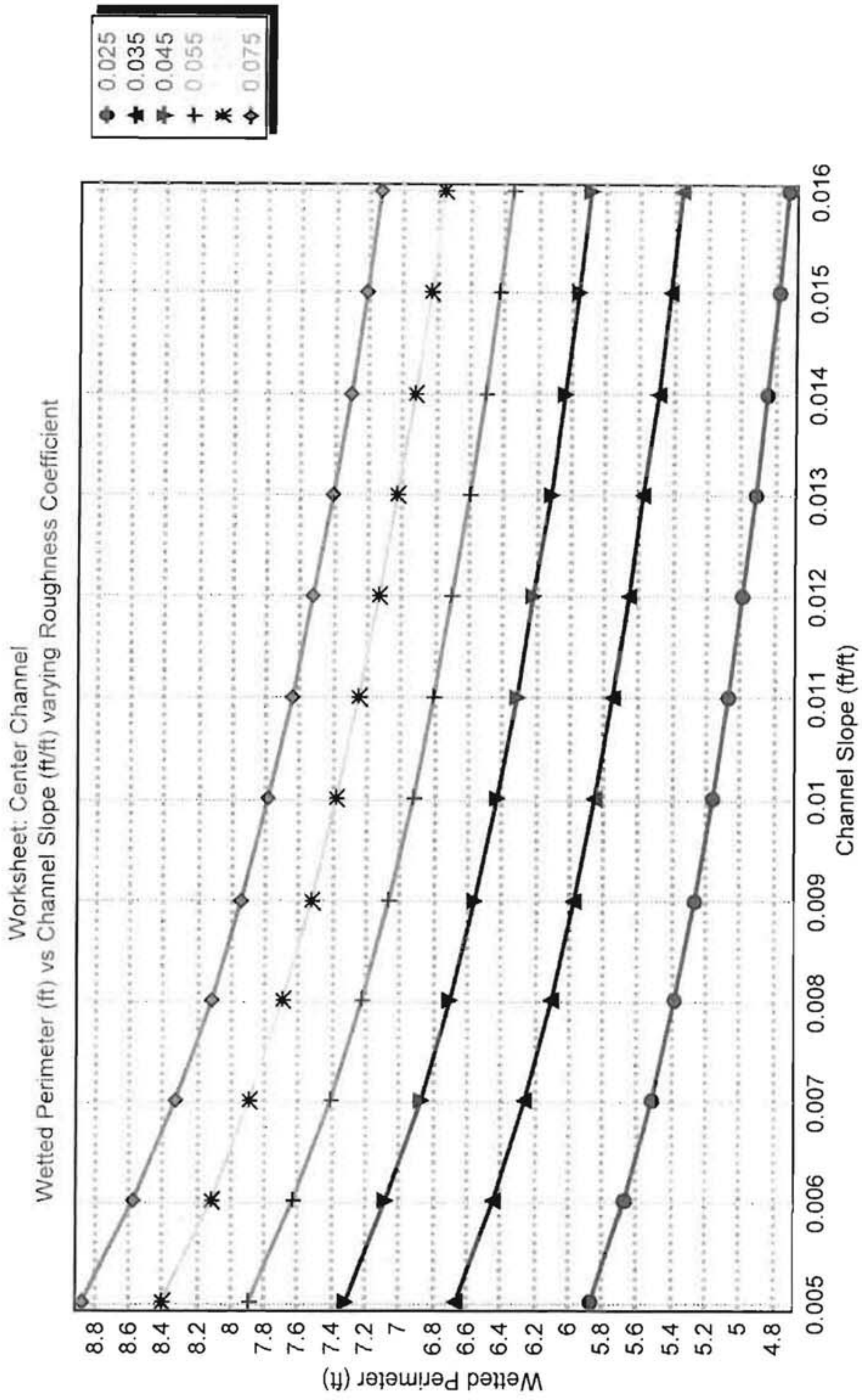
Preparer: 1/8/09 Checker: 6/8/09

Attachment C
Flow Master Output Sheets – Center (cont.)

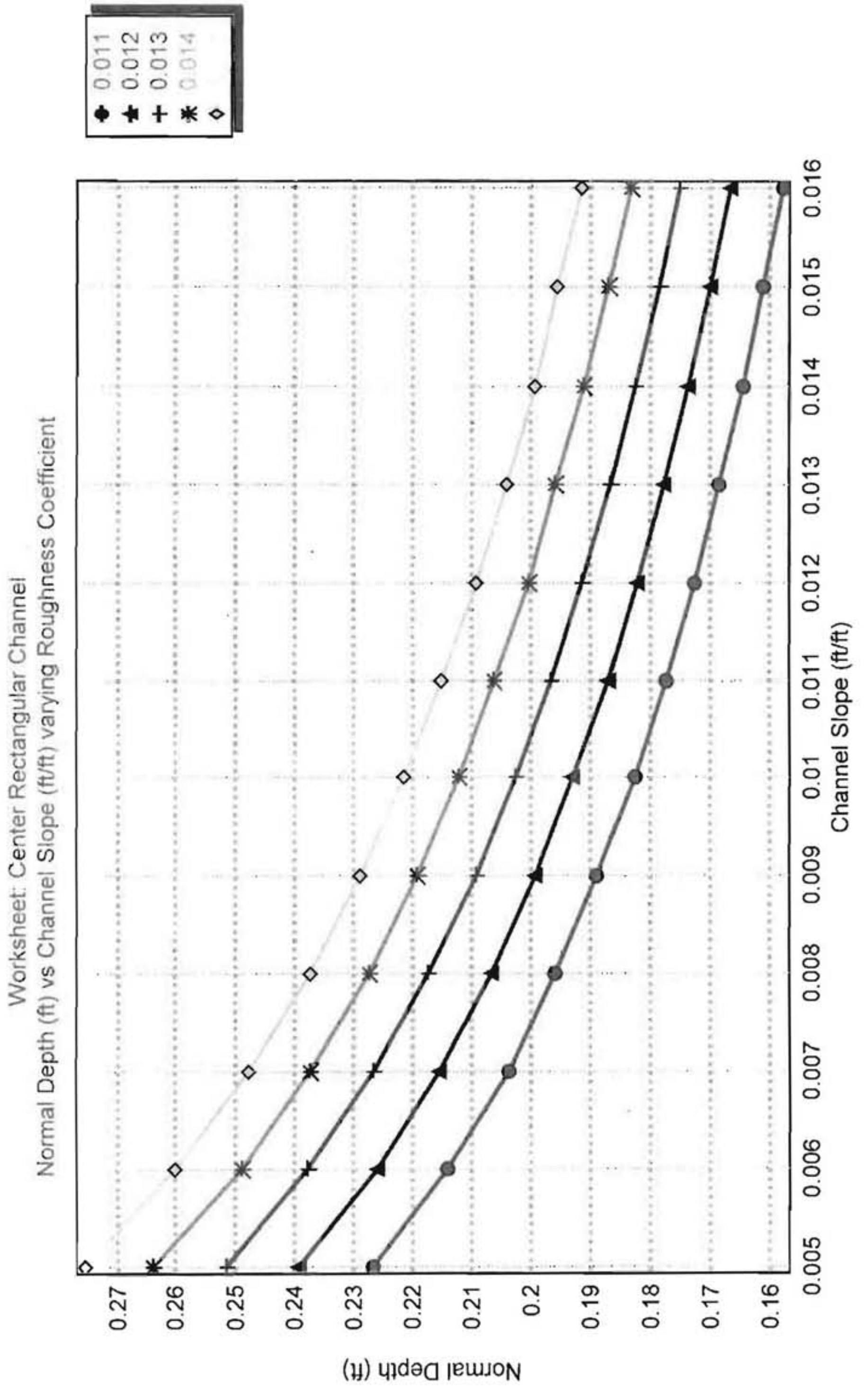


Preparer: 6/8/09 Checker: 8/8/09

Attachment C
Flow Master Output Sheets – Center (cont.)



Attachment C
Flow Master Output Sheets – Center (cont.)



Attachment C
Flow Master Output Sheets – Center (cont.)

Worksheet for Center Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.025	
Channel Slope	0.00550	ft/ft
Left Side Slope	5.00	ft/ft (H:V)
Right Side Slope	5.00	ft/ft (H:V)
Discharge	3.00	ft³/s

Results

Normal Depth	0.57	ft	$> 1.1 d_c \therefore$ OK
Flow Area	1.60	ft²	
Wetted Perimeter	5.77	ft	
Top Width	5.66	ft	
Critical Depth	0.47	ft	$1.1 d_c = .52$
Critical Slope	0.01517	ft/ft	
Velocity	1.87	ft/s	
Velocity Head	0.05	ft	
Specific Energy	0.62	ft	
Froude Number	0.62		$< .86 \therefore$ OK
Flow Type	Subcritical		

Req'd F_b:

$$F_b = .5 + \frac{1.87^2}{64.4}$$

$= .55$

$= .6$ Ft

At bend Add 0.5 Ft

total Depth $= .57 + .6$

$= 1.2$ Ft

@ Bend $= 1.2 + .5$

$= 1.7$ Ft

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.57	ft
Critical Depth	0.47	ft
Channel Slope	0.00550	ft/ft
Critical Slope	0.01517	ft/ft

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Preparer: 6/8/09 Checker: 6/8/09

Attachment C
Flow Master Output Sheets – Center (cont.)

Worksheet for Center Channel - RipRap

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.069		6" D_{50}
Channel Slope	0.00550	ft/ft	
Left Side Slope	5.00	ft/ft (H:V)	
Right Side Slope	5.00	ft/ft (H:V)	
Discharge	3.00	ft³/s	

Results

Normal Depth	0.83	ft	>1.1dc
Flow Area	3.43	ft²	
Wetted Perimeter	8.44	ft	
Top Width	8.28	ft	
Critical Depth	0.47	ft	1.1dc = .52'
Critical Slope	0.11559	ft/ft	
Velocity	0.88	ft/s	
Velocity Head	0.01	ft	
Specific Energy	0.84	ft	
Froude Number	0.24		<.086
Flow Type	Subcritical		STABLE

$F_b = .5 + \frac{.88^2}{64.4}$
$= .50\,Ft$

depth Req'd = .83+.5
= 1.33 Ft

at bend F_b = 1.33+.5
= 1.83 Ft

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.83	ft
Critical Depth	0.47	ft
Channel Slope	0.00550	ft/ft
Critical Slope	0.11559	ft/ft

NSTec

Preparer: 6/8/09 Checker: 6/8/09

Attachment C
Flow Master Output Sheets – Center (cont.)

Worksheet for Center Rectangular Channel

Project Description

Friction Method	Manning Formula	
Solve For	Normal Depth	

Input Data

CONC SPLIT BOX

Roughness Coefficient	0.013	
Channel Slope	0.01450	ft/ft
Bottom Width	4.00	ft
Discharge	3.00	ft³/s

Results

Normal Depth	0.18	ft
Flow Area	0.72	ft²
Wetted Perimeter	4.36	ft
Top Width	4.00	ft
Critical Depth	0.26	ft
Critical Slope	0.00454	ft/ft
Velocity	4.15	ft/s
Velocity Head	0.27	ft
Specific Energy	0.45	ft
Froude Number	1.72	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.18	ft
Critical Depth	0.26	ft
Channel Slope	0.01450	ft/ft
Critical Slope	0.00454	ft/ft

NSTec

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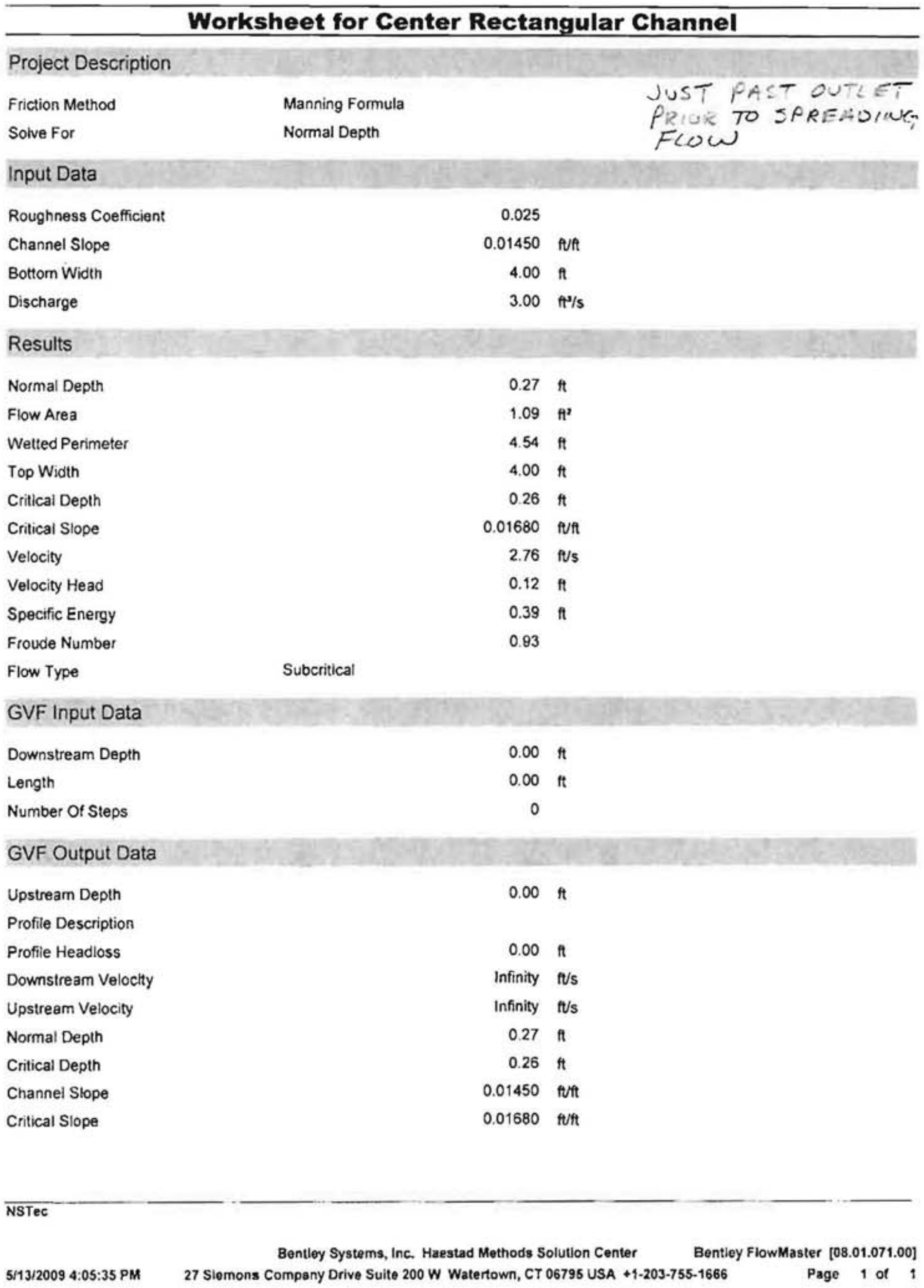
Attachment C
Flow Master Output Sheets – Center (cont.)



Worksheet for Center Rectangular Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

JUST PAST OUTLET PRIOR TO SPREADING OF FLOW

Input Data

Roughness Coefficient	0.025	
Channel Slope	0.01450	ft/ft
Bottom Width	4.00	ft
Discharge	3.00	ft³/s

Results

Normal Depth	0.27	ft
Flow Area	1.09	ft²
Wetted Perimeter	4.54	ft
Top Width	4.00	ft
Critical Depth	0.26	ft
Critical Slope	0.01680	ft/ft
Velocity	2.76	ft/s
Velocity Head	0.12	ft
Specific Energy	0.39	ft
Froude Number	0.93	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.27	ft
Critical Depth	0.26	ft
Channel Slope	0.01450	ft/ft
Critical Slope	0.01680	ft/ft

NSTec

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Preparer: Checker: 6/8/09

Attachment C
Flow Master Output Sheets – Center (cont.)

Worksheet for Center Rectangular Channel

Project Description

Friction Method	Manning Formula		
Solve For	Normal Depth		

JUST PAST OUTLET PRIOR TO SPREADING OF FLOW

Input Data

Roughness Coefficient	0.069	
Channel Slope	0.01450	ft/ft
Bottom Width	4.00	ft
Discharge	3.00	ft³/s

6" D_{50}

Results

Normal Depth		0.52	ft
Flow Area		2.09	ft²
Wetted Perimeter		5.04	ft
Top Width		4.00	ft
Critical Depth		0.26	ft
Critical Slope		0.12798	ft/ft
Velocity		1.44	ft/s
Velocity Head		0.03	ft
Specific Energy		0.55	ft
Froude Number		0.35	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.52	ft
Critical Depth	0.26	ft
Channel Slope	0.01450	ft/ft
Critical Slope	0.12798	ft/ft

Attachment D

Culvert Master Output Sheets

Attachment D
Culvert Master Output Sheets

Culvert Design Report
N/A

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	3,193.60 ft	Storm Event	Design
Computed Headwater Elev	3,193.64 ft	Discharge	40.00 cfs
Headwater Depth/Height	1.02	Tailwater Elevation	N/A ft
Inlet Control HW Elev.	3,193.42 ft	Control Type	Outlet Control
Outlet Control HW Elev.	3,193.64 ft		

Grades

Upstream Invert	3,191.60 ft	Downstream Invert	3,191.23 ft
Length	75.00 ft	Constructed Slope	0.005000 ft/ft

Hydraulic Profile

Profile	M2	Depth, Downstream	1.13 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	1.13 ft
Velocity Downstream	5.45 ft/s	Critical Slope	0.017725 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	2.00 ft
Section Size	24 Inch	Rise	2.00 ft
Number Sections	4		

Outlet Control Properties

Outlet Control HW Elev.	3,193.64 ft	Upstream Velocity Head	0.20 ft
Ke	0.90	Entrance Loss	0.18 ft

Inlet Control Properties

Inlet Control HW Elev.	3,193.42 ft	Flow Control	N/A
Inlet Type	Projecting	Area Full	12.6 ft2
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Computed Headwater > Allowable ∴ No Good

Title: A5 92 Acre Grading and Drainage
g:\..\09\09068\calculations\north culvert.cvm
05/18/09 08:18:28 PM© Bentley Systems, Inc. Haestad Methods Solution Center Watertown, CT 06795 USA +1-203-755-1666

National Security Technologies

Project Engineer: Joseph Depa
CulvertMaster v3.1 [03.01.010.00]
Page 1 of 1

Attachment D
Culvert Master Output Sheets (cont.)

Culvert Design Report
N/A

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	3,193.60 ft	Storm Event	Design
Computed Headwater Elev:	3,193.70 ft	Discharge	40.00 cfs
Headwater Depth/Height	0.84	Tailwater Elevation	N/A ft
Inlet Control HW Elev.	3,193.49 ft	Control Type	Outlet Control
Outlet Control HW Elev.	3,193.70 ft		

Grades			
Upstream Invert	3,191.60 ft	Downstream Invert	3,191.23 ft
Length	75.00 ft	Constructed Slope	0.005000 ft/ft

Hydraulic Profile			
Profile	M2	Depth, Downstream	1.23 ft
Slope Type	Mild	Normal Depth	1.77 ft
Flow Regime	Subcritical	Critical Depth	1.23 ft
Velocity Downstream	5.56 ft/s	Critical Slope	0.015303 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	2.50 ft
Section Size	30 inch	Rise	2.50 ft
Number Sections	3		

Outlet Control Properties			
Outlet Control HW Elev.	3,193.70 ft	Upstream Velocity Head	0.23 ft
Ke	0.90	Entrance Loss	0.21 ft

Inlet Control Properties			
Inlet Control HW Elev.	3,193.49 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	14.7 ft2
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Allowabe Headwater Limited to ditch depth of 2 Ft
Calc Hw > Allow Hw ∴ No Good

Title: A5 92 Acre Grading and Drainage
g:\...\09\09068\calculations\north culvert.cvm
05/18/09 06:20:29 PM © Bentley Systems, Inc. Haestad Methods Solution Center Watertown, CT 06795 USA +1-203-755-1666

National Security Technologies

Project Engineer: Joseph Depa
CulvertMaster v3.1 [03.01.010.00]
Page 1 of 1

Preparer: 6/8/09 Checker: 6/8/09

Attachment D
Culvert Master Output Sheets (cont.)

Culvert Design Report
N/A

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	3,193.60 ft	Storm Event	Design
Computed Headwater Eleva	3,193.37 ft	Discharge	40.00 cfs
Headwater Depth/Height	0.71	Tailwater Elevation	N/A ft
Inlet Control HW Elev.	3,193.17 ft	Control Type	Outlet Control
Outlet Control HW Elev.	3,193.37 ft		

Grades

Upstream Invert	3,191.60 ft	Downstream Invert	3,191.23 ft
Length	75.00 ft	Constructed Slope	0.005000 ft/ft

Hydraulic Profile

Profile	M2	Depth, Downstream	1.06 ft
Slope Type	Mild	Normal Depth	1.45 ft
Flow Regime	Subcritical	Critical Depth	1.06 ft
Velocity Downstream	5.07 ft/s	Critical Slope	0.014611 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	2.50 ft
Section Size	30 inch	Rise	2.50 ft
Number Sections	4		

Outlet Control Properties

Outlet Control HW Elev.	3,193.37 ft	Upstream Velocity Head	0.19 ft
Ke	0.90	Entrance Loss	0.17 ft

Inlet Control Properties

Inlet Control HW Elev.	3,193.17 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	19.6 ft2
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

12" MINIMUM COVER IS ISSUE UNDER ROAD
Try CMPA WITH 30" Equiv Diameter

Title: A5 92 Acre Grading and Drainage
g:\...\09\09068\calculations\north culvert.cvm
05/18/09 06:16:19 PM Bentley Systems, Inc. Haestad Methods Solution Center Watertown, CT 06795 USA +1-203-755-1666
National Security Technologies
Project Engineer: Joseph Depa
CulvertMaster v3.1 [03.01.010.00]
Page 1 of 1

Attachment D
Culvert Master Output Sheets (cont.)

Culvert Design Report
N/A

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	3,191.85 ft	Storm Event	Design
Computed Headwater Elev	3,191.67 ft	Discharge	40.00 cfs
Headwater Depth/Height	0.91	Tailwater Elevation	N/A ft
Inlet Control HW Elev.	3,191.46 ft	Control Type	Outlet Control
Outlet Control HW Elev.	3,191.67 ft		

Grades

Upstream Invert	3,189.85 ft	Downstream Invert	3,189.28 ft
Length	115.00 ft	Constructed Slope	0.005000 ft/ft

Hydraulic Profile

Profile	M2	Depth, Downstream	0.97 ft
Slope Type	Mild	Normal Depth	1.55 ft
Flow Regime	Subcritical	Critical Depth	0.97 ft
Velocity Downstream	5.33 ft/s	Critical Slope	0.016190 ft/ft

Section

Section Shape	Arch	Mannings Coefficient	0.025
Section Material	Steel and Aluminum Var CR	Span	2.92 ft
Section Size	35 x 24 inch	Rise	2.00 ft
Number Sections	3		

Outlet Control Properties

Outlet Control HW Elev.	3,191.67 ft	Upstream Velocity Head	0.19 ft
Ke	0.90	Entrance Loss	0.18 ft

Inlet Control Properties

Inlet Control HW Elev.	3,191.46 ft	Flow Control	Unsubmerged
Inlet Type	Thin wall projecting	Area Full	13.5 ft2
K	0.03400	HDS 5 Chart	34
M	1.50000	HDS 5 Scale	3
C	0.04960	Equation Form	1
Y	0.57000		

O.K

Title: A5 92 Acre Grading and Drainage
g:\...\09\09068\calculations\north culvert.cvm
05/22/09 04:51:28 PM © Bentley Systems, Inc. Haestad Methods Solution Center Watertown, CT 06795 USA +1-203-755-1666

National Security Technologies

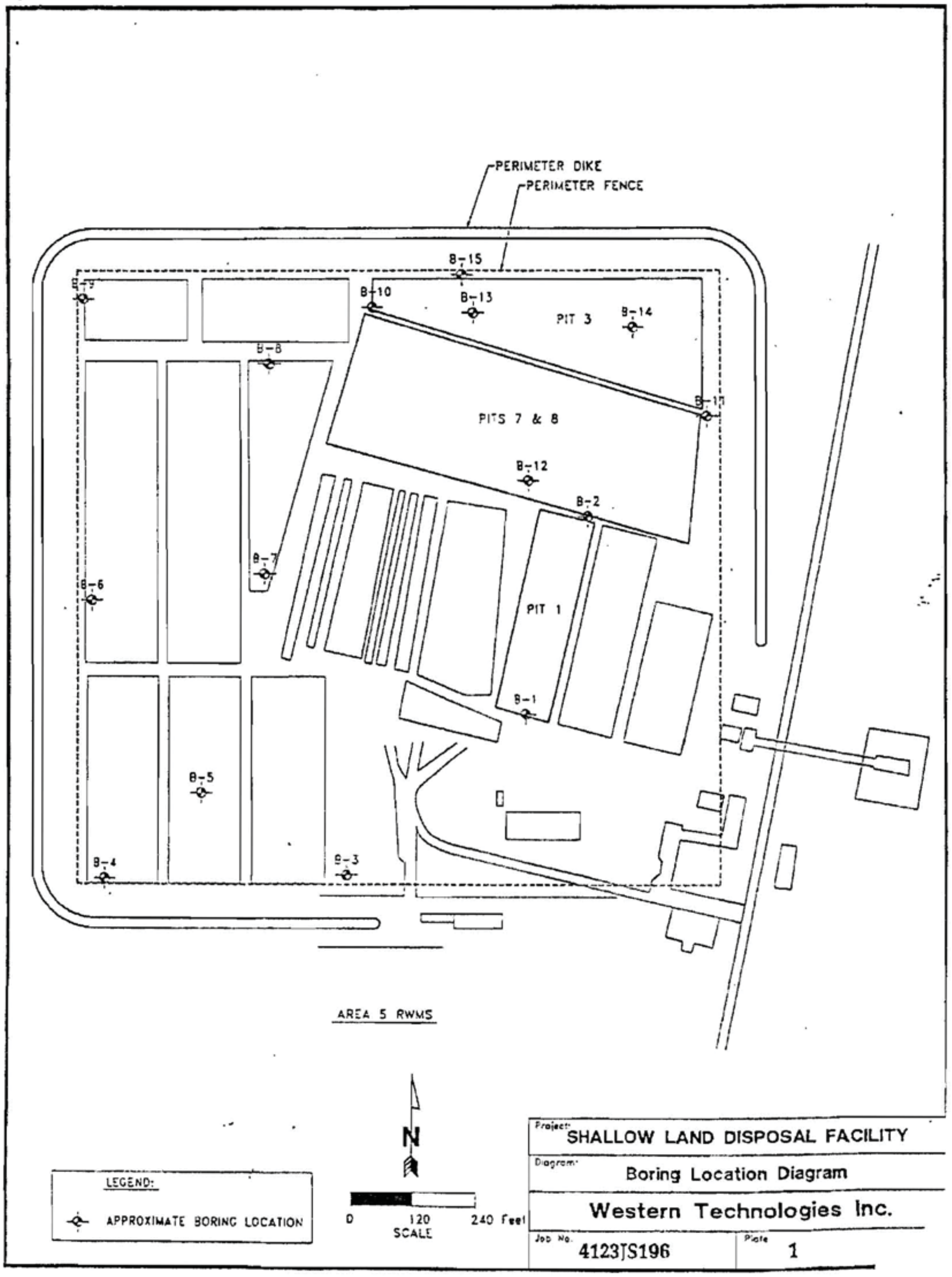
Project Engineer: Joseph Depa
CulvertMaster v3.1 [03.01.010.00]
Page 1 of 1

Preparer: 6/8/09 Checker: 6/8/09

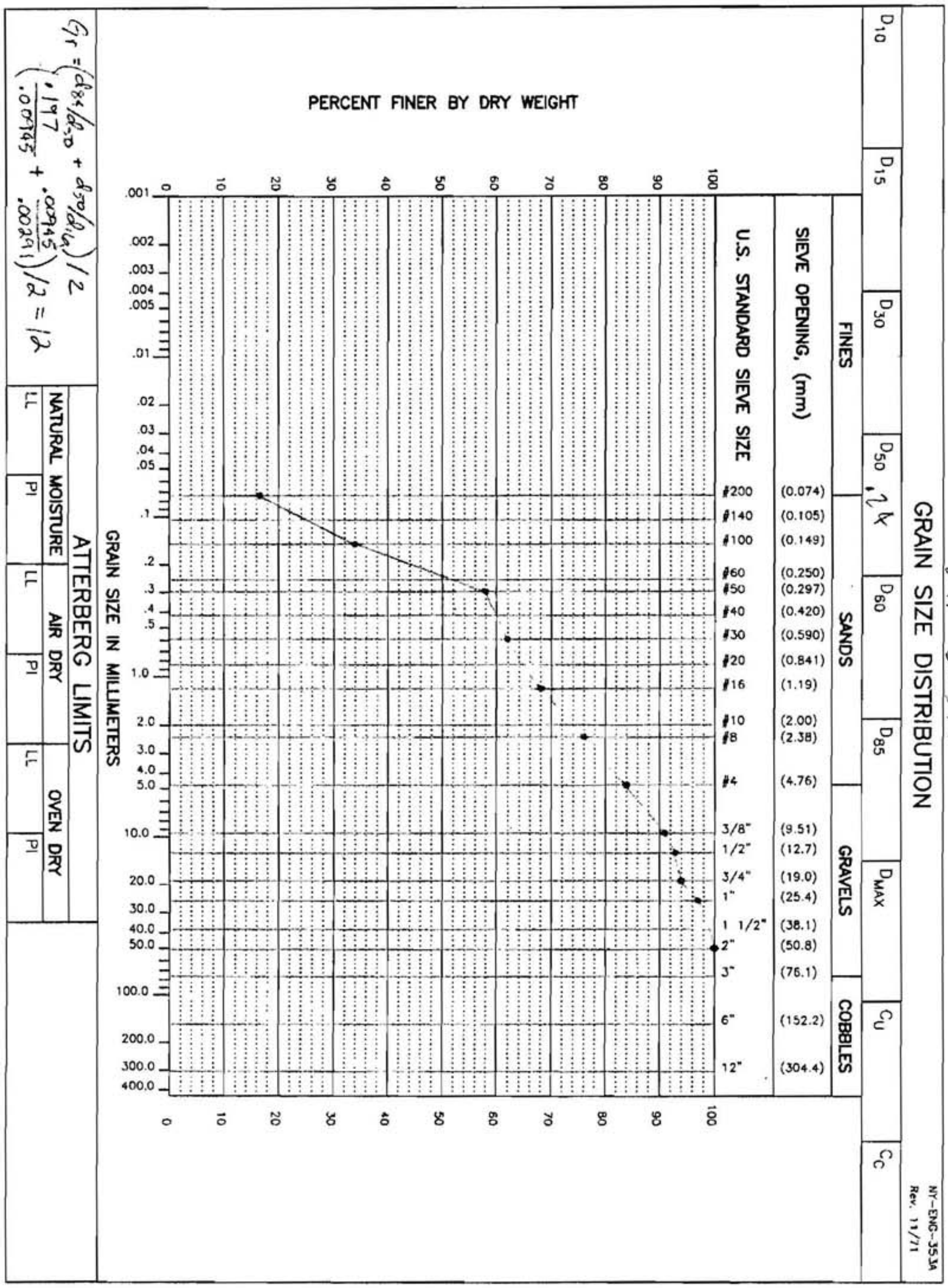
Attachment E

Sieve Analysis Data Sheets

Attachment E
Sieve Analysis Data Sheets



Attachment E
Sieve Analysis Data Sheets (cont.)



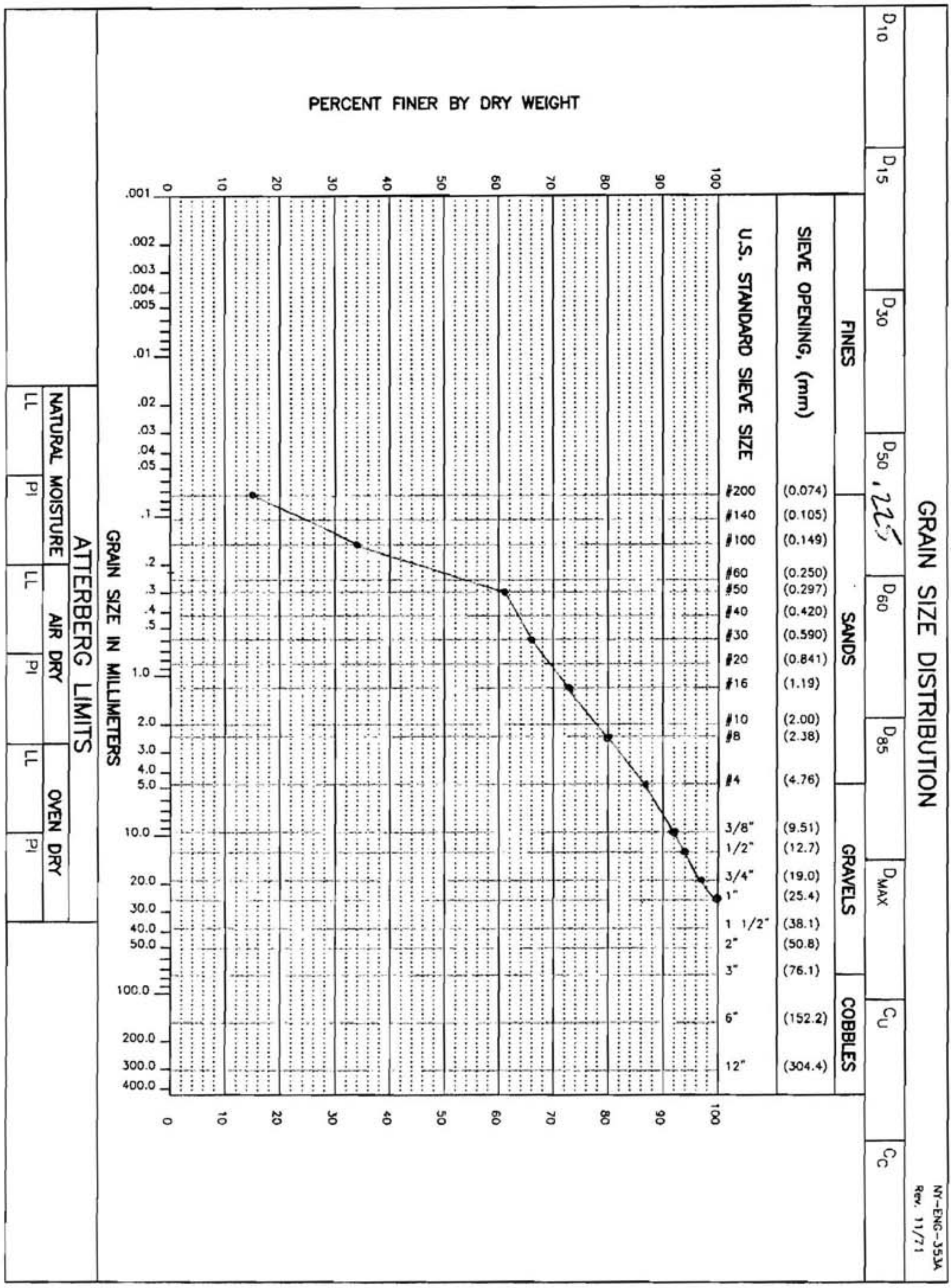
E-11 0-5 Ft

D50 .26

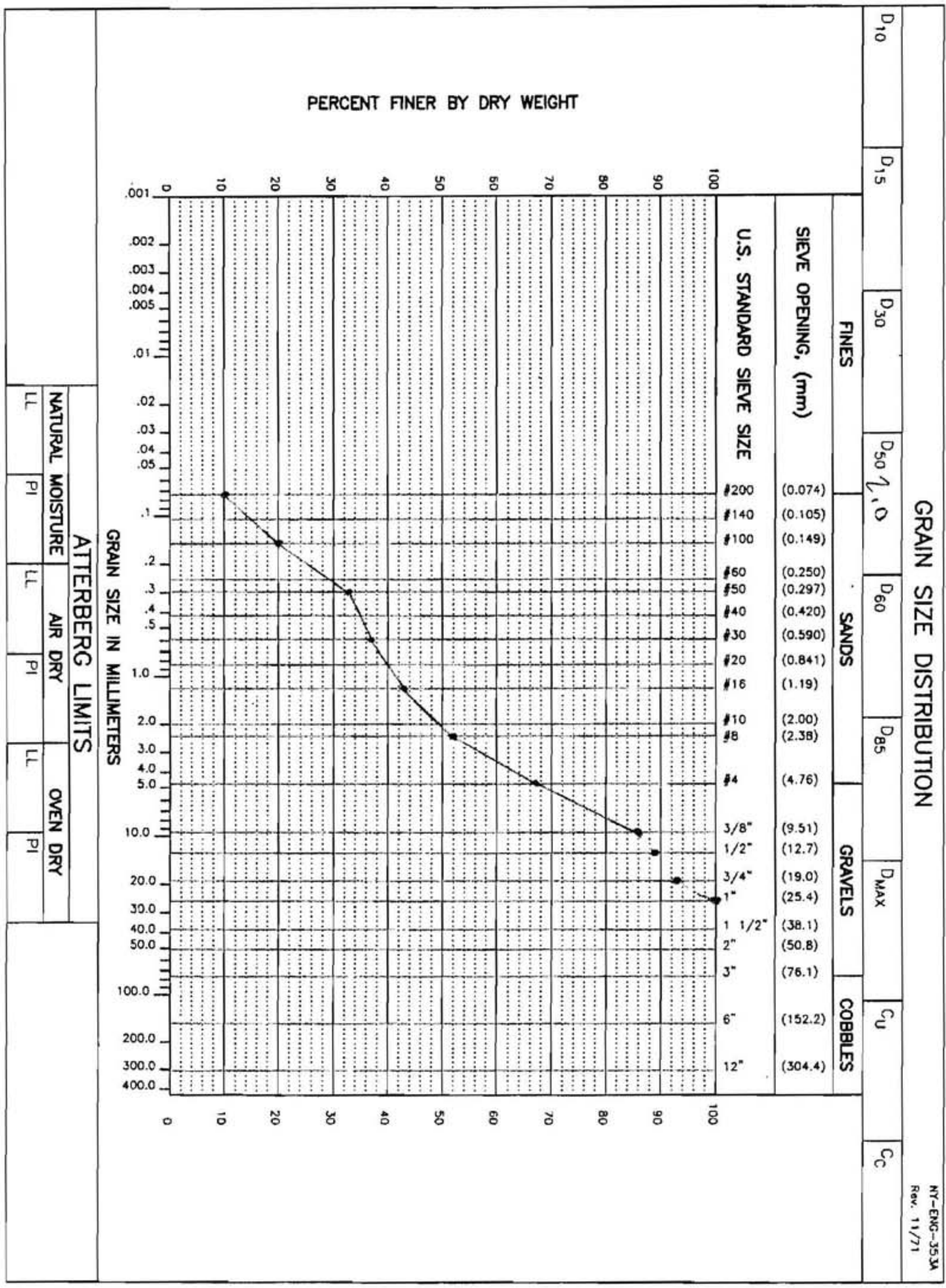
$G_r = (d_{84}/d_{50} + d_{50}/d_{16})/2$

$(.197/.00945 + .00945/.00291)/2 = 12$

Attachment E
Sieve Analysis Data Sheets (cont.)



Attachment E
Sieve Analysis Data Sheets (cont.)



Attachment E
Sieve Analysis Data Sheets (cont.)

PERCENT PASSING STANDARD SIEVE SIZES

SAMPLE IDENTIFICATION	3"	2"	1"	3/4"	1/2"	3/8"	4	8	16	30	50	100	200
B-9 @ 30-35 ft.		100	98	96	91	88	71	54	46	35	34	19	10.1
B-10 @ 25-30 ft.			100	99	98	96	77	57	47	39	34	17	8.2
B-11 @ 0-5 ft		100	97	96	93	91	84	76	68	62	58	34	16.4
B-11 @ 30-35 ft.			100	99	97	96	89	79	69	57	49	21	9.7
B-14 @ 10-15 ft.		100	97	94	92	88	71	55	46	38	33	17	7.6

Project: SHALLOW LAND DISPOSAL FACILITY

Test Results: Sieve Analysis Test Results

Western Technologies Inc.

Job No. 4123JS196 Plate: D-2

Preparer: 6/8/09 Checker: 6/8/09

Attachment E
Sieve Analysis Data Sheets (cont.)

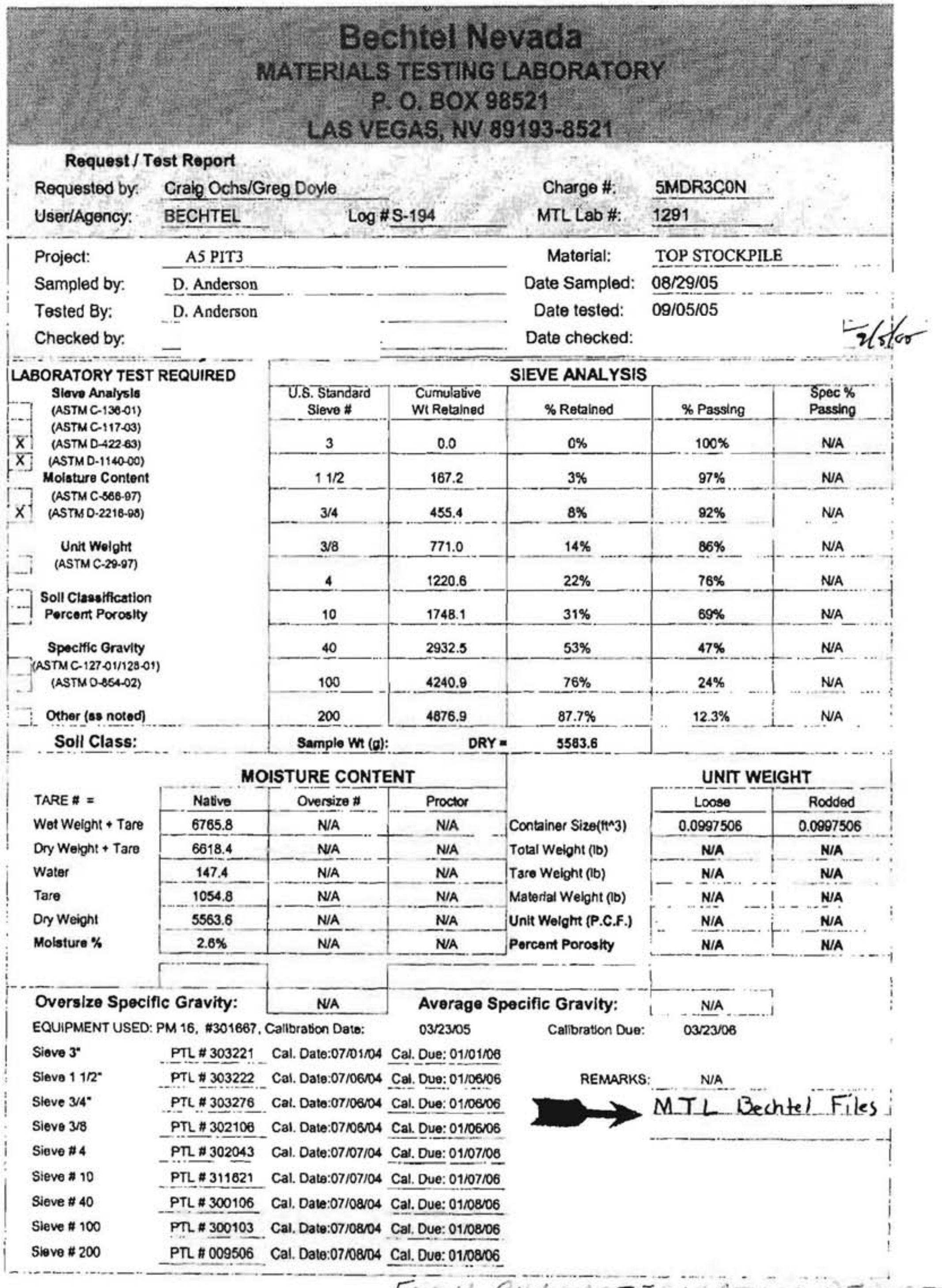
PERCENT PASSING STANDARD SIEVE SIZES

SAMPLE IDENTIFICATION	3"	2"	1"	3/4"	1/2"	3/8"	4	8	16	30	50	100	200
B-1 @ 10-15 ft.				100	98	98	89	79	71	62	56	29	12.1
B-1 @ 20-25 ft.				100	98	97	86	72	62	52	46	22	9.4
B-1 @ 30-35 ft.					100	99	91	69	58	45	37	11	9.3
B-1 @ 40-45 ft.			100	99	99	99	88	72	61	48	41	17	7.2
B-2 @ 5-10 ft.				100	99	98	88	78	66	55	48	50	10.1
B-2 @ 15-20 ft.		100	98	97	96	93	82	70	59	48	41	19	8.1
B-2 @ 25-30 ft.			100	97	97	95	83	64	51	38	31	13	5.7
B-2 @ 35-40 ft.				100	99	96	84	68	51	35	28	10	4.6
B-2 @ 55-60 ft.				100	99	98	92	69	60	47	39	14	5.9
B-3 @ 0-5 ft.			100	97	84	92	87	80	73	66	61	34	14.9
B-3 @ 20-25 ft.			100	99	97	95	87	89	79	66	58	32	6.8
B-4 @ 5-10 ft.		100	93	88	82	76	59	44	35	29	25	14	6.7
B-4 @ 25-30 ft.			100	97	94	86	78	54	47	39	34	17	8.9
B-5 @ 10-15 ft.			100	99	99	97	87	73	63	53	47	24	10.3
B-5 @ 30-35 ft.			100	99	98	98	88	70	60	52	47	28	14.0
B-6 @ 5-10 ft.			100	98	97	96	88	70	60	52	47	28	14.0
B-6 @ 25-30 ft.		100	83	79	73	68	52	40	33	27	23	12	5.9
B-7 @ 20-25 ft.			100	98	97	95	87	77	67	54	46	20	8.9
B-8 @ 15-20 ft.			98	96	94	80	63	53	44	39	22	22	9.6
B-9 @ 0-5 ft.			100	93	89	86	67	52	43	37	33	20	10.0
B-9 @ 10-15 ft.	100	88	84	83	78	74	51	34	27	23	21	13	6.5

Project:
SHALLOW LAND DISPOSAL FACILITY
Test Results:
Sieve Analysis Test Results
Western Technologies Inc.
Job No. 4123JS196
Plate: D-1

Preparer: 6/8/09 Checker: 6/8/09

Attachment E
Sieve Analysis Data Sheets (cont.)



Bechtel Nevada
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

Request / Test Report

Requested by: Craig Ochs/Greg Doyle Charge #: 5MDR3C0N
User/Agency: BECHTEL Log # S-194 MTL Lab #: 1291

Project: A5 PIT3 Material: TOP STOCKPILE
Sampled by: D. Anderson Date Sampled: 08/29/05
Tested By: D. Anderson Date tested: 09/05/05
Checked by: Date checked: 2/5/06

LABORATORY TEST REQUIRED

Sieve Analysis
☐ (ASTM C-136-01)
(ASTM C-117-03)
☒ (ASTM D-422-63)
☒ (ASTM D-1140-00)

Moisture Content
☐ (ASTM C-566-97)
☒ (ASTM D-2216-98)

Unit Weight
☐ (ASTM C-29-97)

☐ **Soil Classification**
Percent Porosity

Specific Gravity
☐ (ASTM C-127-01/128-01)
(ASTM D-854-02)

☐ **Other (as noted)**

Soil Class:

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	% Retained	% Passing	Spec % Passing
3	0.0	0%	100%	N/A
1 1/2	167.2	3%	97%	N/A
3/4	455.4	8%	92%	N/A
3/8	771.0	14%	86%	N/A
4	1220.6	22%	78%	N/A
10	1748.1	31%	69%	N/A
40	2932.5	53%	47%	N/A
100	4240.9	76%	24%	N/A
200	4876.9	87.7%	12.3%	N/A
Sample Wt (g):	**DRY =**	5563.6		

MOISTURE CONTENT

TARE # =	Native	Oversize #	Proctor
Wet Weight + Tare	6765.8	N/A	N/A
Dry Weight + Tare	6618.4	N/A	N/A
Water	147.4	N/A	N/A
Tare	1054.8	N/A	N/A
Dry Weight	5563.6	N/A	N/A
Moisture %	2.6%	N/A	N/A

UNIT WEIGHT

	Loose	Rodded
Container Size(ft^3)	0.0997506	0.0997506
Total Weight (lb)	N/A	N/A
Tare Weight (lb)	N/A	N/A
Material Weight (lb)	N/A	N/A
Unit Weight (P.C.F.)	N/A	N/A
Percent Porosity	N/A	N/A

Oversize Specific Gravity: N/A **Average Specific Gravity:** N/A

EQUIPMENT USED: PM 16, #301667, Calibration Date: 03/23/05 Calibration Due: 03/23/06

Sieve 3"	PTL # 303221	Cal. Date:07/01/04	Cal. Due: 01/01/06
Sieve 1 1/2"	PTL # 303222	Cal. Date:07/06/04	Cal. Due: 01/06/06
Sieve 3/4"	PTL # 303276	Cal. Date:07/06/04	Cal. Due: 01/06/06
Sieve 3/8	PTL # 302106	Cal. Date:07/06/04	Cal. Due: 01/06/06
Sieve # 4	PTL # 302043	Cal. Date:07/07/04	Cal. Due: 01/07/06
Sieve # 10	PTL # 311621	Cal. Date:07/07/04	Cal. Due: 01/07/06
Sieve # 40	PTL # 300106	Cal. Date:07/08/04	Cal. Due: 01/08/06
Sieve # 100	PTL # 300103	Cal. Date:07/08/04	Cal. Due: 01/08/06
Sieve # 200	PTL # 009506	Cal. Date:07/08/04	Cal. Due: 01/08/06

REMARKS: N/A

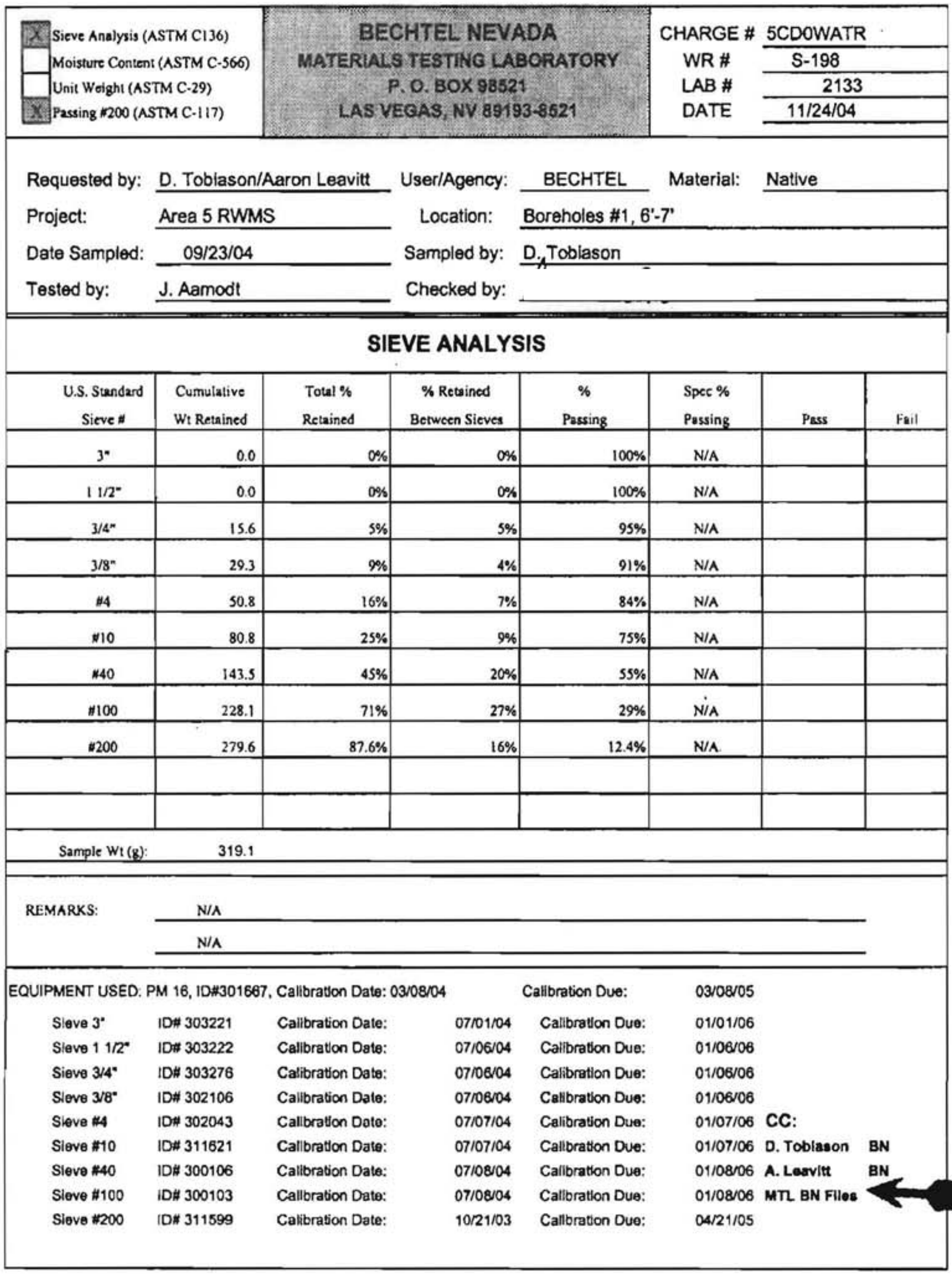
→ MTL Bechtel Files

FROM CHARACTERIZATION REPORT

6/8/09

6/8/09

Attachment E
Sieve Analysis Data Sheets (cont.)



☒ Sieve Analysis (ASTM C136)
☐ Moisture Content (ASTM C-566)
☐ Unit Weight (ASTM C-29)
☒ Passing #200 (ASTM C-117)

BECHTEL NEVADA
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE # 5CD0WATR
WR # S-198
LAB # 2133
DATE 11/24/04

Requested by: D. Tobiason/Aaron Leavitt User/Agency: BECHTEL Material: Native
Project: Area 5 RWMS Location: Boreholes #1, 6'-7'
Date Sampled: 09/23/04 Sampled by: D. Tobiason
Tested by: J. Aamodt Checked by:

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	Total % Retained	% Retained Between Sieves	% Passing	Spec % Passing	Pass	Fail
3"	0.0	0%	0%	100%	N/A		
1 1/2"	0.0	0%	0%	100%	N/A		
3/4"	15.6	5%	5%	95%	N/A		
3/8"	29.3	9%	4%	91%	N/A		
#4	50.8	16%	7%	84%	N/A		
#10	80.8	25%	9%	75%	N/A		
#40	143.5	45%	20%	55%	N/A		
#100	228.1	71%	27%	29%	N/A		
#200	279.6	87.6%	16%	12.4%	N/A		

Sample Wt (g): 319.1

REMARKS: N/A
N/A

EQUIPMENT USED: PM 16, ID#301667, Calibration Date: 03/08/04 Calibration Due: 03/08/05

Sieve 3"	ID# 303221	Calibration Date:	07/01/04	Calibration Due:	01/01/06
Sieve 1 1/2"	ID# 303222	Calibration Date:	07/06/04	Calibration Due:	01/06/06
Sieve 3/4"	ID# 303276	Calibration Date:	07/06/04	Calibration Due:	01/06/06
Sieve 3/8"	ID# 302106	Calibration Date:	07/06/04	Calibration Due:	01/06/06
Sieve #4	ID# 302043	Calibration Date:	07/07/04	Calibration Due:	01/07/06
Sieve #10	ID# 311621	Calibration Date:	07/07/04	Calibration Due:	01/07/06
Sieve #40	ID# 300106	Calibration Date:	07/08/04	Calibration Due:	01/08/06
Sieve #100	ID# 300103	Calibration Date:	07/08/04	Calibration Due:	01/08/06
Sieve #200	ID# 311599	Calibration Date:	10/21/03	Calibration Due:	04/21/05

CC:
D. Tobiason BN
A. Leavitt BN
MTL BN Files

Attachment E
Sieve Analysis Data Sheets (cont.)

☒ Sieve Analysis (ASTM C136)
☐ Moisture Content (ASTM C-566)
☐ Unit Weight (ASTM C-29)
☒ Passing #200 (ASTM C-117)

BECHTEL NEVADA
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE # 5CD0WATR
WR # S-198
LAB # 2134
DATE 11/24/04

Requested by: D. Tobiason/Aaron Leavitt User/Agency: BECHTEL Material: Native
Project: Area 5 RWMS Location: Boreholes #1, 11'-12'
Date Sampled: 09/23/04 Sampled by: D. Tobiason
Tested by: J. Aamodt Checked by:

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	Total % Retained	% Retained Between Sieves	% Passing	Spec % Passing	Pass	Fail
3"	0.0	0%	0%	100%	N/A		
1 1/2"	0.0	0%	0%	100%	N/A		
3/4"	25.4	5%	5%	95%	N/A		
3/8"	44.9	10%	4%	90%	N/A		
#4	84.7	18%	9%	82%	N/A		
#10	141.2	30%	12%	70%	N/A		
#40	249.7	54%	23%	46%	N/A		
#100	356.1	77%	23%	23%	N/A		
#200	409.0	87.9%	11%	12.1%	N/A		

Sample Wt (g): 465.1

REMARKS: N/A
N/A

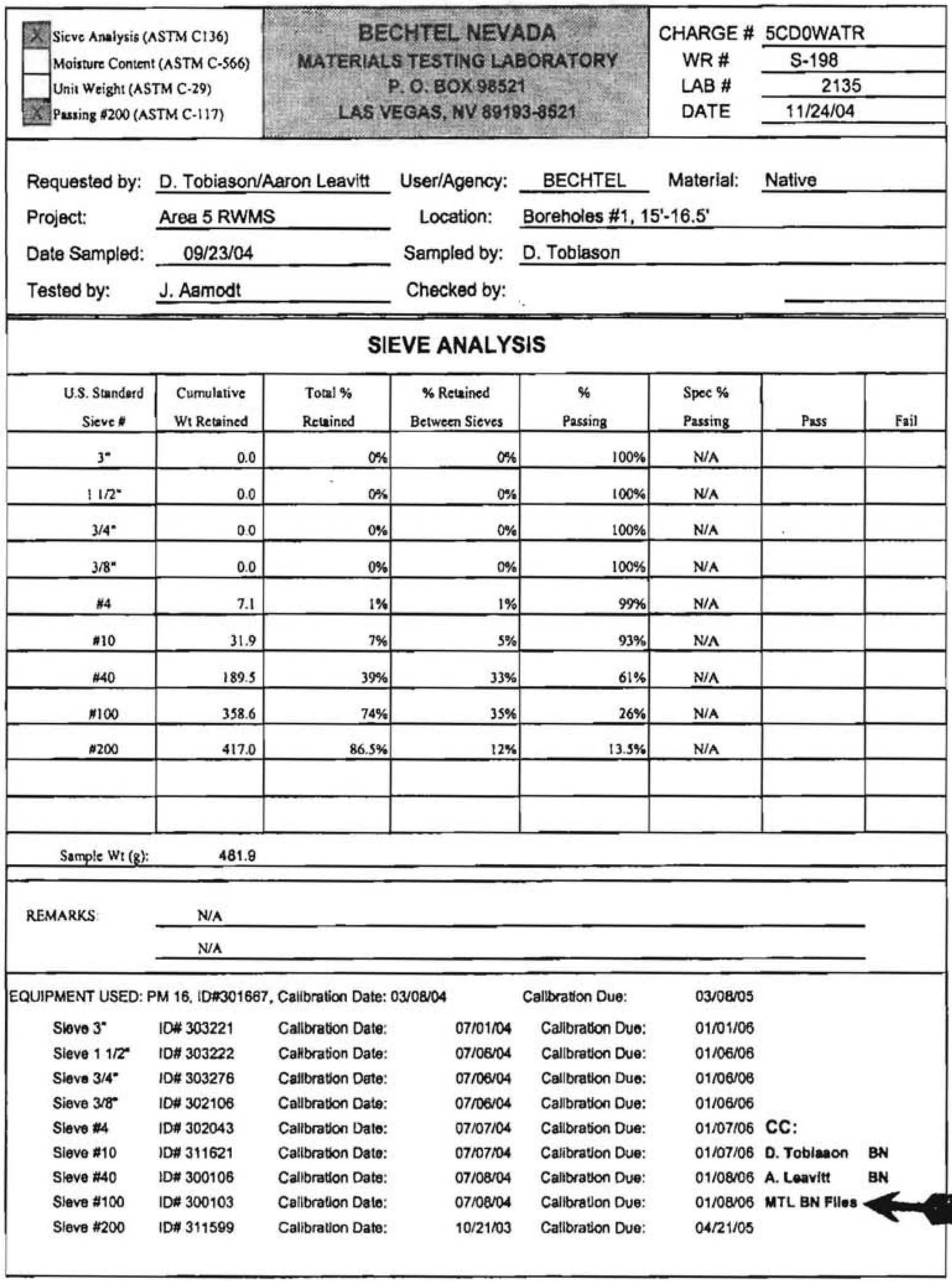
EQUIPMENT USED: PM 16, ID#301667, Calibration Date: 03/08/04 Calibration Due: 03/08/05

Sieve 3"	ID# 303221	Calibration Date:	07/01/04	Calibration Due:	01/01/06		
Sieve 1 1/2"	ID# 303222	Calibration Date:	07/06/04	Calibration Due:	01/06/06		
Sieve 3/4"	ID# 303276	Calibration Date:	07/06/04	Calibration Due:	01/06/06		
Sieve 3/8"	ID# 302106	Calibration Date:	07/06/04	Calibration Due:	01/06/06		
Sieve #4	ID# 302043	Calibration Date:	07/07/04	Calibration Due:	01/07/06	**CC:**	
Sieve #10	ID# 311621	Calibration Date:	07/07/04	Calibration Due:	01/07/06	**D. Tobiason**	**BN**
Sieve #40	ID# 300106	Calibration Date:	07/08/04	Calibration Due:	01/08/06	**A. Leavitt**	**BN**
Sieve #100	ID# 300103	Calibration Date:	07/08/04	Calibration Due:	01/08/06	**MTL BN Files**	
Sieve #200	ID# 311599	Calibration Date:	10/21/03	Calibration Due:	04/21/05		

Preparer: 6/8/09

Checker: 6/8/09

Attachment E
Sieve Analysis Data Sheets (cont.)



☒ Sieve Analysis (ASTM C136)
☐ Moisture Content (ASTM C-566)
☐ Unit Weight (ASTM C-29)
☒ Passing #200 (ASTM C-117)

BECHTEL NEVADA
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE # 5CD0WATR
WR # S-198
LAB # 2135
DATE 11/24/04

Requested by: D. Tobiason/Aaron Leavitt User/Agency: BECHTEL Material: Native
Project: Area 5 RWMS Location: Boreholes #1, 15'-16.5'
Date Sampled: 09/23/04 Sampled by: D. Tobiason
Tested by: J. Aamodt Checked by:

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	Total % Retained	% Retained Between Sieves	% Passing	Spec % Passing	Pass	Fail
3"	0.0	0%	0%	100%	N/A		
1 1/2"	0.0	0%	0%	100%	N/A		
3/4"	0.0	0%	0%	100%	N/A		
3/8"	0.0	0%	0%	100%	N/A		
#4	7.1	1%	1%	99%	N/A		
#10	31.9	7%	5%	93%	N/A		
#40	189.5	39%	33%	61%	N/A		
#100	358.6	74%	35%	26%	N/A		
#200	417.0	86.5%	12%	13.5%	N/A		

Sample Wt (g): 481.9

REMARKS: N/A
N/A

EQUIPMENT USED: PM 16, ID#301667, Calibration Date: 03/08/04 Calibration Due: 03/08/05

Sieve 3"	ID# 303221	Calibration Date:	07/01/04	Calibration Due:	01/01/06	
Sieve 1 1/2"	ID# 303222	Calibration Date:	07/06/04	Calibration Due:	01/06/06	
Sieve 3/4"	ID# 303276	Calibration Date:	07/06/04	Calibration Due:	01/06/06	
Sieve 3/8"	ID# 302106	Calibration Date:	07/06/04	Calibration Due:	01/06/06	
Sieve #4	ID# 302043	Calibration Date:	07/07/04	Calibration Due:	01/07/06	**CC:**
Sieve #10	ID# 311621	Calibration Date:	07/07/04	Calibration Due:	01/07/06	**D. Tobiason BN**
Sieve #40	ID# 300106	Calibration Date:	07/08/04	Calibration Due:	01/08/06	**A. Leavitt BN**
Sieve #100	ID# 300103	Calibration Date:	07/08/04	Calibration Due:	01/08/06	**MTL BN Files**
Sieve #200	ID# 311599	Calibration Date:	10/21/03	Calibration Due:	04/21/05	

Attachment E
Sieve Analysis Data Sheets (cont.)

☒ Sieve Analysis (ASTM C136)
☐ Moisture Content (ASTM C-566)
☐ Unit Weight (ASTM C-29)
☒ Passing #200 (ASTM C-117)

BECHTEL NEVADA
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE # 5CD0WATR
WR # S-198
LAB # 2136
DATE 11/24/04

Requested by: D. Tobiason/Aaron Leavitt User/Agency: BECHTEL Material: Native
Project: Area 5 RWMS Location: Boreholes #2, ~6'
Date Sampled: 09/23/04 Sampled by: D. Tobiason
Tested by: J. Aamodt Checked by:

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	Total % Retained	% Retained Between Sieves	% Passing	Spec % Passing	Pass	Fail
3"	0.0	0%	0%	100%	N/A		
1 1/2"	0.0	0%	0%	100%	N/A		
3/4"	16.2	4%	4%	96%	N/A		
3/8"	19.3	5%	1%	95%	N/A		
#4	38.1	10%	5%	90%	N/A		
#10	84.8	23%	13%	77%	N/A		
#40	173.2	47%	24%	53%	N/A		
#100	269.8	73%	26%	27%	N/A		
#200	325.4	87.8%	15%	12.2%	N/A		

Sample Wt (g): 370.5

REMARKS: N/A
N/A

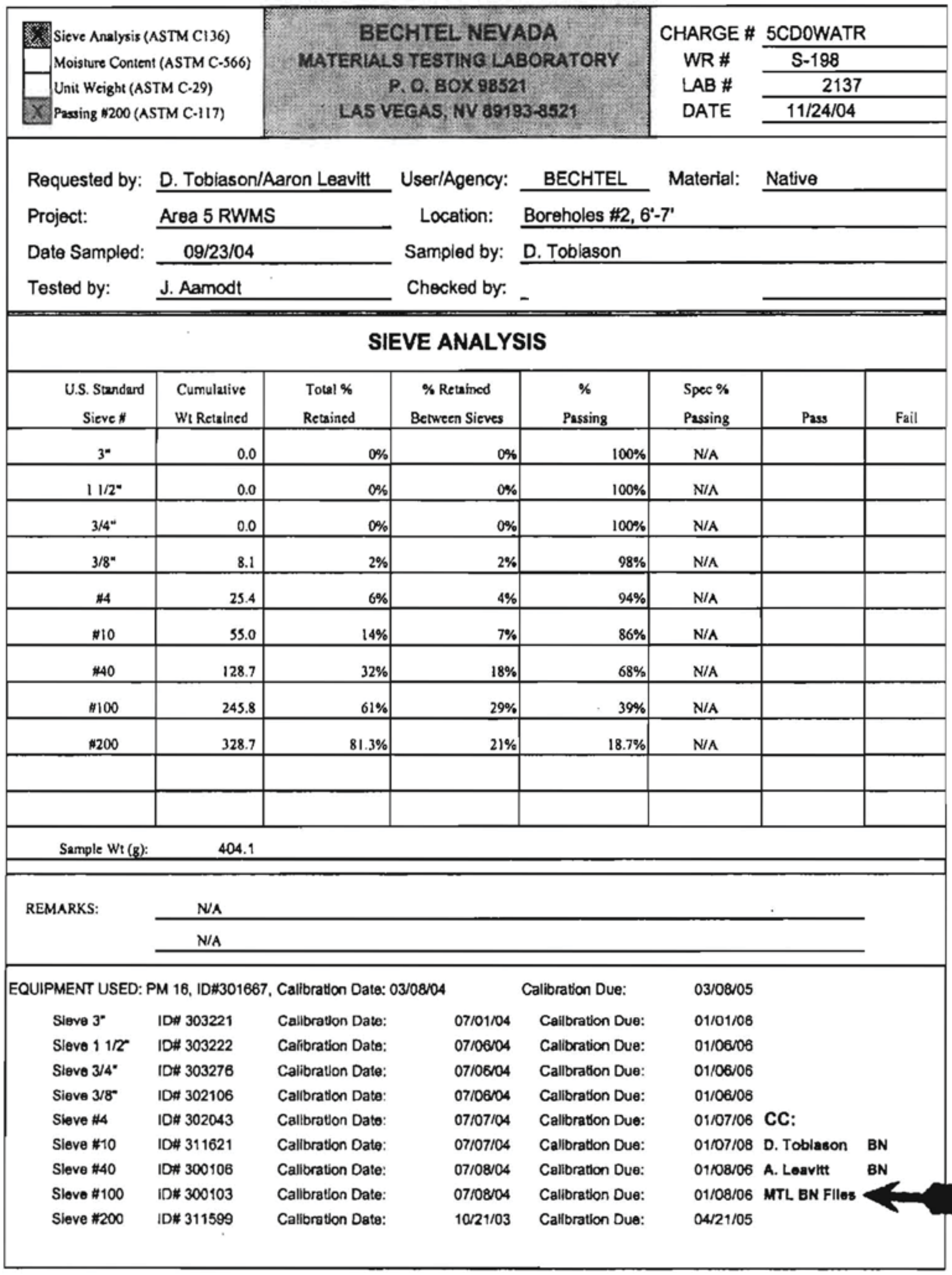
EQUIPMENT USED: PM 16, ID#301667, Calibration Date: 03/08/04 Calibration Due: 03/08/05

Sieve 3"	ID# 303221	Calibration Date:	07/01/04	Calibration Due:	01/01/06
Sieve 1 1/2"	ID# 303222	Calibration Date:	07/06/04	Calibration Due:	01/06/06
Sieve 3/4"	ID# 303276	Calibration Date:	07/06/04	Calibration Due:	01/06/06
Sieve 3/8"	ID# 302106	Calibration Date:	07/06/04	Calibration Due:	01/06/06
Sieve #4	ID# 302043	Calibration Date:	07/07/04	Calibration Due:	01/07/06
Sieve #10	ID# 311621	Calibration Date:	07/07/04	Calibration Due:	01/07/06
Sieve #40	ID# 300106	Calibration Date:	07/08/04	Calibration Due:	01/08/06
Sieve #100	ID# 300103	Calibration Date:	07/08/04	Calibration Due:	01/08/06
Sieve #200	ID# 311599	Calibration Date:	10/21/03	Calibration Due:	04/21/05

CC:
D. Tobiason BN
A. Leavitt BN
MTL BN Files

Preparer: 6/8/09 Checker: 6/8/09

Attachment E
Sieve Analysis Data Sheets (cont.)



☒ Sieve Analysis (ASTM C136)
☐ Moisture Content (ASTM C-566)
☐ Unit Weight (ASTM C-29)
☒ Passing #200 (ASTM C-117)

BECHTEL NEVADA
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE # 5CD0WATR
WR # S-198
LAB # 2137
DATE 11/24/04

Requested by: D. Tobiason/Aaron Leavitt
User/Agency: BECHTEL
Material: Native
Project: Area 5 RWMS
Location: Boreholes #2, 6'-7'
Date Sampled: 09/23/04
Sampled by: D. Tobiason
Tested by: J. Aamodt
Checked by: _

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	Total % Retained	% Retained Between Sieves	% Passing	Spec % Passing	Pass	Fail
3"	0.0	0%	0%	100%	N/A		
1 1/2"	0.0	0%	0%	100%	N/A		
3/4"	0.0	0%	0%	100%	N/A		
3/8"	8.1	2%	2%	98%	N/A		
#4	25.4	6%	4%	94%	N/A		
#10	55.0	14%	7%	86%	N/A		
#40	128.7	32%	18%	68%	N/A		
#100	245.8	61%	29%	39%	N/A		
#200	328.7	81.3%	21%	18.7%	N/A		

Sample Wt (g): 404.1

REMARKS: N/A
N/A

EQUIPMENT USED: PM 16, ID#301667, Calibration Date: 03/08/04 Calibration Due: 03/08/05

Sieve 3"	ID# 303221	Calibration Date:	07/01/04	Calibration Due:	01/01/06	
Sieve 1 1/2"	ID# 303222	Calibration Date:	07/06/04	Calibration Due:	01/06/06	
Sieve 3/4"	ID# 303276	Calibration Date:	07/06/04	Calibration Due:	01/06/06	
Sieve 3/8"	ID# 302106	Calibration Date:	07/06/04	Calibration Due:	01/06/06	
Sieve #4	ID# 302043	Calibration Date:	07/07/04	Calibration Due:	01/07/06	**CC:**
Sieve #10	ID# 311621	Calibration Date:	07/07/04	Calibration Due:	01/07/06	**D. Tobiason BN**
Sieve #40	ID# 300106	Calibration Date:	07/08/04	Calibration Due:	01/08/06	**A. Leavitt BN**
Sieve #100	ID# 300103	Calibration Date:	07/08/04	Calibration Due:	01/08/06	**MTL BN Files**
Sieve #200	ID# 311599	Calibration Date:	10/21/03	Calibration Due:	04/21/05	

Attachment E
Sieve Analysis Data Sheets (cont.)

☒ Sieve Analysis (ASTM C136)
☐ Moisture Content (ASTM C-566)
☐ Unit Weight (ASTM C-29)
☒ Passing #200 (ASTM C-117)

BECHTEL NEVADA
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE # 5CD0WATR
WR # S-198
LAB # 2138
DATE 11/24/04

Requested by: D. Tobiason/Aaron Leavitt
User/Agency: BECHTEL
Material: Native
Project: Area 5 RWMS
Location: Boreholes #4, 5'-6'
Date Sampled: 09/23/04
Sampled by: D. Tobiason
Tested by: J. Aamodt
Checked by:

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	Total % Retained	% Retained Between Sieves	% Passing	Spec % Passing	Pass	Fail
3"	0.0	0%	0%	100%	N/A		
1 1/2"	0.0	0%	0%	100%	N/A		
3/4"	0.0	0%	0%	100%	N/A		
3/8"	4.4	1%	1%	99%	N/A		
#4	22.1	6%	5%	94%	N/A		
#10	51.3	15%	8%	85%	N/A		
#40	112.0	32%	17%	68%	N/A		
#100	208.9	60%	28%	40%	N/A		
#200	280.7	80.7%	21%	19.3%	N/A		

Sample Wt (g): 347.9

REMARKS: N/A
N/A

EQUIPMENT USED: PM 16, ID#301667, Calibration Date: 03/08/04 Calibration Due: 03/08/05

Sieve 3"	ID# 303221	Calibration Date:	07/01/04	Calibration Due:	01/01/06
Sieve 1 1/2"	ID# 303222	Calibration Date:	07/06/04	Calibration Due:	01/06/06
Sieve 3/4"	ID# 303276	Calibration Date:	07/06/04	Calibration Due:	01/06/06
Sieve 3/6"	ID# 302106	Calibration Date:	07/06/04	Calibration Due:	01/06/06
Sieve #4	ID# 302043	Calibration Date:	07/07/04	Calibration Due:	01/07/06
Sieve #10	ID# 311621	Calibration Date:	07/07/04	Calibration Due:	01/07/06
Sieve #40	ID# 300106	Calibration Date:	07/08/04	Calibration Due:	01/08/06
Sieve #100	ID# 300103	Calibration Date:	07/08/04	Calibration Due:	01/08/06
Sieve #200	ID# 311599	Calibration Date:	10/21/03	Calibration Due:	04/21/05

CC:
D. Tobiason BN
A. Leavitt BN
MTL BN Files

6/8/09

6/8/09

Attachment E
Sieve Analysis Data Sheets (cont.)

☒ Sieve Analysis (ASTM C136)
☐ Moisture Content (ASTM C-566)
☐ Unit Weight (ASTM C-29)
☒ Passing #200 (ASTM C-117)

BECHTEL NEVADA
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE # 5CD0WATR
WR # S-198
LAB # 2139
DATE 11/24/04

Requested by: D. Tobiason/Aaron Leavitt User/Agency: BECHTEL Material: Native
Project: Area 5 RWMS Location: Boreholes #4, 15'-16'
Date Sampled: 09/23/04 Sampled by: D. Tobiason
Tested by: J. Aamodt Checked by:

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	Total % Retained	% Retained Between Sieves	% Passing	Spec % Passing	Pass	Fail
3"	0.0	0%	0%	100%	N/A		
1 1/2"	0.0	0%	0%	100%	N/A		
3/4"	0.0	0%	0%	100%	N/A		
3/8"	13.0	2%	2%	98%	N/A		
#4	41.5	8%	5%	92%	N/A		
#10	95.0	18%	10%	82%	N/A		
#40	274.6	52%	34%	48%	N/A		
#100	415.7	79%	27%	21%	N/A		
#200	460.8	87.4%	9%	12.6%	N/A		

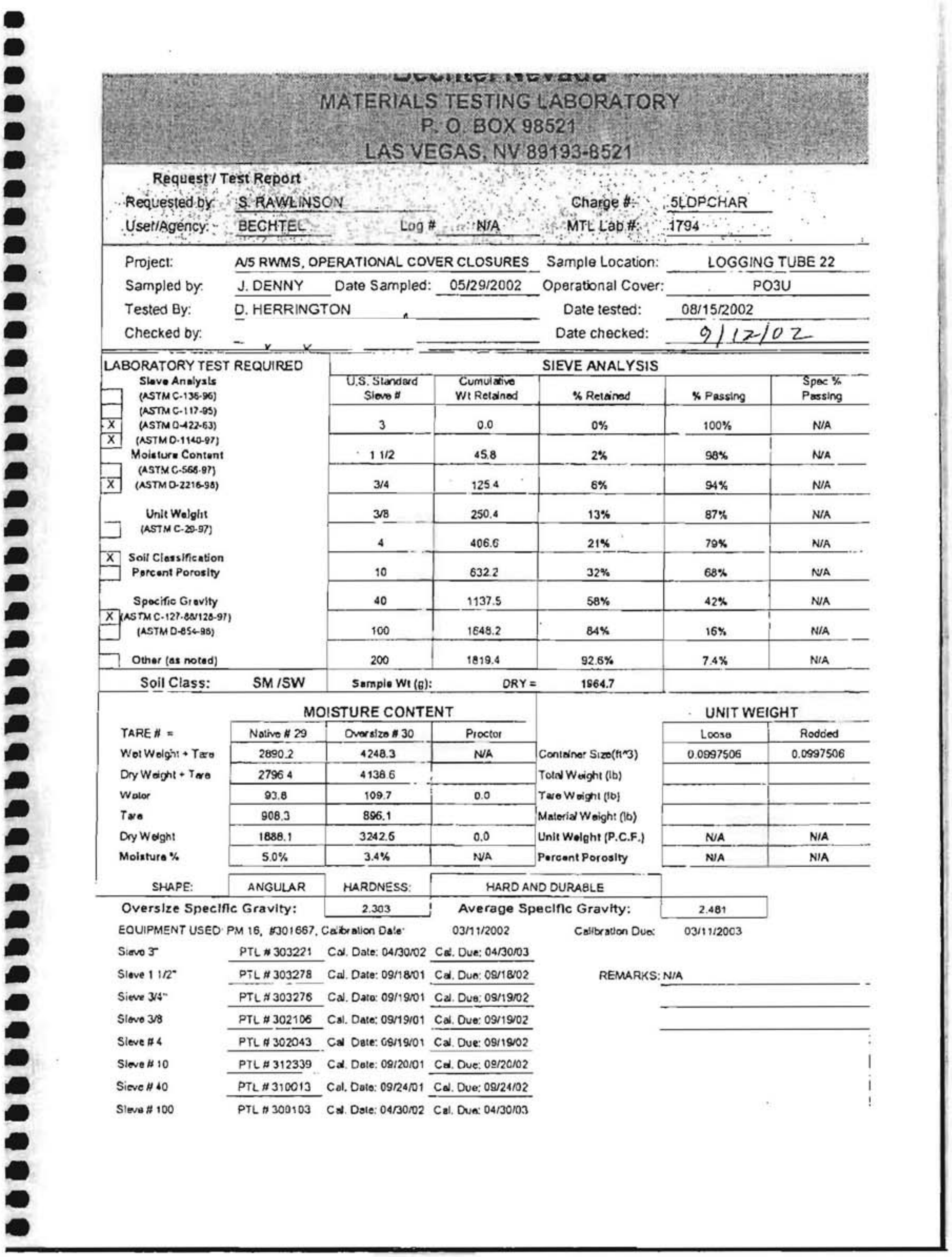
Sample Wt (g): 527.0

REMARKS: N/A
N/A

EQUIPMENT USED: PM 16, ID#301667, Calibration Date: 03/06/04 Calibration Due: 03/08/05

Sieve 3"	ID# 303221	Calibration Date:	07/01/04	Calibration Due:	01/01/06		
Sieve 1 1/2"	ID# 303222	Calibration Date:	07/06/04	Calibration Due:	01/08/06		
Sieve 3/4"	ID# 303276	Calibration Date:	07/06/04	Calibration Due:	01/06/06		
Sieve 3/8"	ID# 302106	Calibration Date:	07/06/04	Calibration Due:	01/06/06		
Sieve #4	ID# 302043	Calibration Date:	07/07/04	Calibration Due:	01/07/06	**CC:**	
Sieve #10	ID# 311621	Calibration Date:	07/07/04	Calibration Due:	01/07/06	**D. Tobiason**	**BN**
Sieve #40	ID# 300106	Calibration Date:	07/08/04	Calibration Due:	01/08/06	**A. Leavitt**	**BN**
Sieve #100	ID# 300103	Calibration Date:	07/08/04	Calibration Due:	01/08/06	**MTL BN Files**	
Sieve #200	ID# 311599	Calibration Date:	10/21/03	Calibration Due:	04/21/05		

Attachment E
Sieve Analysis Data Sheets (cont.)



Bechtel Nevada
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

Request / Test Report

Requested by: S. RAWLINSON Charge #: 5LDPCHAR
User/Agency: BECHTEL Log #: N/A MTL Lab #: 1794

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES Sample Location: LOGGING TUBE 22
Sampled by: J. DENNY Date Sampled: 05/29/2002 Operational Cover: PO3U
Tested By: D. HERRINGTON Date tested: 08/15/2002
Checked by: Date checked: 9/12/02

LABORATORY TEST REQUIRED

- **Sieve Analysis**
  - ☐ (ASTM C-136-96)
  - ☐ (ASTM C-117-95)
  - ☒ (ASTM D-422-63)
  - ☒ (ASTM D-1140-97)
- **Moisture Content**
  - ☐ (ASTM C-566-97)
  - ☒ (ASTM D-2216-98)
- **Unit Weight**
  - ☐ (ASTM C-29-97)
- ☒ **Soil Classification**
- ☐ **Percent Porosity**
- **Specific Gravity**
  - ☒ (ASTM C-127-88/128-97)
  - ☐ (ASTM D-854-98)
- ☐ **Other (as noted)**

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	% Retained	% Passing	Spec % Passing
3	0.0	0%	100%	N/A
1 1/2	45.8	2%	98%	N/A
3/4	125.4	6%	94%	N/A
3/8	250.4	13%	87%	N/A
4	406.6	21%	79%	N/A
10	632.2	32%	68%	N/A
40	1137.5	58%	42%	N/A
100	1648.2	84%	16%	N/A
200	1819.4	92.6%	7.4%	N/A

Soil Class: SM /SW Sample Wt (g): DRY = 1964.7

MOISTURE CONTENT

TARE # =	Native # 29	Oversize # 30	Proctor
Wet Weight + Tare	2890.2	4248.3	N/A
Dry Weight + Tare	2796.4	4138.6	
Water	93.8	109.7	0.0
Tare	908.3	896.1	
Dry Weight	1888.1	3242.6	0.0
Moisture %	5.0%	3.4%	N/A

UNIT WEIGHT

	Loose	Rodded
Container Size(ft^3)	0.0997506	0.0997506
Total Weight (lb)		
Tare Weight (lb)		
Material Weight (lb)		
Unit Weight (P.C.F.)	N/A	N/A
Percent Porosity	N/A	N/A

SHAPE: ANGULAR HARDNESS: HARD AND DURABLE

Oversize Specific Gravity: 2.303 **Average Specific Gravity:** 2.481

EQUIPMENT USED: PM 16, #301667, Calibration Date: 03/11/2002 Calibration Due: 03/11/2003

Sieve 3"	PTL # 303221	Cal. Date: 04/30/02	Cal. Due: 04/30/03
Sieve 1 1/2"	PTL # 303278	Cal. Date: 09/18/01	Cal. Due: 09/18/02
Sieve 3/4"	PTL # 303276	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve 3/8	PTL # 302106	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 4	PTL # 302043	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 10	PTL # 312339	Cal. Date: 09/20/01	Cal. Due: 09/20/02
Sieve # 40	PTL # 310013	Cal. Date: 09/24/01	Cal. Due: 09/24/02
Sieve # 100	PTL # 300103	Cal. Date: 04/30/02	Cal. Due: 04/30/03

REMARKS: N/A

Preparer: 6/8/09 Checker: 6/8/09

Attachment E
Sieve Analysis Data Sheets (cont.)

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

Request / Test Report

Requested by: S. RAWLINSON Charge #: 5LDPCHAR
User/Agency: BECHTEL Log #: N/A MTL Lab #: 1795

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES Sample Location: GRID PT. #B4
Sampled by: J. DENNY Date Sampled: 05/29/2002 Operational Cover: PO4U
Tested By: D. HERRINGTON Date tested: 08/20/2002
Checked by: Date checked: 9/12/02

LABORATORY TEST REQUIRED

Sieve Analysis
- ☐ (ASTM C-136-96)
- ☐ (ASTM C-117-95)
- ☒ (ASTM D-422-63)
- ☒ (ASTM D-1140-97)

Moisture Content
- ☐ (ASTM C-566-97)
- ☒ (ASTM D-2216-98)

Unit Weight
- ☐ (ASTM C-29-97)

- ☒ **Soil Classification**
- ☐ **Percent Porosity**

Specific Gravity
- ☒ (ASTM C-127-88/128-97)
- ☐ (ASTM D-854-98)

- ☐ Other (as noted)

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	% Retained	% Passing	Spec % Passing
3	0.0	0%	100%	N/A
1 1/2	18.6	1%	99%	N/A
3/4	99.5	6%	94%	N/A
3/8	183.5	11%	89%	N/A
4	307.0	18%	82%	N/A
10	499.9	30%	70%	N/A
40	888.0	53%	47%	N/A
100	1330.5	80%	20%	N/A
200	1493.0	89.6%	10.4%	N/A

Soil Class: SM / SP Sample Wt (g): DRY = 1666.7

MOISTURE CONTENT

TARE # =	Native # 31	Oversize # 32	Proctor
Wet Weight + Tare	2580.6	3710.4	N/A
Dry Weight + Tare	2486.2	3621.7	
Water	94.4	88.7	0.0
Tare	896.7	894.6	
Dry Weight	1589.5	2727.1	0.0
Moisture %	5.9%	3.3%	N/A

UNIT WEIGHT

	Loose	Rodded
Container Size(ft^3)	0.0997506	0.0997506
Total Weight (lb)		
Tare Weight (lb)		
Material Weight (lb)		
Unit Weight (P.C.F.)	N/A	N/A
Percent Porosity	N/A	N/A

SHAPE: ANGULAR HARDNESS: HARD AND DURABLE

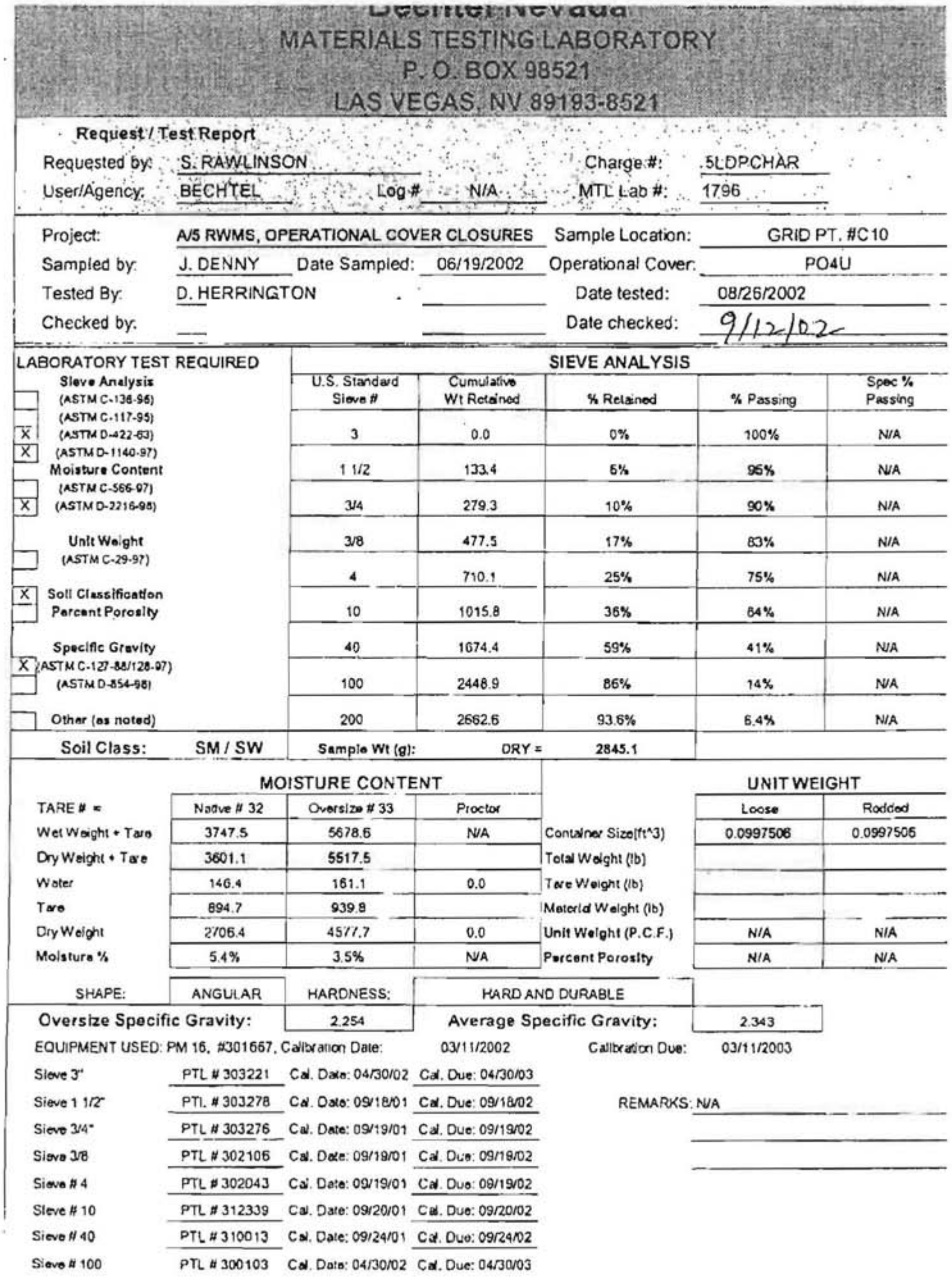
Oversize Specific Gravity: 2.311 **Average Specific Gravity:** 2.462

EQUIPMENT USED: PM 16, #301667, Calibration Date: 03/11/2002 Calibration Due: 03/11/2003

Sieve 3"	PTL # 303221	Cal. Date: 04/30/02	Cal. Due: 04/30/03
Sieve 1 1/2"	PTL # 303278	Cal. Date: 09/18/01	Cal. Due: 09/18/02
Sieve 3/4"	PTL # 303276	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve 3/8	PTL # 302106	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 4	PTL # 302043	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 10	PTL # 312339	Cal. Date: 09/20/01	Cal. Due: 09/20/02
Sieve # 40	PTL # 310013	Cal. Date: 09/24/01	Cal. Due: 09/24/02
Sieve # 100	PTL # 300103	Cal. Date: 04/30/02	Cal. Due: 04/30/03

REMARKS: N/A

Attachment E
Sieve Analysis Data Sheets (cont.)



Bechtel Nevada
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

Request / Test Report

Requested by: S. RAWLINSON Charge #: 5LDPCHAR
User/Agency: BECHTEL Log #: N/A MTL Lab #: 1796

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES Sample Location: GRID PT. #C10
Sampled by: J. DENNY Date Sampled: 06/19/2002 Operational Cover: PO4U
Tested By: D. HERRINGTON Date tested: 08/26/2002
Checked by: Date checked: 9/12/02

LABORATORY TEST REQUIRED

Sieve Analysis
☐ (ASTM C-136-96)
(ASTM C-117-95)
☒ (ASTM D-422-63)
☒ (ASTM D-1140-97)

Moisture Content
☐ (ASTM C-566-97)
☒ (ASTM D-2216-98)

Unit Weight
☐ (ASTM C-29-97)

☒ **Soil Classification**
☐ **Percent Porosity**

Specific Gravity
☒ (ASTM C-127-88/128-97)
☐ (ASTM D-854-98)

☐ **Other (as noted)**

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	% Retained	% Passing	Spec % Passing
3	0.0	0%	100%	N/A
1 1/2	133.4	5%	95%	N/A
3/4	279.3	10%	90%	N/A
3/8	477.5	17%	83%	N/A
4	710.1	25%	75%	N/A
10	1015.8	36%	64%	N/A
40	1674.4	59%	41%	N/A
100	2448.9	86%	14%	N/A
200	2662.6	93.6%	6.4%	N/A

Soil Class: SM / SW Sample Wt (g): DRY = 2845.1

MOISTURE CONTENT

TARE # =	Native # 32	Oversize # 33	Proctor
Wet Weight + Tare	3747.5	5678.6	N/A
Dry Weight + Tare	3601.1	5517.5	
Water	146.4	161.1	0.0
Tare	894.7	939.8	
Dry Weight	2706.4	4577.7	0.0
Moisture %	5.4%	3.5%	N/A

UNIT WEIGHT

	Loose	Rodded
Container Size(ft^3)	0.0997506	0.0997506
Total Weight (lb)		
Tare Weight (lb)		
Material Weight (lb)		
Unit Weight (P.C.F.)	N/A	N/A
Percent Porosity	N/A	N/A

SHAPE: ANGULAR HARDNESS: HARD AND DURABLE

Oversize Specific Gravity: 2.254 **Average Specific Gravity:** 2.343

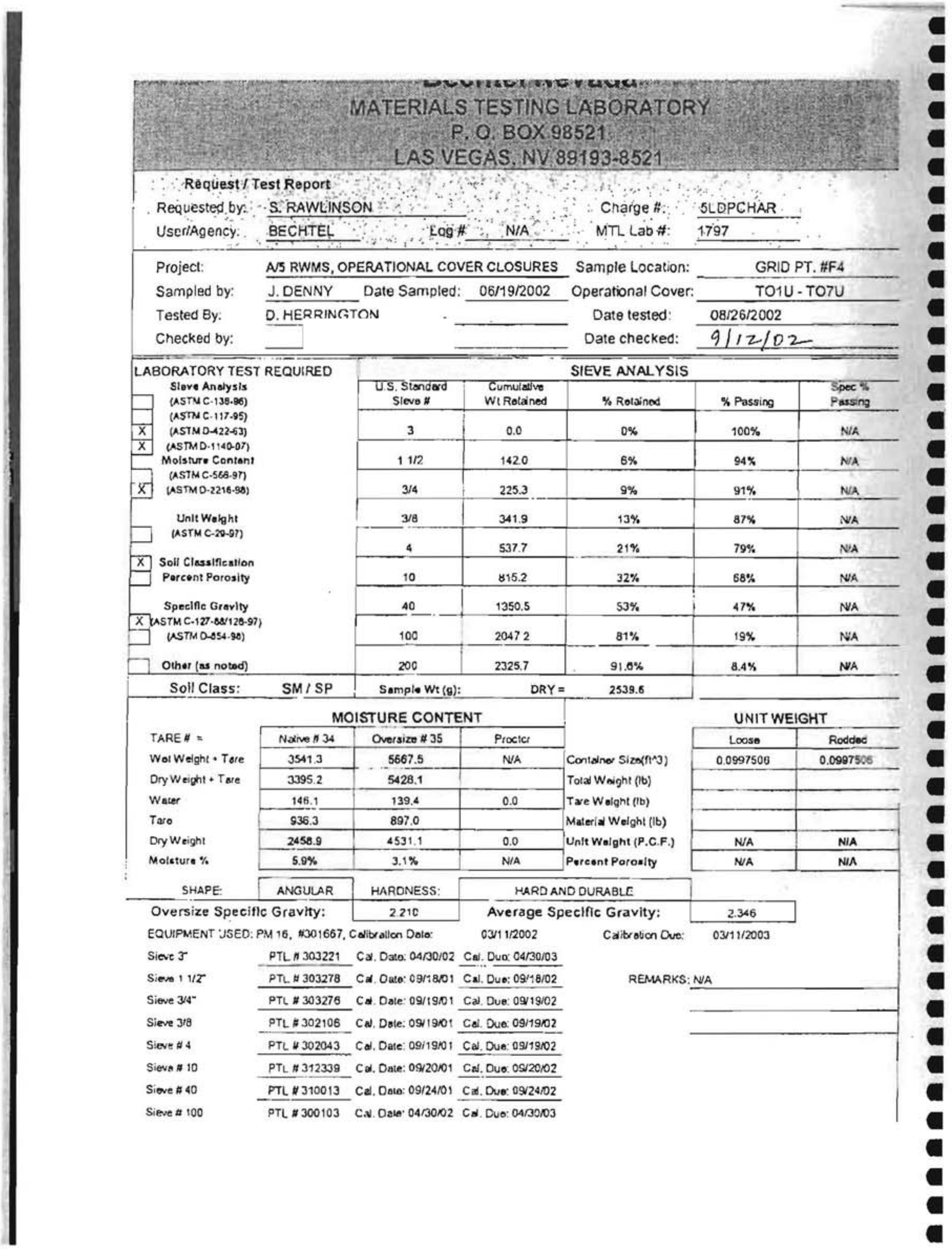
EQUIPMENT USED: PM 16, #301667, Calibration Date: 03/11/2002 Calibration Due: 03/11/2003

Sieve 3"	PTL # 303221	Cal. Date: 04/30/02	Cal. Due: 04/30/03
Sieve 1 1/2"	PTL # 303278	Cal. Date: 09/18/01	Cal. Due: 09/18/02
Sieve 3/4"	PTL # 303276	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve 3/8	PTL # 302106	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 4	PTL # 302043	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 10	PTL # 312339	Cal. Date: 09/20/01	Cal. Due: 09/20/02
Sieve # 40	PTL # 310013	Cal. Date: 09/24/01	Cal. Due: 09/24/02
Sieve # 100	PTL # 300103	Cal. Date: 04/30/02	Cal. Due: 04/30/03

REMARKS: N/A

Preparer: 6/8/09 Checker: 6/8/09

Attachment E
Sieve Analysis Data Sheets (cont.)



MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

Request / Test Report

Requested by: S. RAWLINSON Charge #: 5LDPCHAR
User/Agency: BECHTEL Log #: N/A MTL Lab #: 1797

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES Sample Location: GRID PT. #F4
Sampled by: J. DENNY Date Sampled: 06/19/2002 Operational Cover: TO1U - TO7U
Tested By: D. HERRINGTON Date tested: 08/26/2002
Checked by: Date checked: 9/12/02

LABORATORY TEST REQUIRED

Sieve Analysis
☐ (ASTM C-136-96)
☐ (ASTM C-117-95)
☒ (ASTM D-422-63)
☒ (ASTM D-1140-07)
Moisture Content
☐ (ASTM C-566-97)
☒ (ASTM D-2216-98)
Unit Weight
☐ (ASTM C-29-97)
☒ **Soil Classification**
☐ **Percent Porosity**
Specific Gravity
☒ (ASTM C-127-88/128-97)
☐ (ASTM D-854-98)
☐ **Other (as noted)**

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	% Retained	% Passing	Spec % Passing
3	0.0	0%	100%	N/A
1 1/2	142.0	6%	94%	N/A
3/4	225.3	9%	91%	N/A
3/8	341.9	13%	87%	N/A
4	537.7	21%	79%	N/A
10	815.2	32%	68%	N/A
40	1350.5	53%	47%	N/A
100	2047 2	81%	19%	N/A
200	2325.7	91.6%	8.4%	N/A

Soil Class: SM / SP Sample Wt (g): DRY = 2539.6

MOISTURE CONTENT

TARE # =	Native # 34	Oversize # 35	Proctor
Wet Weight + Tare	3541.3	5667.5	N/A
Dry Weight + Tare	3395.2	5428.1	
Water	146.1	139.4	0.0
Tare	936.3	897.0	
Dry Weight	2458.9	4531.1	0.0
Moisture %	5.9%	3.1%	N/A

UNIT WEIGHT

	Loose	Rodded
Container Size(ft^3)	0.0997506	0.0997506
Total Weight (lb)		
Tare Weight (lb)		
Material Weight (lb)		
Unit Weight (P.C.F.)	N/A	N/A
Percent Porosity	N/A	N/A

SHAPE: ANGULAR HARDNESS: HARD AND DURABLE
Oversize Specific Gravity: 2.210 Average Specific Gravity: 2.346

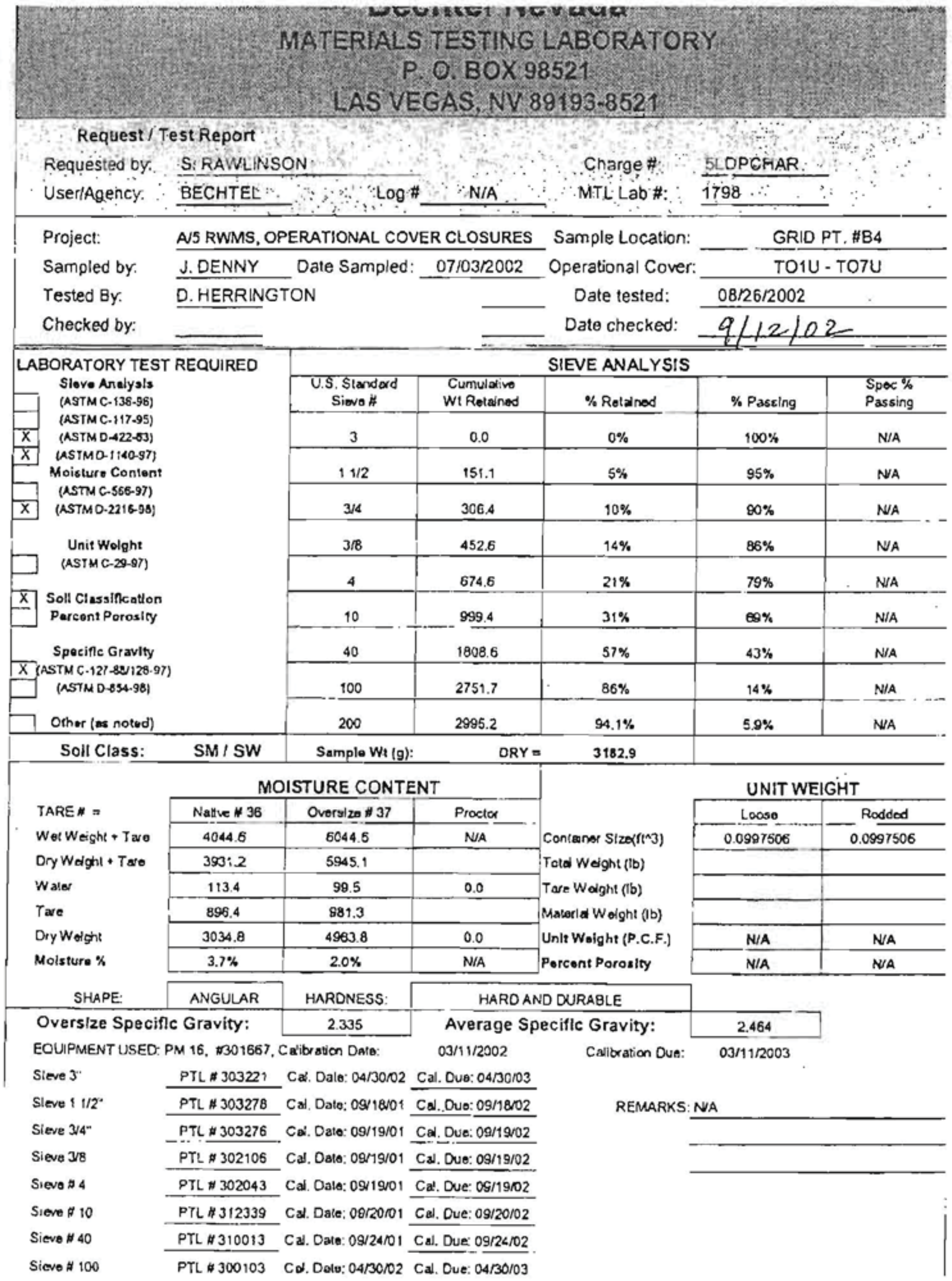
EQUIPMENT USED: PM 16, #301667, Calibration Date: 03/11/2002 Calibration Due: 03/11/2003

Sieve 3"	PTL # 303221	Cal. Date: 04/30/02	Cal. Due: 04/30/03
Sieve 1 1/2"	PTL # 303278	Cal. Date: 09/18/01	Cal. Due: 09/18/02
Sieve 3/4"	PTL # 303276	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve 3/8	PTL # 302106	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 4	PTL # 302043	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 10	PTL # 312339	Cal. Date: 09/20/01	Cal. Due: 09/20/02
Sieve # 40	PTL # 310013	Cal. Date: 09/24/01	Cal. Due: 09/24/02
Sieve # 100	PTL # 300103	Cal. Date: 04/30/02	Cal. Due: 04/30/03

REMARKS: N/A

Preparer: 6/8/09 Checker: 6/8/09

Attachment E
Sieve Analysis Data Sheets (cont.)



MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

Request / Test Report

Requested by: S. RAWLINSON Charge #: 5LDPCHAR
User/Agency: BECHTEL Log #: N/A MTL Lab #: 1798

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES Sample Location: GRID PT. #B4
Sampled by: J. DENNY Date Sampled: 07/03/2002 Operational Cover: TO1U - TO7U
Tested By: D. HERRINGTON Date tested: 08/26/2002
Checked by: Date checked: 9/12/02

LABORATORY TEST REQUIRED

Sieve Analysis
- ☐ (ASTM C-136-96)
- ☐ (ASTM C-117-95)
- ☒ (ASTM D-422-63)
- ☒ (ASTM D-1140-97)

Moisture Content
- ☐ (ASTM C-566-97)
- ☒ (ASTM D-2216-98)

Unit Weight
- ☐ (ASTM C-29-97)

- ☒ **Soil Classification**
- ☐ **Percent Porosity**

Specific Gravity
- ☒ (ASTM C-127-88/128-97)
- ☐ (ASTM D-854-98)

- ☐ **Other (as noted)**

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	% Retained	% Passing	Spec % Passing
3	0.0	0%	100%	N/A
1 1/2	151.1	5%	95%	N/A
3/4	306.4	10%	90%	N/A
3/8	452.6	14%	86%	N/A
4	674.6	21%	79%	N/A
10	999.4	31%	69%	N/A
40	1808.6	57%	43%	N/A
100	2751.7	86%	14%	N/A
200	2995.2	94.1%	5.9%	N/A

Soil Class: SM / SW **Sample Wt (g):** DRY = **3182.9**

MOISTURE CONTENT

TARE # =	Native # 36	Oversize # 37	Proctor
Wet Weight + Tare	4044.6	6044.5	N/A
Dry Weight + Tare	3931.2	5945.1	
Water	113.4	99.5	0.0
Tare	896.4	981.3	
Dry Weight	3034.8	4963.8	0.0
Moisture %	3.7%	2.0%	N/A

UNIT WEIGHT

	Loose	Rodded
Container Size(ft^3)	0.0997506	0.0997506
Total Weight (lb)		
Tare Weight (lb)		
Material Weight (lb)		
Unit Weight (P.C.F.)	N/A	N/A
Percent Porosity	N/A	N/A

SHAPE: ANGULAR HARDNESS: HARD AND DURABLE

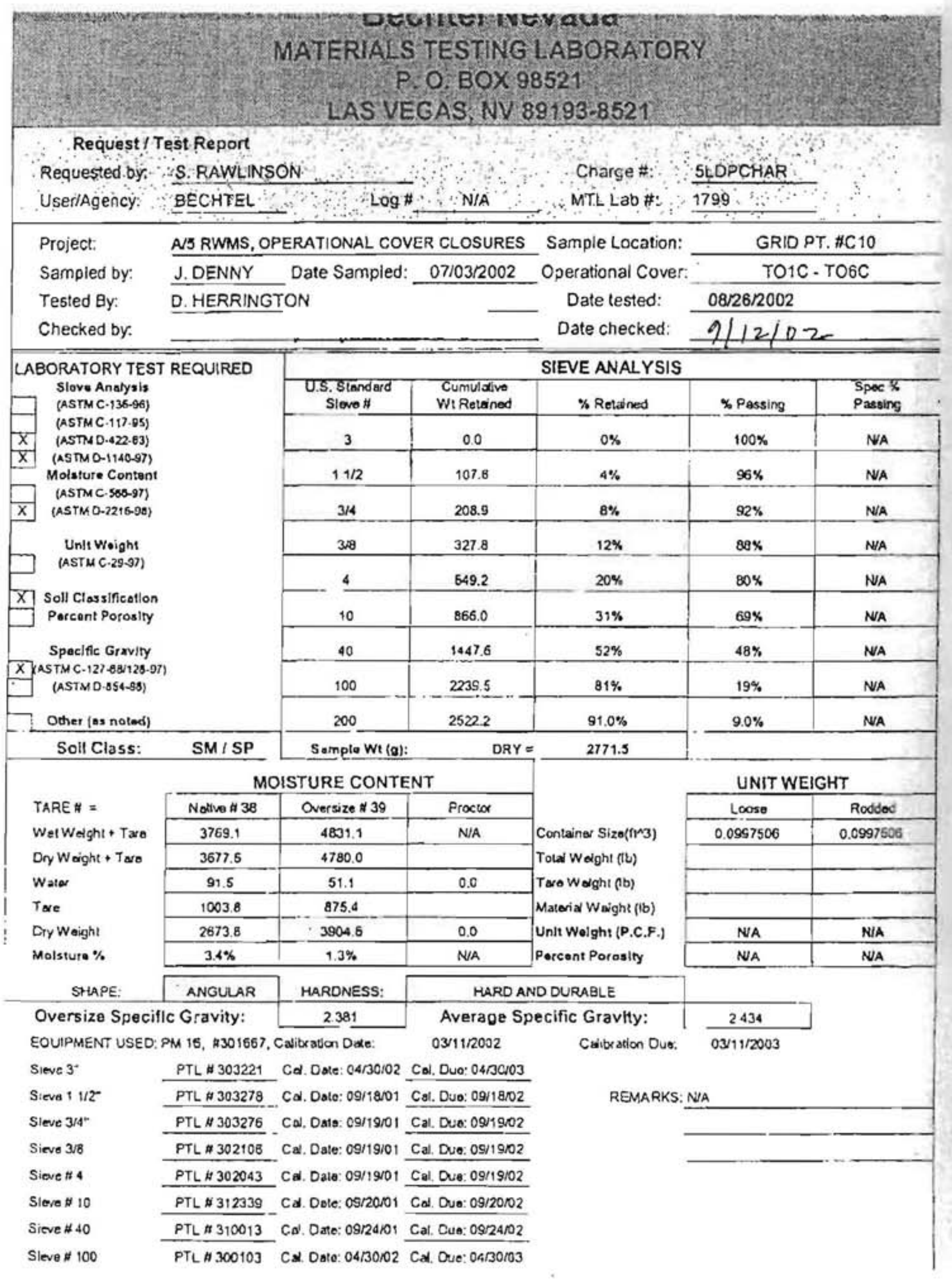
Oversize Specific Gravity: 2.335 **Average Specific Gravity:** 2.464

EQUIPMENT USED: PM 16, #301667, Calibration Date: 03/11/2002 Calibration Due: 03/11/2003

Sieve 3"	PTL # 303221	Cal. Date: 04/30/02	Cal. Due: 04/30/03
Sieve 1 1/2"	PTL # 303278	Cal. Date: 09/18/01	Cal. Due: 09/18/02
Sieve 3/4"	PTL # 303276	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve 3/8	PTL # 302106	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 4	PTL # 302043	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 10	PTL # 312339	Cal. Date: 09/20/01	Cal. Due: 09/20/02
Sieve # 40	PTL # 310013	Cal. Date: 09/24/01	Cal. Due: 09/24/02
Sieve # 100	PTL # 300103	Cal. Date: 04/30/02	Cal. Due: 04/30/03

REMARKS: N/A

Attachment E
Sieve Analysis Data Sheets (cont.)



Bechtel Nevada
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

Request / Test Report

Requested by: S. RAWLINSON Charge #: 5LDPCHAR
User/Agency: BECHTEL Log # N/A MTL Lab #: 1799

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES
Sample Location: GRID PT. #C10
Sampled by: J. DENNY
Date Sampled: 07/03/2002
Operational Cover: TO1C - TO6C
Tested By: D. HERRINGTON
Date tested: 08/26/2002
Checked by:
Date checked: 9/12/02

LABORATORY TEST REQUIRED

Sieve Analysis
- ☐ (ASTM C-136-96)
- ☐ (ASTM C-117-95)
- ☒ (ASTM D-422-63)
- ☒ (ASTM D-1140-97)

Moisture Content
- ☐ (ASTM C-566-97)
- ☒ (ASTM D-2216-98)

Unit Weight
- ☐ (ASTM C-29-97)

- ☒ **Soil Classification**
- ☐ **Percent Porosity**

Specific Gravity
- ☒ (ASTM C-127-88/128-97)
- ☐ (ASTM D-854-98)

- ☐ **Other (as noted)**

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	% Retained	% Passing	Spec % Passing
3	0.0	0%	100%	N/A
1 1/2	107.6	4%	96%	N/A
3/4	208.9	8%	92%	N/A
3/8	327.8	12%	88%	N/A
4	549.2	20%	80%	N/A
10	866.0	31%	69%	N/A
40	1447.6	52%	48%	N/A
100	2239.5	81%	19%	N/A
200	2522.2	91.0%	9.0%	N/A

Soil Class: SM / SP
Sample Wt (g): DRY = 2771.5

MOISTURE CONTENT

TARE # =	Native # 38	Oversize # 39	Proctor
Wet Weight + Tare	3769.1	4831.1	N/A
Dry Weight + Tare	3677.6	4780.0	
Water	91.5	51.1	0.0
Tare	1003.8	875.4	
Dry Weight	2673.8	3904.6	0.0
Moisture %	3.4%	1.3%	N/A

UNIT WEIGHT

	Loose	Rodded
Container Size(ft^3)	0.0997506	0.0997506
Total Weight (lb)		
Tare Weight (lb)		
Material Weight (lb)		
Unit Weight (P.C.F.)	N/A	N/A
Percent Porosity	N/A	N/A

SHAPE: ANGULAR HARDNESS: HARD AND DURABLE

Oversize Specific Gravity: 2.381 Average Specific Gravity: 2.434

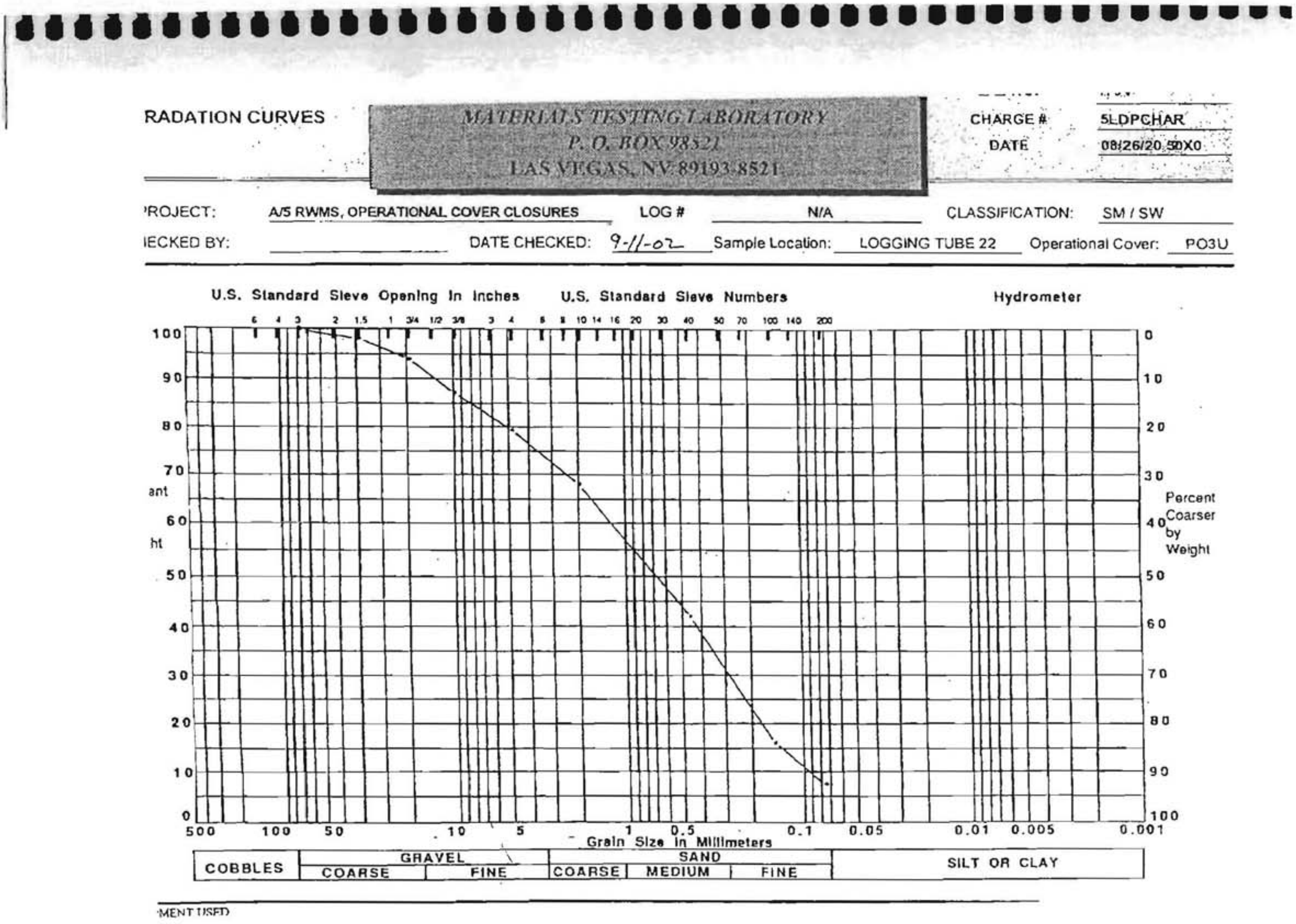
EQUIPMENT USED: PM 16, #301667, Calibration Date: 03/11/2002 Calibration Due: 03/11/2003

Sieve 3"	PTL # 303221	Cal. Date: 04/30/02	Cal. Due: 04/30/03
Sieve 1 1/2"	PTL # 303278	Cal. Date: 09/18/01	Cal. Due: 09/18/02
Sieve 3/4"	PTL # 303276	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve 3/8	PTL # 302106	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 4	PTL # 302043	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 10	PTL # 312339	Cal. Date: 09/20/01	Cal. Due: 09/20/02
Sieve # 40	PTL # 310013	Cal. Date: 09/24/01	Cal. Due: 09/24/02
Sieve # 100	PTL # 300103	Cal. Date: 04/30/02	Cal. Due: 04/30/03

REMARKS: N/A

Preparer: 6/8/09 Checker: 6/8/09

Attachment E
Sieve Analysis Data Sheets (cont.)



RADATION CURVES

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE #: 5LDPCHAR
DATE: 08/26/20 50X0

'ROJECT: A/5 RWMS, OPERATIONAL COVER CLOSURES
LOG #: N/A
CLASSIFICATION: SM / SW

IECKED BY:
DATE CHECKED: 9-11-02
Sample Location: LOGGING TUBE 22
Operational Cover: PO3U

'MENT USED

Preparer: 6/8/09 Checker: 6/8/09

Attachment E
Sieve Analysis Data Sheets (cont.)

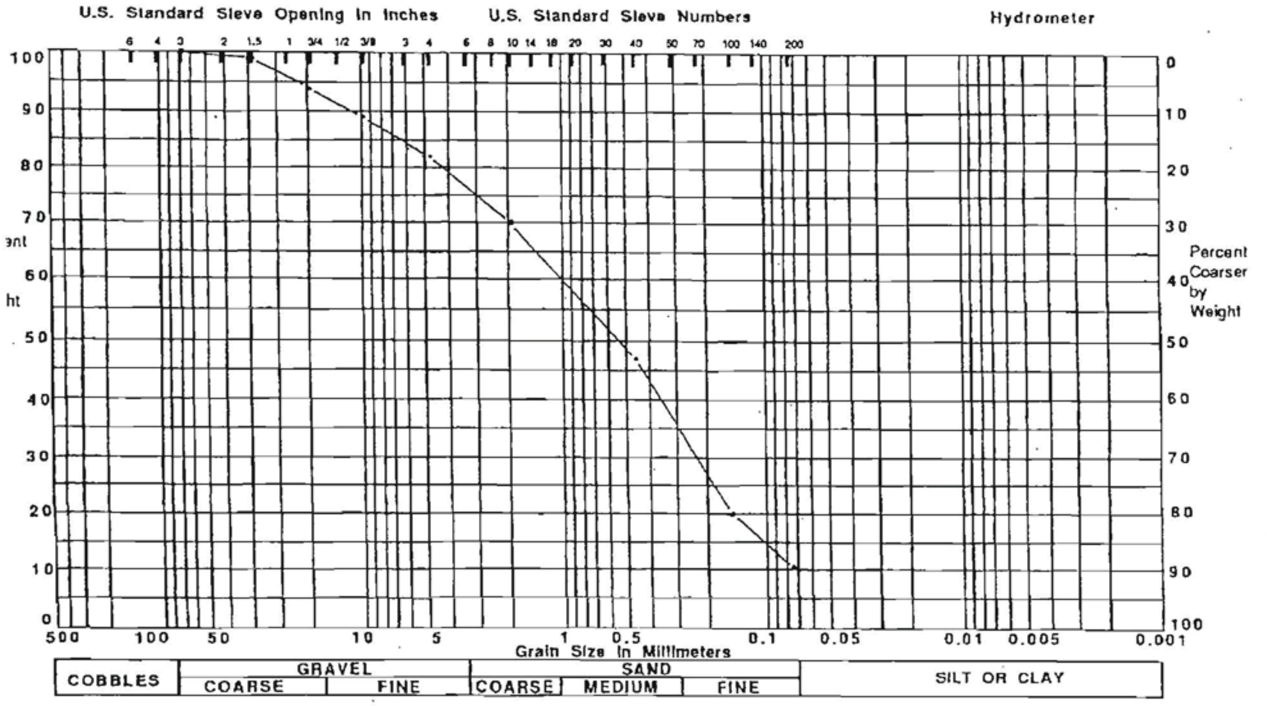
RADATION CURVES

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE # 5LDPCHAR
DATE 08/26/2002

ROJECT: A/5 RWMS, OPERATIONAL COVER CLOSURES
LOG # N/A
CLASSIFICATION: SM / SP

ECKED BY:
DATE CHECKED: 9-11-02
Sample Location: GRID PT. # B4
Operational Cover: PO4U



Attachment E
Sieve Analysis Data Sheets (cont.)

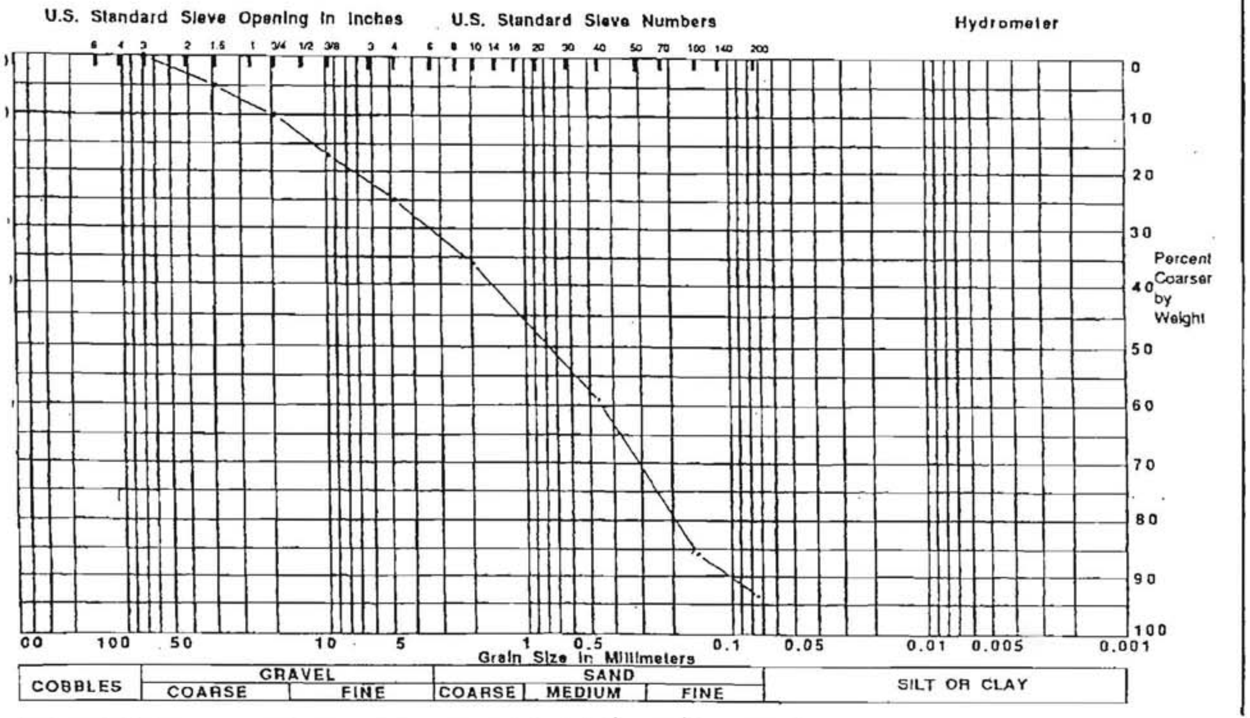
JATION CURVES

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

LAB NO. 1796
CHARGE # 5LDPCHAR
DATE 08/26/2002

ECT: A/5 RWMS, OPERATIONAL COVER CLOSURES LOG # N/A CLASSIFICATION: SM / SW

ED BY: DATE CHECKED: 9-11-02 Sample Location: GRID PT. # C10 Operational Cover: PO4U



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Preparer: 6/8/09 Checker: 6/8/09

Attachment E
Sieve Analysis Data Sheets (cont.)

ADATION CURVES

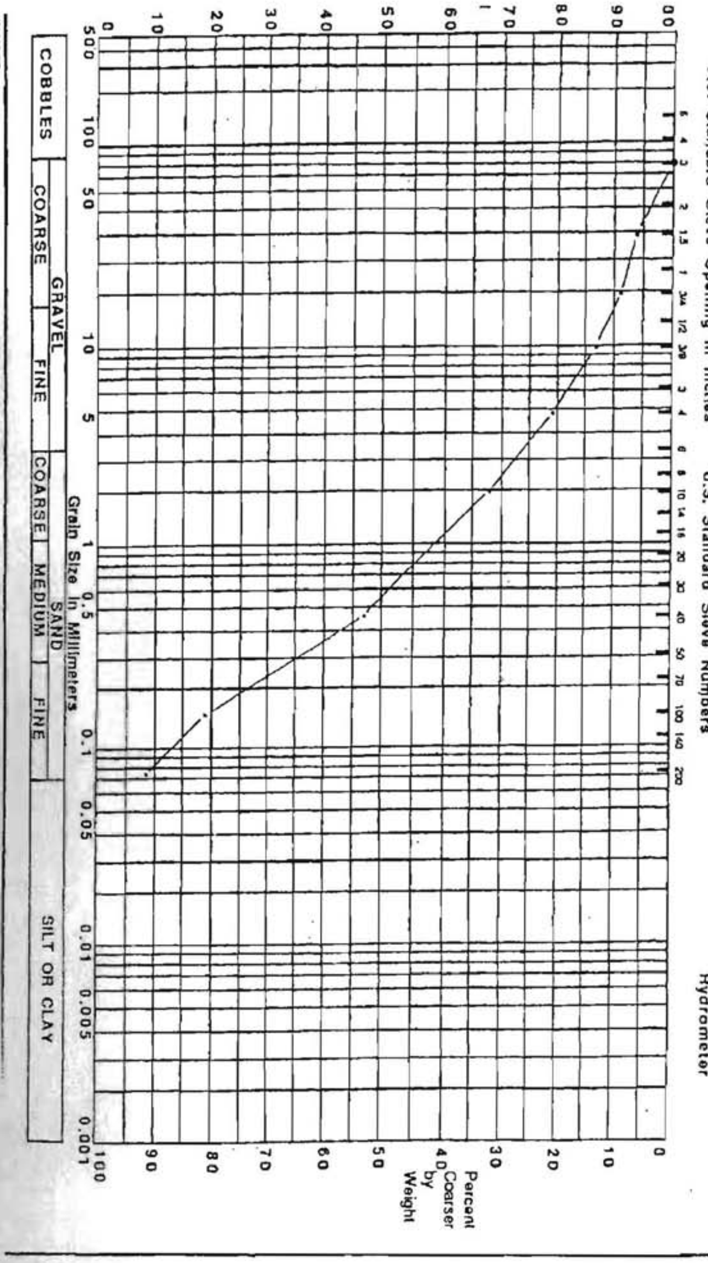
MATERIALS TESTING LABORATORY
P.O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE # 5LDPCHAR

DATE 08/26/2002

DJECT: A/5 RWMS, OPERATIONAL COVER CLOSURES LOG # N/A CLASSIFICATION: SM / SP

:KED BY: DATE CHECKED: 9-11-02 Sample Location: GRID PT. # F4 Operational Cover: TO1U-TO7U



Preparer: 6/8/09 Checker: 6/9/09

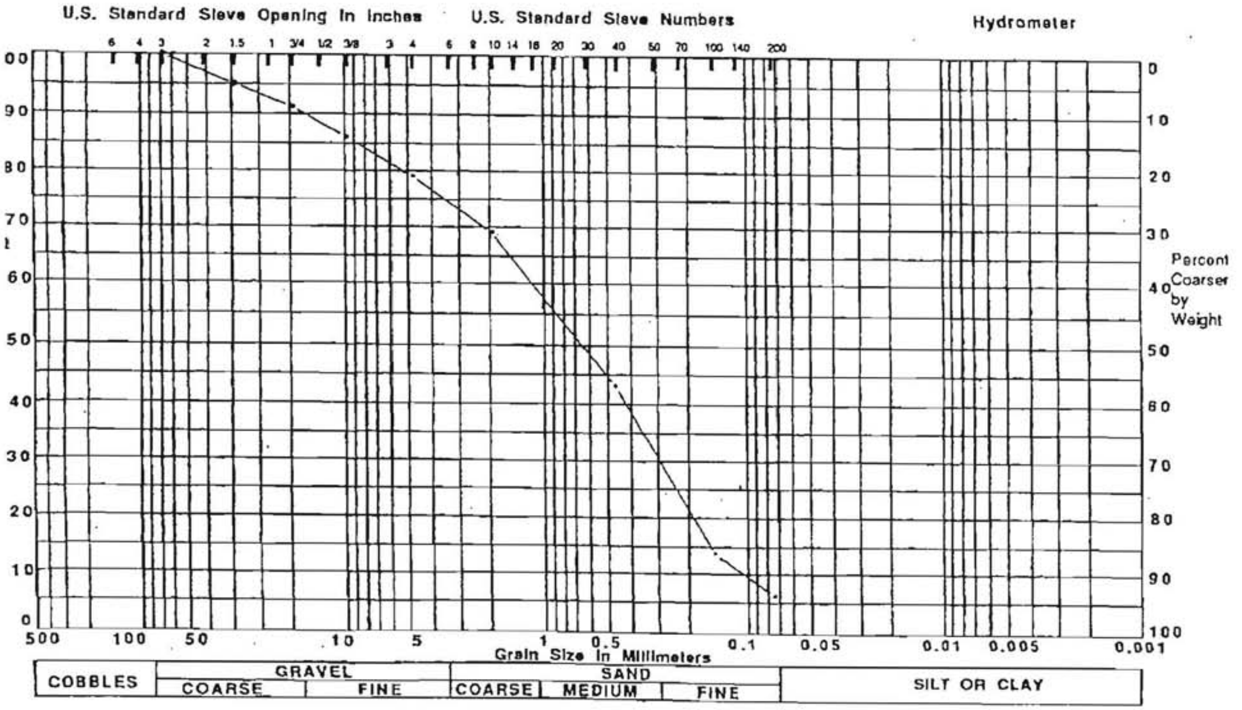
Attachment E
Sieve Analysis Data Sheets (cont.)

ADATION CURVES

Bechtel Nevada
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

LAB NO. 1798
CHARGE # 5LDPCHAR
DATE 08/26/2002

OJECT: A/5 RWMS, OPERATIONAL COVER CLOSURES
LOG # N/A
CLASSIFICATION: SM / SW
CKED BY:
DATE CHECKED: 9-11-02
Sample Location: GRID PT. # B4
Operational Cover: TO1U-TO7U



Preparer: 6/8/09 Checker: 6/8/09

Attachment E
Sieve Analysis Data Sheets (cont.)

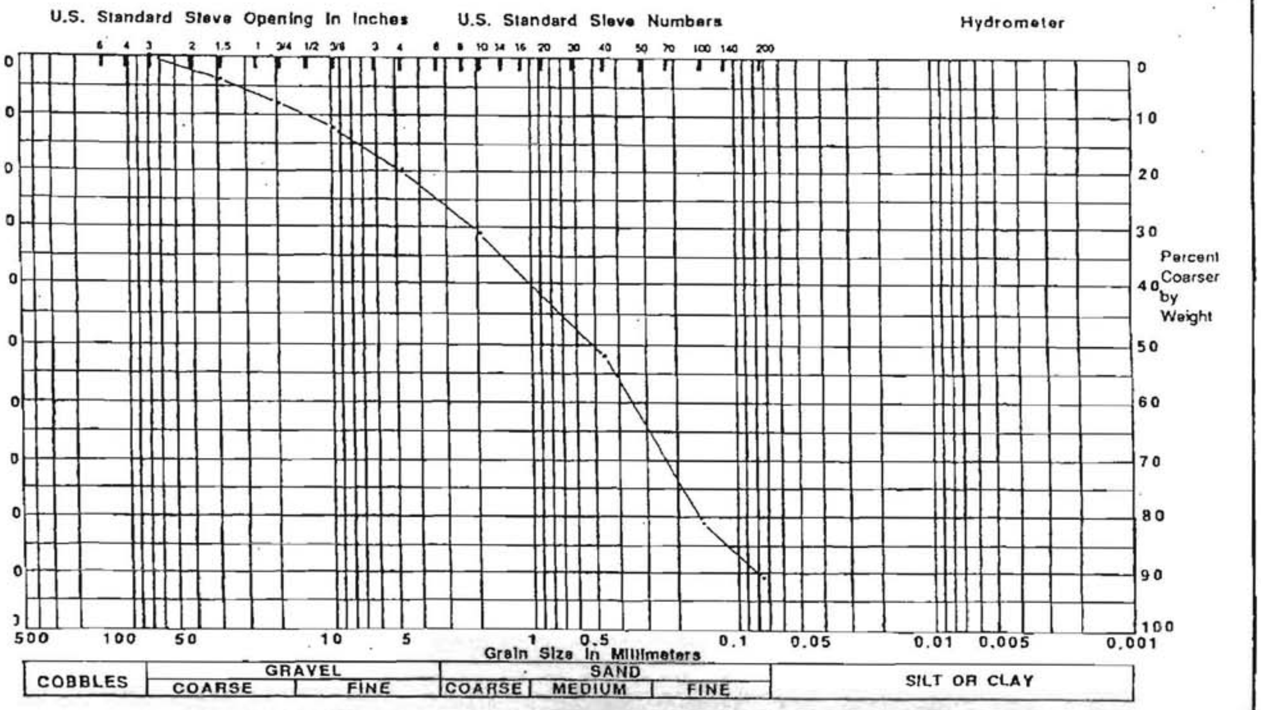
DATION CURVES

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

LAB NO. T799
CHARGE # 5LDPCHAR
DATE 08/26/2002

JECT: A/5 RWMS, OPERATIONAL COVER CLOSURES LOG # N/A CLASSIFICATION: SM / SP

KED BY. DATE CHECKED: 9-11-02 Sample Location: GRID PT. # C10 Operational Cover: TO1C-TO6C



T USED.

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APPENDIX D

PROJECT ORGANIZATION

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PROJECT ORGANIZATION

For this project, the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) points of contact are as follows:

NNSA/NSO LLW Federal Sub-Project Director: Jhon T. Carilli
Telephone Number: (702) 295-0672

NNSA/NSO Waste Management Federal Project Director: E. Frank Di Sanza
Telephone Number: (702) 295-5855

The identification of the project Health and Safety Officer and the Quality Assurance Officer can be found in the appropriate plan. However, personnel are subject to change, and it is suggested that the appropriate U.S. Department of Energy Federal Sub-Project Director be contacted for further information. The Task Manager will be identified in the *Federal Facility Agreement and Consent Order* Monthly Activity Report prior to the start of field activities.

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APPENDIX E

CORRECTIVE ACTION INVESTIGATION RESULTS

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CORRECTIVE ACTION INVESTIGATION RESULTS

A Corrective Action Investigation was not performed for this project. The results of site characterization, environmental monitoring, and modeling that have been performed for the site are presented in Section 2.2 of this document. These studies and the waste inventory are also summarized in the Data Quality Objectives provided in Appendix A of this document.

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APPENDIX F

DATA ASSESSMENT

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DATA ASSESSMENT

This section is not applicable to this project because Corrective Action Investigation data were not collected.

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APPENDIX G

EVALUATION OF RISK

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EVALUATION OF RISK

A detailed assessment and systematic analysis of the potential risks posed by the Area 5 Radioactive Waste Management Site to the public and the environment and a comparison of those risks to established performance objectives was completed as part of the Performance Assessment described in Section 2.1.9 of this document and Section 1.2.1 of the Data Quality Objectives in Appendix A.

The Performance Assessment predicts, through modeling, the future behavior of complex environmental systems and human populations. The high potential evapotranspiration, low rainfall, and thick vadose zone at the Area 5 Radioactive Waste Management Site prevent contaminants from being leached from the waste to the aquifer. The extremely low water content of the near-surface alluvium minimizes the potential for upward advection and diffusion of dissolved solutes. The potential for release by plant uptake is reduced by the low productivity and shallow rooting depth of native floral communities. These characteristics combine to minimize the release of contaminants from the intact waste disposal units.

The impact of contaminants released from the facility is minimized by the low population density and limited land use options near the site. Protection of groundwater resources is ensured by the natural properties of the disposal site rather than the performance of engineered barriers or stabilized waste forms.

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APPENDIX H

SAMPLING AND ANALYSIS PLAN

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SAMPLING AND ANALYSIS PLAN

This section is not applicable to this project because samples will not be collected for site closure.

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APPENDIX I

REVEGETATION PLAN FOR THE 92-ACRE AREA

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REVEGETATION PLAN
FOR THE 92-ACRE AREA

Prepared by

David C. Anderson
Environmental Technical Services
Ecological Services

January 2008

1.0 INTRODUCTION

Cover performance objectives for closure of the 92-Acre Area of the Area 5 Radioactive Waste Management Site (RWMS) at the Nevada Test Site (NTS) include minimizing the migration of water off and through the cover, creating a cover that requires minimal maintenance, maintaining the integrity of the cover over time, and meeting U.S. Department of Energy performance objectives. The cover designed for the 92-Acre Area is a vegetated monolayer that has been approved by the Nevada Division of Environmental Protection at other NTS sites and uses an evapotranspirative technique to meet cover performance objectives.

The establishment of a native plant community will minimize wind and water erosion and help maintain the integrity of the cover. The loss of water through transpiration is maximized and the potential for water to penetrate to buried waste is minimized. The vegetated cover prevents the establishment of invasive plants (Anderson and Ostler, 2002; National Security Technologies, LLC [NSTec], 2007). Invasive plants, which are typically annual plants, will not meet closure cover objectives because they do not maximize evapotranspiration and are not effective in controlling wind and water erosion, which could compromise the integrity of the cover.

This revegetation plan provides guidelines for successfully establishing a native plant community on the cover. Revegetation is the colonization of plants through natural plant succession or by human-induced means. Natural plant succession may require centuries for complete plant colonization, especially in the Mojave Desert (Angerer et al., 1995; Carpenter et al., 1986; Romney et al., 1980; Vasek et al., 1975a; Vasek et al., 1975b; Vasek, 1980; Wallace et al., 1980; Webb and Wilshire, 1980). However, human-induced means may shorten the time for establishment of a viable plant community. Various revegetation efforts in arid and semi-arid regions of the Southwest have shown that establishing a plant community by re-seeding is practical and cost effective when proper revegetation techniques are employed (Anderson, 1987; Anderson and Ostler, 2002; Bainbridge et al., 1995; Clary, 1983; Edgerton, Germeshausen, and Grier Energy Measurements, Inc., [EG&G/EM], 1993; EG&G/EM, 1994; Graves et al., 1978; Kay, 1979; Ostler et al., 2002a; Trw Environmental Safety Systems, Inc., 1999).

Revegetation in this area presents unique challenges. The site is located in the harsh Mojave/Great Basin Transition Desert, which is characterized by extreme temperatures and limited, erratic precipitation. Perennial plant establishment under natural conditions usually occurs only during favorable rainfall years (Anderson and Ostler, 2002; Beatley, 1975; Romney et al., 1980; Wallace and Romney, 1972), which occur approximately one out of five years (Ries and Day, 1978). This low and unpredictable precipitation is almost without exception the factor limiting successful revegetation in the arid/semi-arid Southwest (May, 1975).

The revegetation strategy outlined in this plan employs proven reclamation techniques. Site preparation is the first critical task, followed by seeding with native adapted species, mulching to conserve soil moisture, supplemental irrigation to ensure seed germination and plant establishment, and monitoring to evaluate revegetation success and identify any remedial actions necessary to ensure the maintenance of a viable vegetative cover (Ostler et al., 2002a; Winkel et al., 1999). Timing is paramount to the success of this strategy. Late fall and early spring are the best times for successful seed germination and eventual plant establishment. The late fall seeding window is from approximately October 15 to December 15, and the spring window is February to early March. Implementation of these techniques creates the optimum conditions for seed germination and plant establishment (Anderson and Ostler, 2002; Ostler et al., 2002a).

2.0 PROCEDURES

2.1 SITE PREPARATION

The top 12 inches (in.) of soil will have physical and chemical characteristics that support plant growth (Table I-1). Appropriate amendments may be used to enhance germination and establishment of seeded species. Soil amendments could include 1) fertilizers, 2) organic matter, 3) water-holding copolymers, and 4) remedies for sodic soils such as gypsum.

TABLE I-11. SUITABLE SOIL PARAMETERS FOR REVEGETATION*

SOIL PARAMETER**	SUITABILITY	
	GOOD	FAIR
Texture	Fine sandy loam, very fine sandy loam, loam, silt loam, sandy loam	Clay loam, sandy clay loam, silty clay loam
Salinity (EC, mmhos/cm)	< 3	3 to 6
Alkalinity (Exchangeable Sodium Percentage)	< 4	4 to 8
pH	6.1 to 7.8	5.1 to 6.1 7.9 to 8.4
Organic Matter (Percentage)	> 1.5	0.5 to 1.5

*U.S. Department of Agriculture (USDA) Forest Service, 1979
**Parameters are listed in order of relative importance.

A key component of site preparation is alleviation of soil compaction. Compacted soils are not conducive to plant growth. A sequence of ripping, disking, and harrowing will be used to alleviate soil compaction, increase water infiltration, and provide a firm seedbed for good contact between soil and seeds (Munshower, 1994; Ostler et al., 2002a). Soils will be ripped perpendicular to the slope at a depth of 12–18 in. Ripping typically creates large clods of soil, and a tractor-drawn tandem disk will be used to break up the soil clods. After disking, the site will be harrowed to create a firm seedbed. Disking and harrowing, like ripping, will be done with the contour of the area so as not to create channeling or drainage off the cover.

The cover will be constructed to allow access for revegetation equipment such as farm tractors, road graders, four wheel drive trucks, strawblowers, and tractor-drawn implements, such as drill seeders, disks, and chisel-tooth harrows or crimpers.

2.2 SEEDING

Plant species recommended for revegetation are native to the area (Table I-2) based on data from adjacent undisturbed areas (EG&G/EM, 1992), visual surveys of the vegetation in the region, and a review of local literature (Beatley, 1976; Ostler et al., 2000). Most of the species have been successfully used at other revegetation projects in the area (NSTec, 2007), and most seed is available from commercial sources. The percentage of each species in the mix is based on the relative contribution of each species to the total perennial plant cover of adjacent native plant communities, the size of the seed, and performance of the species at the NTS. The final mix will depend on seed availability. Some seed may be treated by washing, chemical treatments, or mechanical treatments to break seed dormancy (Hansen, 1989; Ostler et al., 2002b).

The site will be broadcast-seeded at a rate of 21.4 pure live seed (PLS) pounds per acre (lb/ac). Seeding will be done with a tractor-drawn seed drill having seedboxes that accommodate small, fluffy, and large seeds. Drag chains will be used behind the seed drill to cover the seed.

TABLE I-2. RECOMMENDED SEED MIX AND SEEDING RATES

SCIENTIFIC NAME	COMMON NAME	PLS* lb/ac
Shrubs		
Ambrosia dumosa	White bursage	2.00
*Atriplex polycarpa***	Desert Saltbush	0.05
Atriplex confertifolia	Shadscale	1.00
*Atriplex canescens***	Fourwing saltbush	1.00
Encelia farionosa	Brittlebush	0.50
Ephedra nevadensis	Nevada Ephedra	3.00
Ericameria nauseosa	Rubber Rabbitbrush	0.30
Eriognum fasciculatum	Buckwheat	1.00
Grayia spinosa	Spiny Hopsage	0.50
Hymenoclea salsola	Burrobush	0.10
Krascheninnikovia lanata	Winterfat	5.00
*Larrea tridentata***+	Creosote	2.00
Lycium andersonii +	Desert Thorn	0.20
Grasses		
Achnatherum hymenoides	Indian Ricegrass	3.00
Elymus elymoides	Squirreltail	1.00
Forbs		
Baileya multiradiata	Marigold	0.25
Sphaeralcea ambigua	Globe Mallow	0.25
Penstemon palmeri	Palmer's penstemon	0.25
		Total = 21.40

*Pure Live Seed, or number of seeds per acre divided by percent germination
**Deep-rooted plants
+ Species should be considered for transplanting

2.3 MULCHING

The site will be mulched with grain straw at a rate of 4,000 lb/ac. The mulch will be applied evenly over the surface with a strawblower. The mulch will then be crimped into the soil perpendicular to the slope with a tractor-drawn disk crimper to secure the straw and incorporate a portion of the straw into the soil, which will increase the amount of organic matter in the soil.

2.4 IRRIGATION

Irrigation is a critical component to ameliorate the harsh growing conditions due to sporadic and unpredictable precipitation. It ensures sufficient moisture for seed germination and growth during the first year. Plants typically survive harsh desert conditions if roots have penetrated deeper water sources, which can occur during the first year of growth.

The Area 5 RWMS receives approximately 6.69 in. of precipitation annually, which is below the 9.84 in. suggested for successful reclamation (National Academy of Science, 1974). An initial period of supplemental irrigation will provide sufficient moisture for seed germination and plant establishment (Hall and Anderson, 1999; Winkel and Boone, 1999). If insufficient natural precipitation is received for several years after seeding, much of the seed will be lost to predation or poor viability (Ostler et al., 2002a; Plummer et al., 1968). Under these circumstances, the site would need reseeding to achieve revegetation success.

Prior to irrigating the site, the water source will be tested for quality. Four basic criteria are used to evaluate water quality (Ludwig et al., 1976):

1. Total soluble salt content (salinity hazard)
2. Relative proportion of sodium cations to other cations (sodium hazard)
3. Bicarbonate anion concentration as related to calcium plus magnesium cations
4. Concentration of elements that may be toxic

The irrigation system will be a solid set sprinkler-type system designed to produce an even distribution of water across the cover. Sprinkler heads are selected to apply water at the optimal rate, spray pattern, and droplet size while minimizing runoff and wind drift.

Supplemental irrigation occurs prior to, during, and after germination (Aldon et al., 1976; Danielson, 1967; Ries and Day, 1978). Irrigation prior to germination in late fall and early winter recharges the soil profile and encourages deep-rooting. Irrigation during late winter and early spring keeps surface soils moist to promote seed germination and seedling emergence. Irrigation during late spring and early summer aids plant establishment and survival over hot and dry summer months. The frequency of application is based on the amount of rainfall received and other climatic conditions.

2.5 SCHEDULE

Mid- to late November is the preferred period for seeding to ensure dormancy-breaking requirements for germination are met and seeds are in the ground prior to winter precipitation. Site preparation, delivery of seed and straw, and mobilization of reclamation equipment will take place prior to the seeding window. Soil amendments will be added to the soil during site preparation or seeding. Mulching and crimping will occur immediately after seeding. The irrigation system will be installed after revegetation is complete. Irrigation will then begin and continue into late June or as required.

2.6 SPECIAL CONSIDERATIONS

2.6.1 Interim Soil Stabilization

If cover construction is completed after the seeding window, revegetation may have to be rescheduled for the following fall or spring. A temporary means of soil stabilization may be required to minimize erosion. Interim soil stabilization may include applying a copolymer soil stabilizer, which typically has an effective life of 6 to 12 months depending on application rate and weather conditions. The site would be monitored following application of the copolymer to check the integrity of the soil stabilization. If the copolymer is not adequately controlling erosion, reapplication may be necessary.

A chemical soil stabilizer may be more cost effective. However, if a more permanent stabilization of the soil is required, straw mulch followed by crimping may be appropriate. Surface soils are disked and ripped, and a layer of straw mulch is applied and crimped into the loosened soils.

2.6.2 Transplants

Many native plant species are difficult to establish using the direct seeding method. Two such species are *Larrea* and *Lycium* (Table I-1). The best method for establishing these species is to use transplants. The use of transplants requires more time. Seed from both species is collected from native populations of the species on or near the revegetation area. The seed is then used to grow plants under greenhouse conditions for approximately one year. After a hardening period, they are placed in the field, typically some time after seeding. Each transplant is watered as it is placed in the ground to ensure sufficient soil moisture for survival. Subsequent watering may occur using the irrigation system.

2.6.3 Remediation

In the unlikely event that plants do not become established, remedial action may be taken. Such action may involve additional site preparation, re-seeding, mulching, or use of transplants.

3.0 MONITORING

Monitoring should occur during the first 2 to 3 years to evaluate the success of revegetation and identify concerns such as erosion, poor seed germination, or poor plant establishment. Erosion is evaluated using a modified classification system used by the Bureau of Land Management (Table I-3). Monitoring focuses on erosion conditions and plant densities. The success of seed germination and plant establishment is estimated annually during the first 2 to 3 years by determining the density of plants that were seeded and those that were not seeded but have naturally invaded the site.

Long-term establishment of plants is monitoring in subsequent years, typically every 5 years or as requested. Plant density, plant cover, and other vegetative parameters are measured to provide a quantitative assessment of the success of revegetation. An undisturbed area, similar to the revegetation site, is also sampled as a reference site.

TABLE I-3. EROSION CONDITION CLASSIFICATION*

SURFACE LITTER	PEDESTALLING	RILLS < 9 IN.	RILLS > 9 IN.
1 – Accumulating in place	1 – No visual evidence	1 – No visual evidence	1 – No visual evidence
2 – Slight Movement	2 – Slight pedestalling at > 10-foot intervals	2 – Rills in evidence at > 10-foot intervals	2 – Rills in evidence
3 – Moderate Movement	3 – Small rocks and plants pedestalling	3 – Rills at 10-foot intervals	3 – Rills at 10-foot intervals
4 – Extreme Movement	4 – Pedestalling plants and roots exposed	4 – Rills at 5- to 10-foot intervals	4 – Rills at 5- to 10-foot intervals
5 – Very little litter remaining	5 – Most plants and rocks pedestalling and roots exposed	5 – Rills at < 5-foot intervals	5 – Rills at < 5-foot intervals
Rating ________	Rating ________	Rating ________	Rating ________

Numerical Rating	Erosion Condition Class
0.0 to 4.0	Stable
4.1 to 8.0	Slight
8.1 to 12.0	Moderate
12.1 to 16.0	Critical
16.1 to 20.0	Severe

*USDA, 1992

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APPENDIX J

NEVADA DIVISION OF ENVIRONMENTAL PROTECTION COMMENT RESPONSE FORM

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Document Title: Draft Corrective Action Decision Document/Corrective Action Plan for the 92-Acre Area and Corrective Action Unit 111: Area 5 WMD Retired Mixed Waste Pits

Revision Number: 0

Responsible NNSA/NSO ERP Federal Sub-Project Director: Kevin Cabble

Document Date: April 2009

Author/Organization: NSTec

Reviewer/Organization/Phone: Jeff MacDougall/NDEP/486-2850 ext 233

Review Criteria: Full

No.	Comment	Comment Response
1	Section 1.2, last paragraph: Suggest removing language pertaining to Clean Closure. Perhaps the language may be used appropriately in Section 3.4. Also, if there is additional support for Closure in Place, include it in this section.	The language pertaining to Clean Closure has been moved to Section 3.4. In addition, the following text has been added to Section 1.2 to support Closure in Place: "Of the CAAs evaluated based on short-term reliability and effectiveness; reduction of toxicity, mobility, and/or volume; long term reliability and effectiveness; feasibility; and cost, the Closure in Place with Administrative Controls alternative received the highest score and therefore will have the most desirable overall impact on these factors."
2	General Comment, Sections 2.1.1 – 2.1.8: Consider expanding upon the discussion in each section as appropriate, keeping in mind to explain the relevance of the specified monitoring, its purpose, and the meaning of results that have been obtained. Section 2.1.6 is an adequate example of the type of information that is appropriate for each for the other sections, as it fully explains the relevance (what, why, how…) of the monitoring and includes an appropriate discussion of the results and their meaning.	Sections 2.1.1 – 2.1.8 have been revised as follows to include additional information regarding purpose, implementation, relevance, and results of each monitoring activity: **2.1.1 Direct Radiation Monitoring** To assess external radiation, measure gamma radiation levels, and detect changes, direct radiation monitoring is conducted with thermoluminescent dosimeters (TLDs) at 12 locations shown in Figure 2. TLDs measure ionizing radiation exposure from all sources, including natural and man-made radioactivity, and results represent the potential external dose to a hypothetical person residing at the Area 5 RWMS. At each location, a pair of TLDs is placed at 1 m above ground surface. The TLDs are exchanged for analysis on a quarterly basis, and analysis is conducted with automated TLD readers. Since monitoring began in 1998, exposure rate measurements have generally fallen within the range of background measurements collected at locations across the NTS and indicate that a member of the public will not receive a dose greater than 25 millirems per year (mrem/yr), even if they were to reside at the Area 5 RWMS. The highest measurement recorded was 0.6 milliroentgens per day (mR/day) in 2004. **2.1.2 Air Monitoring** Air monitoring of tritium and radioactive particulates is conducted at two locations downwind of the Area 5 RWMS. Tritium is monitored because it is a highly mobile radioactive isotope and is an indicator of volatile radionuclide migration from waste cells into the atmosphere. Atmospheric moisture is continuously collected using molecular sieve columns, and samples are analyzed every 2 weeks for tritium by liquid scintillation counting. Tritium concentrations in air have been well below the DOE Derived Concentration Guide (DCG) of 100,000 picocuries per cubic meter (pCi/m^3) for tritium. The DCG is the concentration of a radionuclide in air that, if inhaled for 1 year, would result in the DOE radiation limit of 100 mrem/yr committed dose equivalent to the public. The highest measurement recorded was 47.4 pCi/m^3 in 2006. Air particulates are collected on glass fiber filters, which are screened weekly for gross alpha and beta radioactivity to detect changes in airborne radioactivity. Monthly composites of the weekly samples are analyzed

No.	Comment	Comment Response
		by gamma spectroscopy for gamma-emitting radionuclides and by radiochemical analysis for americium and plutonium. Americium and plutonium concentrations in air have been well below the respective DCGs of 0.02 and 0.03 pCi/m^3. In 2007, the highest measurement recorded for americium was 0.00000595 pCi/m^3, and the highest measurement recorded for plutonium was 0.0000321 pCi/m^3. **2.1.3 Radon Flux Monitoring** Radon flux measurements have been collected since 2000 at various locations at the Area 5 RWMS to meet the performance objective of DOE O 435.1 and assess whether radon levels exceed the regulatory limit. Measurements are collected once a year at one or two locations. These locations are chosen because they are most likely to have elevated results based on disposal units that contain radon and thorium-bearing waste. Radon flux domes placed on the ground surface collect the measurements. The highest measured radon flux was 4 picocuries per square meter per second (pCi/m^2s) in 2004, well below the regulatory limit of 20 pCi/m^2s. **2.1.4 Groundwater Monitoring** Groundwater monitoring has been conducted since 1993 at three wells shown in Figure 2. Water levels in each well are measured every 3 months, and water samples are collected every 6 months. Based on groundwater elevations, the water table under the Area 5 RWMS is essentially flat. Calculated groundwater flow velocities are approximately 0.1 m per year. Water samples are analyzed for indicators of contamination (pH, specific conductance, total organic carbon, total organic halides, and tritium) and general water chemistry parameters (calcium, magnesium, potassium, sodium, iron, manganese, bicarbonate, sulfate, silicate, chloride, and fluoride). Investigation levels (ILs) were established as the compliance criteria for indicators of contamination by NNSA/NSO and NDEP in 1998 (Bechtel Nevada [BN], 1998). Groundwater monitoring data have remained stable and below ILs since monitoring began; therefore, these indicate no measurable impact to the uppermost aquifer from the Area 5 RWMS. **2.1.5 Meteorology Monitoring** The Area 5 RWMS is located in a windy, arid climate with high average temperatures and low precipitation rates. Meteorological parameters, including precipitation, solar radiation, air temperature, relative humidity, wind speed and direction, and barometric pressure, are measured at a 3-m meteorology tower near the southeast corner of the Area 5 RWMS to quantify the exchange of water and heat between the soil and the atmosphere. Reference evapotranspiration, the rate at which readily available soil water is vaporized from the surface, is calculated from these meteorological parameters. The ratio of reference evapotranspiration to precipitation is then determined. In 2007, the ratio of reference evapotranspiration to precipitation was 12.9, indicating that the rate of evapotranspiration upwards through the cover far exceeds the rate of infiltration of precipitation downwards toward the waste cells. **2.1.6 Vadose Zone Monitoring** Vadose zone monitoring is conducted at three operational covers, one pit floor, and two weighing lysimeters to assess water balance, confirm the key assumption of no downward pathway to groundwater, and evaluate the

No.	Comment	Comment Response
		performance of operational covers. Water balance studies use meteorology data to calculate evapotranspiration, directly measure evapotranspiration and bare-soil evaporation with weighing lysimeters, and measure volumetric moisture content of the soil, soil water potential, and temperature. Data indicate that vegetation and the arid climate prevent precipitation from percolating deep into the soil by returning moisture to the atmosphere by evapotranspiration. Vegetated lysimeter data were used to generate a vadose zone flow model that confirms there is no downward pathway under vegetated conditions. Time-domain reflectometry (TDR) data for the operational covers continue to indicate dry conditions. **2.1.7 Soil Gas Monitoring** Soil gas monitoring for tritium has been conducted since 1990 at borehole GCD-05 to evaluate tritium movement. This borehole has a large tritium inventory (approximately 2.2 million curies at the time of disposal) buried from 20 to 36 m below ground surface. Two strings of nine soil gas sampling probes are buried in the borehole. A depth profile of soil gas tritium concentration is measured from 3 to 36 m below ground surface to provide a direct measure of changes in tritium activity with depth as a result of degradation of waste containers, advection, and diffusion. During the 18-year measurement period, soil gas tritium concentrations show extremely slow upward movement of tritium through soil from the waste, which indicates that tritium and associated waste remain contained. **2.1.8 Biota Monitoring** Bioturbation and plant uptake are two release mechanisms that potentially transport tritium upward through waste covers and into the atmosphere. Plants can transport tritium by root uptake and subsequent evapotranspiration, and animal burrows may potentially intrude into waste; however, root depths of the species in this area are generally less than 2 m, and animal burrows only extend approximately 0.3 m below ground surface. Biota (plant and animal) samples are collected every 2 years to measure tritium concentrations. Analyses of samples collected at the Area 5 RWMS show detectable levels of tritium. Although these results show tritium uptake, there is no evidence that plants or animals have intruded into the waste, and it is unlikely that plant roots or animal burrows extend to a depth that could impact buried waste.
3	Section 2.1: Figure 2 is referenced but not included.	Figure 2 is included on Page 3 of the document. The text in Section 2.1 has been revised to point the reader to Figure 2 as follows: "The current monitoring network is summarized in Table 1 and shown in Figure 2 on Page 3 of this document."
4	Section 2.1.1: "…Typical exposure rate measurements are at background levels…" Clarify what is meant here. Are the TLD measurements equivalent to, above, or below background?	The statement has been revised as follows: "Since monitoring began in 1998, exposure rate measurements have generally fallen within the range of background measurements collected at locations across the NTS and indicate that a member of the public will not receive a dose greater than 25 millirems per year (mrem/yr), even if they were to reside at the Area 5 RWMS."

No.	Comment	Comment Response
5	Section 2.1.2: Explain the relevance of tritium monitoring and what it means in the big picture. Also, are americium and plutonium concentrations in air routinely monitored, and if so, how?	The following text has been added to Section 2.1.2 to explain the relevance of tritium monitoring: "Tritium is monitored because it is a highly mobile radioactive isotope and is an indicator of volatile radionuclide migration from waste cells into the atmosphere." Americium and plutonium concentrations in air are routinely monitored. Monthly composites of weekly air particulate samples are analyzed by radiochemical analysis for americium and plutonium. This information is included in Section 2.1.2 as follows: "Air particulates are collected on glass fiber filters, which are screened weekly for gross alpha and beta radioactivity to detect changes in airborne radioactivity. Monthly composites of the weekly samples are analyzed by gamma spectroscopy for gamma-emitting radionuclides and by radiochemical analysis for americium and plutonium."
6	Section 2.1.3 and Table 1: Is the location of the radon flux measurement the same from year to year or does it change location? Why is only one measurement location used?	The locations of radon flux measurements change periodically. The locations are chosen because they are most likely to have elevated results (i.e., above disposal units that contain radon and thorium-bearing waste). In December 2008, measurements were collected at two locations at the Area 5 RWMS, Pit 6 and Pit 13, as shown in Figure 9. Section 2.1.3 has been revised as follows: "Radon flux measurements have been collected since 2000 at various locations at the Area 5 RWMS to meet the performance objective of DOE O 435.1 and assess whether radon levels exceed the regulatory limit. Measurements are collected once a year at one or two locations. These locations are chosen because they are most likely to have elevated results based on disposal units that contain radon and thorium-bearing waste."
7	Section 2.1.4: Last sentence, explain how and why the results of the data over time allow this conclusion to be made.	The sentence has been revised as follows: "Groundwater monitoring data have remained stable and below investigation levels since monitoring began; therefore, these indicate no measurable impact to the uppermost aquifer from the Area 5 RWMS."
8	Section 2.1.5: Indicate the relevance of meteorological monitoring, and what the results have been and what they reveal over a specified period of time.	The following text has been added to Section 2.1.5: "Reference evapotranspiration, the rate at which readily available soil water is vaporized from the surface, is calculated from these meteorological parameters. The ratio of reference evapotranspiration to precipitation is then determined. In 2007, the ratio of reference evapotranspiration to precipitation was 12.9, indicating that the rate of evapotranspiration upwards through the cover far exceeds the rate of infiltration of precipitation downwards toward the waste cells."
9	Section 2.1.7: Provide explanation for soil gas monitoring for tritium, specify the period of time for which this has been performed.	The following text has been added to Section 2.1.7: "A depth profile of soil gas tritium concentration is measured from 3 to 36 m below ground surface to provide a direct measure of changes in tritium activity with depth as a result of degradation of waste containers, advection, and diffusion. During the 18-year measurement period, soil gas tritium concentrations show extremely slow upward movement of tritium through soil from the waste, which indicates that tritium and associated waste remain contained."

No.	Comment	Comment Response
10	Section 4.0, second paragraph: "... Selection of this CAA is consistent with past practices for sites that contain buried wastes..." Support/justify this statement by citing examples and including the rationale behind the selection of this alternative at those sites. If this cannot be done, remove or modify this statement appropriately.	The following text has been added to this paragraph: "For example, CAU 92, Area 6 Decon Pond Facility, a RCRA unit consisting of an unlined pond used for the disposal of untreated liquid effluent from the laundering of radioactively contaminated clothing and decontamination of heavy equipment, was closed in place. A Corrective Measures Study found that this was the most cost-effective method of meeting the closure objectives and complying with regulatory requirements (DOE, 1997). CAU 110, Area 3 RWMS U-3ax/bl Disposal Unit, was closed in place with an engineered RCRA alternative cover designed to accommodate differential subsidence. The cover is a vegetated natural alluvium mono-layer cover. It was determined that the disposal unit could accommodate infiltration, evaporation, and plant and animal activity in its present state and keep buried waste contained (NNSA/NV, 1999)."
11	Section 5.2: Add text providing description of the general closure activities rather than relying on the engineering drawings in Appendix C. For example, include information on the construction of the two engineered caps approximately 2.5 meters in thickness. Caps will be constructed in 1-foot lifts with each lift being compacted using what and to what standard? How many compaction tests will be conducted per lift? Installation of the two fence lines enclosing the north cap and south cap. Specify the type of fences. Installation of subsidence monuments, describe the monuments and specify the number of monuments to be installed. If the cover is to be vegetated, describe how this will be done, with native seed or plants or both. Will mulch be applied? Will the planted cover be initially irrigated? Will the cover material come from a borrow pit? If so, is it an existing pit or will one be developed? Will the soil be conditioned at the borrow pit before being placed? Etc.	Sections 5.1 and 5.2 have been revised to include additional detail on site preparation, cover construction, subsidence monument installation, vegetation establishment, fence installation, use restriction implementation, sieve analysis, and compaction tests. The following sections have been added: **5.1.1 Site Preparation** The site will be cleared and grubbed prior to installation of the cover. All aboveground electrical panels, monitoring devices, and junction boxes, except as noted in the engineering design, will be removed. The existing chain link and smooth wire fencing will be removed. The GCD boreholes will be backfilled. The TDR monitoring cabinets in Pit 3 and Pit 4 will be raised and reinstalled on the new surface. All existing underground water, sewer, and communication lines will remain in place. Underground power lines will be abandoned in place. The siren pole that is currently located near Pit 1 will be relocated to a location outside the cover. **5.1.2 Engineered Cover Construction** With the exception of three active pits (P03, P06, and P09), all trenches and pits in the 92-Acre Area have current operational covers approximately 2.4 m thick; therefore, construction of the cover over these units will consist of augmenting the current operational covers to the final thickness, grade, and slope required by the final engineering design. For the open pits, the backfill will be placed in 12-inch lifts and compacted to not less than 90 percent of the maximum dry unit weight according to American Society for Testing of Materials Standard D1557. An existing stockpile of clean soil located at the site will be used for backfill and for construction of the cover. The soil does not require conditioning prior to use, as it meets the engineering specifications. To minimize the volume of soil needed for construction of the cover while promoting drainage and minimizing erosion, the cover will consist of three smaller covers separated by drainage channels, a concrete culvert, and corrugated metal culverts. Riprap will also be installed in select areas to minimize erosion of the covers, side slopes, and drainage channels. The typical surface side slope of the covers will be 5:1. **5.1.3 Subsidence Monument Installation** A total of 68 concrete subsidence survey monuments, measuring 2 feet by 2 feet by 6 inches high, will be installed on the covers. Brass caps will be installed on the monuments and stamped with the elevation and geographical coordinates measured at the time of installation.

No.	Comment	Comment Response
		5.1.4 Vegetation Establishment After cover construction is complete, the cover will be seeded with a mixture of shallow rooting native plant species. The vegetation will minimize wind and water erosion and remove water from the cover through evapotranspiration. The top 12 to 18 inches of soil will be prepared to provide a suitable environment for the establishment of the seeds. This includes adding amendments to the soil and alleviating soil compaction. Straw mulch will be applied over the seeds to protect them from erosion and conserve soil moisture. Irrigation will initially be used to augment precipitation and provide optimal conditions to ensure successful seed germination. Irrigation will be minimized to limit infiltration through the cover. Additional details on the establishment of vegetation on the cover are included in Appendix I. **5.1.5 Fence Installation** A fence is not required around the 92-Acre Area. A 3-strand wire fence currently exists around the entire RWMS, and this fence serves to enhance access control to the site as a best management practice. Quarterly post-closure inspections, as described in Section 7.1, will identify any animal burrows that may affect the integrity of the cover. These animal burrows will be backfilled within 60 calendar days of discovery. **5.1.6 Use Restriction Implementation** UR warning signs and concrete monuments will be installed according to the FFACO *Use Restriction Posting Guidance* to delineate the UR area (FFACO, 2003). Concrete monuments that currently mark the boundaries of disposal units and measure 2 feet by 2 feet by 5 feet high will be re-installed along the perimeter of the UR area, and UR warning signs will be attached to the monuments. A UR will be implemented to prohibit any unauthorized intrusive activity. A final survey plat will be prepared and certified by a professional land surveyor. Post-closure inspections and monitoring will be implemented according to the requirements in Section 7.0. **5.2.1 Construction Field Sample Collection Activities** Additional details on construction field sample requirements are included in the engineering specifications in Appendix C. Sieve analysis will be performed at a frequency of one test per 1,000 cubic yards of fill, and at least once per day, to ensure backfill has a maximum particle size of 3 inches and a maximum of 20 percent passing the number 200 sieve. Compaction tests will be performed near the bottom of each lift at a frequency of one test per 10,000 square feet, and at least three per lift, to ensure backfill is compacted to at least 90 percent of the maximum dry unit weight according to American Society for Testing of Materials Standard D1557.
12	Section 5.5.2 or 5.5.4: If a borrow pit for cap material is to be developed and a permit or NEPA evaluation will be required, please specify.	The following text has been added to Section 5.5.1: "A new borrow pit will not be developed for closure of the site because an existing stockpile of clean soil is located at the site for backfill and construction of the cover; therefore, an additional NEPA evaluation will not be required."

No.	Comment	Comment Response
13	Section 6.0: Is May 29, 2011, the date both caps will be completed? In addition, the time required for the public review process for the closure of Pit 3 must be taken into consideration and noted in the schedule (both in the text and also in Figure 35).	Closure activities for the 92-Acre Area will be completed by May 29, 2011, and the text has been revised to clarify this as follows: "Closure activities for the entire 92-Acre Area will be completed by May 29, 2011, which is 180 days after the final volume of waste will be received." The following text has been added to the bulleted list in Section 6.0: "The public will have 30 days to submit written comments on the plan and request modifications to the plan." Figure 35 has been modified to include the public review process.
14	Section 7.0, Table 5: Will any additional non-scheduled inspections be required following major precipitation events? At other closed CAUs following a major precipitation event (as specified in the closure document) an inspection is required to examine the cap for erosion and the presence of ponding.	The following text has been added to Section 7.1: "In addition, non-scheduled inspections will be conducted if precipitation occurs in excess of 1.0 inch in a 24-hour period at the rain gauge shown in Figure 2, which is located near the southeast corner of the Area 5 RWMS. These inspections will be conducted to verify the continued integrity of the cover and document any ponding or erosion." The following text has been added to Table 5: "Additional inspections for ponding and erosion after precipitation events in excess of 1.0 inch in a 24-hour period."
15	Section 7.0, Table 8, Step 2, Description: What is meant by the phrase "Drill 3-m borehole for neutron probe…" a 3-meter wide hole or a borehole that extends 3 meters below the bottom of the waste cell? Please clarify.	The statement has been revised as follows: "Drill borehole for neutron probe monitoring or install TDR probes adjacent to waste cells to a depth of 3 m beneath the waste zone."
16	Appendix C, Drawing C-1010: The drawing shows an 8-ft security fence surrounding the north cap and a 3-ft three wire fence surrounding the south cap. Since the Area 5 Performance Assessment sensitivity analysis found that the PA is most sensitive to plant uptake and animal burrowing suggest that the south cap fence be enhanced with chicken wire to discourage burrowing animals. At several other closed CAUs that include a cover (CAUs 92 and 417) the fence line is intended to discourage animals from entering the site and burrowing into the cover. If the fence is enhanced add a description to Section 5.0.	The following text has been added to Section 5.1.5: "A fence is not required around the 92-Acre Area. A 3-strand wire fence currently exists around the entire RWMS, and this fence serves to enhance access control to the site as a best management practice. Quarterly post-closure inspections, as described in Section 7.1, will identify any animal burrows that may affect the integrity of the cover. These animal burrows will be backfilled within 60 calendar days of discovery." It was determined that placing chicken wire around the existing 3-strand wire fence is not cost effective or efficient. At other post-closure sites, such as CAU 110, chicken wire does not prevent burrowing animals from entering the site. Quarterly monitoring and repair has been proven to be successful to maintain the integrity of the cover.

No.	Comment	Comment Response
17	Appendix C, Drawing C-3001: Several drawings refer to drawing C-3001 for compaction specifications. The notes on C-3001 specify how compaction tests will be done and the frequency of the tests, but do not specify an actual value for the compaction. Please provide a compaction specification. How will the requirements for note 4, no greater than 20% passing the #200 sieve, be met?	The engineering specifications that identify compaction requirements have been added to Appendix C, and the following text has been added to Section 5.2.1: "Sieve analysis will be performed at a frequency of one test per 1,000 cubic yards of fill, and at least once per day, to ensure backfill has a maximum particle size of 3 inches and a maximum of 20 percent passing the number 200 sieve. Compaction tests will be performed near the bottom of each lift at a frequency of one test per 10,000 square feet, and at least three per lift, to ensure backfill is compacted to at least 90 percent of the maximum dry unit weight according to American Society for Testing of Materials Standard D1557."
18	Appendix C: No drawing shows the approximate number and location of the subsidence monuments or any details of the monument specifications/dimensions. Will they be 2-ft by 2-ft by 4-inch concrete blocks with stamped brass survey pins attached as at other sites?	Drawing 09068-C-5001, which shows the monument fabrication detail, has been added to the engineering drawings in Appendix C, Drawings 09068-C-1017 and 09068-C-1018 have been revised to show the locations of the subsidence monuments, and the following text has been added to Section 5.1.3: "A total of 68 concrete subsidence survey monuments, measuring 2 feet by 2 feet by 6 inches high, will be installed on the covers. Brass caps will be installed on the monuments and stamped with the elevation and geographical coordinates measured at the time of installation."

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