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Facility Safety Plan for Material Disposal Area B

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Acronyms

AC	Administrative Controls
ADEP	Associate Director of Environmental Programs
AEGL	Acute Exposure Guideline level
AGL	Above Ground Level
AIChE	American Institute of Chemical Engineering
ALARA	As Low as Reasonably Achievable
ARF	Airborne Release Fraction
BOS	Balance of Site
CAP	Corrective Action Plan
CAS	Chemical Abstract Service
CFR	Code of Federal Regulations
CHC	Chemical Hazard Categorization
CM	Configuration Management
COO	Conduct of Operations Program
CPM	Counts per Minute
DIF	Definitive Identification Facility
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DP	Delta Prime
DPT	Direct Push Technology
DSA	Documented Safety Analysis
ECP	Excavation Control Plan
EG	Evaluation Guidelines
EM&R	Emergency Management and Response
EPA	U.S. Environmental Protection Agency
ERP	Emergency Response Program
ERPG	Emergency Response Planning Guideline

FHA	Fire Hazard Analysis
FL	Field Laboratory
FOD	Facility Operations Director
FPP	Fire Protection Program
FSP	Facility Safety Plan
GC-MS	Gas Chromatography-Mass Spectrometry
GPR	Ground-Penetrating Radar
HA	Hazard Analysis
HAZWOPER	Hazardous Waste Operations and Emergency Response
HC	Hazard Category
HEPA	High-Efficiency Particulate Air
HMR	Hazardous Material Regulations
HSP	Health and Safety Program
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
ISM	Integrated Safety Management
IWD	Integrated Work Document
IWM	Integrated Work Management
LANL	Los Alamos National Laboratory
LASO	Los Alamos Site Office (DOE)
LANS	Los Alamos National Security, LLC
LEL	Lower Explosive Limit
LLW	Low-level waste
MAR	Material at risk
MDA	Material Disposal Area
MEOI	Maximally Exposed Offsite Individual
MP	Maintenance Program
NDA	Nondestructive Assay
NESHAPs	National Emission Standards for Hazardous Air Pollutants

NFPA	National Fire Protection Association
NMED	New Mexico Environmental Department
NNSA	National Nuclear Security Administration
NPH	Natural Phenomena Hazard
OL	Operating Limit
ORPS	Occurrence Reporting and Processing System
OSHA	Occupational Safety and Health Administration
PAC	Protective Action Criteria
PC	Performance Category
PCBs	Polychlorinated Biphenyls
PE-Ci	Plutonium Equivalent Curies
PPE	Personal Protective Equipment
PPM	Parts per Million
QA	Quality Assurance
RAD	Responsible Associate Director
RCRA	Resource Conservation and Recovery Act
RCT	Radiation Control Technician
RF	Release Fraction
RPP	Radiation Protection Program
RWP	Radiological Work Permit
SBP	Safety Basis Procedure
SIH	Standard Industrial Hazards
SME	Subject Matter Expert
SMO	Sample Management Office
SMP	Safety Management Programs
SOP	Standard Operating Procedure
SSC	Structures, Systems, and Components
SSHASP	Site-Specific Health and Safety Plan

SSO	Site Safety Officer
SVOC	Semivolatile Organic Compounds
TA	Technical Area
TAL	Target Analyte List
TEDE	Total Effective Dose Equivalent
TEEL	Temporary Emergency Exposure Limit
TNT	Trinitrotoluene
TQ	Threshold Quantities
TRU	Transuranic
TSD	Transportation Safety Document
USGS	United States Geological Survey
TWA	Time Weighted Average
VOC	Volatile Organic Compounds
VP	Vapor Pressure
WCSA	Waste Container Staging Area
WIPP	Waste Isolation Pilot Plant
WMP	Waste Management Program
XRF	X-Ray Fluorescence

Executive Summary

Technical Area (TA) 21, Material Disposal Area (MDA) B is a buried waste site, a 1940's landfill known as the *contaminated dump*, with radionuclides and chemicals from process waste disposed of from 1945 to 1948 by the experimental nuclear weapons and science programs.

MDA B was categorized as a Hazard Category 3 (HC-3) nuclear facility as approved under a Documented Safety Analysis (DSA) dated October 2008 (MDAB-ABD-1001, R.0) [Ref. 1]. However, using the segmentation approach specified in DOE-STD-1027-92 and DOE-STD-1120-2005 to downgrade to *Less than HC-3* (radiological), a Final Hazard Categorization (FHC) document for MDA B (MDAB-ABD-1004, R.0) was submitted to the National Nuclear Safety Administration/Los Alamos Site Office (NNSA/LASO) on March 17, 2009 [Ref. 2]. LASO approved the MDA B downgrade to *Less than HC-3* on March 24, 2009 [Ref. 3]. Revision 4 incorporated changes approved by LASO on September 16, 2010 [Ref. 4], allowing a MAR limit at each excavation area of 0.52 PE-Ci.

In August 2010 [Ref. 5] a high-material-at-risk (MAR) anomaly was discovered that exceeded the HC3 Threshold Quantity of 0.52 PE-Ci. Because of this discovery and the potential to uncover similar material, the FHC was revised, based on methodology described in DOE-STD-1027, to incorporate justifications to disposition material in any one independent facility segment of up to and including 5 PE-Ci (dependent on the combustible content of excavated material), as a "less than Hazard Category 3" activity. The revised FHC was submitted to LASO on October 20, 2010 [Ref. 6]. Also, on October 18, 2010, NNSA/LASO submitted to the Deputy Administrator for Defense Programs, NNSA, NA-10, a request for exemption from 10 CFR 830, subpart B, "Safety Basis Requirements" for Los Alamos National Laboratory Material Disposal Area B [Ref. 7]. The exemption request was approved on October 20, 2010 [Ref. 8]. This revision (5.1) of the Facility Safety Plan (FSP) describes the controls required to preserve the assumptions embodied in the revised FHC and actions to be followed if the new MAR limits are exceeded in accordance with the commitments in the exemption request. The FHC has also been revised (Rev 1.1) to acknowledge the exemption and to clarify assumptions applicable to WCSAs outside of the MDAB boundary.

This FSP includes evaluation of the chemical hazard categorization (CHC) of MDA B, based on the historical chemical data provided in the LA-UR-07-2379 report (August 2007) [Ref. 9] and summarized in Appendix B of the FHC report [Ref. 2]. The CHC is performed in accordance with the requirements of SBP 111-1.0, *Facility Hazard Categorization and Documentation* [Ref. 10]. Based on conservative inventory assumptions, only nickel carbonyl, hydrochloric acid, and ammonium hydroxide would exceed the threshold quantities (TQs) for a Chemical High Hazard site at 20 m. However the high volatility and low boiling point of these chemicals would result in only trace quantities remaining after a greater-than-60-yr duration, which has included three major fires. With these chemicals excluded, MDA B can be categorized as a Low Chemical Hazard site. Thus, MDA B is a Low Chemical Hazard and a *Less than HC-3* or *Radiological* facility. The site does not contain any explosives or biological materials. In accordance with SBP 113-1, *Nonnuclear Safety Basis Documentation* [Ref. 11], a FSP is required.

Because of the close proximity of the public, an additional chemical safety review was performed to identify chemicals that could exceed PAC 2 TQs at 30 meters [Appendix E]. Thirty meters was chosen because analytical methodology and regulatory precedent is limited to distances no less than 30 m. The use of conservative screening criteria (PAC 2), conservative meteorological conditions (F stability), and the assumption that chemicals available in powder form will be present in powder form, compensate for the fact that the MEOI is actually closer than 30 m. This additional review was done to ensure that adequate controls for chemical hazards are in place to protect the health and safety of the public.

This FSP evaluates hazards (standard industrial hazards [SIH], chemicals including beryllium, and radiological hazards) associated with the operations of MDA B and appropriate controls to ensure that the workers, the public, and the environment are protected. Mitigated risks are low and minimal for the workers, collocated workers, and public. The FSP is organized into the following four chapters and five appendices:

Chapter 1 – Site Location and Description

Chapter 2 – Site Layout and Activities

Chapter 3 – Hazard Analysis and Categorization

Chapter 4 – Hazard Controls

Appendix A – Hazardous Materials Identification Worksheet

Appendix B – Chemical Inventory List in MDA B

Appendix C – Beryllium Exposure to Workers and Public

Appendix D – Results of What-If/Hazard Analysis

Appendix E – Comparison of MDA B Chemical Inventories to PAC-2 TQs at 30m

The Responsible Line Manager for MDA B is the TA-21 Facility Operations Director (FOD), and the Responsible Associate Director (RAD) is through the Environmental Programs (ADEP) directorate.

1.0 Introduction

Los Alamos National Laboratory (LANL or the Laboratory) prepared this Facility Safety Plan (FSP) for the removal, characterization, and restoration activities at Technical Area (TA)-21, Material Disposal Area (MDA) B, in accordance with SBP112-1, Nuclear Safety Analysis Documentation [Ref. 13], SBP113-1, *Nonnuclear Safety Basis Documents*, [Ref. 11] and SBP 111-1, *Facility Hazard Categorization and Documentation* [Ref. 10]. The removal, characterization, and restoration activities at MDA B are referred to as the MDA B project. Material Disposal Area (MDA) B is a buried waste site, a 1940s landfill known as the *contaminated dump*, with radionuclides and chemicals from process waste disposed from 1945 to 1948 by the experimental nuclear weapons and science programs.

The MDA B Project Team reviewed operational records and determined that Areas 9 and 10 were not used for radiological disposal. The 2009 field sampling effort concluded that the maximum measured concentration for radionuclides and chemicals for these two areas were below residential Site Action Limits and Soil Screening Levels. Based on these findings, open excavations of Areas 9 and 10 may be performed and are excluded from the control set established by Section 4.0 of this document.

The purpose of this FSP is to evaluate the hazards and identify the appropriate controls that will ensure that workers, the public, and the environment are protected from radiological, chemical, and other hazardous materials/substances associated with the MDA B project. The FSP is organized as follows:

Chapter 1: Provides the background and describes site characteristics, locations, and area features. General site characteristics and those that apply specifically to MDA B are described, as well as an operational history of MDA B and its current status.

Chapter 2: Describes the site layout and the operational activities of the MDA B project, and also provides the bases for the hazard analysis for work activities during the MDA B project.

Chapter 3: Describes the hazard analysis, including hazard identification and evaluation, and hazard categorization from chemical and radionuclide perspectives.

Chapter 4: Provides a summary of controls derived from the hazards analysis. It focuses on safety management program (SMPs), including institutional programs, and discusses operational limits (OLs) relative to various operational activities to ensure safe operations to protect the workers, the public, and the environment.

Appendix A: Provides a checklist for standard industrial hazards (SIH), radiological hazards, and chemical hazards. Only hazards that are screened in are evaluated.

Appendix B: Lists the inventory of about 170 chemicals in terms of form, amount, and threshold quantities (TQ) for PAC 3 at 100 m and 20 m. Only a few chemicals are screened in for further evaluation.

Appendix C: Beryllium 1-lb powder is screened out. However, due to the health hazard of chronic beryllium disease and in accordance with the 10 CFR 850 Rule, *Chronic Beryllium Disease Prevention Program* [Ref. 14], Be exposure is evaluated as an unlikely event. The workers and public are well protected.

Appendix D: Describes unmitigated hazard scenarios and mitigated hazard scenarios using controls implemented through an SMP. Mitigated risks are low and minimal for the workers and public.

Appendix E: Lists the inventory of about 170 chemicals in terms of form, amount, and threshold quantities (TQ) for PAC 2 at 30 m.

The MDA B was initially categorized as an HC-3 nuclear facility as approved under a Documented Safety Analysis (DSA) dated October 2008 (MDAB-ABD-1001, R.0) [Ref. 1]. However, using the segmentation approach specified in DOE-STD-1027-92 and DOE-STD-1120-2005 to downgrade to *Less than HC-3* (radiological), a Final Hazard Categorization document for MDA B (MDAB-ABD-1004, R.0) was submitted to the National Nuclear Safety Administration/Los Alamos Site Office (NNSA/LASO) on March 17, 2009 [Ref. 2]. LASO approved the MDA B downgrade to *Less than HC-3* on March 24, 2009 [Ref. 3].

On August 24, 2010, routine sample results indicated that an active waste bin receiving waste from excavation work at TA-21, MDA B Excavation Enclosure #1 in Area 6 contained MAR in excess of the 0.52 PE-Ci operating limit for exposed MAR for all the MDA B enclosures combined. The facility conducted additional sampling, which confirmed that the waste bin contained an estimated 2.86 PE-Ci in the approximately 40,000 lbs or 18 yd^3 of excavated dirt. This inventory exceeds the threshold quantities for Hazard Category 3 (HC-3) nuclear facilities according to DOE STD-1027. This event necessitated revisiting the rationale for reclassifying MDA B as a Less than HC-3 facility. A methodology allowed by DOE-STD-1027-92 and DOE-STD-1120-2005 was applied to adjust the HC 3 Threshold Quantities based on changes in the ARF and RF for unique forms of material. This analysis justified raising the HC 3 Threshold Quantities to 5 PE-Ci, dependent upon combustible content, and it was incorporated into a revision of the Final Hazard Categorization document for MDA B (MDAB-ABD-1004, R.1 [Ref. 6]) submitted to LASO on October 21, 2010 [Ref. 15].

The FSP contains an evaluation of chemical hazards for the purpose of hazard classification. Based on the history of the site and the historical chemical data provided in the LA-UR-07-2379 report [Ref. 9], 5% of the maximum container size for each chemical documented in the historic chemical inventory for the Laboratory, as a conservative estimate, was assumed to be buried at the site. Only nickel carbonyl, hydrochloric acid, and ammonium hydroxide exceed the TQs for a Chemical High Hazard site at 20 m, the distance to the public road. However, the high volatility and low boiling point of these chemicals would result in only trace quantities remaining after a greater than 60-yr duration, which includes three major fires. Therefore, MDA B can be categorized as a Low Hazard site. Other hazards include potential reactive chemicals that may lead to an explosion affecting non-involved workers (SB-DO: CALC-08-011) [Ref. 16]. According to SBP 111-1, *Facility Hazard Characterization and Documentation* [Ref. 10], this event may lead to a Moderate Hazard categorization. However, with operating limits in place to protect non-involved workers, a site can be categorized as Low Hazard.

Thus, MDA B is a *Low Chemical Hazard* and a *Less than HC-3* or a *Radiological* site. The site does not contain any explosives or biological materials, as defined in SBP 111-1 [Ref. 10].

The Responsible Line Manager for MDA B is the Environmental and Waste Management Facility Operations Director (FOD), and the Responsible Associate Director (RAD) is through the Environmental Programs directorate (ADEP).

Changes to the site or to the operations will be evaluated against the description in the FSP as required by the MDA-B Configuration Management Program.

1.1 Background

The NNSA administers and Los Alamos National Security (LANS) operates the Laboratory and its 32 currently active Technical Areas. Figure 1-1 shows the location of TA-21 and MDA B with respect to other Laboratory technical areas and surrounding land. For more than 60 years, the Laboratory has been the location for experimental nuclear weapons and science programs. MDA B is a legacy site associated with disposal of materials related to these programs from 1944 to 1948.

1.2 Approach

The MDA B project involves excavating, assessing, sorting, stabilizing, characterizing, packaging, staging, and shipping waste that consists of radiologically and chemically contaminated materials. Most of these activities represent radiological and chemical hazards to the workers and will be described in a hazardous waste operations (HAZWOPER) health and safety plan. The FSP is not expected to address the full scope of SIHs and controls typically covered by HAZWOPER. The focus of the hazard analysis is the identification of structures, systems, or components and the administrative controls that prevent or mitigate a release of radionuclides or hazardous chemicals. In addition, safety management programs are identified that implement safety provisions.

This FSP uses a *What-if* checklist as a rigorous, qualitative method for evaluating potential hazards and impacts to identify appropriate type, level, and number of physical and administrative barriers to prevent or mitigate potential accident consequences to the workers, the public, and the environment. The hazard controls and safety management programs for the MDA B project are implemented through the FSP controls identified and described in this document. This methodology provides a rigorous implementation and enforcement process.

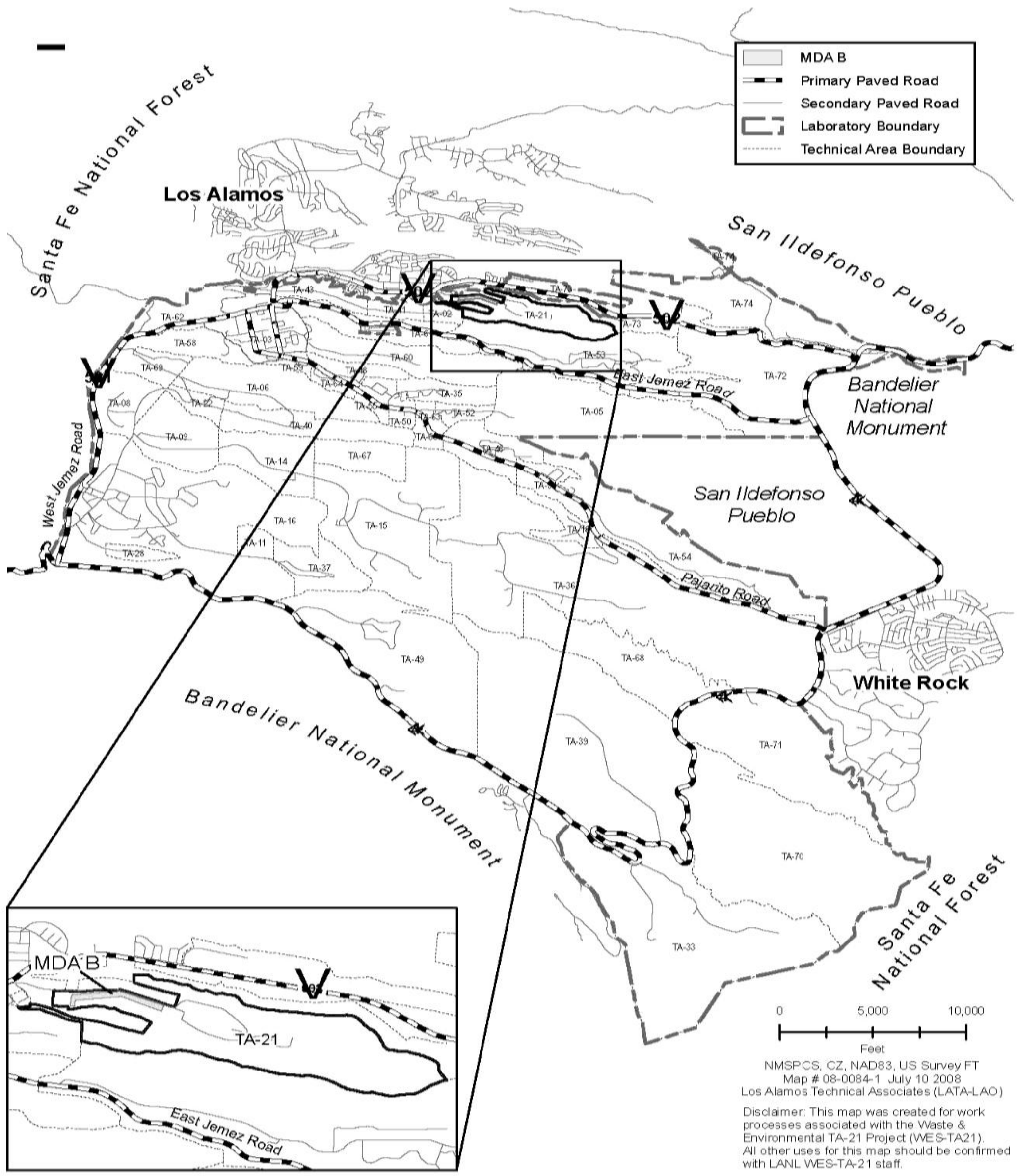

Figure 1-1. Location of TA-21 and MDA B

1.3 Site Location and Description

1.3.1 Geography

The Laboratory, and the residential and industrial areas associated with the townsite of Los Alamos (inclusive of the White Rock community), are located in Los Alamos County in north-central New Mexico, approximately 96.6 km (60 mi) north-northeast of Albuquerque and 40 km (25 mi) northwest of Santa Fe (Figure 1-2). The area surrounding the Laboratory, including portions of Los Alamos, Sandoval, Rio Arriba, and Santa Fe Counties, is largely undeveloped. Santa Fe National Forest, the Bureau of Land Management, Bandelier National Monument, the General Services Administration, and Los Alamos County own or manage large tracts of land north, west, and south of the Laboratory. Thirteen Native American pueblos are located within an 80-km (50-mi) radius of the Laboratory. San Ildefonso Pueblo borders the Laboratory to the east.

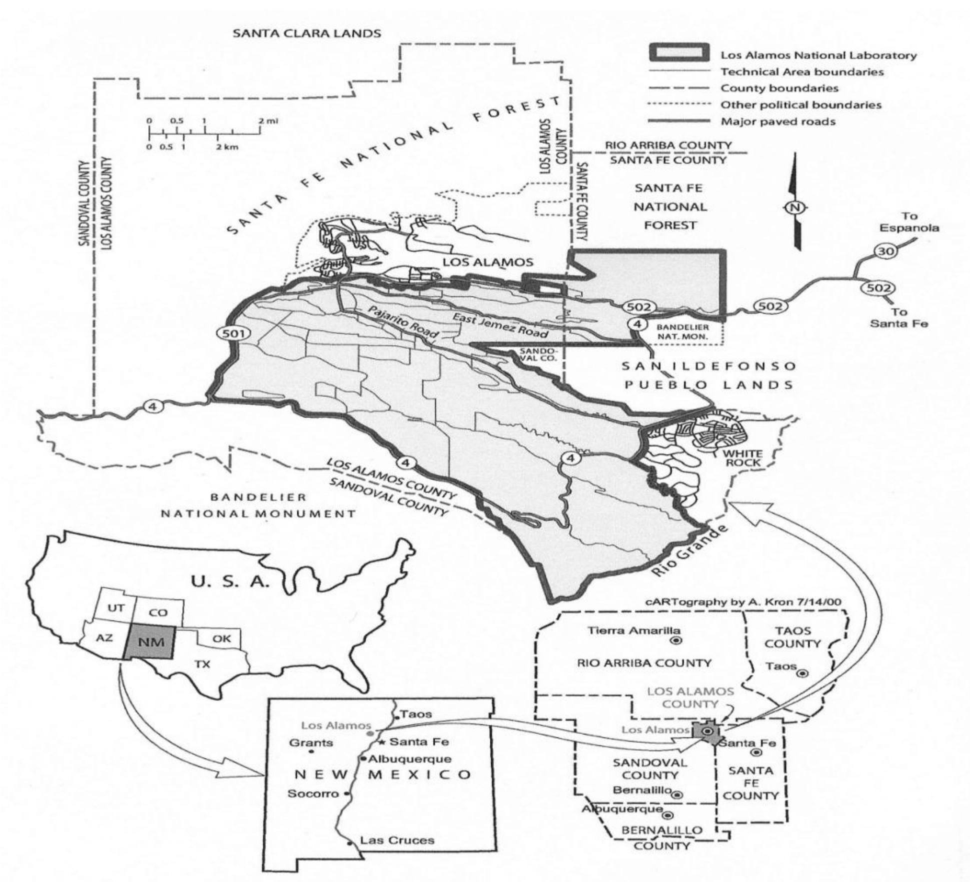

Figure 1-2. Location of the Laboratory

The 111-km^2 (43-mi^2) Laboratory site and the adjacent communities are situated on the Pajarito Plateau, a shelf approximately 16 to 24 km (10 to 15 mi) wide and 72 km (45 mi) long. The Pajarito Plateau consists of a series of east-trending, finger-like mesas separated by deep canyons cut by streams. The mesa tops range in elevation from approximately 2,400 m (7,800 ft) on the flanks of the Jemez Mountains to about 1,900 m (6,200 ft) at their eastern termination above the Rio Grande Valley. The Laboratory is located at altitudes ranging from 1,800 to 2,500 m (6,000 to 8,000 ft) on the eastern slopes of the Jemez Mountains.

1.3.2 Location of MDA B

MDA B is located within TA-21 between Delta Prime (DP) Canyon and Los Alamos Canyon, south of DP Road and west of the main TA-21 complex. MDA B is located at the western edge of TA-21, approximately 488 m (1,600 ft) east of the intersection of DP Road and Trinity Drive. The northern, fenced boundary of MDA B is approximately 1.5 m (5 ft) from DP Road. MDA B covers approximately 24,400 m^2 (6.03 acre). The closest distance from the buried waste to the public road is approximately 20 m (66 ft).

1.3.2.1 Public Exclusion Areas and Access Control Areas

MDA B is inside TA-21, a DOE-controlled area, although public access to DP Road is not currently controlled.

1.3.2.2 Receptor Locations

Laboratory property includes the area north of the MDA B site boundary to the public road and the parking lot that is immediately south of DP Road. The parking lot will be cordoned off as needed to ensure the greatest separation distance from the excavation area to the public. Thus, the closest distance from the buried waste to the public receptor along DR Road is approximately 20 m (66 ft). A public receptor may also be present on the mesa south of MDA B at minimum distances of 63 m (206 ft); however, the public receptor present north of MDA B represents the maximally exposed offsite individual (MEOI).

1.3.2.3 Energy Sources and Facilities near MDA B

A natural gas line (46 m/150 ft east), a 100,000-gal, decommissioned water tower, and overhead electric power lines are located in the vicinity of MDA B. Vehicular traffic and buried county utilities are also nearby. Commercial businesses are located north of DP Road, directly opposite the center and western sections of MDA B. Energy sources associated with MDA B activities are discussed in other sections of this chapter.

1.3.2.4 Proximity to Roads and Utilities

MDA B lies along DP Road. The natural-gas line runs along the western boundary of the facility. A sewer line runs northwest and north of DP Road. A Los Alamos County sanitary sewer lift station is located outside the fence near the southeastern corner of the site. Buried water and communications lines are located under the area between the north fence and DP Road. A water hydrant is located inside the northwestern corner of the fence, and an air-monitoring station is located outside the east fence. Overhead electric power lines run along the far eastern end of MDA B and will not interact with MDA B project activities except to supply power to MDA B structures.

1.3.2.5 Vegetation

The Laboratory site and surrounding areas are generally forested and have high fuel loadings. MDA B borders forested areas containing indigenous evergreen trees and wild vegetation. To the south, Los Alamos Canyon separates MDA B from large forested areas with high fuel loadings.

A thinly forested canyon to the north separates State Highway 502 from MDA B. The Los Alamos townsite separates MDA B from the Jemez Mountains to the west. Native vegetation covers, and is immediately adjacent to, MDA B.

1.4 MDA B Site History

MDA B is an inactive subsurface disposal site, located in TA-21 at the Laboratory (Figure 1-1). From 1944 until it closed in 1948, MDA B received contaminated materials from the earliest Laboratory operations and may contain both hazardous chemical and radioactive waste. Known in the 1940s as the "contaminated dump," MDA B was the first common disposal area for radioactive waste generated at the Laboratory. The waste disposal units at MDA B consist of shallow pits and trenches. The overall length of the MDA B waste disposal areas is approximately 594 m (1,950 ft), and the overall width ranges between 22 m (75 ft) and 91 m (300 ft). Trench widths vary from 5.5m (18ft) to 11.9m (39ft). Interstitial soil and fill material are likely present in some areas between and within waste disposal units. The cover at MDA B consists of soil and gravel. Asphalt coverage of an estimated 0.1 to 0.15 m (4 to 6 in) previously existed over approximately 70% of the site. The soil overburden averages about 3 ft in the previously asphalted area. The Laboratory installed a variety of cover systems during a pilot study in the early 1980s over the unpaved portion of MDA B. Historically, the total cover thickness on the unpaved portion of MDA B was approximately 2 m (6.5 ft). Subsequent grading activities have resulted in an average overburden of about 3 feet. Figure 1-3 shows the location of MDA B relative to DP Road and area businesses.

1.4.1 Operational History

The report entitled *MDA B Process Waste Review 1945–1948* (LANL 2007) [Ref. 9] reviewed the available documents and information relevant to site operations at MDA B, including historic records and reports, some previously classified historic memoranda and other correspondence; and aerial photographs taken in the 1940s. The objectives of the report were to address the following questions in lieu of disposal records:

- What information is available concerning the physical boundaries, characteristics, and timing of waste burials at MDA B?
- What programs and organizations were active at Los Alamos in the mid to late 1940s that may or may not have contributed wastes to MDA B?
- What specific process information is available that describes the types and quantities of wastes produced?
- What program, organization, or process information is available to exclude wastes from MDA B?

The existing reports, records, archived memoranda, additional correspondence, and other documents reviewed substantiated the assumption that no formal disposal records for MDA B are known to exist. The available evidence, including reports and memoranda archived from the operating groups, logbooks, aerial photographs, and personal interviews, provided perspective on the processes employed by the Laboratory's various operating groups, the scale of the processes used, and the handling of spent chemicals and solutions, glassware, and contaminated items and debris. Collectively, this body of evidence, which focused on land burial of waste, provided the context for knowledge of waste generation and management during the MDA B operational period from 1944 to 1948.

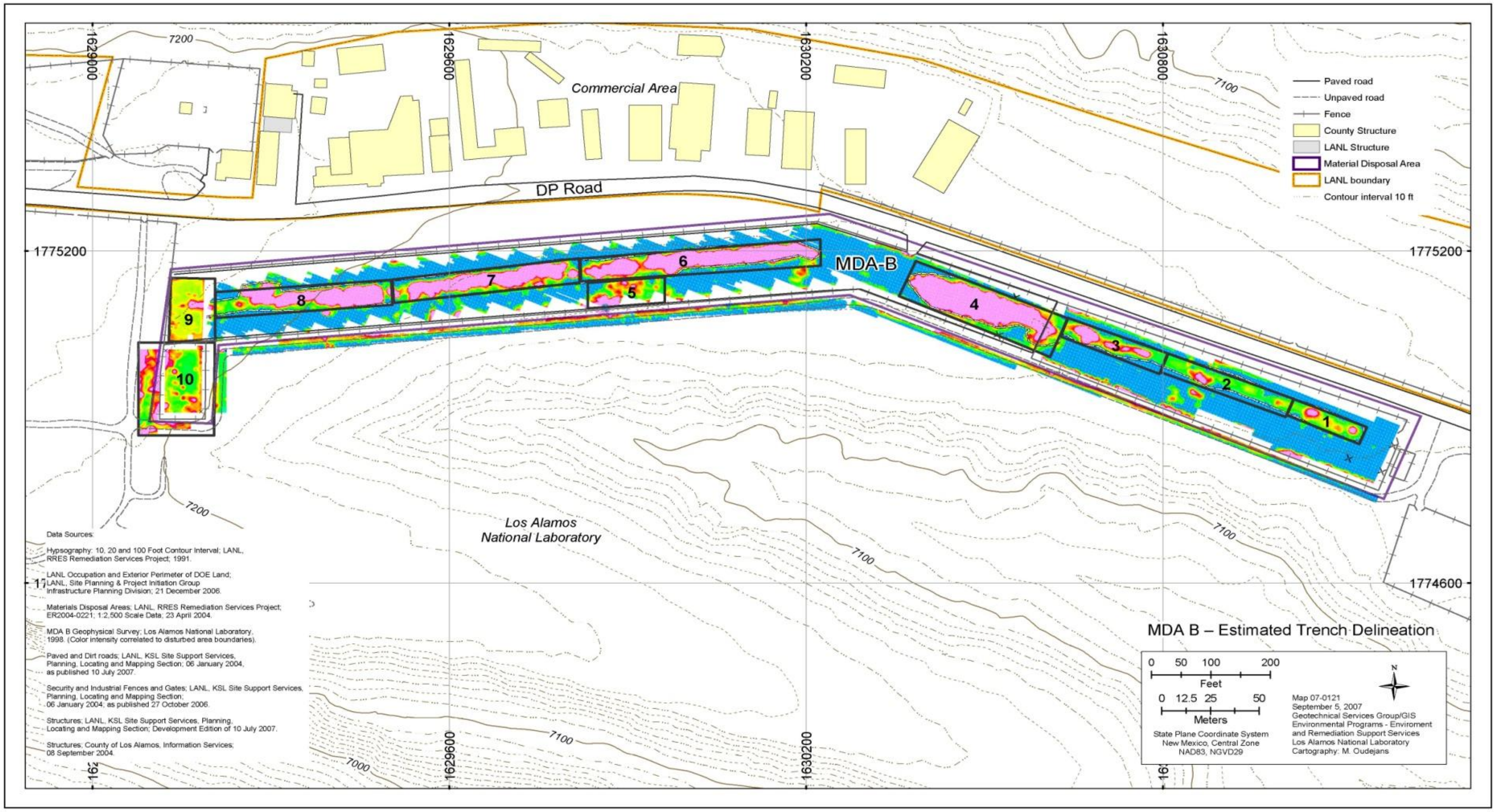

Figure 1-3. MDA B Location Showing Managerial Segmentation of the Waste Disposal Units

Waste generator sites that used MDA B would have been the original technical area (TA-01), DP Site (TA-21), the contaminated laundry (TA-01, then TA-21), the Bayo Canyon Radio Lanthanum (RaLa) project (TA-10), and the Omega Site (TA-02), which included the water boiler reactor and other experiments. This assessment was confirmed by monthly reports and correspondence of the operating groups and logbooks kept by the drivers of a truck that picked up contaminated trash and debris from these sites and delivered them to MDA B. Explosives wastes were not disposed of at MDA B because Anchor Ranch, S Site, and other explosives production and test areas used what is now known as MDA R (located in today’s TA-16) for these types of wastes. The limited information suggested that, during the 1946 time frame, some radioactive waste may have been shipped offsite for ocean dumping, but that information could not be verified because records were poor or nonexistent. During the war, TA-01 contained plutonium and enriched-uranium research, purification, recovery, and metal fabrication operations. After the war, DP West assumed responsibility for the pilot plant–scale plutonium purification, reduction, metal fabrication, and recovery operations. Polonium operations moved to DP East. The uranium activities remained in TA-01, but D Building was converted to plutonium research and analytical support.

The Laboratory’s historical record and retiree interviews documented the scarcity of plutonium and enriched uranium and provided the context that it was imperative to recover these materials from process chemicals, crucible molds, lathe turnings, or other process residuals. Reports compiled by the operating groups of the period described the application of significant resources and research efforts to the recovery of these precious radionuclides, as well as measures to store residual solutions until methods to recover them could be developed. Uranium and plutonium-purification solutions and materials were required to be returned to the recovery processes, and similar recovery methods were applied to any medium offering precious radionuclide residue. Solutions that contained more than 1 mg/L of plutonium or enriched uranium were stored for later recovery. It was calculated that 344 g of plutonium and americium were stored in the General’s Tanks for later recovery. Liquids, including process waste solutions, decontamination, and other mop and wash water, were analyzed for radionuclides and, if below the release tolerance of 0.1 mg/L, were released to the environment down industrial sewer drains through outfalls and absorption beds. Liquid wastes may have also been dumped down sanitary drains. Treatment plants were not built until after 1948.

By 1947, all laboratories had established waste disposal procedures that required laboratory and salvage wastes to be boxed and sealed. Large items and equipment were wrapped with paper or placed in wooden crates and tagged to indicate waste status. One eyewitness account indicates that some wastes may have been placed in large metal boxes and sealed before burial. In general, wastes in boxes were reportedly emplaced simply by piling truckloads into the waste disposal unit. Using a bulldozer, Zia Company workers subsequently covered the material with fill dirt on a weekly basis. No effort was made to separate waste types or to compact the wastes beyond the soil cover compaction efforts.

The decontamination efforts employed during the 1940s indicated that the Laboratory tried to conserve and reuse equipment and other supplies. If items could not be decontaminated and could not avoid disposal, personnel had to obtain a release from the property office. No property records of this type have been located to date, however. Items that did not pass decontamination requirements after normal use were reportedly sent to MDA B; these included empty gas cylinders that typically would have been used to store oxygen, neon, helium, argon, and nickel carbonyl; glassware from the polonium operations and the plutonium analytical and research laboratories; and miscellaneous mechanical equipment. The presence of gas cylinders at MDA B is important for present-day excavation safety as the cylinders might still be partially pressurized and may contain residues of toxic chemicals. There is no evidence that fully pressurized gas cylinders or hydrogen fluoride tanks were disposed of at MDA B.

The MDA B waste disposal units consist of pits and trenches that are approximately located on the geophysical map (Figure 1-3). These pits and trenches were constructed by progressive eastward expansion; the earliest waste disposal units are on the far western end of MDA B. The far eastern end of MDA B is thought to consist of small waste disposal units that contain glass bottles with unknown chemicals, as well as radioactive waste. Aerial photographs taken in 1946 and 1947 document which waste disposal units were active in those years. During 1946, 1947, and 1948, three fires took place in the active portions of MDA B; these fires indicated that uncontained chemicals, such as battery acids or other oxidizers, were placed in MDA B’s open pits and mixed with combustible materials, such as clothing, wood, and other organic debris, which created conditions conducive to spontaneous combustion. The locations of the fires could be approximated from photographs of the period.

1.4.2 Post-Closure Activities

After the closure of MDA B in June 1948, a fence was constructed around the entire area. The U.S. Geological Survey was asked to assess the filled-in portion of MDA B for commercial use by Los Alamos County. The USGS drilled 12 test borings around MDA B in 1966 from 25- to 50-ft depths and analyzed the samples for moisture, gross alpha and beta radiation, plutonium, and uranium. The distribution of moisture indicated that some lateral movement of water, probably from the contaminated waste pit, had occurred, but radiochemical analyses of the samples showed no indication of radioactive contamination. It was recommended that an asphalt cover be installed on the pit with drainage to minimize the movement of surface water onto MDA B. The western two-thirds of MDA B were fenced, compacted, and paved in 1966 and leased by DOE to Los Alamos County for trailer and vehicle storage. Other monitoring efforts were conducted in the period during which the County used the area for storage, and none of the readings recorded above background [Ref. 9]. The DOE requested that the County vacate the site by September 30, 1990, and, since that time, access has been controlled by the Laboratory.

Some post-closure subsidence has been observed at MDA B and is consistent with what is observed at legacy landfill sites with containerized waste. During a small mammal field investigation in 1980, a member of one of the Laboratory’s environmental studies groups reportedly fell through the surface and into a hollow area of MDA B in the eastern portion of the landfill. The employee stated that he was working alone in the unpaved, eastern area of MDA B and fell into what appeared to be subsidence that was approximately 5 to 6 ft deep. He observed at least two stacks of large laboratory glass bottles on pallets, with an open area between the pallets of approximately 2 ft by 5 ft. The subsidence was located approximately in the south-central portion of the eastern area of MDA B. He climbed out of the subsidence and called his supervisor. He was monitored by a radiation technician, and no indication of radiation above background was measured. The hole was then backfilled with soil and re-graded [Ref. 9].

In 1982, the Laboratory sampled biota at the site to examine the rooting patterns of long-lived plants into radioactive wastes, the uptake of transuranic materials by plants, and the transport of radionuclides from waste disposal units [Ref. 17]. This biota sampling project is the only intrusive sampling or excavation known to have taken place at MDA B and included the local excavation of tree roots because of the presence of exposed debris with measurable radioactivity (about 2,000 alpha counts per minute [cpm] per 60 cm^2). Beneath the roots, some copper and electrical wires were uncovered but had no measureable radioactivity. At a depth of about 40 cm, a mass of rubber gloves was excavated, which showed surface radioactivity varying from 0 to 6,000 alpha cpm. Other gloves in the area had no measurable alpha radioactivity. At a depth of 45 cm, a large lateral root had come into contact with a rubber glove that contained a 6-cm ball of radioactive waste with 10,000 alpha cpm. The excavation was discontinued because of the high radiation levels. Rubber tubing, plaster, painted metal tubing, and brown Duroglass bottles still filled with liquid were also found. Roots and soils were collected, and the hole was backfilled [Ref. 17].

Surface stabilization and experimental capping studies were conducted on the eastern end of MDA B on July 6, 1982, and were completed by October 15, 1982. The fence was moved outward by 10 ft, surfaces were decontaminated, vegetation was removed, and the area was covered with soil, compacted, and reseeded.

1.4.3 Current Condition

MDA B is generally divided into the following three main areas:

- A small soil-covered area at the extreme western end of MDA B (approximately 32 m/105 ft by 46 m/150 ft).
- A larger unpaved area occupying the eastern leg of MDA B (approximately 183 m/600 ft long by 46m/150 ft wide).
- An area occupying the long western leg and the central portion of the site (approximately 457 m/1,500 ft long by 37m/120 ft wide) that was covered in 1966 by asphalt, which has now been removed.

A galvanized-steel chain link fence encloses the entire site.

The Laboratory has conducted numerous surface and subsurface environmental investigations at and near MDA B beginning in 1966. Early activities focused on collecting data to support site stabilization efforts at the disposal area. More recent investigations have focused on defining the nature and extent of contamination migration outside of the waste disposal units following the cessation of waste disposal and the subsequent installation of both asphalt and soil covers over the disposal area. The Laboratory conducted the most recent investigation in 2009. Review of data from the field investigations of MDA B indicates that the data were of sufficient quality and quantity to support the following statements:

- Some radionuclides and metals are present at concentrations greater than background values in surface soils along the perimeter of the site in areas not originally covered by asphalt or the 1982 cover.

- Volatile organic compounds (VOCs) were detected in the subsurface soil pore gas in the seven angled boreholes drilled beneath the disposal area in 1998.
- Tritium, plutonium-239, uranium, and lead are present at concentrations above background values in three of the seven boreholes drilled beneath the disposal area in 1998.

Note: Tritium concentrations are known to exist across DP mesa and are interpreted to be the result of atmospheric releases from DP East.

- Other inorganic compounds were detected above background values.
- The average moisture content in soils beneath the asphalt (10.6 wt%) was elevated compared with the surrounding surface soils (5.1 wt%) and subsurface materials (5.6wt%).
- Investigators detected elevated radionuclides, organic chemicals, and inorganic chemicals in some surface soil samples.

Surface releases appear to be related to past disposal operations that distributed primarily isotopic plutonium to the surface soils along the perimeter of MDA B. The cessation of disposal operations and the placement of an interim cover of soil and asphalt (asphalt recently removed to facilitate final remediation activities) have prevented additional releases. A subsurface release to tuff of low concentrations of contaminants was limited in extent. The primary subsurface contaminants are tritium (as noted above) and VOCs in the vapor phase. Additionally, some minor concentrations of isotopic plutonium were detected. The vertical extent of these detections was very limited and indicated that releases were minor. The sources of subsurface contamination appeared to be limited to past disposal practices at the waste disposal units, diffusion of vapor-phase tritium from a DP East atmospheric release, and VOCs in low concentration from the disposed waste.

1.4.4 Summary of Inventory Characterization

The MDA B waste disposal units were interpreted in LANL 2007 [Ref. 9] to be located approximately as shown on the geophysical map (Figure 1.3). These waste disposal units were constructed by progressive eastward expansion of a series of semi-contiguous waste disposal units during the 1944 to 1948 period. The earliest waste disposal units are located on the far western end of MDA B. The far eastern end of MDA B is thought to consist of small pits and trenches that contain glass bottles with chemicals, as well as radioactive waste. The estimated waste disposal unit depths and historical aerial photos were used to estimate the waste volume in each of 10 areas shown on Figure 1-3. Table 1-1 tabulates the results of the waste estimates by area.

Most of the waste disposed of at MDA B was contaminated with residual radioactivity, including routine laboratory waste, contaminated glassware, obsolete equipment and wooden laboratory furniture, demolition debris, building materials, clothing, glassware, paper, trash, and small amounts of chemicals from the laboratory areas. The largest waste contributors may have been the contaminated laundry and building demolition debris as laboratory structures and equipment were upgraded after the war. Nonroutine waste included materials from spills and accidental releases of plutonium (30 to 70 mg) and radium to clothing, soils, and building materials that were determined to be unrecoverable. Actinium research at DP East would have generated wastes contaminated with actinium-227, while wastes from the RaLa implosion experiments at Bayo Canyon would have been contaminated with strontium-90.

Items that did not pass decontamination requirements after normal use included empty gas cylinders that typically would have been used to store oxygen, neon, helium, argon, and nickel carbonyl; glassware from the polonium operations and the plutonium analytical and research laboratories; and miscellaneous mechanical equipment. It was assumed that small volumes of waste chemicals were disposed at MDA B. Residual chemicals buried at MDA B may have included cleaning solutions, such as trichloroethylene, and other chemicals, such as acids, bases, and experimental solvents generated at the bench scale. Process waste solutions are not considered part of the contribution to the MDA B waste stream, as these were analyzed for radionuclides and, if below the release tolerance of 0.1 mg/L, were released, untreated, down industrial sewer drains through outfalls and absorption beds to the environment. At least one truck contaminated with fission products from the Trinity test may be buried in the western portion [Ref. 9].

Table 1-1. Estimated Waste Volume by Area at MDA B

Area	Description	Estimated Dates of Use	Estimated Waste Disposal Unit Depth (ft)	Estimated Maximum Capacity* (yd^3)	Estimated Waste Volume** Range (yd^3)
1	Chemical slit trenches	1947–1948	5	1,177	704–1,111
2	Chemical slit trenches	1947–1948	5	1,177	778–1,111
3	Chemical slit trenches/debris pits	1947–1948	5	785	556–741
4	Debris pits subject to 1948 fire	1947–1948	12	6,776	5,926–6,296
5	Debris pits and adjacent disturbed area	1946	12	6,534	4,444–5,926
6	Debris pits	1946–1947	12	1,936	1,370–1,630
7	Debris pits	1946	12	3,872	2,333–3,111
8	Debris pits	1945	12	4,356	2,630–3,481
9	Suspect chemical waste discharge	1944–1945	5	2,880	926–1,111
10	Suspect chemical waste discharge	1944–1945	5	6,534	2,111–2,519

* Maximum capacity is estimated from the boundaries of geophysical disturbance and projected depth of waste disposal units in section and includes waste and overburden.

** Nominal 24,405 yd^3 of waste is estimated as sum of averages.

A calculation of the plutonium inventory in MDA B presented in LANL (2007) [Ref. 9] used the limited analytical data, measurements, and observations recorded in *Cesium-137, Plutonium-*

239/240, Total Uranium, and Scandium in Trees and Shrubs Growing in Transuranic Waste at Area B [Ref. 17] to estimate the Pu-239/240 inventory in waste disposal units at MDA B. Primary inventory components include the interstitial soils and fill added during waste disposal operations, gloves and other protective equipment, discarded laboratory glassware and debris, and intact liquid containers. Additionally, based on an eyewitness account, glass bottles are buried in at least one pit on the eastern end of MDA B. Although the process waste review was unable to definitively identify the source of these bottles, a possibility remained that they may contain residual plutonium or other exotic elements.

Based on the known Laboratory operations, the concentrations of plutonium were estimated to be approximately 1 mg/L of plutonium, a concentration considered in the late 1940s to be potentially recoverable, but too concentrated to release into the environment. Application of the soil concentration and surface contamination data ranges from Wenzel et al., 1987 [Ref. 17] and the range of possible liquids in intact containers at MDA B to the calculation method indicated that the total possible MDA B plutonium inventory ranged from 24 to 246 g of plutonium [Ref. 9]. The results in SB-DO: CALC-07-054 [Ref. 18] indicate that the 50th percentile value is similar to the previous estimate of 6.2 PE-Ci. Figure 1-4 depicts the graphical results of the statistical analysis of the potential plutonium inventory in MDA B.

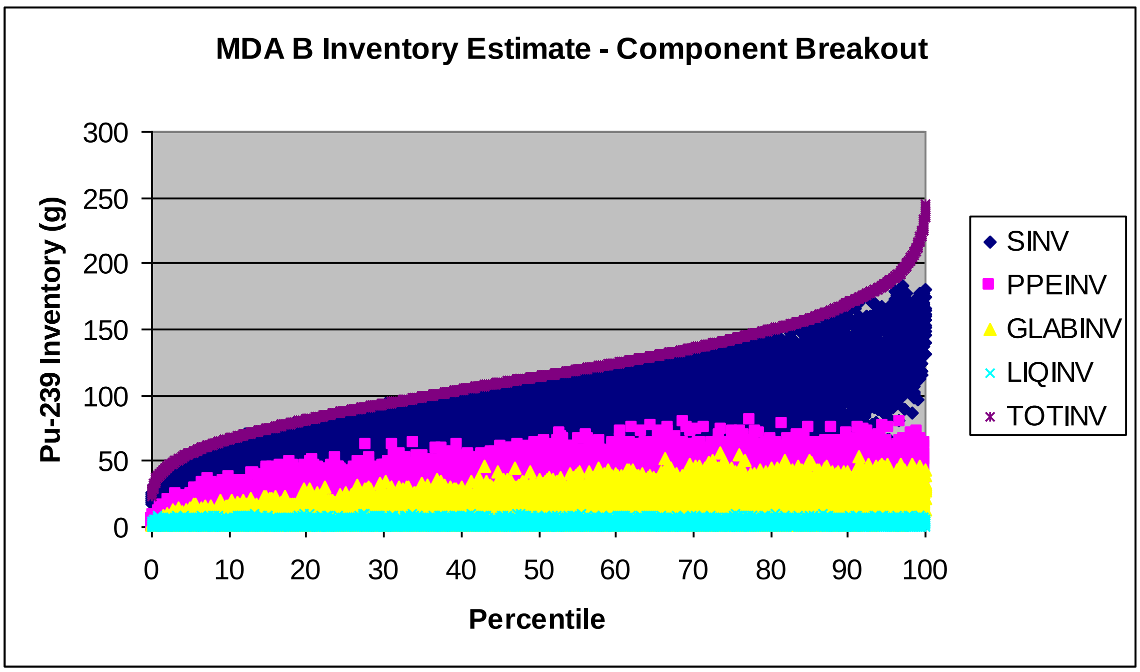

Figure 1-4. Results of Statistical Analysis of MDA B Plutonium Inventory by Component

The Pu-239 inventory at the 97th percentile indicated the following distributions:

- 97th percentile of total inventory (TOTINV) 200 g (12.40 Ci)
- Interstitial soil and fill (SINV) 169 g (10.51 Ci)
- Gloves and personal protective equipment (PPEINV) 13 g (0.81 Ci)
- Glassware and lab debris (GLABINV) 10 g (0.62 Ci)
- Intact liquid containers (LIQINV) 8 g (0.50 Ci)

Assuming uniform distribution and the smallest estimated total waste disposal unit volume, the resulting concentration is 7.5E-4 PE-Ci/m^3. This dimensional analysis indicated that contaminated soils represent most of the plutonium inventory at MDA B and suggested that the inventory is homogenously distributed throughout the entire volume of MDA B. Based on the waste process history during 1945 to 1948, individual items may possess locally higher or lower levels of contamination, but they would not represent a significant change in the majority fraction of the plutonium inventory in MDA B.

As of October 1, 2010, 34% of the waste had been excavated (7339 yd^3), removing a total of 0.44 PE-Ci of radiological material (excluding the anomalous item found in August 2010). The low contamination levels of the excavated soil indicated that the average concentration may actually be less than 7.5E-4 PE-Ci/m^3. Note that the volume of contaminated combustibles has been low. According to a review of the Waste Management Logbooks, as of October 15, 2010, combustibles have constituted between 0.1% to 0.2% of the total volume of excavated material. Recent Geoprobe® data also supports the conclusion that 7.5E-4 PE-Ci/m^3 ,as an average, is conservative and that the total inventory is approximately 9 PE-Ci. The recent discovery of unexpected, highly contaminated material (containing an estimated 2.86 PE-Ci) indicates that localized higher concentrations of radiological material may be discovered. However, the total excavated radioactive material, including the recently discovered high-MAR material and the other excavated waste, contains 3.3 PE-Ci, which is less than the 4.2 PE-Ci that would be expected in 34% of the inventory at a 7.5E-4 PE-Ci/m^3 average concentration.

These data also indicated that the majority of the waste at MDA B could be characterized as low-level radioactive waste. Hazardous materials would augment this characterization, as would the presence of asbestos-containing material and polychlorinated biphenyls (PCBs) [Ref. 9].

2.0 Site Layout and Activities

This chapter provides a summary description of MDA B project areas and activities, which are shown graphically in Figure 1-3. The MDA B project activities are being conducted in accordance with the Investigation/Remediation Work Plan approved by the New Mexico Environment Department (NMED), and are expected to be completed within 3 yr after this FSP has been approved and implemented. The MDA B project activities included within the scope of this FSP are:

- Excavation and retrieval of buried waste from MDA B;
- Sorting, assessment, characterization, stabilization, packaging, staging, and shipping of retrieved chemical and radioactive waste items; and
- Characterization of the residual soil and bedrock to determine the nature and extent of any residual contamination.

2.1 Site Layout

Work areas include the excavation areas, the Definitive Identification Facility (DIF), the Waste Container Staging Areas (WCSAs), the Field Laboratory (FL), the decontamination area, the South Haul Road, administrative support structures/facilities, the clean soil and material staging areas, and the truck scales. The South Haul Road and other work areas are cleared of vegetation and serve as fire breaks, as shown in Figure 2-1.

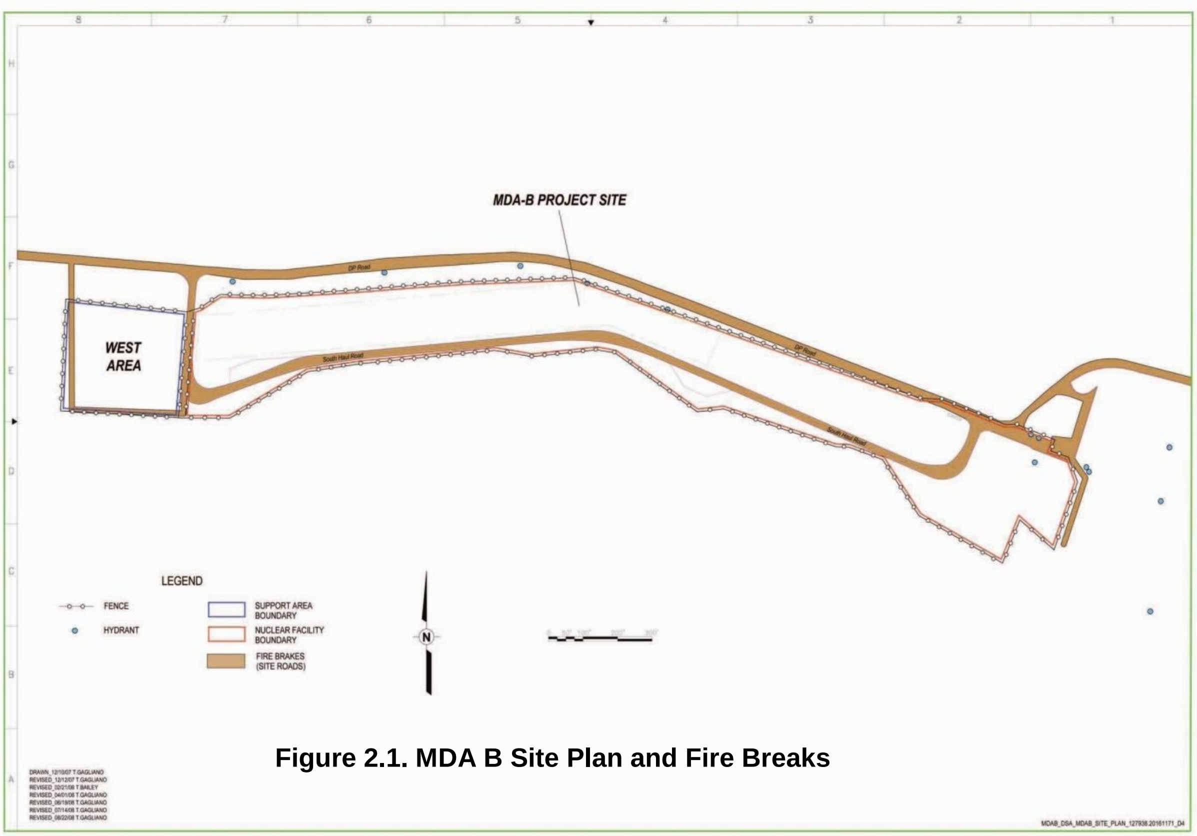

Figure 2.1. MDA B Site Plan and Fire Breaks

2.1.1 Material Disposal Areas

A material disposal area is an area within MDA B where excavation activities are occurring. Excavation areas are established over the waste disposal units until each is excavated and the landfill material removed and processed. Equipment, supplies, waste containers, and additional fill material may be stored on the material disposal area.

2.1.2 Excavation Areas

An excavation area is the area within the excavation enclosure. There will be no more than six enclosures mobilized at any given time. The excavation enclosure(s) include temporary, relocatable structures of standard commercial design and construction. These may vary in size—typically 65 ft wide by 65 ft long by 35 ft high—and consist of

- A metal frame covered with ametal skin;
- Personnel and equipment doors (personnel egress doors will be established at distances no greater than 75 ft, per National Fire Protection Association [NFPA] 101); and
- High-efficiency particulate air (HEPA)-filtered ventilation.

Other excavation enclosures are permanently installed metal structures that average 140 ft by 76 ft and are also equipped with HEPA-filtered ventilation.

Activities within the excavation area include excavating landfill materials at the dig face; waste sorting, assessing, and packaging; operating excavator, waste handling equipment, dust suppression equipment and fire suppression equipment; and staging of waste containers and packaging supplies, monitoring equipment and supplies, and personnel protection equipment.

2.1.3 Definitive Identification Facility

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The DIF is located within the western portion of the facility. The DIF is a fire-resistant structure that provides a safe, controlled environment to investigate, stabilize, and characterize waste materials and containers that have been removed from the excavation areas. The floors are textured, nonslip metal surfaces. The DIF is equipped with a ventilation system, including one or more chemical hoods and flexible ventilation ducts. The installation and operation of the DIF fulfills Laboratory and Occupational Safety and Health Administration (OSHA) requirements for the investigation, characterization, and stabilization of waste materials and containers removed from the excavation areas.

2.1.4 Field Laboratory

The Field Laboratory (FL) is a mobile facility that is divided into work areas for sample characterization and sample analysis. The samples brought into the FL have relatively small volumes and have been collected as representative samples of waste materials. The waste is generally expected to be low-level waste (LLW) mixed with various chemical constituents.

2.1.5 Decontamination Area

The decontamination area is a temporary area and is established on an as-needed basis. It provides an area to decontaminate equipment such as trucks, trailers, and excavation and waste management equipment. It is equipped with run-on and run-off controls and a temporary tank for holding decontamination water.

2.1.6 Waste Container Staging Areas

The Waste Container Staging Areas (WCSAs) provide locations to stage waste containers before offsite shipment. Other activities occurring in the WCSAs include inspection, document processing, and coordination with transportation and receiving organizations. The WCSAs may contain packaged and sorted landfill material containing industrial, hazardous, LLW, mixed LLW, transuranic (TRU), or mixed TRU waste. Wastes that have been processed/stabilized and packaged in the DIF can also be stored in the WCSAs. There are active WCSAs within MDA B. Other WCSAs are located elsewhere in TA-21. The WCSAs are positioned to optimize work flow, so the locations are subject to change. Figure 2-2 shows typical WCSA placement.

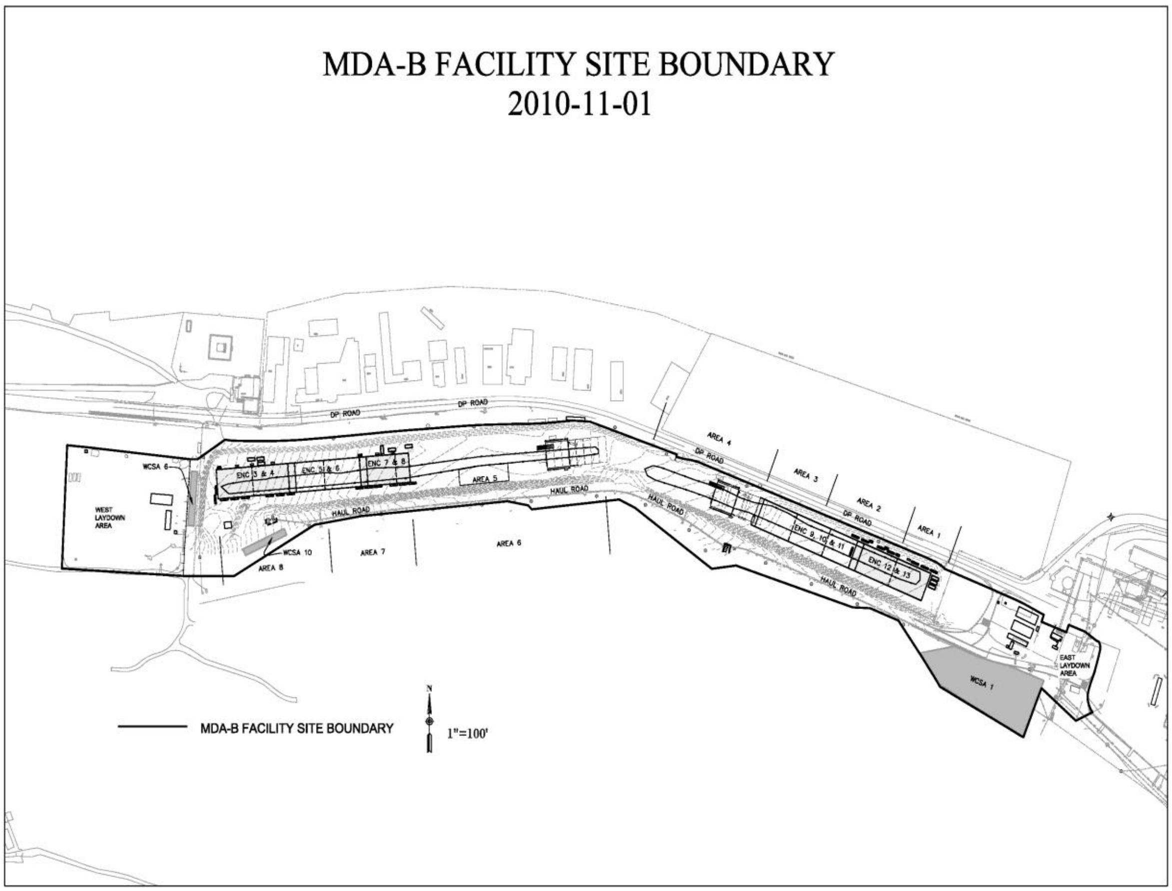

Figure 2-2 MDA B Site showing Typical WCSA Locations

2.1.7 Balance of Site

The balance of site (BOS) is the area inside MDA B where excavation areas, DIF, or WCSAs have not been established. The BOS includes the FL discussed in Section 2.1.3. Equipment, supplies, waste containers, and additional fill material may be stored in this area.

2.1.8 Site Infrastructure Support Structures, Decontamination Area, and South Haul Road

MDA B work areas require minimal infrastructure. Because natural gas or propane is not used for heating, there is not an associated piping system at MDA B. Domestic water is supplied to the Break and Shower/Locker trailers. The effluent wastewater is collected in temporary tanks that are routinely emptied. Electrical power is drawn from the existing TA-21 power grid. Electrical transformers are installed and relocated as necessary to supply power to the support trailers, DIF, and excavation areas. Fire hydrants are located along DP Road; further information is provided in the Fire Hazard Analysis [Ref. 19]. Water for any extended fire suppression efforts is supplied by the Los Alamos Fire Department through hoses from these fire hydrants.

Support structures include showers and sanitary facilities, break rooms, and change rooms. The trailers are mobile to enable them to be used near the excavation areas. When placed, the trailers are secured to the ground and are supplied with electrical power for lighting, heating, and cooling.

The South Haul Road provides an engineered roadway that connects the excavation areas, DIF, and WCSAs. The road is on the south side of the facility and is bounded on the south side by the facility boundary fence. The South Haul Road will be sufficiently illuminated during nighttime operations.

2.2 MDA B Site Activities

The MDA B project consists of excavating and sorting, classifying, stabilizing, and packaging landfill material, supported by administration and waste management and transportation activities.

2.2.1 Description of Activities

The overall set of activities needed to execute the MDA B project is listed below:

- Site characterization activities:
    - Nonintrusive site characterization.
    - Direct push sampling.
    - Excavation Plan development.
- Excavation activities
    - Construction/relocation of enclosure.
    - Excavation of landfill material.
    - Sorting of landfill material.

    - Excavation area monitoring.
    - Assessment of unknown items.
    - Stabilization of unknown items.
- Packaging:
    - Assessed items.
    - Sorted landfill material.
    - Residual material.
- Waste container transfer:
    - Assessed items to DIF.
    - Sorted landfill material.
    - Residual material.
- Material characterization:
    - Field Lab.
    - DIF.
- Waste container staging.
- Waste container shipping.
- Equipment decontamination.
- Site maintenance.
- Demobilization.
- Site closure and stabilization.

2.2.2 Site Characterization Activities

Site characterization activities include the nonintrusive activities, such as surveys, and intrusive activities involving direct push sampling. In some cases, the data obtained from the site characterization activities will provide input to excavation plan development.

2.2.2.1 Nonintrusive Site Characterization

Nonintrusive site characterization activities, such as surveys, provide additional site data for MDA B. For example, radiological surveys can identify surface and near-surface radiation fields, Ground-Penetrating Radar (GPR) surveys can assess subsurface features (such as waste disposal areas), and geodetic surveys can be used to delineate topography.

2.2.2.2 Direct Push Sampling

Direct push sampling is used to provide subsurface site characterization data for the waste disposal and surrounding areas of MDA B. Direct push technology (DPT) is a portable sampling device that collects a small-volume sample using a push tube technique rather than a rotating bit, thereby minimizing the mixing of landfill materials during sampling.

The DPT sampling locations were selected using statistical methods and assigned to a statistically significant number of nodes not greater than a 10-ft by 10-ft grid system placed over MDA B. The DPT cores were collected and analyzed in accordance with an NMED-approved work plan. The core sleeves are opened, and samples are collected and packaged. Sample analysis may include alpha- and gamma-emitting target analyte list (TAL) metals, semivolatile organic compounds (SVOCs), and volatile organic compounds (VOCs).

2.2.3 Excavation Plan Development

The sample results from Geoprobe activities are used to develop the excavation plans. Each excavation plan limits the volume of material to be excavated in order to maintain the MAR for the excavation area. This is done by dividing the MAR limit by the best available radiological inventory concentration. The Geoprobe results will be used to define the allowable volume to be authorized via the excavation plan. This is based on the smallest estimated total waste disposal unit volume of 16,515 m^3 (21,600 yd^3), which yields the highest concentration. The excavated volumes may be increased or decreased as necessary to maintain compliance with the MAR limit.

If the sampling indicates the presence of a highly hazardous (e.g., toxic or reactive) substance and/or shock-sensitive substance, then the excavation plan may require additional volume restrictions and/or other monitoring restrictions, e.g. additional video, chemical, and/or thermal monitoring. The excavation plan also considers chemical constituents from sample analysis. Although considered unlikely, the Geoprobe and subsequent surveys performed on the excavated material may identify TRU waste levels of contamination. TRU waste will be accounted for in the excavation plan. Excavation of landfill material will occur according to a grid system no larger than 10 ft by 10 ft. The excavation plan will also include the specific grids to be excavated in the identified batch and the sequence of excavation, so that the dig face geometry will be controlled.

2.2.4 Excavation Area Activities

The activities in the excavation area include construction/relocation of the excavation enclosures, excavation, characterization, and sorting of landfill materials. Sorting of landfill materials includes assessing, sorting, and stabilizing unknown items that may be present in the bulk materials.

2.2.4.1 Construction/Relocation of Excavation Enclosures

There can be up to six active excavation enclosures. The excavation enclosures are constructed or moved to the excavation area before commencement of excavation activities. Overburden may be removed from the site to facilitate construction of the enclosures and work areas. Electrical power is supplied to the excavation enclosures, and the required video, air, and other monitoring equipment is also installed. Other equipment includes hand tools and trucks and transport vehicles, including hydraulic lifts, graders, front-end loaders, bobcats, and excavation equipment such as a backhoe. Before relocation of the excavation enclosures, all landfill materials, unknown items, and artifacts are containerized or transferred to waste staging or the DIF. Moving the excavation enclosures may require limited disassembly, such as disconnecting the electrical power lines and disconnecting the ventilation system. Multiple cranes or other equipment may be used to move the excavation enclosures.

2.2.4.2 Excavation of Landfill Material

Excavation activities involve removing landfill materials from the waste disposal units and removing contaminated residual material from the side walls and underlying tuff. Excavation activities may be performed manually, remotely, or a combination of these as appropriate. Excavation operations are estimated to include the removal of a nominally estimated volume of 18,350 m^3 (24,000 yd^3) of material, including landfill and residual materials. Residual materials are soil, sediment, rock, vegetative, or asphalt material that is suspected of being contaminated because of migration of radioactivity or chemicals from landfill material and does not contain landfill material or MAR. Material removed from MDA B will be characterized and prepared for disposal in accordance with the NMED-approved Investigation/ Remediation Work Plan.

Excavation is performed in a batch process to maintain the MAR limits according to the excavation plan, which is developed from the Geoprobe sampling data. The dimensions of the excavation area vary according to each approved excavation plan, and the excavation is conducted according to a grid system. Each plan identifies the volume of material impacted by the excavation, the sequence of excavation, the types of waste anticipated, and the specific controls that are required if special conditions were identified in the pre-excavation sampling. A series of plans is required for the entire volume of MDA B.

A sloped dig face is used, and the waste is removed in shallow-depth swaths that allow the dig face to assume the angle of repose. Large objects may be encountered, such as intact drums, waste containers, or other debris (such as vehicle parts), and each removed individually. The excavated landfill material is laid out in the sorting area in a thin layer, nominally 12 in., so individual items can be removed from the bulk material before it is packaged. Individual sorting piles are separated from each other and the excavation enclosure wall in accordance with the Fire Hazards Analysis (FHA) [Ref. 19]. Dust control measures are used during all excavation activities to limit airborne dust and contaminants. A mobile fire suppression system is deployed at each excavation area.

The dig face and sorting area are monitored by video and other instruments, including VOC monitors and a radiological monitor mounted on the excavator boom. Readouts from monitoring instruments are assessed real-time from a co-located control room as the digging progresses. A sloped dig face is used, and the waste is removed in shallow depth swaths that allow the dig face to assume the angle of repose. Large objects may be encountered such as intact drums, waste containers, or other debris—such as vehicle parts—and each removed individually. The excavated landfill material is laid out in the sorting area in a thin layer, nominally 12 in., so that individual items can be removed from the bulk material before it is packaged. Individual sorting piles are separated from each other and the excavation enclosure membrane in accordance with the FHA. Because there will be multiple enclosures, separation distances are maintained between enclosures and between the excavation enclosure and the dig face to ensure that potential fires do not affect the enclosure membrane in accordance with the FHA. Dust control measures are used during all excavation activities to limit airborne dust and contaminants. A mobile fire suppression system is deployed at each excavation area.

2.2.4.3 Sorting of Landfill Material

Because of the disposal practices and subsequent aging of MDA B waste, soils, debris, and artifacts are removed from the waste disposal units as mixed media. It is anticipated that some metal and glass containers may have retained structural integrity. Sorting of landfill material consists of removing evident waste materials, segregating intact waste containers and other large debris, and grouping materials into suspected waste types. Containers that appear intact or may contain suspect hazardous or radioactive materials are termed unknown items. Materials are sorted at the bottom of the excavation trench by anticipated waste type (i.e., LLW, TRU) or by matrix (i.e., soil, combustibles, or containerized chemicals) to facilitate waste management. The size of the sorting area is associated with the operational needs, and the area includes a staging area for unknown items. In accordance with the Fire Protection Program, separation distances are maintained to ensure that potential small fires do not propagate into larger ones. Unknown items may pose an immediate danger to workers because of content or configuration. Examples include gas cylinders, drums, cans, bottles, or other containers that appear to be intact and may contain radioactive, reactive, or hazardous liquids, solids, fine powders, or particulates. Unknown items that are identified as potentially explosive or display signs of overpressurization are dispositioned for safe handling within the excavation area; this may include venting containers in the excavation area.

2.2.4.4 Excavation Area Monitoring

Monitoring is conducted in the excavation area for radiation levels in support of the limits of material at risk and to identify hazards associated with release of hazardous substances from the excavated landfill materials. The percentage by volume of combustibles is estimated as the material is excavated by a trained waste technician who ensures the TQ curve presented in Figure 4-1 is not exceeded. Monitoring of radioactive materials is conducted to confirm that the concentrations of radioactive constituents in excavated materials remain within the range identified in the excavation plan. Techniques may include

- Scanning of the dig face and landfill materials with the FIDLER or similar equipment to identify discrete plutonium (americium) sources and areas of elevated activity;
- Characterizing with portable isotope identification systems;
- Sampling of interstitial fill and debris for processing and analysis in the field laboratory to estimate the concentration of plutonium and other radionuclides present; and
- Conducting surface radiological contamination surveys.

Monitoring of the excavation area for release of hazardous substances and incipient events includes VOC monitoring to ensure levels are below lower explosive limits, and dust concentration. It also includes the use of an infrared thermometer to measure the heat of the excavated materials; as well as visual and video monitoring during the excavation and waste sorting processes. Incipient events would occur principally during excavation when the excavator bucket is thrust into the landfill material and the operator cannot see what is buried. Once the materials are laid out for inspection and sorting, incipient events may continue to propagate, but assessment and management procedures reduce the likelihood and consequences of a significant event. Table 1-2 presents monitoring techniques.

Table 2-1 Event Description and Monitoring Technique

Incipient Events	Monitoring Technique
Fire	Visual, infrared, and/or video monitoring
Deflagration of chemical container	Visual and chemical sensors
Gaseous release of (semi) volatile organic compounds and or (highly) toxic substance	Chemical sensors for VOCs, toxic chemicals, and lower explosive limits
Liquid release of VOC or toxic substance	Visual via video monitoring and chemical sensors for VOCs and lower explosive limits
Exothermic chemical reactions	Infrared monitoring and chemical sensors for reaction products

2.2.4.5 Assessment of Unknown Items

The assessment process is used to identify the integrity of and hazards associated with unknown items at the excavation area, including gas cylinders, drums, cans, bottles, or other containers that appear to be intact and may contain radioactive or hazardous gases, liquids, solids, or fine powders. Assessment is an initial part of characterization and the visual or physical inspection and evaluation of an unknown item to determine immediate hazards, to tentatively identify contents, and to establish guidelines for segregating, stabilizing, or transferring the assessed item to the DIF or other waste treatment, storage, or disposal facilities. For example, exhumed gas cylinders and intact chemical containers are evaluated to determine if they are safe to move to the DIF for full evaluation. Evaluation of gas cylinders includes inspection of labels, tags, embossed markings, and construction and condition of valves and piping, etc. Chemical containers are evaluated for structural integrity and to determine if they contain reactive or shock-sensitive materials. Unlabeled containers are considered to be hazardous until the contents are characterized. Containers with suspect integrity are managed as small-quantity spills and may require absorbents or other containment measures. Absorbed materials may be packaged as part of the excavated materials or packaged in accordance with the Hazardous Material Protection Program. Assessment may determine that unknown items are simply artifacts and are to be managed accordingly. Examples include simple debris, breached gas cylinders, damaged drums, cans, or other containers.

2.2.4.6 Stabilization of Unknown and Assessed Items

The assessment of unknown items and artifacts may result in the determination that stabilization is required before transport to the DIF or packaging in a final waste shipping container. Stabilization includes physical or chemical methods to mitigate hazards associated with gas cylinders, drums, cans, bottles, or other containers that may contain radioactive, hazardous, or reactive chemicals. The purpose of stabilization is to render a container or an artifact in a safe condition. Stabilization and management of materials will follow all applicable state and federal regulations.

Unknown items suspected to be an imminent danger have the highest priority and are managed first. If a potentially explosive unknown item is identified, MDA B activities are paused to assess the potential explosion hazard or condition and to ensure that controls are sufficient and in place to prevent or mitigate a possible explosion hazard. A disposition pathway to mitigate the explosion hazard is determined so that the potentially explosive item may be managed at the excavation area.

If an unknown item is determined to be immediately dangerous to life and health, the requirements of 29 CFR 1910.120 [Ref. 20] shall be followed and LANL's Emergency Management and Response organization is contacted. Preparation for transfer of assessed items to the DIF is performed in accordance with the Hazardous Material Protection Program and the Characterization Plan. Items that pose explosive or deflagration hazards will be stabilized prior to transfer to the DIF.

2.2.5 Characterization Facilities / Locations

The material characterization activities support waste determination decisions regarding bulk and containerized wastes, confirm compliance with waste acceptance criteria, confirm compliance with Hazardous Material Regulations (HMR) shipping requirements, and supply supplemental data to identify site-specific hazards. The characterization activities are conducted at the FL, the DIF, and the excavation areas.

2.2.5.1 Field Laboratory

Characterization of representative samples of sorted landfill material and residual material is managed or conducted at the FL. Analytical techniques may include a variety of field monitoring and assay techniques, analyses at the FL, and analyses at offsite laboratories. Analytical techniques and equipment that may be used include gas chromatography-mass spectrometry (GC-MS), inductively coupled plasma mass spectrometry (ICP-MS), stationary alpha and gamma spectroscopy systems, liquid scintillation counting, and solid crystalline or gas-filled gross alpha and gross beta counting systems. Basic sample preparation techniques, including grinding, sieving, and drying, may be used.

2.2.5.2 Definitive Identification Facility and Excavation Area

A variety of field and laboratory techniques are used to determine the contents or hazards associated with waste materials to ensure compliance with waste acceptance criteria. Assessment of unknown items in the excavation area determines that items are safe to move and do not pose an explosive hazard. Items that cannot be moved may require stabilization in the excavation area. Items that are determined safe to move are packaged for transport from the excavation area. Characterization techniques for unknown and assessed items may include the following:

- Direct measurement of gamma exposure and dose rates using ion chambers or sodium iodide exposure rate detectors;

- Direct measurement of gamma-emitting radionuclides in sealed containers using in-situ gamma spectroscopy;
- Application of x-ray fluorescence (XRF) detection and other nondestructive assay (NDA) systems;
- Evaluation of labels, serial numbers, types, and conditions of valves and stoppers and other manufacturer markings on containers that may cross-reference with potential contents;
- Evaluation of crystalline deposits potentially indicative of reactive or shock-sensitive chemicals, including chemical test strips or other qualitative tests;
- Thermal monitoring detection equipment to identify potential heat-generating reactions;
- Organic vapor-monitoring equipment at various ionization potentials to identify potential VOCs;
- Laser-operated particulate monitors to assess total particulate emissions from containers or objects;
- Drager tubes to identify various acids, organics, and other compounds;
- Hazards categorization kit testing and reagent processes to identify various chemical compounds; and
- Explosives identification reagent test kits.

Once assessed items and artifacts segregated from landfill materials are identified at the DIF or through other field methods, they are considered a part of the inventory of sorted landfill material and are packaged and managed accordingly.

2.2.6 Packaging

Packaging of waste may occur in any of the MDA B areas. Packaged material may include sorted landfill material, residual material, and assessed items. Sorted landfill material, including LLW, MLLW (potential waste), and TRU waste, is packaged inside the excavation area. Temporary packaging of assessed items is allowed for transfer from the excavation area. The reusable containers may be lined to minimize contamination on the surfaces of the container. The containers are of various sizes and types and may include standard waste boxes, drums, supersacks, and intermodal containers. Combustible waste forms are packaged in noncombustible containers. The TRU and LLW wastes (also MLLW) will be packaged in accordance with the waste acceptance criteria of the receiving facility. The TRU waste is placed in vented, metal containers that meet the TA-54 and Waste Isolation Pilot Plant (WIPP) waste acceptance criteria.

2.2.7 Waste Container Staging Areas

The WCSAs are located both within MDA B and elsewhere within TA-21. They receive waste containers from the excavation area, the DIF, and the FL. Waste characterization may or may not be complete for all containers. These areas provide capacity for waste staging to accommodate document processing and coordination with transportation and receiving organizations and facilities.

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2.2.8 Waste Container Shipping

A shipment takes place when a container leaves TA-21 for over-the-road transport to a receiving waste treatment, storage, or disposal facility. Once the waste containers are loaded on a transport vehicle and exit the facility, the requirements of P151-1, *LANL Packaging and Transportation Program Procedure*, apply [Ref. 21]. If the waste cannot be packaged to meet requirements, the LANL Packaging and Transportation group will be consulted to determine the path forward for the waste.

2.2.9 Excavation and Sampling of Residual Material

In accordance with the NMED Consent Order, the Laboratory is required to perform activities to characterize the extent of any residual subsurface contamination once landfill materials are removed. Subsurface residual contamination is soil, sediment, or rock that is suspected of being contaminated because of migration of radioactivity or chemicals from landfill material and that does not contain landfill material or MAR. Excavation of residual material may occur in the enclosure or outside of the enclosure. Once residual material is excavated, environmental sampling may occur utilizing both shallow and deep subsurface samples, and may involve hand or power tools and drilling rigs for boreholes. These activities are necessary to evaluate the nature and extent of environmental contamination.

2.2.10 Equipment Decontamination

Equipment involved in excavation, drilling, and other material-removal/handling activities is decontaminated in accordance with specified requirements. Methods may include dry decontamination, including the use of wire brushes and scrapers, to remove residual material adhering to equipment. A high-pressure sprayer, along with long-handled brushes and rods, may be used to remove contaminated material from equipment more effectively. It is anticipated that decontamination of heavy equipment will occur during demobilization, but it may also be required for equipment change-out, repair, or maintenance.

2.2.11 Site Maintenance

Maintenance includes preventative and corrective repair and upkeep of the structures, systems, and components (SSCs), equipment, and the site that are needed to support the remediation, characterization, and restoration of MDA B. The SSCs and equipment that require maintenance include enclosures; electrical, and fire suppression systems; ventilation equipment; vehicles; monitoring equipment, and light and heavy excavation equipment. Site maintenance includes the repair and upkeep of roads and grounds; parking and storage areas; walkways, including replacement of damaged or poorly visible signage; repair of fencing and posts; and removal of snow, mud, and other debris to keep access, traffic, staging areas, fire hydrants, road barriers, and rights-of-way clear and unobstructed.

Site maintenance activities also include maintenance of vegetation, erosion control measures, and the cover. Vegetation control includes mowing, clearing brush, removing debris, and removing trees. It is ongoing throughout the project and is adjusted for seasonal growth of vegetation to minimize the potential for wildfire. Erosion controls may include maintaining drainages, repairing ground surfaces, and replacing soils associated with erosion control devices; installing or placing silt fences and riprap; and installing culverts and drainages. Maintenance of the cover over the waste disposal units includes maintaining the surface and overburden layers at the material disposal area, such as adding fill material.

2.2.12 Demobilization

Demobilization will be planned to follow excavation and site closure activities. Demobilization includes

- Confirmation that site perimeter fencing has been appropriately repaired and that all gates are secure and functional;
- Decontamination of light and heavy equipment;
- Containment of decontamination fluids and water;
- Packaging of all waste material and shipping of all packaged waste material;
- Processing of decontamination and water for unrestricted discharge or hazardous/radioactive disposal;
- Removal of temporary facilities and utility connections that are unlikely to be used in future; and
- Removal of support and heavy equipment not anticipated to be reused within three months.

2.2.13 Site Closure and Stabilization

Following excavation, the site will be returned to grade, and topsoil/native seed mix will be placed to stabilize the site. Additional barriers, roads, and paths will be provided as deemed necessary. Best management practices and controls (e.g., drainage) will be installed as necessary to prevent and retard erosion and contain sediment. Site restoration will include raking and re-contouring disturbed areas, mulching, and reseeding with approved mixtures of seed to stabilize disturbed areas.

3.0 Hazard Analysis and Categorization

This chapter describes the hazard analyses for the MDA B project. It analyzes the hazards that exist and the potential releases from accidents that are postulated to occur during MDA B activities. These activities are as follows:

- Pre-excavation activities, including site characterization and construction, and installation of the relocatable excavation area enclosures;
- Excavation activities, including excavating and sorting landfill material; excavation area monitoring; assessing unknown items; and stabilizing unknown or assessed items;
- Packaging of assessed items, sorted landfill material, and residual material;
- Waste container transfer of assessed items, sorted landfill material, and residual material to the relocatable DIF or the Waste Containers Staging Areas;
- Storage of containers in WCSAs;
- Characterization in the FL and the DIF; and
- Waste container loading, staging, and preparation for offsite shipment.

General facility hazards and hazards in nearby LANL facilities are considered in Sections 3.1 and 3.2. These sections present the results of a hazards analysis to evaluate how the identified hazards could lead to potential releases of the hazardous materials (e.g., from operational accidents). The hazards analysis uses the results of the hazard identification process to consider the quantity of chemical and radiological inventory, form, location, and interaction with available energy sources for the final hazard categorization as presented in Sections 3.2 and 3.3.

The analysis recognizes that some of the MAR may be stored in WCSAs outside of the MDA B site boundary. However, the WCSAs outside of the site boundary will be limited to an inventory of 0.52 PE-Ci and subject to the same distance limitations as the other WCSAs.

3.1 Methodology

Hazard analysis provides a comprehensive assessment of facility hazards and accident scenarios that could produce undesirable consequences for workers and the public. Hazard analysis is divided into three main parts:

- Hazard identification (ID) of the potential hazards associated with activities at MDA B.
- Hazard categorization.
- Unmitigated and mitigated hazard evaluation. The Hazard ID and unmitigated hazard evaluation present a comprehensive evaluation of potential process-related that can affect the workers, public, and environment.

3.1.1 Hazard Identification

Hazard ID involves identifying the facility and process hazards and energy sources. Hazard ID is a comprehensive, systematic process by which known facility hazards (hazardous materials and energy) are identified, recorded, and screened. Hazard ID is divided into two steps: division of the MDA B project into activities per the description in Chapter 2, and screening for SIHs.

The information from the hazard identification is the basis for the hazard evaluation. Only those hazards that could result in a radiological or chemical release during MDA B activities are considered in the hazard evaluation. Eliminated from consideration in the hazard evaluation are those hazards considered to be SIHs and identified during the hazard identification process. SIHs are hazards that are routinely encountered in general industry and construction, and for which national consensus codes or standards exist (e.g., Occupational Safety and Health Administration [OSHA], transportation safety) to guide safe design and operation, thus eliminating the need for special analysis to devise safe design or operational parameters. After review of the potential hazards at MDA B, the potential for an energetic release from a chemical bottle is retained as a physical hazard.

3.1.2 Hazard Evaluation

Unmitigated Hazard Evaluation

The purpose of the unmitigated hazard evaluation is to identify and evaluate hazards and to qualitatively estimate accident consequences and likelihood. The hazard evaluation ensures a comprehensive assessment of facility hazards and focuses attention on those events that pose the greatest risk to the workers and public. Risk ranking (the product of accident consequences and likelihood) of hazardous events is considered for both the public and MDA B facility workers. Following the evaluation of the hazard scenario consequence, likelihood, and risk ranking, the identification of potential mitigative and preventive controls is also performed.

Onsite co-located workers are considered as being impacted by, and protected from, a hazardous event scenario in the same manner as the public and facility workers. A combination of the guidance in LANL SBP 114.2, *Hazard Evaluation and Accident Analysis* [Ref. 22], and the AIChE *Guidelines for Hazard Evaluation* [Ref. 23] was used for developing the qualitative hazard evaluation. Frequency, consequence, and risk for the workers and public are consistent with the guidance provided in DOE-STD-5506-2007 [Ref. 24] and are shown in Tables 3-1 to 3-3, respectively

Frequency (Likelihood of Hazard Scenario)

The assignment of unmitigated and mitigated frequency estimates is an important step in identifying controls important to safety in the hazards analysis. Table 3-1 identifies the frequency bins that are used.

Table 3-1. Qualitative Frequency Bins

Frequency	Descriptor	Description
I (10^{-1}/yr to10^{-2}/yr)	**ANTICIPATED (A)**	**Likely to occur often to several times during the life of the facility.** (Incidents that may occur during the lifetime of the facility; these are incidents with a mean expected likelihood of once in 50 years)
II (10^{-2}/yr to 10^{-4}/yr)	**UNLIKELY (U)**	**Should not occur during the life of the facility.** (Incidents that are not anticipated to occur during the lifetime of the facility but could; these are incidents having a likelihood of between once in 100 years to 10,000 operating years)
III (10^{-4}/yr to 10^{-6}/yr)	**EXTREMELY UNLIKELY (EU)**	**Unlikely but possible to occur during the life of the facility.** (Incidents that will probably not occur during the lifetime of the facility; these are incidents having a likelihood of between once in 10,000 years and once in a million years)
IV (Below 10^{-6}/yr)	**BEYOND EXTREMELY UNLIKELY (BEU)**	**Should not occur during the life of the facility.** (All other incidents having a likelihood of less than once in 1,000,000 operating years)

The unmitigated frequency estimates do not take credit for active safety controls that could lower the frequency. These estimates are based on an interpretation of *unmitigated* to mean that no special safety controls are implemented above and beyond standard industrial practices, and do not credit many of the Laboratory's institutional procedures. The controlled or mitigated frequency is based on how the controls lower the frequency of the hazard scenario.

Consequences

As with the frequency categories, quantitative consequence severity categories are assigned to each of the postulated accident scenarios. These consequence severity categories are qualitatively assessed and consider radiological factors such as inventory, material form, and energy of release; toxic factors include toxicity, inventory, and volatility. Table 3-2 identifies the consequence categories for the public that are used to assess the various consequence categories for the postulated accident scenarios.

Chemical volatility and chemicals with very high vapor pressure and low boiling point have mostly degraded or evaporated during three major fires and more than 60-yr duration. Also, factors such as limited chemical shelf-life (which further increases its degradation over time due to oxidation), microbial actions, and evaporation are considered. These considerations easily reduce the inventory by about an order of magnitude.

Table 3-2. Public and Worker Consequence Binning Table

Consequence Level (Abbreviation)	Public (P)	Collocated Worker (CW) (at 100 m)	Worker (W) (Involved worker within facility boundary)
High (H)	Considerable offsite impact on people or the environs. CHALLENGE 25 rem EG *	Significant onsite impact on people or the environs. > 100 rem TED	For SS designation, consequence levels such as prompt death, serious injury, or significant radiological and chemical exposure, must be considered.
Moderate (M)	Only minor offsite impact on people or the environs. ≥ 1 rem TED	Considerable onsite impact on people or the environs. ≥ 10 rem TED	No distinguishable threshold
Low (L)	Negligible offsite impact on people or the environs. < 1 rem TED	Minor onsite impact on people or the environs. < 10 rem TED	No distinguishable threshold

*Per DOE-STD-3009, the EG for the public is 25 rem. As stated in Section 6.3 of DOE-STD-5506, a public dose greater than 10 rem should be considered sufficient to *challenge* the EG.

Risk

After developing frequency and consequence estimates, the risk rank of each scenario is determined using the matrices given in Table 3-3, and then listed in the Hazard Analysis (HA) tables. The risk rank is listed for the public and workers, for both the uncontrolled and controlled cases.

Table 3-3. Qualitative Risk Ranking Bins

Consequence Level	Beyond Extremely Unlikely (BEU) Below 10^{-6}/yr	Extremely Unlikely (EU) 10^{-4} to 10^{-6}/yr	Unlikely (U) 10^{-2} to 10^{-4}/yr	Anticipated (A) 10^{-1} to 10^{-2}/yr
High Consequence	III	II	I	I
Moderate Consequence	IV	III	II	II
Low Consequence	IV	IV	III	III

[1] Industrial events that are not initiators or contributors to postulated events are addressed as SIHs.

Mitigated Hazard Evaluation

Hazard events with risk to the public or worker that fall in risk ranks I or II must be considered for further qualitative evaluation and control identification. Public and worker events that fall in risk rank III are generally protected by Safety Management Programs (SMPs) and are still considered. Unique risk rank combinations, such as a worker consequence of M and a frequency of A which would result in a risk rank of II, are also covered under SMPs.

Several guidelines are considered in determining the need and classification of controls:

- The risk matrix should never be the decision-maker. A risk matrix is not sophisticated enough to replace sound engineering logic. Therefore, it is important to recognize that the risk matrix only provides useful information to aid in decision-making.

- One major factor used to assess the significance of safety controls is the risk reduction they provide. One measure of risk reduction can be obtained by examining the risk rankings of applicable accidents for the uncontrolled and controlled cases.

- Risk ranking should not circumvent the HA process. In other words, low initial risk is not an excuse to dismiss a hazard or scenario without further analysis.

The selection of safety controls follows guidelines in SBP 114-2 [Ref. 22].

- Administrative controls (ACs) may reduce the scenario frequency by a factor of 10. If there are two or more independent ACs, a maximum of two orders of magnitude (one frequency bin) in scenario frequency reduction may be attained.

- Engineering controls that have surveillance requirements or are passive may reduce the frequency by a factor of 100 (one frequency bin), unless specific data available for the control indicates otherwise.

- The mitigated hazards analysis is generally conservative because only one frequency bin reduction is utilized, even if several controls are selected to prevent or mitigate a hazard scenario, unless otherwise noted.

- The accident scenario frequencies are qualitative and based primarily on engineering judgment. When available, site-specific data may be used if it provides added insight.

A similar philosophy is applied when applying bin reductions for frequency as a result of crediting different types of controls.

3.2 Hazard Identification

The hazard identification focused on the following MDA B activities:

- Pre-excavation
- Excavation
- Waste container packaging, transportation, and staging
- Characterization

Digging and equipment movement activities could incur occupational hazards. Thus, SIHs, with the exception of slips, trips, and falls, were identified, as well as the nature of the hazard, quantity, or measure where appropriate. Appendix A shows the checklist that was used to identify these hazards.

The types of hazards usually associated with such operations are industrial and chemical/radiological hazards. Only the chemical/radiological hazard identifications are performed using guidelines from P 114-2, *Hazard Evaluation and Accident Analysis* (or successor document) [Ref. 22]. Industrial hazards are due to human errors, equipment failure, or other unexpected events that can cause worker injuries. Industrial hazards also include fire hazards, electrical and thermal hazards, vehicle, forklifts, and material handling equipment hazards. A brief description of major industrial hazards is provided below:

The major hazards identified and associated with the MDA B activities are described in Section 3.2.1. For some hazards (e.g., chemical or radiological materials), additional data beyond that provided on the hazard identification checklists is presented in text form to provide more detailed descriptions. Also included is a discussion of the facility operating history, with a special focus on past incidents that provide important insights into potential safety concerns.

3.2.1 Facility Operating History

Accidents/hazardous events occurring during a facility’s operating history may also provide a perspective on potential future facility hazards. The following four known accidents/hazardous events have occurred during MDA B’s history:

- A chemical fire lasting approximately 2 hr occurred at MDA B in 1946. An incident report described the fire as more of a chemical reaction than a fire. The fire department controlled the fire with water; however, when application of water was stopped, the fire resumed. Bulldozers pushed dirt over the affected area to ultimately extinguish the fire. There were no known injuries.

- In 1947, a second fire was recorded. The fire was reported about 10:30 a.m. and was extinguished by noon. The material on fire was reported to consist of cardboard boxes containing trash (e.g., paper and rubber gloves). The burned area was immediately covered with dirt after the fire was extinguished. The firemen were given respirators and cautioned to stay upwind of the dump. The wind was noted to have been varying in direction. No alpha counts above 400 cpm were found, and the fire equipment was monitored and found to be negative.

- A third fire occurred at MDA B in 1948. The fire was estimated to have lasted 2 hr, had great intensity, and covered a landfill material area of 232 m^2 (2,500 ft^2). The probable cause was combustion of mixed chemicals in landfill material such as clothing and building debris. The landfill material may have contained polonium, plutonium, americium, and strontium. Fires are not known to have occurred in areas where the landfill materials are covered. In the fire, several cartons of landfill material caused minor explosions, and, on one occasion, a cloud of pink gas arose from the debris in the dump. Based on historical accounts, dense smoke forced the evacuation of personnel in areas east and west of the site. There were no known injuries. Subject matter experts (SMEs) determined that the May 1948 fire occurred in the area of Trench 4 (Figure 1-3).

- During a field investigation of MDA B in the 1980s, a Laboratory employee fell through a weak ground area into a void in one of the landfill material cells. The employee was not injured.

3.2.2 Facility Activities

Hazards per activity were identified and documented on Hazard ID checklists, which are presented in Appendix A.

Results of Hazard Identification

Major hazards present at the MDA B site are based on historical data, which was compiled in LA-UR-07-2379 [Ref. 9] and used to develop potential contaminants and inventory estimates. Chemical inventory is shown in Appendix B, with identification of those chemicals that could exceed PAC 3 levels at 20m. General hazards identified in LA-UR-07-2379, as well as those associated with radiological and chemical data from the facility operating history, were documented and the HA tables are developed, as shown in Appendix D. Appendix E provides the results of a comparison of the chemicals in Appendix B that, given additional conservative assumptions, could exceed PAC 2 levels at 30 m.

3.3 Hazard Analysis Results

The following sections present the results of the hazard identification and evaluation.

3.3.1 Radioactive Materials

Radionuclide Inventory

During the period of time that MDA B was an active disposal site, the main radionuclides in use at the Laboratory, and which therefore could be disposed of at MDA B, included ^{235}U, ^{140}La, ^{140}Ba, ^{90}Sr, ^{210}Po, ^{239}Pu, ^{240}Pu, and ^{240}Am [Ref. 9]. Quantities of nuclear material greater than 1 g are not expected to be found in a single distinct location at MDA B because laboratory practices at LANL in the 1940s involved recovering as much of the radionuclides as practical [Ref. 9].

Metal chips and lathe turnings resulting from nuclear weapons research, as well as associated reflector material, were also recovered because of their rarity and resulting high economic discard value. If present in the MDA B waste disposal units, these materials are considered minor contributors to the overall radioactive material inventory. Radioactive sources that will be used in calibration and checking of the continuous air monitors (CAMs) and other instrumentation used to detect and monitor radioactivity do not significantly contribute to the MAR of any particular MDA B activity or the total inventory of MDA B.

From the historical records [Ref. 9], the majority of the radioactive material inventory is expected to be directly in the soil, in miscellaneous discarded laboratory waste, or in intact solution containers with low radionuclide concentrations. SB-DO:CALC-07-054, *Calculation of Plutonium Inventory at Material Disposal Area B* [Ref. 18], provides an overall estimate of the amount of plutonium equivalent in the MDA B waste disposal units. This calculation uses a Monte Carlo technique to estimate the concentration of the different types of material and the volume of the landfill material. The result of the Monte Carlo calculation (with a 97.7th percentile confidence level) is a derivation of estimated total quantities of MAR in Pu-239 equivalent curies (PE-Ci) associated with the different waste matrices buried at MDA B, as shown in Table 3-4. The Monte Carlo calculation estimates that a total MAR of 12.4 PE-Ci (equivalent to roughly 200 equivalent-plutonium-239 [Pu-239] grams) is found within the MDA B waste disposal units.

Table 3-4. Estimate of Maximum Inventory of Waste Matrix

Waste Matrix	**Quantity (PE-Ci)**
Soil/fill	10.51
Gloves and PPE	0.81
Glassware and lab debris	0.67
Intact liquid containers	0.50
Total	**12.5**

The total MDA B inventory of 12.4 PE-Ci is distributed in the total MDA B waste disposal unit volume of 16,515 m^3, resulting in a calculated average concentration of 7.5E-4 PE-Ci/m^3, indicating that the calculated radioactive material concentration in the landfill material is low.

Recent data indicates that the actual average concentration could be lower. As of October 1, 2010, 34% of the waste had been excavated (7339 yd^3), removing a total of 0.44 PE-Ci of radiological material (excluding the anomalous item found in August 2010). The low contamination levels of the excavated soil indicated that the average concentration may actually be less than 7.5E-4 PE-Ci/m^3. Note that the volume of contaminated combustibles has been low (1-2% of total). Recent Geoprobe data also supports the conclusion that 7.5E-4 PE-Ci/m^3 ,as an average, is conservative and that the total inventory is approximately 9 PE-Ci. However, the recent uncovering of an unexpected, highly contaminated item indicates that localized higher concentrations of radiological material may be discovered.

While fissile material is identified in the hazard identification tables, criticality is screened from further consideration in the hazard evaluation. The maximum quantity of Pu-239 buried in MDA B is 12.4 PE-Ci. In accordance with DOE-STD-1027, for quantities below 28 PE-Ci, criticality is precluded, and criticality controls are not required beyond the minimum required for a facility. Therefore, criticality is not considered a credible scenario during MDA B activities.

Radiological Releases During Excavation

The direct push sampling and excavation processes require disturbing the material such that some of the contamination may become airborne. As excavated landfill material is placed in the sorting area, the excavated material may fall or be dropped from heights of 1.5 m (5 ft) and occasionally from the height of the waste disposal unit or intermodal (approximately 3.7 m [12 ft]), resulting in possible airborne radiological contamination. The release of airborne radiological contamination caused by excavation activities is considered to be in frequency category A (Anticipated). The release of airborne radiological contamination above concentrations characterized during pre-excavation activities is considered to be in frequency category U (unlikely).

3.3.2 Chemical History and Hazards

Appendix B presents a list of about 170 chemicals that were used or may have been used during 1944–1948 at the Laboratory. The list includes chemical compounds and substances that were identified during historical review of Laboratory processes and includes product or unused chemicals, spent or waste chemicals, and, where noteworthy, degradation chemicals. The list in Appendix B was taken from *Material Disposal Area B: Process Waste Review, 1945–1948,* LA-UR-07-2379 [Ref. 9], and reports general stock and chemical inventory on August 12, 1946. Some chemicals in the inventory represent a 6 months' supply. A second list, dated October 1, 1947, shows the quantities that were required by the Laboratory's safety organization to be reported; many of the chemicals required reporting of small quantities (e.g., 1, 2, or 5 lb).

There is no evidence that these chemicals were disposed of at MDA B, and the presence, quantities, or location cannot be fully verified before removal operations. Process waste liquids and chemicals are known to have been released to the environment through outfalls or absorption beds, so large quantities of liquid waste chemicals are not expected at MDA B. The disposal of waste in 55-gal drums was rare in the 1940s. Nonflammable oils, such as mineral oil, were typically used in these applications. It was assumed that small volumes of waste chemicals were disposed of at MDA B because of the 1947 policy that chemicals could not be returned to the stockroom once they had been in contaminated areas. Storing or disposing chemicals, including valuable chemicals, in landfill was not considered a viable option. Only glassware and equipment that contained chemical wash rinses and chemical residues or wastes were apparently used for disposal in MDA B.

Residual chemicals buried at MDA B may have included cleaning solutions and other chemicals such as acids, bases, and experimental solvents generated at the bench scale. This included glass jars with metal lids, metal cans of chemical reagents, and waste mixtures that may remain intact, as well as compressed gas cylinders with residual contents. Traces of chemicals spilled to the surrounding soils from deteriorated containers will be evident during characterization analyses conducted prior to excavation, but some intact containers may not be evident until excavated. It is assumed that some of these chemicals were disposed of either as mixtures or as excess reagents. It was assumed that chemical containers sent to MDA B were either partially used reagents from laboratory cleanouts, or empty with some residues.

Based on the historical review of the chemicals and best engineering judgment, the expected chemical content of MDA B is probably 1%-3% of the maximum container size for each chemical listed in Appendix B. However, as a conservative estimate, 5% is assumed to be present in MBA B. Thus, the original inventory estimate is reduced from a full container to 5%, which is also shown in Appendix B. This chemical inventory was used to determine the potential of exceeding PAC-3 levels at 20 m. Due to the close proximity of the public an additional analysis was done to identify chemicals that could exceed PAC-2 levels at 30 m. The result of this analysis is given in Appendix E.

During the operating history of MDA B, there have been three major fires, each lasting for about 2 hr:

- The first fire occurred in 1946, which was described as mainly due to chemical reactions.
- The second fire occurred in 1947, which was largely due to cardboard boxes containing trash (e.g., paper and rubber gloves).
- The third fire occurred in 1948, which was probably due to combustion of mixed chemicals in landfill material such as clothing and building debris.

These three fires undoubtedly produced intense heat and propagated heat within the landfill. Some chemicals could have been converted to oxide forms, which are usually more stable than their original forms. Some chemicals could have degraded or evaporated due to their low boiling point (such as organic chemicals, e.g., acetone, benzene, toluene, gases released from cylinders). Organic chemicals usually degrade over time due to dissociation of their structure, such as double or triple bonds, by oxidation and microbial actions. Most of the chemicals have most likely degraded over 60 yr because of their limited shelf life. Those volatile chemicals with high vapor pressure and low flash point would have easily degraded or evaporated due to heat in a fire. Examples of these chemicals are nickel carbonyl, hydrochloric acid, and ammonium hydroxide, whose physical properties are shown in Table 3-5.

Table 3-5 Physical Properties of Volatile Chemicals with High Vapor Pressure

#	Chemical, CAS #	Mol Wt.	VP* mm Hg	BP** & Density	Comment
1	Nickel carbonyl 13463-39-3	135	400 at 26 °C	BP = 43 °C D = 1.32 g/cc	Liquefied gas, flammable, explodes at 60 °C. Reacts in air or water to form nickel oxide
2	Hydrochloric acid Conc. (42%) 7647-01-0	36.5	709 at 20 °C	BP = -110 °C D = 1.27 g/cc	Colorless gas or fuming liquid, suffocating odor, soluble in water
3	Ammonium hydroxide (28%) 1336-21-6	35	556 at 21 °C	BP = 56 °C D = 0.891 g/cc	Liquid and vapor extremely irritating to eyes

*VP = vapor pressure
**BP = boiling point

These chemicals with high VP have low BPs, easily form vapor, and are flammable and explosive. These characteristic properties strongly suggest that these chemicals have degraded or evaporated during major fires. Further, each chemical has a limited shelf life, which leads to its degradation over time. Organic chemicals such as nickel carbonyl, ethyl ether, and acetone degrade faster than inorganic chemicals. Thus, over 60 yr, their contribution to the inventory is negligible.

The list of chemicals in Appendix B includes flammables, pyrophorics, oxidizers, and time-sensitive chemicals. After 60 yr, many of the chemicals have deteriorated or corroded. This may have rendered much of the organic material noncombustible. Ethyl ether was used from 1945 to 1946 in the plutonium and uranium purification processes, but the processes required that the ether solutions be evaporated, so there were no specific ether wastes. Typical process chemical disposals were down the acid drain lines to the canyons. It is recognized, however, that some chemicals may have been disposed of at MDA B, either in mixtures or as excess reagent in bottles, as non-routine wastes.

For the reasons mentioned above and in Table 3-8, ethyl ether has mostly degraded or evaporated during major fires and time since disposal. However, the concern that peroxide crystals may form from ether and sodium dichromate, as discussed below, was submitted in the *Final Hazard Categorization for Material Disposal Area B* that was submitted to LASO in March 2009 [Ref. 2], for the downgrade from HC-3 to *Less than HC-3* (*Radiological*). This discussion is highly conservative and focuses on the physical hazard.

Of particular concern are those substances, such as ethyl ether and sodium dichromate, that form peroxide crystals. These crystals may be shock-sensitive. Other shock-sensitive oxidizers, such as sodium nitrite and lead dioxide, may be present, but ethyl ether peroxide formation is assumed to produce the bounding quantity of shock-sensitive material. Peroxide crystals are shock- and light-sensitive with the potential to cause an explosion. The shock-sensitive quality of ethers and peroxide crystals was known during the 1940s, and waste ether solutions were disposed of in an ether disposal pit located at TA-21 but outside the MDA B waste disposal units. (Remediation of the ether disposal pit was completed in 2007 and is not part of the MDA B project). However, it is presumed that 2- and 4-L containers of ether used in bench-top experiments and research may have been disposed of in the waste disposal units.

In consideration of the bounding hazard for shock-sensitive chemicals, the 9-L volume is chosen as a maximum-sized bottle that could reasonably be present at MDA B. Ether has a relatively high vapor pressure, and sufficient oxygen must be available for the ether to form a 10% peroxide solution. Generally, soil has an oxygen content of 15%. Through diffusion and other mechanisms, it is postulated that there had been sufficient oxygen to form a 10% peroxide solution if the 9-L container of ether was not sealed. SB-DO:CALC-07-052, *TNT Equivalent of the Possible Shock-Sensitive Explosive Material at TA-21 MDA B* [Ref. 25], estimates the TNT equivalent of a 9-L bottle of ether in which 10% of the volume has formed peroxide crystals.

The hazards analysis is conservative in the assumption that even one bottle containing a peroxide-forming compound may be found, so the scenario where one bottle exploding causes a sympathetic explosion of several other peroxide-containing bottles is considered beyond extremely unlikely. The small pits in the eastern part of MDA B are suspected of containing chemicals in bottles. These materials will be excavated so that the items may be removed and assessed individually and will not be removed *en masse* by the excavator. The most likely scenario for the unmitigated disturbance of the ether bottle is when the excavator bucket is thrust into the mixed landfill material and the operator cannot see what will come out next. Once the materials have been exposed for assessment and further segregation, components of the safety management programs (i.e., HAZWOPER) reduce the likelihood of unmitigated disturbance.

Furthermore, this explosion scenario is based on highly conservative assumptions. The calculation of the potential explosive forces of a peroxide detonation assumed not only that 10% of the inventory of a 9L bottle converts to peroxide, but also that the remaining 90% of the ether remains in the bottle. Deflagration of the ether provides the majority of the explosive force. The presence of enough oxygen to produce the peroxide crystals would require a compromise in the container seal. An unsealed container would immediately allow the egress of diethyl ether, which has an extremely high vapor pressure, approximately 400 mm Hg at 20 ^{o}C [Ref. 26]. Peroxide crystals also degrade over time. They are subject to thermal cleavage with a very low heat of activation (i.e., are unstable), and themselves have a relatively high vapor pressure (170 mm Hg at 25 ^{o}C [Ref. 27]. Furthermore, they undergo decomposition in the presence of ferrous and manganese ions [Ref. 28]. The conditions in the landfill are such that the survival of peroxide crystals for 60 years is unlikely.

There is the possibility of other potentially shock-sensitive material in the landfill. The largest potential source of shock-sensitive materials is ammonium nitrate formed though interaction of nitric acid (approximately 100 lbs in the landfill) and ammonium hydroxide (9 Carboys). Ammonium nitrate is used commercially as an explosive. Deliberate detonation of ammonium nitrate – fuel oil (ANFO) mixtures requires the use of a primer or booster, usually a commercial high explosive such as pentolite (TNT/PETN) or Comp A (RDX-wax), along with a detonator. ANFO is produced through saturation of ammonium nitrate particles with fuel [Ref. 29]. Fuel leaks from equipment operating in the landfill could theoretically provide a fuel source for generation of the ANFO. However, ammonium nitrate marketed for use in explosives is

”prilled,” i.e. formed into small, low-moisture content, non-setting, porous spheres (average diameter range between 0.055 to 0.078 in [1.4 to 2.0 mm]). The particle density of the prills allows uniform absorption of added fuel, which enhances reactivity. Cases in which ammonium nitrate has been known to detonate without added fuel require either carefully controlled conditions or multiple tons of ammonium nitrate. Conditions in the landfill would prevent a configuration of ammonium nitrate that would allow the material to act as an explosive. Ammonium nitrate in the landfill would be of diverse particle size and would be dispersed in the soil. Furthermore, ammonium nitrate is highly hygroscopic and will rapidly dissolve in the presence of water. Any significant quantity of ammonium nitrate would not be expected to survive landfill conditions for extended periods of time.

Because of uncertainty in the landfill inventory, the presence of shock-sensitive material cannot be entirely discounted. However, the environmental conditions and the passage of time would degrade the buried material and decrease the explosive potential. Therefore, scenarios involving shock-sensitive material are considered EU (extremely unlikely).

Chemical Spill Releases

A chemical spill may occur due to the loss of container integrity from corrosion or impact during Geoprobe or excavation activities. The buried landfill material is a combination of soil, contaminated lab equipment, contaminated PPE, wood and cardboard boxes, possible mixed chemical solutions, pure chemical reagents, etc. Most of the organic items probably have deteriorated after 60 yr of being buried because of oxidation and microbial actions. Deterioration may also include oxidation of metal objects including gas cylinders, metal lids, cans, and drums, as well as rubber stoppers used on laboratory glassware.

Given the list of various chemicals that could be buried in the MDA B waste disposal units, a release of hazardous chemicals during excavation or landfill sorting activities cannot be discounted. A chemical release event of any of the chemicals listed in Appendix B during MDA B excavation and sorting activities is considered to be in frequency category A (anticipated) for the *unmitigated* case, based on the historical data and the facility operational history. Release of a specific chemical that may exceed ERPG/TEEL-3 is considered to be in frequency category U (Unlikely).

3.3.3 Other Hazards

Fire Hazards

Fire hazards include flammable and combustible fuels in vehicles, combustible waste found in the waste disposal units, combustible aspects of any erected MDA B structures, vegetation, and transient combustibles.

Brief summary descriptions of the flammable and combustible material sources considered in the HA follow:

- Vehicles with diesel or gasoline fuel tanks with volumes up to 200 gal.
- Waste container transport vehicles (typically pickup trucks or service vans, with gasoline tanks of approximately 25 to 50 gal capacity).

- Liquid- and gas-powered vehicles exchanging gas cylinders used for radiological monitoring or waste characterization activities.
- Use of oxyacetylene torches or other spark-producing activities for size reduction of excavated equipment.
- Workers performing characterization activities may use small volumes of flammable or combustible solvents for cleaning.
- Electrical components used for MDA B equipment.
- Ordinary combustibles associated with performing the work (e.g., contaminated clothing, wood, paper, etc.)
- Excavated waste may release flammable vapors or liquids from broken containers.

Electrical Energy

Electrical power will be used to energize the fans and blowers for the excavation enclosures and DIF as well as lighting, monitors, and alarms. Electrical power lines will be tapped into the existing TA-21 grid. Transformers converting the 480 V to 220 V and 120 V will be located along South Haul Road. These electrical hazards may be initiators for fire and explosion events.

Thermal Energy

Thermal hazards typically present in the facility are heaters, electrical equipment, wiring, and engine exhaust. These thermal hazards may be initiators for fire and explosion events.

Vehicles, Forklifts, and Material-Handling Equipment

Using motorized equipment is generally an SIH. However, because of the limited site space, the presence of waste containers with excavated material, and the frequency of handling them, vehicles and forklifts pose a physical hazard that can damage containers. Forklift tines or drum grapplers (used for lifting containers) can puncture or damage containers if not used properly. Containers can be dropped or overturned during vehicle loading and unloading and during handling. In addition, vehicle fuels are fire hazards. Drum dollies, hand trucks, and other manually operated material handling equipment also present a potential hazard. Containers can be mishandled and dropped, for example, during transport. Other mechanical insults to waste containers stem from container lifting operations.

Kinetic Energy (Linear)

As part of normal excavation and waste container transfer, MDA B activities contain multiple sources of kinetic energy as well. These include vehicles, motors, power tools, moving parts associated with equipment (e.g., belts, bearings), earth-moving vehicles, and movement of waste containers with a forklift. Other kinetic energy hazards identified include the use of gears, grinders, fans, drills, presses, shears, and saws for possible size reduction of characterized waste. These hazards may be initiators for loss of confinement events. Specifics of accidents due to kinetic energy of equipment follow:

- Vehicle causes or falls into a sinkhole—Most of the MDA B waste disposal units are covered with soil overburden and asphalt. At one time, private vehicles (e.g., motor homes) were stored on the previously asphalted portion of MDA B; therefore, sinkholes are not expected in these areas. This scenario is most likely to occur over the eastern end of the site because this is the area where a LANL employee fell into such a sinkhole. However, additional cover material was applied to the site after the employee fell through. Additional characterization (such as finer-scale ground-penetrating radar in conjunction with direct push sampling) may be used in this area to identify potential sinkholes. A vehicle creating or falling into a sinkhole could cause a release of radioactive or hazardous material. If a fire ensued, combustibles could ignite, causing a spread of a fire. An accident involving a vehicle (or person) falling into a sinkhole at the MDA B site is considered to be in the frequency category of A (Anticipated).

- Container accidents initiated by human error during operations that result in a release of radioactive material are generally considered to be in frequency category A (Anticipated) for the unmitigated case. Such accidents include container mishandling accidents, vehicle accidents, and accidents caused by operating equipment incorrectly in which a waste container with contaminated landfill material is breached and radioactive material is released.

Frequency estimates for some mitigated accident scenarios will remain the same as the unmitigated frequency category, but the estimates for other scenarios could be reduced to the next lower frequency category depending on the controls that are implemented. Equipment failures that lead to significant radiological releases of landfill material are generally considered to have an unmitigated frequency of category U (Unlikely). Types of equipment failures considered include forklift/vehicle breakdowns, rigging failures, electrical faults, and significant degradation of a waste container. For accidents involving vehicles that are not facility-related, a single frequency bin reduction is estimated.

Estimates for mitigated frequencies of accident scenarios initiated by equipment failures could be lowered one frequency category if measures are identified to significantly improve the reliability of the particular item.

Potential Energy

Suspended loads represent one source of potential energy. The suspended loads occur during general excavator operation (i.e., a loaded bucket), crane operation during maintenance or enclosure relocation, or man-lift during maintenance.

Additional potential energy hazards include pressurized gas bottles (e.g., fire extinguishers) and pressurized systems (e.g., hydraulic system on forklifts and excavators). Excavated landfill material may contain aerosol cans, compressed gas cylinders (also discussed above), or small quantities of reactive materials.

The field laboratory will also use pressurized gas cylinders of helium and nitrogen.

Screened Hazards

Expected hazards encountered during routine excavation activities include:

- Excavation and sorting of landfill material, which may expose workers to soils mixed with radioactive and chemical contaminants, and
- Excavation and sorting of landfill material which may result in spill of hazardous material to the surrounding soil.

The radiological or chemical releases from these expected, routine hazards are managed in accordance with the LANL Radiation Protection Program, the Site-Specific Health and Safety Plan, and NESHAP requirements, and are thereby screened from consideration in the hazard evaluation.

Table 3-6 provides a list of other hazard categories that were identified during the process review and facility walkdowns, but later screened out from further evaluation. Those hazards that are less significant, but could initiate accidents involving more significant hazards, were carried forward to hazard evaluation and addressed as accident initiators. For example, an electrical short was identified initially as an SIH; however, because it could ignite combustible material and initiate a fire, it was carried forward to hazard evaluation as an accident initiator. This case and other similar cases are noted in Table 3-6.

Table 3-6. Hazards Screened from Further Evaluation

Hazard	Reason for Screening
Electrical equipment–low voltage (110- to 120-V electrical service)	In general, electrical equipment is considered an SIH and thus screened from further evaluation. However, it should be included when it is considered a potential fire (i.e., accident) initiator.
Compressed gas cylinders	In general, compressed gas cylinders are considered an SIH. Compressed gas cylinders that are punctured or that lose confinement are carried forward if they can cause a radioactive or hazardous material release.
Slippery surfaces caused by lubricants or similar materials	Slippery surfaces are screened out because they are considered an SIH.
Pinch points, sharp edges, cutting tools, and other mechanical situations that can cause injury	These mechanical hazards are screened out because they are SIHs. They are considered if the sharp edge can result in loss of containment and release of radioactive material.
Hot surfaces, burns, hot work covered by LANL work control program	Hot items relative to burn hazards covered by LANL work control program are excluded because they are considered an SIH. However, they may carried forward when considered an accident initiator (i.e., can initiate a fire that can impact radioactive or hazardous material).
Secondary low-level waste (LLW)	Secondary LLW and loose/fixed contamination are generally screened from detailed hazards analysis because they are present in limited quantities (e.g., less than 10% of the HC-3 threshold) and are bounded by the inventory and hazards present in the landfill waste. LLW is considered as a combustible load, as appropriate.
Forklift/vehicle battery recharging (hydrogen off-gassing)	Forklift battery recharging is an SIH that takes place outside of the excavation area to prevent interaction with nuclear material and is thus screened out.

Table 3-6. Hazards Screened from Further Evaluation

Hazard	Reason for Screening
Hazardous chemicals—routine lubricants, solvents, and corrosives in quantities used for routine maintenance	No hazardous chemicals will be introduced in quantities that would be considered greater than SIHs.
Pneumatic and power hand tools	Pneumatic hand tools are considered an SIH. Their misuse or failure, however, can impact radioactive materials. When they are considered potential accident initiators, they are carried forward for further evaluation.
NOTE: In some cases, hazards are only partially screened and are carried forward if they can cause a radioactive material release.	

3.4 Hazard Categorization

3.4.1 Chemical Hazard Categorization

In accordance with SBP 111-1, *Facility Hazard Categorization and Documentation* [Ref. 10], a facility's Chemical Hazard Categorization (CHC) is based on comparison of maximum expected quantities to TQs based on Protective Action Criteria (PAC)-3, AEGL/ERPG/TEEL-3 levels as a function of distance. These guidelines specify three levels of increasing severity, as shown in Table 3-7. AEGL/ERPG/ TEEL-3 is defined as the "the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects" [Ref. 10, Appendix C]. The MBA B site contains no explosives or biological materials. Therefore, the hazard categorization discusses only chemicals.

Table 3-7. Nonnuclear Facility Hazard Category Thresholds

Hazard Type	High	Moderate	Low
Chemical	The maximum anticipated quantities have calculated consequences that exceed PAC-3 levels for a member of the public at the nearest site boundary location.	The maximum anticipated quantities have calculated consequences that exceed PAC-3 levels at 100 m (see note below).	The maximum anticipated quantities have calculated consequences that do not exceed PAC-3 levels at 100 m (see Note below).
	NOTE: If the facility hazard categorization documents that the closest non-involved worker is > 100 m from the facility, then this distance may be used for the CHC.		
NOTE: A spreadsheet with TQs using PAC-3, AEGL/ERPG/TEEL-3 values as a function of selected distances for various chemicals is listed in calculation SB-DO 2007 [Ref. 18]. SBP-111-1 also suggests not using regulatory TQs as noted by 29 CFR 119 (*Occupational Safety and Health Administration* [OSHA]) and 40 CFR 68 (*Environmental Protection Agency* [EPA]) for hazard categorization. Values in Appendix B are upgraded to Rev. 24.			

The TQs for PAC 2 and PAC 3 for about 3,200 chemicals at distances from 30 meters to 100 meters are posted on the Safety Basis website [Ref. 39].

A facility is considered to be Low hazard if the chemical quantity is below the TQ of PAC-3 level at 100 m or the facility boundary, Moderate if the chemical quantity exceeds the TQ at 100 m for a non-involved worker, and High if the chemical quantity exceeds the TQ at the site boundary. Site boundary distance for most facilities is typically higher than 100 m distance, and thus TQs for the public are usually higher than TQs at 100 m for the workers. However, the MBA site boundary is only 20 m, which is 5 times shorter than 100 m and presents an unusual situation. The TQs for PAC-3 (Rev 24) at 20 m for the public are about 9.4 times lower than TQs at 100 m for the workers, and these values (lb)are listed in Appendix B, which contains information on about 170 chemicals. According to this list, three chemicals exceed the TQs for PAC 3. However, these three chemicals have very high vapor pressures (see Table3-5), and are therefore unlikely to survive landfill conditions. Therefore, MDA B is a Low hazard chemical site.

Summary

MBA B is a Low Hazard chemical site according to the methodology described in SBP 111-1, *Facility Hazard Categorization and Documentation* [Ref. 10].

3.4.2 Nuclear Hazard Categorization

MDAB-ABD-1004, Rev 0 and Rev 1, *Final Hazard Categorization for Material Disposal Area B*, establishes MDA B as a Less-than-HazCat-3 nuclear or radiological facility [Refs. 2, 3, 6].

DOE-STD-1027-92 [Ref. 31] defines HC-3 facilities as those for which a hazard analysis identifies "the potential for significant but localized consequences." Facilities with quantities of hazardous radioactive materials that meet or exceed the HC-3 threshold values specified in DOE-STD-1027, Table A.1, but are less than the HC-2 quantities, fall into the HC-3 category. The HC-3 threshold values presented in the cited table represent levels of material that, if released, could produce more than 10 rem doses at 30 m based on a 24-hour exposure period.

The initial hazard categorization of a facility is based strictly upon the total inventory of radioactive materials. An HC-3 facility is one for which the sum of fractions of the inventory of each radionuclide to its HC-3 Threshold Quantity (TQ) of DOE-STD-1027-92 exceeds one, but the sum of fractions based on HC-2 TQs is less than one. The standard then identifies four methods for modifying a facility's initial hazard categorization during final hazard categorization. The methods are:

- ***Reducing inventory***: Once the radiological inventory is reduced below the HC-3 threshold, the facility becomes a radiological facility and exits the 10 CFR 830 requirements for DSA/TSRs. This method cannot apply to MDA B prior to remediation work.

- ***Segmentation***: DOE-STD-1027-92 provides flexibility in segmenting a facility that effectively reduces the inventory for each segment. Segmentation may be applied where facility features preclude bringing material together or causing harmful interaction from a common severe phenomenon. This is commonly applied when a facility consists of several independent buildings containing radiological inventory. The burden of proof is on the analyst to show that the hazardous material in one segment cannot interact with hazardous materials in other segments. No administrative controls can be credited for segmentation; only passive engineering controls can be demonstrated to survive all postulated events.

  Hazard analysis and categorization is to be performed on "processes, operations, or activities," not necessarily on whole facilities. When independence can be shown from consequences derived from a common severe phenomenon, segmentation is justified. For example, segmentation can be applied to a facility where buildings are separated by distance and do not share common heating, ventilating, and air-conditioning systems, because these buildings are considered independent facility segments for facility segmentation purposes.

- ***Applying*** a DOE-approved alternative airborne release fraction (ARF): DOE Technical Position NSTP 2002-2 states that the HC-3 threshold values for radionuclides may be revised if, based on the physical and chemical form and available dispersive energy sources for the site, the credible ARF can be shown to be significantly different than the values used in DOE-STD-1027-92. All potential scenarios must be considered under unmitigated conditions. Because these sites occur over large areas, it is important to determine the inventory at risk that can be released physically from the site relative to the entire inventory from bounding unmitigated scenarios. DOE must approve all proposed alternate ARF changes.

- ***Performing*** a hazard analysis on an unmitigated release and proving that the material quantity, form, location, dispersibility, or interaction with available energy sources supports downgrading a facility hazard categorization: The inventory at risk may be evaluated based on the fraction of the inventory (MAR) impacted by bounding scenarios and subjected to airborne dispersal. This MAR quantity can then be compared to the TQs for determining hazard categorization. Thus, if no plausible scenario that could conceivably release a significant amount of inventory exists, it could result in a defensible position to downgrade a facility's categorization.

For HC-3 determination, a footnote to Table A.1 of Attachment 1 to DOE-STD-1027-92 notes that the TQs for certain fissionable isotopes can be used only if segmentation or the nature of the process precludes the potential for criticality; otherwise it provides lower TQs. There is no criticality hazard at MDA B, so MDA B does not have the potential for a nuclear criticality. The total quantities of fissile materials are expected to be much less than minimum critical masses and are widely dispersed throughout the landfill. For example, if all of the 12.4 PE-Ci were from Pu-239, this would translate to 200 g, which is less than the 450-g minimum critical mass listed for the hazard categorization criterion from DOE-STD-1027-92. Guidance in SBP 111-1.0, *Facility Hazard Categorization and Documentation*, [Ref. 10] is used to perform the hazard categorization and complies with the guidance and requirements in DOE-STD-1027-92, Chg. 1.

NES-ABD-0101, *Documented Safety Analysis for Surveillance and Maintenance of Nuclear Environmental Sites at Los Alamos National Laboratory*, established MDA B as a HazCat-3 nuclear facility [Ref. 40]. This was based on an estimate that the MDA B waste disposal units contained 6.2 PE-Ci. SB-DO:CALC-07-054, *Calculation of Plutonium Inventory at Material Disposition Area B*, calculates that MDA B contains approximately 12.4 PE-Ci or less with a 97.7th percentile confidence level [10]. The results in SB-DO:CALC-07-054 indicate that the 50th percentile value is similar to the previous estimate of 6.2 PE-Ci. The radioactive sources used to calibrate radiation analytical instrumentation do not contribute significantly to the radioactive material inventory and so do not impact the hazard category determination. The calculated 12.4 PE-Ci MAR at MDA B in its entirety indicated that it should be considered as a HazCat-3 nuclear facility. The above categorization was based on the estimated total quantity of material in the MDA B waste disposal units, consistent with the initial hazard categorization from DOE-STD-1027-92.

3.4.2.1 Segmentation of MDA B Work Areas

The following discussion reflects analysis that justified reduction of MDA B categorization to a Less Than HC 3 (Radiological) facility, as approved by LASO in March 2009. The MDA B waste retrieval project involves several discrete work areas in which MAR could be located on the site. These include (1) excavation areas; (2) WCSAs; (3) the DIF; and (4) onsite transportation, including South Haul Road. There are also WCSAs located outside of MDA B, within TA-21. The field laboratory and equipment decontamination area are expected to have minimal quantities of MAR as compared to the other work areas and processes. Buried waste materials are not considered at risk until the material is exhumed through excavation activities. This is because historically waste has been covered with approximately 3 to 5 ft of soil overburden plus 4 to 6 in. of asphalt pavement (now removed) over ~70% of the site and approximately 6.5 ft of soil overburden over the remaining unpaved ~30%, and there are no credible accidents that can disperse this material when maintained in this configuration with no intrusive activities. This conclusion is supported by hazard analyses described in DOE-STD-1120, Appendix D, *Inactive Waste Site Criteria*.

A small fraction of the waste material in trenches and pits will be exhumed at any one time within an excavation area that is enclosed within a temporary excavation structure. Exhumed soil and waste materials are considered the MAR quantity within an Excavation Area that is subject to comparison to DOE-STD-1027-92, *Hazard Category 3 TQ*. The estimate of this MAR is based on the following assumptions:

- The total inventory of 12.4 PE-Ci is a conservative estimate that is a 97.7th percentile confidence level from a Monte Carlo analysis of sampling data acquired primarily from the later years of landfill operation; these samples would have much higher concentrations than those from the early years of filling the landfill due to the extreme rarity of plutonium and uranium in the mid-1940s. These higher samples were extrapolated to the entire waste volume. Assuming that the 12.4 PE-Ci is distributed in the total MDA B waste disposal unit volume of 16,515 m^3, a conservative bounding estimated concentration is 7.5E-4 PE-Ci/m^3.
- Within each excavation area, the active dig face will involve a nominal area of 10 ft by 10 ft and up to 15 ft deep, depending on the depth of the trench being excavated and the slope of the walls required to maintain stability. This represents a volume of approximately 1,500 ft^3 (42.5 m^3) disturbed during a single excavation.
- Applying the average soil concentration to the volume of an active dig face yields approximately 0.032 PE-Ci.

The above assumptions are based on historical information and sampling data. As illustrated by the recent discovery of a high-MAR item [Ref. 5], there may be areas of significantly higher MAR content (see Section 3.4.3).

As the material is excavated, it is spread out in a sorting pile approximately 1 ft deep to remove any unknown items for disposition. Another sorting area may also be nearby to allow loading the first pile into the transportation container after it is inspected, but, operationally, the piles and the dig face are required to be separated in accordance with fire protection requirements. However, for an unmitigated analysis, this separation distance is not credited to determine a bounding estimate of MAR per dig site.

A key assumption is to maintain a separation between excavation enclosures. By conservatively limiting excavation areas to a volume of material to be exposed based on a conservative estimate of concentrations from new Geoprobe sampling data, the MAR will be managed below, the HC-3 TQ, for each excavation area [Ref. 4]. This assumption will be protected to support the segmentation justification (see section 3.3.4). If the separation distances cannot be maintained, then those units that are closer than the separation distance will be managed as one MAR unit, and together be limited to below HC-3 threshold quantities. Up to six excavation enclosures may be aqctive, with one dig face per excavation enclosure at any one time. However, the exposed MAR shall not meet or exceed HC-3 TQ for each excavation area.

The other remaining MDA B work areas with MAR are DIF and WCSAs that will be managed as independent segments for hazard categorization purposes with a 60-ft separation distance. The WCSAs outside of the site boundary will be limited to MAR inventory of <0.52 PE-Ci. Thus, overall, independent segments are comprised of the excavation areas, DIF, and WCSAs, and the MAR in each segment will be maintained below HC-3 adjusted TQs (except for the WCSAs outside of MDA B) and according to defined distances required by fire protection requirements [Ref. 19]. These values, considered protected assumptions, are described in Table 3-8. The hazard analysis demonstrates that no credible accident can involve the MAR in more than one work area when maintained under the required separation distances.

3.4.2.2 Justification for 60-ft Separation Distance for Excavation Areas, DIF, and WCSAs

In MDA B-ABD-1004, Rev. 0, *Final Hazard Categorization for Material Disposal Area B* [Ref. 2] , a separation distance of 115 ft for operations was established for excavation areas with a MAR limit of 0.15 PE-Ci, which was also part of the *Key Assumptions to Preserve Final Hazard Categorization* [Ref. 2]. Similarly, a separation distance of 80 ft and a MAR limit of 0.44 PE-Ci were established between an excavation area and other MDA B structures (e.g., DIF) and segments (e.g., WCSAs). The same information was referenced in MDAB-ABD-1005, *Facility Safety Plan for MDA B*, Rev. 1 and Rev. 2 [Refs. 32, 33].

The TQ for Pu-239 is 0.52 curies for HC-3, per DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, Change Notice No. 1, September 1997. A 0.15-plutonium equivalent curie (PE-Ci) limit for excavation areas and other facility segments was established to preserve the *Less than HC-3* or *Radiological* final categorization. The 115-ft separation for the excavation area and 197-ft separation for DIF and WCSAs were chosen during development of the draft MDA B *Fire Hazards Analysis* (FHA) and response to NNSA/LASO review comments.

The final *Fire Hazard Analysis for Material Disposal Area B*, MDAB-ABD -1003 [Ref. 34] provides an updated interpretation of DOE-STD-1088-95, *Fire Protection for Relocatable Structures*, June 1995 [Ref. 37] on separation distance and recommends 60-ft separation distances for excavation areas. LANL proposed to revise the 115-ft separation distance between excavation areas or between an excavation area and other MDA B structures downward to 60 ft (11), based on technical justifications from evaluations of an aircraft crash, the blast distance, and the MDA B FHA which are provided as follows. Note that the FHA addresses limitations on structure locations other than the MDA B work areas. However, the potential risk from fires in structures that do not contain MAR is bounded by the analysis.

In addition, in order to meet New Mexico Consent Order requirements, LANL also requested that the restriction of 0.15 PE-Ci per dig face be removed and that the MDA B site be limited to <0.52 PE-Ci for each exposed area. Up to six active excavation enclosures would be permitted. (See Section 3.4.2.4 for additional changes to MAR limits.) If the separation distances cannot be maintained, then those enclosures that are closer than 60 ft will be managed as one enclosure and together be limited to below HC-3 threshold quantities.

Technical justifications for these changes are provided below.

(a) ***Aircraft Crash***: An aircraft crash that has the capability to penetrate a waste protective overburden or depth up to 3 ft, create a sizeable crater, and dispense a high-octane gasoline that results in a fire is one of the most damaging events. Table 15 of DOE-STD-3014-96, *Accident Analysis for Aircraft Crash into Hazardous Facilities* [Ref. 38], lists the probabilities per unit area of all aircrafts at DOE sites. For LANL, commercial carrier and large military crashes are less than the Standard's screening criterion of 1E-6/yr. The crash probability for large commercial carriers is 2E-7 crashes/mi^2/yr, and for large military carriers is 1E-7 crashes/mi^2/yr [Ref. 38]. The MDA B site is about 6.03 acres, which is 9.5E-3 mi^2 [Refs. 1, 32]. Thus, the probability is 9.5E-3 × 2E-7 = 1.9E-9/yr for commercial carriers and 9.5E-3 × 1E-7 = 1E-9/yr for military carriers, which are both incredible.

However, a general aviation aircraft is credible and accessible to the MDA B site. The probability of a general aviation crash was estimated to be 2E-4 crashes/mi^2/yr. The probability is 9.5E-3 × 2E-4 = 1.9E-6/yr, which is a credible event. (Note that these estimates have been revised – see Section 3.4.2.4.) For general aviation aircraft, DOE-STD-3014-96, Table B-18 [Ref. 38] lists a mean skid distance of 60 ft and no impact beyond a 3-ft depth. Thus, in an excavation area, the 60-ft separation distance is bounded by the skid distance, which supports segmentation during excavation activity.

(b) ***Blast Distance***: MDA B was a disposal site for many radionuclides, chemicals, reagents, and wastes from 1944 to 1948 [Ref. 2]. Among the chemicals disposed was ether, which was used in the plutonium and uranium purification processes. Excess ether or ether waste in bottles was disposed in the landfill. Ether has most likely degraded or evaporated over 50 to 60 yr. However, ether forms peroxide crystals with sodium dichromate, and thus leads to physical hazard. These crystals may be shock-sensitive, with a potential to cause an explosion.

A 9-L volume was chosen as a maximum-sized bottle that could reasonably be present at MDA B. Ether has a relatively high vapor pressure (442 mm Hg), low boiling point (34° C), and low density (0.71 g/cc). Sufficient oxygen must be available for the ether to form a 10% peroxide solution. Generally, soil has an oxygen content of 15%. Through diffusion and other mechanisms, it is postulated that there had been sufficient oxygen to form a 10% peroxide solution if the 9-L container of ether was not sealed. A 9-L bottle of 10% peroxide and 90% diethyl ether solution is equivalent to 6-lb of TNT, as shown in

SB-DO:CALC-07-052, *TNT Equivalent of the Possible Shock-Sensitive Explosive Material at TA-21 MDA B* [Ref. 25]. MacAfee et al. [Ref. 39] showed through calculations that the distance that primary peroxide fragments (e.g., sized ¼ in. by ¼ in, by ½ in) from an inadvertent shock-sensitive reaction with an initial velocity of 1 km/ sec would travel is approximately 54 ft, which also supports a 60-ft separation distance for excavation sites. A distance of 60 ft is also applied to overpressure protection requirements for site workers. Thus a 60-ft blast zone is a safe distance.

(c) ***Fire Hazard Analysis*** using DOE-STD-1088-95: Simultaneous hazards associated with operating multiple excavation sites are essentially independent events, and are considered as such by the hazard analysis for any given excavation area. Per the MDA B FHA [Ref. 34], a minimum of 60 ft of defensible space must be maintained between the active excavation enclosures. Based on Section 6.1 of DOE-STD-1088-95, *Standard for Fire Protection for Relocatable Structures* [Ref. 37], a defensible space of 60 ft also bounds the maximum distance for parallel relocatable structures or enclosures.

For NPHs, heat flux in material construction of the enclosure will not propagate a fire between fire areas separated by 60 ft with no intervening combustibles. Table 2.2-1 of the FHA document states a minimum 60-ft separation distance in an enclosure fire area [Ref. 34]. For the DIF and WCSAs, the MDA B FHA states a minimum of 60-ft separation from all other fire areas [Ref. 34]. Thus, 60 ft bounds the separation distance for the FHA.

Summary

Based on the GAA crash skid distance, the blast zone of a shock-sensitive peroxide chemical, and the MDA-B FHA that provides the interpretation of DOE-STD-1088-95 [Ref. 37] separation requirements, a 60-ft separation distance is common among three potential accidents and is technically justified for segmentation and operations in excavation activities. Furthermore, the 60-ft separation will also preserve the final hazard categorization as “Less than HC-3” or Radiological.

LANL submitted a request to NNSA/LASO in March 2010, to downgrade the distances to 60-ft separation among the excavation areas, DIF, and WCSAs with a MAR limit of <0.52 PE-Ci for each segment [Ref. 35]. LASO approved the separation distances of 60 ft and MAR limits of 0.52 PE-Ci on April 16, 2010 {Ref. 36]. (See Section 3.4 for further adjustments in the MAR limits.)

On September 2010, LANL submitted a request to LASO to revise the MAR limit to apply to each excavation area, separated by a minimum of 60 ft. LASO approved the request on September 16, 2010 [Ref 37] as follows:

- As many as six excavation enclosures will be separated by a minimum of 60 ft at all times while the enclosures are active.
- Each excavation enclosure will be managed separately to below the HC-3 threshold quantities.

- If the separation distances cannot be maintained, then those enclosures that are closer than 60 ft will be managed as one enclosure and together be limited to below HC-3 threshold quantities (see Section 2.3.5 for adjusted TQs).

All other assumptions will be managed as previously approved in LASO 2010a.

These 60-ft separation distances are listed in Table 3-8.

3.4.2.4 Justification for Use of Alternative Airborne Release Fraction

DOE Technical Position NSTP 2002-2 states that the HC-3 threshold values for radionuclides may be revised if, based on the physical and chemical form and available dispersive energy sources for the site, the credible ARF can be shown to be significantly different than the values used in DOE-STD-1027-92 (1E-3 for HC3 TQs. In October 2010 [Ref. 6], LANL provided a justification for an increase of the allowable exposed MAR from <0.52 to $\leq$5 PE-Ci, with an argument for remaining a “Less than HC3” (radiological) site as detailed in MDAB-ABD-1004, Rev. 1, *Final Hazard Categorization for Material Disposal Area B*. The justification is briefly summarized below. A key assumption in the analysis is that the bounding concentration of MAR in soil is 275 PE-nCi/g (5PE-Cis in 18,200 kgs of soil).

Bounding accidents selected for the purpose of hazard categorization were:

Fires

- Excavating fire
- Fire affecting TRU containers

Explosions

- Explosion of Shock-Sensitive Chemicals
- External explosion affecting TRU containers

Loss of Confinement/Spills

- Dumping wastes from routine excavating
- Spills from TRU containers

For each of the scenarios, an appropriate ARF × RF was determined. The TQ was adjusted and a sum of fractions (SOF) determined as a ratio of the actual MAR (based on an exposed inventory of 5 PE-Ci) to the adjusted TQ.

3.4.2.4.1 Fires

Fire affecting a filled waste bin or TRU containers was considered. Using the ARF × RF for heating contaminated soil from DOE-HDBK-3010 of 6E-5, an allowable adjustment to the HC-3 TQ is 1E-3/6E-5 = 16.7, resulting in a fire-adjusted TQ of 8.67 PE-Ci. The HC-3 TQ ratio is as follows:

$$\text{HC-3 TQ ratio}_{\text{waste bin}} = 5\text{ PE-Ci MAR} / 8.67\text{ PE-Ci TQ} = 0.58$$

Fires during excavating of soil/debris with exposed contaminated combustibles were assumed to include a pool fire. The ARF × RF for heating contaminated soil from DOE-HDBK-3010 is 6E-5. Combustible loading was bounded at 10% by volume. The bounding ARF × RF for contained cellulose mixed waste subject to thermal stress is 5E-4×1.0 (5E-4) from DOE-HDBK-3010. The overall ARF × RF for the waste involved in the fire is calculated as (0.9) (6E-05) + (0.1) (5E-04) = 1.04E-04. The allowable adjustment to the HC-3 TQ is 1E-3/1.04E-4 = 9.6 increase. This allows a direct MAR adjustment to 5 Ci.

The HC-3 TQ ratio is as follows:

$$\text{HC-3 TQ ratio}_{\text{10\% contaminated combustibles}} = \text{5 PE-Ci MAR / 5 PE-Ci TQ} = 1.0$$

3.4.2.4.2 Explosions

Explosion scenarios included shock-sensitive explosion during characterization. Determination of the amount of soil dislodged was based on DOE/TIC-11268, *A Manual for the Prediction of Blast and Fragment Loading on Structures*, and estimated to be 71 ft^3. The 71 ft^3 (2.0 m^3) crater will dislodge 3.2E+6 g soil (.898 PE-Ci), assuming the pre-excavated density of 1.6 g/cm^3. The respirable release quantity is given by DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities* as 0.2 times the quantity of TNT involved in the accident or 1.2 lb (545 gm) for a 6 lb TNT equivalent explosion. The ARF × RF is the source term divided by the MAR, or 545 g / 3.2E+6 g = 1.7E-4. The allowable adjustment to the HC-3 TQ is 1E-3/1.7E-4 = 5.9 increase. The adjusted HC-3 TQ is 3.07 PE-Ci.

$$\text{HC-3 TQ ratio}_{\text{crater}} = \text{0.89 PE-Ci MAR / 3.07 PE-Ci TQ} = 0.29$$

The scenario "Shock Sensitive Explosion during Excavating" used similar arguments. DOE/TIC-1128 provides two estimates of the magnitude of potential involvement of soil and MAR from a 6-lb TNT explosion, both based on DOE-HDBK-3010. By one method, a 6 lb TNT-equivalent surface explosion results in the dislodgement of 348 kg of soil or 0.22 m^3 . The source term made airborne is 0.2 × the TNT equivalence, or 1.2 lb (545 g) for a 6-lb TNT explosion equivalent to 0.078 PE-Ci. The ARF × RF is the source term divided by the MAR, or 0.545 kg / 348 kg = 1.57E-3, and a MAR adjustment downward to .33.

$$\text{HC-3 TQ ratio}_{\text{method1}} = \text{0.078 PE-Ci MAR / 0.33 PE-Ci TQ} = 0.23$$

In the scenario addressing "External Explosion Impacting TRU Containers," an explosion is assumed to cause an impact to TRU containers such that the ARF × RF is 1E-4. This magnitude of accident stress is similar to that described in Section 2.3.5.5 for spills/loss of confinement events, gas cylinder missiles, high wind missiles, and seismic debris damage. Therefore, the allowable adjustment to the HC-3 TQ is 1E-3/1E-4 = 10 increase.

The HC-3 TQ ratio is as follows:

$$\text{HC-3 TQ ratio}_{\text{explosion}} = \text{5 PE-Ci MAR / 5.2 PE-Ci TQ} = 0.96$$

3.4.2.4.3 Loss of Confinement/Spills

The scenario "Excavating and Dumping Wastes" involves the normal process function of excavating contaminated waste, spreading out in a sorting area, and filling the waste bin, which results in emission of contaminated particulates (commonly referred to as fugitive dust). The MAR in this event is twice the 5 PE-Ci MAR assumption, since the soil/debris is dumped twice, once to the sorting pile and then into the waste bin. The quantity of particulate emissions generated by a drop/spill may be estimated using the following empirical expression from the EPA (EPA 2006, p.13.2.4-4):

$$E = 0.0016 \times k \times (U/2.2)^{1.3} / (M/2)^{1.4}$$

where:

E = Emission Factor (kg/Mg)

k = particle size multiplier (dimensionless)

U = mean wind speed (m/s)

M = material moisture content (%).

A wind speed of 4.5 m/s (10 mph) is selected as conservative to bound the release potential. This assumption is based on the following:

- The ground rules of DOE-STD-1027-92 for HC-3 TQs are based on the EPA model assumptions for very calm dispersion conditions, i.e., 1.0 m/s and Stability Class D.
- The ground rules of DOE-STD-1027 HC-2 TQs assume a 4.5 m/s wind speed with Stability Class D to represent typical dispersion conditions.
- During waste disposal operations, atmospheric Stability Class D conditions are more likely to prevail – this is the dominant stability class during the daylight hours and has higher associated wind speeds than the 1.0 m/s assumption for the HC-3 TQ.

The particle size multiplier (or RF) is taken to be 0.35 for <10 micron AED particles (EPA 2006, pg 13.2.4-4). The soil moisture content, M, is conservatively selected from the lowest LANL soil moisture content of 6%, as described in Section 1.2.3, *Current Conditions*. Inserting these values in the above equation yields the following:

$$E = 0.0016 \times 0.35 \times (4.5/2.2)^{1..3} / (6/2)^{1.4} = 1.5E\text{-}4 \text{ kg/Mg} = 1.5E\text{-}7 \text{ kg/kg.}$$

The 1.5E-7 kg/kg is equivalent to an ARF × RF. Rounding to 1E-6, the allowable adjustment to the HC-3 TQ is 1E-3/1E-6 = 1,000 increase.

$$\text{HC-3 TQ ratio}_{dumping} = 5 \text{ PE-Ci MAR} / 520 \text{ PE-Ci TQ} = 0.019$$

For loss of confinement of material in TRU waste containers, it should be noted that DOE-STD-5506, Table 4.5-1, also recommends 6E-4 for spills of contaminated soil/debris based on the conservative assumption that it will behave as powders. The basis is presented in Section 4.5.3.1, *Spills*, as follows:

> The behavior of TRU waste in the form of soils or loose powders is approximated by experiments described in Section 4.4.3.1.2 of DOE-HDBK-3010. The bounding [ARF][RF] values for cohesionless powders are 2E-3/0.3. These values are applied to spills involving lower energy levels as opposed to “impacts” involving a higher distance drop of materials than 10 ft, seismically induced forces, or impacts from vehicle accidents.

However, footnote 6 to Table 4.5-1 allows justifying other values for the higher impact stress event associated with the 1E-3 ARF × RF. The historical practice of assuming a 1E-4 ARF × RF for spills and low-energy impacts to TRU waste containers is deemed appropriate for the high-moisture soils being retrieved from MDA B. Therefore, the allowable adjustment to the HC-3 TQ is 1E-3/1E-4 = 10.

$$\text{HC-3 TQ ratio}_{\text{spill}} = 5 \text{ PE-Ci MAR} / 5.2 \text{ PE-Ci TQ} = 0.96$$

3.4.2.4.4 Aircraft Crash

Applying the methodology described in DOE-STD-3014, due to the proximity of the MDA B site to the Los Alamos airport, the frequency of a GAA crash into a high-MAR anomaly, based on the hypothetical 1-ft^2, 1-ft-tall crash area calculated in SB-DO-CALC-07-050, was estimated as 6E-6/yr.

During an aircraft crash, material may be released through two mechanisms. The force of the initial impact of the aircraft into the excavation area will drive some of the contaminated soil airborne. After the initial impact, fuel from the ruptured aircraft fuel tanks is expected to be ignited. This secondary fire may release additional material. The combustible content of the waste involved in the accident is assumed to be 10%, the maximum combustible fraction evaluated previously to maintain less than HC-3. The remaining 90% of the waste is assumed to be contaminated soil (powder).

The displaced material from the impact crater is estimated to be (18 m)(0.91 m)(1.5 m), or 24.6 m^3. One engine is assumed to strike the sorting area, involving 5 PE-Ci in 14 m^3 ready to be placed in a waste bin. An additional 10.6 m^3 of soil below the high-MAR soil is also made airborne due to the 3-ft depth of the crater from the engine strike. Assuming the 97.7th percentile concentration of 7.4E-4 PE-Ci/m^3, this results in an additional 7.8E-3 PE-Ci involved at the sorting area. The second engine is assumed to impact the excavation area, making another 24.6 m^3 airborne, which results in an additional 1.8E-2 PE-Ci involved, assuming the 97.7th percentile concentration.

The total MAR involved in the impact is 7.8E-3 PE-Ci + 5.0 PE-Ci + 1.8E-2 PE-Ci = 5.026 PE-Ci.

The bounding ARF × RF for the suspension of the soil from the crash impact is assumed to be bounded by the suspension of bulk powder due to shock-impact from falling debris and is 1E-03 × 0.1, or 1E-4 (DOE 1994, pg 4-87). The allowable adjustment to the HC-3 TQ is 1E-3/1E-4 = 10 increase, resulting in an impact-adjusted TQ of 5.2 PE-Ci.

After impact, aviation fuel spreads over 30-m (100-ft) diameter area (707 m^2) and is ignited. Due to potential skidding of the aircraft, a shallow pool depth is assumed, equivalent to 0.27 cm for a 1,893-L (500-gal) fuel tank that is typical for the GAA size of plane. Consistent with the operational fires evaluated earlier, the resulting fire heats the contaminated material to a depth of 7.6 cm (3 inches) and releases radioactive materials. Also, the same depth of soil is assumed to be heated by the aircraft crash fire, as was assumed for the fire in the excavation enclosure. The material available for release is 53.7 m^3 of material. Assuming the 97.7th percentile 7.4E-4 PE-Ci/m3 concentration, the resulting MAR affected by the pool fire is 0.04 PE-Ci. The HC-3 TQ ratio is as follows:

$$\text{HC-3 TQ ratio}_{fire} = 0.04 \text{ PE-Ci} / 0.52 \text{ PE-Ci} = 0.076$$

For “Aircraft Crash into TRU Waste Staging Area,” likelihood of an aircraft crash into one or a few containers containing less than 5 PE-Ci is qualitatively believed to be less than the 1E-6/yr screening criterion from DOE-STD-3014. This is based on the following qualitative considerations:

1. The MDA B calculation is based on a conservative methodology as presented in DOE-STD-3014 and the aircraft crash history for the LANL site as of 1996. The DOE-STD-3014 is believed to be conservative for LANL, based on:

    - Aircraft crashes/accidents/incidents are recorded in two databases provided by the National Transportation Safety Board and the Federal Aviation Agency. These databases were reviewed for the events since January 1, 1980. Events prior to 1980 have less data available. Similarly, the general aviation statistics in DOE-STD-3014 did not include years prior to 1986 due to incompleteness of the data. Since January 1, 1980, 16 aircraft events were recorded near Los Alamos. (The mid-air collision in 2006 is listed twice, once for each aircraft involved.)
        - 14 of the events occurred on the airport/airstrip.
        - 1 event is listed as being off the airport/airstrip, but was reported as hitting the terrain short of the runway.
        - The other event off the airport/airstrip was a crash on Redondo Peak. This event is not an accident during an airport operation.
    - None of the 16 recorded events is a crash outside the airport due to airport operations. For comparison, DOE-STD-3014 [Ref 38] predicts that Los Alamos Airport would have 9 crashes (6 crashes during landings and 3 crashes during takeoff) in 30 years (using the airport data in the SB-DO_CALC-07-050 (32) calculation), compared to the one landing crash above. Although the Los Alamos

crash data is too sparse for meaningful numerical analysis, it does show that DOE-STD-3014 is conservative for LANL.

2. As discussed in Section 1.2.1.5 *Airports and Air Traffic*, DOE-STD-3014 does not reflect the reduced traffic at the Los Alamos airport due to the termination of routine commercial flights.
3. One or a few TRU waste containers (e.g., Standard Waste Box), total less than 5 PE-Ci, staged until shipped to the TA-54 Area G operations for disposal at the Waste Isolation Pilot Plant have a very small footprint that reduces the likelihood of an aircraft crash.
4. The amount of time that TRU waste in a SWB would be present at MDA B is relatively short, considering that there is less than six months to achieve completion of the environmental remediation excavating activities to meet the New Mexico Consent Order[1].

Based on the above, it is qualitatively judged to not represent a credible event for hazard categorization purposes for a GAA crash to impact a TRU waste staging area.

3.4.2.4.5 Conclusion

The calculations documented in MDAB-ABD-1004, Rev 1 support the adjustment of the HC3 Threshold Quantities to 5 Curies for the MDA B, based on analysis of a suite of bounding accidents, including fire, loss of confinement, and airplane crash. The analysis provides assurance that, with the increased MAR threshold, the potential consequences of an accident to workers remains below the 10 rem at 30 m HC-3 criteria. The MAR and separation distances are summarized in Table 3-8.

Table 3-8. MDA B Area MAR Limits and Separation Distances

Area	MAR Limit PE-Ci	Separation Distance (ft)				
		Excavation Area	DIF	WCSAs	Other MAR	Public Receptor
Each Excavation Area*	≤ 5	60	60	60	NA	NA**
Inactive Excavation Area***	0	20	20	20	NA	NA
DIF	≤ 5	60	N/A	60	NA	60
Waste Container Staging Area (WCSA) inside MDA B	≤ 5	60	60	60	NA	60
Waste Container Staging Area (WCSA) outside MDA B	≤.052	60	60	60	60	60

* Up to six exposed dig faces are allowed. Accident analysis requires MAR to be separated by 60 feet. Excavation areas are separated from each other based on the requirements of DOE-STD-1088-95 and NFPA 80A, unless specifically exempted.

**A separation distance between the excavation enclosure and the public boundary is not required because the distance is restricted by the physical location of the MDA B waste disposal units and DP Road.

***Inactive excavation areas have no exposed MAR.

3.4.3 Dose Calculations: One Dig Face Volume

For comparison, the following dose calculations are provided for the collocated worker (at 100m) assuming an accident involving the MAR at the dig face. 5 PE-Ci's are assumed present at the dig face.

Table 4.5.1 in DOE-STD-5506-2007, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities*, cites an ARF × RF value as 6E-5 for fire in soil/gravel, powder, and granules [Ref. 24]. DOE-STD-1120 supports the use of an ARF x RF value of 1E-6 for drops/spills. For conservatism, the ARF × RF of 6E-5 is used for these calculations. Then the source term (ST) is as follows.

ST = MAR × ARF × RF × DR × LPF = 5 × 1E-3 = 3 E-4 PE-Ci (DR and LPF are assumed as unity).

$$\text{Dose (rem)} = ST \times \chi/Q \times BR \times DCF \quad (1)$$

where

ST = 3E-4 PE-Ci
χ/Q = Atmospheric dispersion coefficient; 1.51 E-2 sec/m^3 at 100 m with 0.3 cm/sec deposition velocity

The χ/Q value was calculated from MACCS2 taken at 95% from 5 yr (2003–2007) meteorological data from the TA-53 tower [Ref. 40]

BR = breathing rate; 3.33 E-4 m^3/sec

DCF = 1.85 E+8 rem/Ci for Pu for M class (ICRP 72)

$$\text{Dose (rem) at 100 m} = 3\text{E-4 Ci} \times 1.51\text{ E-2 s/m}^3 \times 3.33\text{ E-4 m}^3\text{/s} \times 1.85\text{ E+8 rem/Ci}$$

$$= .28\text{ rem} \quad (2)$$

The dose is acceptable for co-located workers at 100 m.

3.4.4 Final Hazard Categorization Conclusions

The hazard categorization for the MDA B can be maintained as a Less than HC-3 (Radiological) facility based on allowed provisions of DOE-STD-1027-92 and DOE-STD-1120-2005 for segmentation and use of adjusted ARF × RF factors. The nature of planned activities and the fact that only a small fraction of the entire waste inventory will be exposed at any one time supports a facility hazard categorization that is less than HC-3.

The final hazard characterization recognizes the potential for discovery of higher-MAR items up to 5PE-Ci. However, assumptions listed in SB-DO:CALC-07-054 [Ref. 18] justify that the original calculated quantities of 170 g at the 90th percentile and 200 g at the 97.7th percentile are conservative in that:

(1) The calculation applies a high compaction coefficient to gloves, PPE, laboratory glassware, and debris that may not be representative of the waste disposal practices of the late-1940’s, as wastes were typically placed in cardboard boxes and dumped into the disposal trenches. No significant volume compaction at either the point of site collection or the disposal trenches has been described [Ref. 18].

(2) The total alpha surface contamination value of 30,000 dpm/100 cm^2 as applied to the surface area of gloves and glassware in MDA B is developed from the maximum surface contamination measurement of 10,000 cpm described in Wenzel et al. [Ref. 17], and the input to the calculation approaches this maximum. Other objects were removed from the disposal cell that yielded no surface contamination above background. Common laboratory and site disposal practices in the 1940’s probably included significant quantities of non- or slightly-contaminated trash to the waste containers bound for MDA B. The practice of discarding consumables that are potentially contaminated, but likely not, continues today.

(3) The soil contamination factor is applied to the entire estimated waste trench volume of MDA B. The documented practice at the time was to place clean soils over the waste materials, and not all of these soils would have been affected by dry materials such as building demolition debris.

(4) The total alpha surface contamination value is solely attributed to Pu-239.

(5) Approximately 1,300 L of solution in intact bottles are assumed to be present exceeding the 1940's Pu-239 discard limit of 1 E-3 g/L. Some of the solutions may not have contained plutonium at all. Given past handling and disposal practices, it is likely that many of the solutions have leaked from broken or damaged containers and has integrated the associated plutonium inventory to the soil and interstitial fill matrix, contributing to the levels presented in Wenzel et al. [Ref. 17].

DOE-STD-1120-2005 recognizes that waste materials or contamination, such as that at MDA B, may be buried or distributed unevenly over a large area and is not subject to dispersive forces until it is exhumed. The MDA B project will retrieve and manage buried wastes that possess inherent uncertainties in the volume, distribution, and type of contamination. Although the pre-excavation characterization will reduce the uncertainties through sampling and analysis of soil and waste materials, the project can additionally reduce the consequences of hazards and accidents by placing physical limits on the MAR, which will preserve the below-HC-3 determination. These physical limits include limits on waste retrieved in the excavation areas, based on real-time monitoring, as well as MAR limits on staging of waste materials. The MAR and separation distances for the distinctive MDA B areas to preserve the final hazard categorization are summarized in Table 3-8. The distance limits preclude events in one area from affecting other areas.

The 60-ft separation distances cited in Table 3-8 are based on fire hazard analysis, aircraft crash, and blast zone distance. These considerations minimize or prevent the likelihood of fire propagation between MDA B structures and activities (dig faces, DIF, FL, and support trailers), ensuring that an aircraft crash, fire, or any other accident will not involve hazardous materials in more than one work area, and minimizing the exposure of the public and collocated workers to hazardous materials from a postulated release from a given work area. The distances between the dig faces and the public boundary are restricted by the physical location of MDA B and DP Road.

Summary

MBA B is classified as a Less Than HC-3 or Radiological and a Low Chemical Hazard site. There are no explosives (i.e., ordinance, blasting caps, detonators, primers, or devices designed to explode) present at the MBA B site. There are no biological materials at the MBA B site.

3.5 Hazard Evaluation

3.5.1 Beryllium Exposure to Workers and Public

Beryllium (Be) with 1-lb powder inventory is screened out in Appendix B. However, because of the health hazard of chronic beryllium disease and the 10 CFR 850 Rule, *Chronic Beryllium Disease Prevention Program* [Ref. 14], Be exposure is evaluated in the unlikely event of a major fire scenario. The total Be inventory (1 lb) is assumed to be present in a localized area and available for release in a plume to the receptors (workers and public).

Appendix C provides detailed information on the protective action criteria (PACs; AEGL/ ERPGs/ TEELs) for Be, airborne release fraction/respirable fraction (ARF/RF) values, chemical dispersion calculations, and their relevance to regulatory requirements to protect the workers and public. A brief summary follows.

Beryllium concentrations (mg/m^3) at 100 m and 30 m (20 m, public) are orders of magnitude lower than the ERPG-1 value of 0.01 mg/m^3, indicating no concern for the workers or the public. The Environmental Protection Agency (EPA) 40 CFR 61 subpart C [Ref. 41] has set a Be air quality emission standard of 0.01 µg/m^3, to protect the public (no expected chronic beryllium disease). This emission limit is averaged over a 30-day time-weighted average (TWA), which is equivalent to 28.8 µg/m^3 in a 15-min TWA period. The calculated Be concentration of 0.068 µg/m^3 at 30 m (20m, public) is orders of magnitude lower than 28.8 µg/m^3, which implies that the public is well protected, and so are non-involved workers at 100 m.

For involved workers, the occupational exposure threshold limiting value (TLV) on 8-hr TWA is 2.0 µg/m^3. However, 10 CFR 850, *Chronic Beryllium Disease Prevention Program,* Final Rule [Ref. 14], Section 850.23, requires a protection level at an exposure of 0.2 µg/m^3 for the workers in the worker's breathing zone by personal monitoring to further reduce or prevent the potential for chronic beryllium disease. This guideline coupled with best practices and procedures such as P 101-21, *Chronic Beryllium Disease Prevention Program* [Ref. 43], the beryllium monitoring program, worker training, work process control, and emergency preparedness, provide an additional safety margin to protect the involved workers.

3.5.2 Results of Unmitigated Chemical and Radiological Hazards Evaluation

The Hazards Analysis (Appendix D) summarizes the results of the hazard evaluation, which utilizes a modified *What-if/*hazards analysis approach to understanding the hazard scenarios and selecting the appropriate controls for the prevention and/or mitigation of a specific hazard scenario. The what-if/ hazards analysis tables are organized by MDA B activity and qualitatively consider the frequency, consequence, and risk associated with each hazard scenario with respect to the public, collocated worker, and worker.

Similar hazard scenarios that are evaluated on one or more of the tables are not specifically evaluated for all applicable activities. However, the evaluated scenarios were chosen to bound the consequences and control set selection for those activities that are not evaluated.

The FSP does not require evaluation for the public. However, because the distance to the site boundary is only 20 m, public consequences are considered.

The frequency estimates of occurrence of the accidents considered in Appendix D typically are consistent with DOE practices for evaluation of safety at facilities that typically have a 50-yr life span. The MDA B project has a minimum duration (<l year), so the frequency estimates are based on the probability that the scenario will occur during the MDA B project. For example, the release of the chemicals that exceed TEEL-2 is considered frequency category U (unlikely), because these significant events are only a portion of all scenarios that may occasionally release any quantity of the larger array of chemicals listed in Appendix B.

From Appendix D, there are no scenarios that result in an unmitigated risk to the public of greater than III. For the worker and collocated worker, most of the scenarios in the categories of Fire, Loss of Confinement, Explosion/Deflagration and Radiation Exposure result in unmitigated risks of II. One scenario (E3 – A mechanical failure of equipment results in a gas cylinder leak and subsequent explosions and fire) imposes a risk of I to the worker.

Although MDA B is a low hazard chemical facility, an additional analysis was performed to ensure that sufficient controls are in place to protect the public from chemical hazards. This analysis was based on the inventory in Appendix B, augmented by three chemicals that were released at low concentrations when a container was breached on October 27, 2010, as documented in ORPS report number NA-LASO-LANL-DPWEST-2010-0008 [Ref. 44]. These three chemicals were naphthalene, chloroethane, and isopropyl alcohol, none of which were in the original inventory.

This analysis was more conservative than the one that was done for the purpose of chemical classification because:

- The screening was done against PAC-2 levels instead of PAC-3 levels.
- Containers were assumed to contain the maximum container size, instead of the 5% assumed for chemical classification.
- Meteorological conditions were assumed to be F stability, 1 m/sec wind speed.

PAC-2 levels are defined as the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape.

The analysis was less conservative than the one that was done for the purpose of chemical classification in that the airborne concentrations were modeled at 30 m instead of 20 m, because analytical methodology and regulatory precedent is limited to distances of no less than 30 m. However, the additional conservatism in the analysis, as listed above, compensates for the increased distance. Reactions or interactions of chemical mixtures are evaluated by general class (instead of an exhaustive permutation of chemical interactions) to identify reaction products that might require controls. These evolved reaction products are not quantified and compared to TEEL-2 limits, but are qualitatively considered for adequacy of controls.

The results of this analysis are given in Appendix E.

A subset of 48 chemicals was determined to have the potential to exceed PAC 2 levels at 30 m. These chemicals are presented in Table 3-9, grouped according to form.

3.5.3 Results of Mitigated Hazard Evaluation

Appendix D also identifies the controls that will prevent or mitigate each hazard scenario. The mitigated hazard evaluation is performed to determine the controls required to protect the worker and the public from both radiological and chemical hazards. As discussed above, for each hazard scenario analyzed, the frequency of occurrence, public and worker consequences, and risk ranking were qualitatively estimated for the uncontrolled (or unmitigated) case using the matrices presented in Section 3.1. Then safety controls (SMPs) that could reduce the scenario frequency or consequences were evaluated as to their effectiveness in preventing or mitigating the hazard scenario. Controls which prevent or mitigate hazard scenarios with high consequences are those determined to be most important for safety.

The final step was to estimate the controlled frequency and consequences considering the credited safety controls. To reduce the frequency by one bin, two preventative administrative controls or one engineering control is required; to reduce the consequence by one bin, two mitigative administrative controls or one engineering control is required; and to reduce the consequence by two bins, two mitigative administrative controls, and one engineering control are required.

All scenarios are mitigated to a risk of III or IV. Hazard scenarios with high or moderate consequences to either the collocated worker or worker are prevented or mitigated through SMPs and specific elements of the SMPs. Assumptions are preserved according to Section 4.0.

The results of this analysis are based on the critical assumption regarding the limits for MAR and spacing of operations, as they limit the amount of hazardous material available for release. The spacing requirements limit the accident from propagating from one work area to another. The fact that the MDA B MAR is buried, and only a portion can be exhumed at any one time in a given area, limits the availability of the entire MDA B MAR inventory. These specific controls, coupled with other administrative controls, provide multiple barriers to the workers and the public and provide defense-in-depth protection.

The methods to detect and/or mitigate the consequences from release of chemicals that could exceed PAC-2 levels at 30 m are given in Table 3-9.

Table 3-9 MDA B Chemicals Potentially Exceeding PAC 2 Concentrations at 30 m

Chemical	Detection or Control[1]	Comments[2]
Gases		
Acetylene	VOC monitor	Visual detection of gas cylinder
Liquids		
Ammonium hydroxide	Monitor	
Bromine	Monitor	
Chromic acid (chromic trioxzide)	Acid monitoring	
Ethyl Ether	VOC monitor	
Hydrochloric acid	Acid monitoring	
Nickel Carbonyl	Violent reaction risk – infrared monitoring at digface CO monitor	Reacts with air to form nickel oxide and carbon monoxide. Continued presence in landfill considered unlikely
Nitric acid (conc)	Acid monitor	Strong oxidizer
Phosphorus trichloride	Infrared monitor at digface Acid monitor	Forms hydrogen chloride in air Exothermic with water High VP
Thionyl chloride	Acid monitors	Reacts with water to release HCL and SO_2
Powders[3]		
Ammonium bisulfate	HEPA filtration	Reducer
Arsenic and arsenic compounds	HEPA filtration	
Cadmium metal	HEPA filtration	Reducer
Calcium nitrate	HEPA filtration	Reducer
Cupric acetate	HEPA filtration	
Cupric chloride	HEPA filtration	
Cupric oxide	HEPA filtration	

Table 3-9 MDA B Chemicals Potentially Exceeding PAC 2 Concentrations at 30 m

Chemical	Detection or Control[1]	Comments[2]
Cupric sulfate	HEPA filtration	Explosion hazard
Ferric ammonium oxalate	HEPA filtration	Ferric ammonium oxalate
Ferric oxalate	HEPA filtration	Ferric oxalate
Hydroxyl-amine	HEPA filtration	
Iodic Acid	HEPA filtration Acid monitor	Acts as a reducer to produce iodine.
Lead bromide	HEPA filtration	
Lead chloride	HEPA filtration	
Lead chromate	HEPA filtration	
Lead carbonate	HEPA filtration	Lead carbonate
Lead iodide	HEPA filtration	
Lead oxide (yellow)	HEPA filtration	
Lead nitrite	HEPA filtration	Oxidizer
Lead nitrate	HEPA filtration	Strong oxidizer
Lead oxalate	HEPA filtration	
Litharge (lead mono-oxide)	HEPA filtration	
Phosphoric anhydride	HEPA filtration	Tends to form phosphoric acid Violent reactions with water, alcohols, metals strong bases
Phosphorus oxychloride	HEPA filtration	Reacts with water to form HCl
Phosphorus trichloride	HEPA filtration	Strong oxidizer
Potassium dichromate	HEPA filtration	Oxidizer
Potassium hydroxide	HEPA filtration	
Selenium	HEPA filtration	Reducer
Selenium compounds	HEPA filtration	Reducer
Sodium chromate	HEPA filtration	Sodium chromate
Sodium cobalt nitrate	HEPA filtration	Strong oxidizer
Sodium dichromate	HEPA filtration	Strong oxidizer

Table 3-9 MDA B Chemicals Potentially Exceeding PAC 2 Concentrations at 30 m

Chemical	Detection or Control[1]	Comments[2]
Sodium fluoride	HEPA filtration	Reacts with acids to produce HF
Sodium hydroxide (also listed as caustic soda)	HEPA filtration	Exothermic reaction with water
Sodium nitrite	HEPA filtration Infrared monitoring at digface	Oxidizer
Thallium oxide	HEPA filtration	
Yellow phosphorus	HEPA filtration Infrared monitor Fire suppression	Ignites in air to form diphosphorus deca-oxide Reducer
Zinc sulfate	HEPA filtration	
Reaction or decomposition products[4]		
Ammonia	Chemical Monitor	
Bromine	Chemical Monitor	
Chlorine	Infrared monitor Chemical Monitor ing	
Hydrogen cyanide	Acid Monitor	
Hydrogen fluoride	Acid Monitor	
Hydrogen sulfide	Chemical Monitor	
Phosphine	Chemical Monitor	

[1]For chemical releases detected through monitoring, the mitigation is provided through emergency response procedures.
[2]Note: Interaction between oxidizer and reducer may be violently exothermic. Detection is through an infrared monitor at the dig face, and mitigation is provided through emergency response procedures.
[3]Hazard level conservatively assumes particulate form. If dissolved in water (e.g., by dust suppression water) dispersability would dramatically decrease.
[4]Chemicals generated through decomposition or reaction may be monitored following detection of an exothermic reaction at the dig face.

3.5.4 Planned Design and Operational Safety Improvement

There are no planned improvements as a result of the hazards evaluation. The MDA B project is a temporary activity that was scheduled for 2–3 yr, with less than one year remaining of activity.

4.0 Hazard Controls

4.1 Introduction

This section presents the summary of the controls to preserve the assumptions that form the basis for the hazard analysis results shown in Appendix D. The controls ensure the safe operation of the MDA B project.

The controls consist of the following:

- Operating limits necessary to maintain the operations within the hazards analysis,
- Requirements for passive engineered controls and,
- Commitments to safety management programs (SMPs).

The regulatory requirements that establish the basis for control selection and their implementation in the MDA B document include the following:

- 29 Code of Federal Regulations 1910.120, *Hazardous Waste Operations and Emergency Response (HAZWOPER)* [Ref. 20]
- 10 Code of Federal Regulations 835, *Occupational Radiation Protection*
- Department of Defense Standard 6055, *DOD Ammunition and Explosives Safety Standard* [Ref. 45]

The following priority is applied during the analysis of selection for safety controls:

- Elimination of Hazard (or substitution is possible)
- Engineered Controls (Passive then Active)
- Administrative Controls as follows:
    - Integration of Operating Limits to ensure key parameters to support analysis are maintained
    - Implementation of Management Programs to provide infrastructure to safe operations

The selected hazard controls for the MDA B project consist of the following:

- Operating limits necessary to maintain the operations within the hazard analysis.
- Operating limits protect the key assumptions to protect segmentation during remediation activities.
- Commitments to SMPs.

4.1.1 Operating Limits

4.1.1.1 Purpose

The purposes of the operating limits (OLs) are to state the provisions relating to organization and management, procedures, record keeping, review and audit, reporting, and safety control programs necessary to ensure safe operations at MDA B. Unless otherwise stated, these OLs are applicable to MDA B at all times.

4.1.1.2 Compliance

The Facility Operations Director, through the Operations Manager or designee, is responsible for ensuring that the requirements are met. Compliance is demonstrated by the following:

- Operating within the OLs and associated VRs during their applicability.
- Operating within the actions of OLs when required.
- Performing VRs when required.
- Establishing, implementing, and maintaining the required ACs.

4.1.1.3 Noncompliance

Failure to comply with a programmatic AC (SMP) is a noncompliance when either the AC (SMP) is directly violated, or the intent of a referenced program is not fulfilled.

Emergency actions that depart from an approved OL may be taken when no ACTIONS consistent with the OL are immediately apparent, and when these ACTIONS are needed to protect workers, the public, or the environment from imminent and significant harm. Such ACTIONS must be approved by a person in authority as designated in the OL.

4.1.2 Safety Management Programs

Safety Management Programs (SMPs) ensure that a facility is operated in a manner that adequately protects workers, the public, and the environment. The SMPs include configuration management, quality assurance, maintenance of safety systems, training and qualification, radiological protection, fire protection, waste management, emergency preparedness, criticality, and conduct of operations. They are required by DOE or another regulatory authority, or committed to in a contractor’s safety basis description, and will be adhered to for a scope of work by a facility or site in support of the work.

4.1.3 Organization and Management Responsibilities

This section identifies and describes management responsibilities, including those for the Responsible Associate Director (RAD), FOD, and tenant organizations.

General responsibilities for managing the MDA B project/site are identified and described in:

- P 313.3, *Roles, Responsibilities, Authorities, and Accountability*

Responsibilities and requirements for coordination of facility support services are identified and described in:

- P 312-2, *Institutional Service Model for Facility Management and Operations*

Responsibilities and authorities for safety basis development, implementation, and maintenance are identified and described in:

- PD 110, *Safety Basis*
- SBP 111-1, *Facility Hazard Categorization and Documentation*
- SBP 113-1, *Nonnuclear Facility Safety Basis Documentation*

Note: Management responsibilities-defining documents include the successor documents to the documents listed above.

4.1.4 Abnormal Events Processes

The abnormal events process is entered according to the action statements defined in the operating limits. The process consists of:

- Daily inspection of enclosure integrity.
- Excavator refueling limited to quantities of 100 gal or under.
- Use of Type A waste containers (i.e. 55-gal drums and SWBs) to contain material meeting the definition of TRU waste.
- Restriction on lift height for Type A containers to ensure that material is not elevated above the drop limitations of the container to mitigate the consequences of a drop.
- Restore combustible percentage by volume to levels below the .8 TQ curve.

The abnormal events process may be exited when the operating limit is restored

4.2 Operating Limits

4.2.1 Material-At-Risk Limit: Excavation Area

OL 4.2.1.1: The total MAR of excavated landfill material within each excavation area including transport vehicles SHALL be $\leq$ 5 PE-Ci.

OL 4.2.1.2: One exposed dig face per enclosure.

OL 4.2.1.3: No more than six exposed dig faces operating at MDA B site at any time.

ACTIVITY APPLICABILITY: This limit is applicable at all times.

AREA APPLICABILITY: Excavation areas

ACTIONS:

Condition	Action	Completion time
A: The total MAR of excavated landfill material within each excavation area including transport vehicles is > 5 PE-Ci.	A.1 Terminate excavation activities within the affected excavation areas except those necessary to restore the MAR limit. **AND** A.2 NotifyLASO Field Operations **AND** A.3.1 After a safe and stable condition is achieved, develop a plan to disposition the high MAR object(s)/material and restore MAR limit. **OR** A.3. Submit a CAP for LASO approval	Immediately Immediately 1 day 2 days
B: Greater than one exposed dig face per enclosure.	B.1 Reduce exposed dig face to one. **AND** B.2 Develop a RAD-approved Corrective Action Plan to preclude recurrence.	Immediately Within 2 working days of discovery.
C: Greater than six exposed dig face operating at MDA B at any time.	C.1 Reduce number of exposed dig face to ≤ six. **AND** C.2 Develop a RAD-approved Corrective Action Plan to preclude recurrence.	Immediately Within 2 working days of discovery.

Basis: The constraints allow for safe operations to continue within other excavation areas based on separation distance. The time frames allow for adequate characterization and securing of the waste. The provision to bury the waste under at least three feet of soil overburden to remove material from exposed inventory ensures that High MAR material is not vulnerable to accidents for extended periods of time.

Number	Verification Requirement	Frequency
VR 4.2.1.1	Verify the MAR of landfill material within each excavation area is ≤ 5 PE-Ci, including transport vehicles.	At the beginning of each shift when the dig face is uncovered. **AND** Monthly when the dig face is covered.
VR 4.2.1.2	Verify the number of dig face to be one per enclosure.	At the beginning of each shift when the dig face is uncovered. **AND** Monthly when the dig face is covered.
VR 4.2.1.3	Verify the number of dig face to ≤ six.	At the beginning of each shift when the dig face is uncovered. **AND** Monthly when the dig face is covered.

The MAR for each MDA B activity is intentionally selected so that radioactive releases are below HC-3 thresholds and can be readily implemented without impacting excavation activities.

The MAR control restricts the total quantity of radioactive material available for accidental release. From historical data, the MAR consists mainly of uranium, Pu-239, and minor amounts of other isotopes. The MAR is tracked according to Pu-239 equivalent curies. The Excavation Area MAR limit is lower than the adjusted DOE-STD-1027 threshold quantity for HC-3 so that radioactive material releases are minimized to Radiological levels.

4.2.2 Material-At-Risk Limit: Definitive Identification Facility

OL 4.2.2: The total MAR at the Definitive Identification Facility shall be ≤ 5 PE-Ci.

ACTIVITY APPLICABILITY: This limit is applicable at all times; unknown items are not allowed in the DIF.

AREA APPLICABILITY: Definitive Identification Facility

ACTIONS:

Condition	Action	Completion Time
A: The total MAR within the DIF is > 5 PE-Ci.	A.1 Terminate DIF operations except those necessary to reduce MAR. **AND** A.2 Notify LASO Field Operations. **AND** A.3.1 Restore MAR limit. **OR** A.3.2 Submit a CAP for LASO approval.	Immediately Immediately 1 day 2 days

Basis: The constraints allow for safe operations to continue within other areas based on separation distance. The time frames allow for adequate characterization and securing of the waste. The provision to bury the waste under at least three feet of soil overburden to remove material from exposed inventory ensures that high-MAR material is not vulnerable to accidents for extended periods of time.

Number	Verification Requirement	Frequency
VR 4.2.2.1	Verify the total MAR inventory at the Definitive Identification Facility AND any MAR to be added is $\leq$ 5 PE-Ci.	Prior to receiving new material within the DIF

The DIF is located > 60 ft (18.3 m) away from other active areas. This separation distance ensures that potential accidents from one area cannot propagate or cause an accident in a separate area, and thus minimizes the consequences of radioactive or chemical releases or the effects of an explosion to the public.

4.2.3 Material-At-Risk Limit: Waste Container Staging Areas

OL 4.2.3.1: The total MAR within each WCSA inside MDAB shall be $\leq$ 5 PE-Ci.

OL 4.2.3.2: The total MAR within each WCSA outside MDAB shall be $\leq$ 0.52 PE-Ci.

ACTIVITY APPLICABILITY: This limit is applicable at all times; unknown items are not allowed in the WCSAs.

AREA APPLICABILITY: Waste Container Staging Areas

ACTIONS:

Condition	Action	Completion Time
A: The total MAR within each WCSA is > 5 PE-Ci for WCSAs within MDA B and ≥0.52 PE-Ci for WCSAs outside of MDA B.	A.1 Terminate WCSA activities, except those necessary to restore MAR limit. **AND** A.2 Notify LASO Field Operations. **AND** A.3.1 Restore MAR limit. **OR** A.3.2 Submit a CAP for LASO approval.	Immediately Immediately 1 day 2 days

Basis: The constraints allow for safe operations to continue within other areas based on separation distance. The time frames allow for adequate characterization and securing of the waste. The provision to bury the waste under at least three feet of soil overburden to remove material from exposed inventory ensures that high-MAR material is not vulnerable to accidents for extended periods of time.

Number	Verification Requirement	Frequency
VR 4.2.3.1	Verify the MAR inventory in the affected WCSA AND any MAR to be added is ≤ 5 PE-Ci for WCSAs within MDA B and ≤ 0.52 PE-Ci for WCSAs outside of MDA B.	Prior to receiving new MAR at the affected WCSA

4.2.4 Distance Limit: Excavation Area

OL 4.2.4: The distance limits for the EXCAVATION AREA shall meet the following:

1. Each Active Excavation Area SHALL be > 60 ft (18.3 m) away from any DIF, WCSAs, and any other Active Excavation Area, except for the distance between excavation areas TA-21-9 and TA-21-12 prior to 06/30/2011.

2. The dig-face for TA-21-9 must be at least 60 ft (18.3 m) away from the dig face for TA-21-12 prior to opening up the retrieval area in TA-21-9.

a. Transient combustible material in excess of 1 lb may not be staged or stored within the separation distance.

b. Only non-combustible materials or combustible materials stored within a closed metal container may be stored within the separation distance.

c. No activities that could introduce combustible or flammable material, other than maintenance, will occur within this separation distance.

3. Each Inactive Excavation Area SHALL be > 20 ft (18.3 m) away from any DIF, WCSAs, or any Active Excavation Area.

ACTIVITY APPLICABILITY: This limit is applicable at all times.

AREA APPLICABILITY: MDA B site and WCSAs within TA-21

ACTIONS:

Condition	Action	Completion Time
A. Any active excavation area is <60 ft away from any DIF, WCSA, or other active excavation area, with the exception of the distance between excavation areas TA-21-9 and TA-21-12.	A.1 Manage multiple units within 60 ft as one MAR unit. **<u>OR</u>** A.2.1 Terminate excavation activities at the affected excavation area, except those necessary to restore distance limits. **<u>AND</u>** A.2.2 Restore distances between affected excavation area and DIF or WCSA, or between affected excavation enclosures.	Immediately Immediately 8 hours
B. The distance between the dig face in TA-21-9 is < 60 ft away from the dig face in TA-21-12.	B.1 Manage the two dig faces within 60 ft as one MAR unit. **<u>OR</u>** B.2.1 Terminate excavation activities in TA-21-12, except those necessary to restore distance limits. **<u>AND</u>** B.2.2 Restore distances between dig faces at TA-21-9 and TA-21-12.	Immediately Immediately 8 hours

Condition	Action	Completion Time
C. Transient combustible material ≥ 1 lb is staged or stored between the dig face in TA-21-9 and the dig face in TA-21-12.	C.1 Remove transient combustible material	Immediately
D. Combustible waste other than in a closed container is stored between the dig face in TA-21-9 and the dig face in TA-21-12.	D-1 Remove waste.	8 hours
E. Activity that could introduce combustible or flammable material, other than maintenance is conducted between the dig face in TA-21-9 and the dig face in TA-21-12.	E-1 Cease activity	Immediately
F. Inactive excavation area is within 20 ft of any DIF, WCSAs,other inactive enclosure areas or any Active Excavation Area	F-1 Restore separation distance.	8 hours

Number	Verification Requirement	Frequency
VR 4.2.4.1	**Verify** all active excavation areas are ≥ 60 ft (18.3 m) away from the DIF, WCSAs, and other active excavation areas, with the exception of the separation distance between excavation areas TA-21-9 and TA-21-12.	When excavation area becomes active. **AND** When DIF and WCSAs are established

VR 4.2.4.2	Verify that the dig face in TA-21-9 and the dig face in TA-21-12 are separated by ≥ 60 ft (18.3 m).	Prior to excavation activities in either TA-21-9 or TA-21-12.
VR 4.2.4.3	Verify that transient combustible material stored between the dig face in TA-21-9 and the dig face in TA-21-12 does not exceed .1 lb.	Prior to each shift
VR 4.2.4.4	Verify that combustible waste other than containerized waste is not stored between the dig face in TA-21-9 and the dig face in TA-21-12	Prior to each shift
VR 4.2.4.5	Verify inactive excavation area is ≥ 20 ft from any DIF, WCSAs, and any Active Excavation Area	When inactive excavation area is established or when excavation area becomes inactive. **AND** When DIF and WCSAs are established

Separation distances between excavation areas (i.e., the excavation enclosure) are also determined to be prudent, in order to prevent the consequences from an accident within one Excavation Area from impacting another Excavation Area. An aircraft impacting an Excavation Area is first considered. The potential for aircraft crash into the MDA B is presented in SB-DO-CALC-07-050, *Frequency Estimates for Aircraft Impacts at TA-21, MDA B* [Ref. 46]. The calculation cites that the skid distance of a general aviation craft accident is 60 ft (18.3 m) or less as per DOE-STD-3014. So, 18.3 m (60 ft) is considered as a minimum separation distance.

Another bounding accident that should be considered is the spread of a fire between excavation areas. As indicated in the FHA [Refs. 19,, 34], and based on the engineering judgment of the expert fire protection engineer for the MDA B project, it was judged that a minimum of 60 ft adequately provides defensible space between the excavation enclosures; therefore, this separation distance is applied to between Excavation Areas. The implementation of this separation distance also ensures that accident scenarios would not impact multiple MDA B radioactive material inventory areas containing hazardous materials. In addition, the separation distance provides protection against fire propagation between fire areas in the event of a wildfire. Heat flux alone, given the estimated size and material construction of the enclosure, will not propagate a fire between fire areas separated by 60 ft with no intervening combustibles [Refs. 19, 34].

Each Excavation Area is located > 60 ft (18.3 m) away from other excavation areas, the DIF, and WCSAs. The separation distance ensures that potential accidents from one area cannot propagate or cause an accident in the other MDA B work areas. The separation distance, in combination with the MAR limit, ensures that potential doses to the public are minimized. A separation distance requirement between the excavation area and the MDA B vehicle transport routes is not selected due to the transitory nature of vehicles as they pass by the Excavation Area, coupled with controls implemented through a Transportation Plan which cites requirements on the methods for the movement of waste within MDA B and the east staging area. Inactive excavation areas are areas with no ongoing excavation activities and no exposed MAR. These may be within 20 ft of other structures.

A one-time excursion has been authorized by the LANL Fire Protection Engineer to provide a 60-ft separation measured from the dig face of TA-21-9 to the dig face of TA-21-12, applicable only prior to opening up the retrieval area in TA-21-9 and prior to COB 6/30/10 [Ref. 47]. During this one-time excursion, no transient combustible materials may be stored or staged within the 60-ft separation zone, combustible waste stored within this separation zone must be within a closed container, and no activities other than maintenance will occur within this separation zone.

The provision to bury the waste under at least three feet of soil overburden to remove material from exposed inventory ensures that high-MAR material is not vulnerable to accidents for extended periods of time.

4.2.5 Reserved

4.2.6 Distance Limits: Waste Container Staging Area and DIF

OL 4.2.6: The distance limits for all Waste Container Staging Areas are:

1. WCSAs shall be > 60 ft (18.3 m) away from other WCSAs, from the DIF, from the nearest public receptor, and from other MAR within TA-21.

2. The DIF shall be > 60 ft (18.3 m) away from the nearest public receptor.

ACTIVITY APPLICABILITY: This limit is applicable at all times.

AREA APPLICABILITY: MDA B site and WCSAs within TA-21

ACTIONS:

Condition	Action	Completion Time
A. The WCSA is ≤ 60 ft (18.3 m) away from other WCSAs, the DIF, the nearest public receptor or from other MAR.	A.1 Manage all MAR-containing units within 60 ft of one another as one MAR unit	Immediately
	OR	
	A.2.1 Terminate all activities in the WCSA except those necessary to restore distance limits.	Immediately
	AND	
	A.2.2.1 Restore distance(s).	8 hours
B. The DIF is < 60 ft	B. 1 Terminate all activities in the	

Condition	Action	Completion Time
(18.3 m) away from the nearest public receptor.	DIF except those necessary to restore distance limits. **AND** B.2 Restore distance(s).	Immediately 8 hours

Number	Verification Requirement	Frequency
VR 4.2.6.1	Verify the WCSA is ≥ 60 ft (18.3 m) away from the DIF(s), from other WCSAs, from the nearest public receptor and from other MAR within TA-21.	When WCSA or DIF is placed into position. **AND** Prior to establishing WCSA.
VR 4.2.6.2	Verify the DIF is ≥ 60 ft (18.3 m) away from the nearest public receptor.	When DIF is placed into position.

All WCSAs are located > 60 ft (18.3 m) away from the DIF, from public receptors, the Excavation Areas within MDA B, and from other MAR within TA-21. The DIF is 60' away from the nearest public receptor. These separation distances ensure that potential accidents from one area cannot propagate or cause an accident in a separate area. Also, the separation distance in combination with the MAR limits ensures that the potential radioactive dose (or chemical) consequences to the public due to accidental releases at the WCSAs are minimized to the extent practical.

4.2.7 Overpressure Limit

OL 4.2.7: The blast pressure shall be limited to 1.2 psig at the site boundary by:

- Establishing an exclusion area 60 ft (18.3 m) around the dig face.

  AND/OR

- Designing and installing an engineered control.

ACTIVITY APPLICABILITY: During excavation of landfill material or assessment of unknowns

AREA APPLICABILITY: Excavation Areas

ACTIONS:

Condition	Action	Completion Time
A. The exclusion area extends less than 60 ft (18.3 m) from the dig face **AND** the engineered control is not installed	A.1 Terminate all activities in the affected enclosure. **AND** A.2.1 Restore distance. **OR** A.2.2 Restore the engineered control.	Immediately Prior to any excavation activities

Number	Verification Requirement	Frequency
VR 4.2.7	VERIFY the exclusion area extends at least 60 ft (18.3 m) from the dig face OR the engineered control is installed.	Prior to excavation operations

The public and public structures must be protected from the effects of an explosion caused by encountering an unknown item that may be shock-sensitive or explosive. The bounding explosive event is anticipated to be a 6-lb-TNT-equivalent explosion from a 9-L bottle of ether with 100,000 ppm (10%) peroxide. Ether was used in the early plutonium purification process in 1945 and 1946. There was no specific ether waste stream, as the resulting solutions were aqueous in nature and the disposition of the aqueous wastes is well documented. A 9-L bottle of reagent-grade chemical may have been improperly disposed in MDA B with other laboratory wastes in the earliest waste disposal units that date to 1945–1946. The detonation of a 9-L bottle is interpreted to bound other detonations or deflagrations that may result from reactions of other chemicals.

Experiments conducted at LANL in support of the MDA B project indicated that an overpressure wave from a 6-lb-TNT-equivalent explosion is effectively mitigated by distance and shielding [Ref. 39]. At distances greater than 70 ft (21 m), the overpressure is calculated to be less than 1.0 lb per square inch (psi). An overpressure of 1.2 psig is considered to cause only minor injuries to the persons or damage to public buildings (DoD 6055.9, *Ammunition and Explosive Safety Standards*) [Ref. 45]. Shielding created by barriers such as the fabric of the excavation enclosure was demonstrated to reduce the overpressure by 25%; thus, at distances as close as 50 ft (15 m), the overpressure wave would be mitigated to less than 1.0 psig by the presence of the enclosure fabric [Ref. 48]. Other controls, such as the dig face configuration, will contribute to lowering the overpressure [Ref. 48].

Overpressures are also produced by a chemical explosion, and the peak overpressures decay rapidly as a function of distance. Overpressure calculations show that SB-DO:CALC-08-011 [Ref. 16] for the unmitigated 6-lb-TNT-equivalent detonation, peak overpressure exceeds 13 psig and decreases very rapidly over the first 10 m (30 ft); a 2.3-psig overpressure is calculated to occur at 13.3 m (44 ft) from the detonation site. Based on DoD 6055.9 [Ref. 42], personnel exposed to the overpressure are not expected to be seriously injured at 2.3 psig; therefore, this is established as the worker protection criterion.

According to DOD 6055.9, *Ammunition and Explosive Safety Standards* [Ref. 42], personnel in the open at this overpressure are not expected to be injured from the blast overpressure. For instance, at a blast overpressure of 3 psig, there is a 1% probability that a person will experience eardrum rupture, the eardrum being the most conservative criterion for worker protection.

4.2.8 Blast Fragment Energy Limit

OL 4.2.8 The energy of fragments sized ¼ in. by ¼ in, by ½ in, from an inadvertent shock-sensitive reaction with an initial velocity of 1 km/s, shall be maintained to less than 58 ft-lb by:

1. Establishing an exclusion area 60 ft (18.3 m) around the dig face.

   AND/OR

2. Designing and installing an engineered control.

ACTIVITY APPLICABILITY: During excavation activities

AREA APPLICABILITY: Excavation Areas

ACTIONS:

Condition	Action	Completion Time
A. The exclusion area is less than 60 ft (18.3 m) away from the dig face **AND** the engineered control is not installed.	A.1 Terminate all activities in the affected enclosure **AND** A.2.1 Restore distance. **OR** A.2.2 Restore the engineered control	Immediately Prior to any excavation activities

Verification Requirements

The following verification requirements shall be performed and documented:

Number	Verification Requirement	Frequency
VR 4.2.8.1	**Verify** the exclusion area is greater than 60 ft (18.3 m) away from the dig face **OR** the engineered control is installed.	Prior to excavation operations

The 6–lb-TNT-equivalent detonation is postulated from a 9-L bottle of 10% peroxide/ether solution that may be buried within the landfill material. The peroxide is a shock-sensitive

material that may detonate upon movement. Calculations of primary fragments from the 9-L bottle establish a conservative energy of glass fragments that could be expelled from the glass container during detonation. The shielding must be capable of reducing the energy of these fragments to below the Department of Defense (DoD) 6055.9 [Ref. 45] damage threshold (SB-DO:CALC-08-011) [Ref. 16].

The fireball diameter associated with a 6-lb-TNT-equivalent detonation is limited to less than 2 m from the point of the detonation. The blast or fragment PPE is designed to withstand effects of a fireball and limit worker exposure to heat flux less than 12.56 kW/m^2 (0.3 $Cal/cm^2/sec$) DoD 6055.9 [Ref. 48]. Personnel shielding for workers up to 60 ft (18.3 m) from activities involving unknown items will not need to be positioned within 2 m of the activity, and personnel shielding does not need to be designed to withstand fireball effects.

Generated fragments are classified as either primary or secondary and have energies greater than 58 ft-lb [Ref. 45]. Secondary fragments travel slower than primary fragments because initial energy transferred to secondary fragments is much less. McAfee et al. [Ref. 39] calculates that the distance that primary fragments retain sufficient energy to remain hazardous is approximately 54 ft. This distance is from an unmitigated detonation and does not account for interaction of the fragments with any potential obstacles. As such, workers within 60 ft of a potential detonation site do not incur injury from generated fragments [Ref. 48].

The 60 ft (18. 3 m) distance established for hazardous fragments is also applied to overpressure protection requirements for site workers. That is, workers within 60 ft of a potential detonation site must be protected from fragments and blast overpressures. According to DoD 6055.9 [Ref. 45], personnel in the open at this overpressure are not expected to be injured from the blast overpressure. For instance, at a blast overpressure of 3 psig, there is a 1% probability that a person will experience eardrum rupture, the eardrum being the most conservative criterion for worker protection.

4.2.9 Limits on Amount of Contaminated Combustibles in Waste

OL 4.2.9 Amount of contaminated combustibles in waste shall be limited to below the .8 TQ Ratio curve in Figure 4-1:

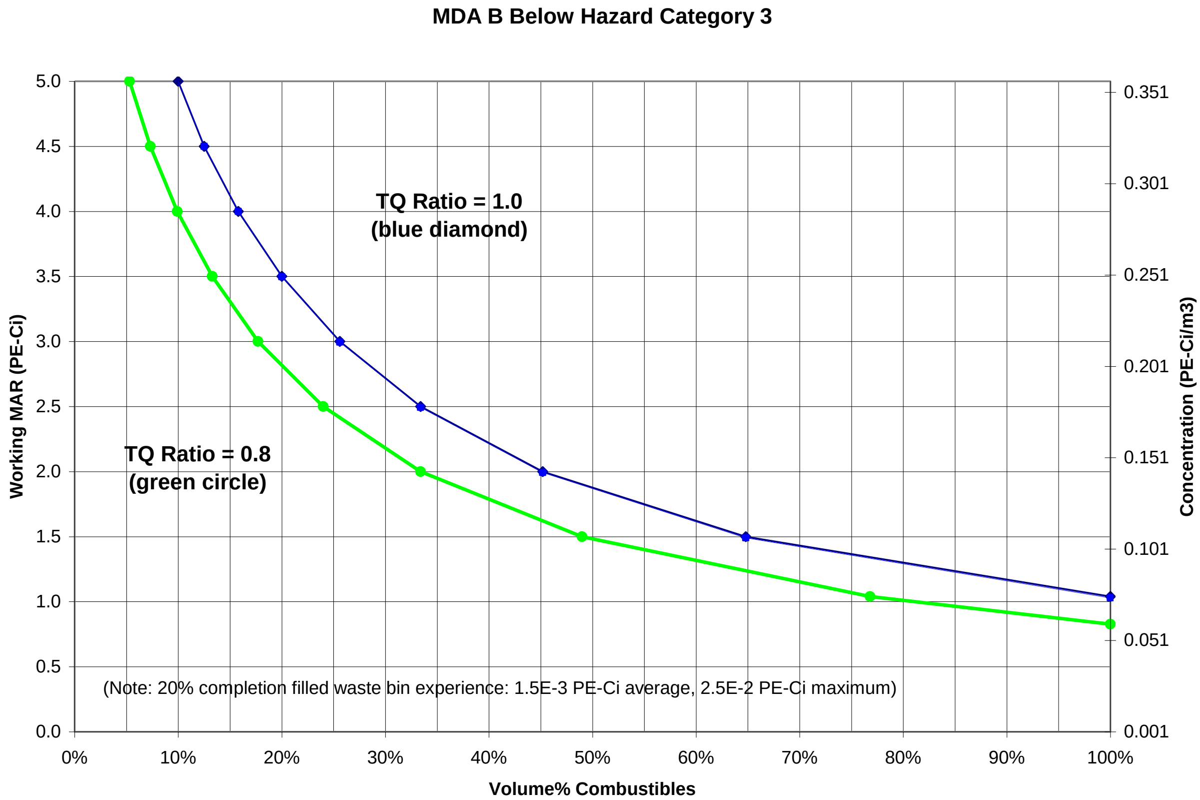

Figure 4-1 MDA B Below Hazard Category 3 Control of %-Contaminated Combustibles Exposed

ACTIVITY APPLICABILITY: During excavation

AREA APPLICABILITY: Excavation Areas

ACTIONS:

Condition	Action	Completion Time
A. Estimated amounts of combustibles in waste in combination with exposed MAR exceed the TQ ratio of 0.8	A.1 Terminate all activities in the affected enclosure **AND** A.2 Enter the Abnormal Events Process (section 4.1.4)	Immediately 24 hours

Verification Requirements

The following verification requirements shall be performed and documented:

Number	Verification Requirement	Frequency
VR 4.2.9.1	**Verify** the amount of contaminated combustibles in waste is below the .8 TQ curve in Figure 4-1	While the waste container is being loaded.

The amount of contaminated combustibles in waste is an important parameter in the ARF × RF should a fire occur. The justification for an adjusted HC3 TQ is based on the assumption that the amount of contaminated combustibles does not exceed the 1.0 TQ curve in Figure 4-1. An operational limit of .8 TQ curve will ensure that the MDAB does not pose an unacceptable risk to the public, collocated workers or workers.

4.2.10 Limits on the Amount of Fuel in any Single Vehicle or Piece of Equipment

OL 4.2.10: Amount of fuel in any single vehicle or piece of equipment within 60 ft of exposed MAR shall not exceed 200 gal when exposed MAR is $\geq$ 0.52 PE Ci.

ACTIVITY APPLICABILITY: All activities

AREA APPLICABILITY: MDA B site and WCSA storage sites within TA-21

ACTIONS:

Condition	Action	Completion Time
A. Amount of fuel in any single vehicle or piece of equipment within 60 ft of exposed MAR exceeds 200 gal with exposed MAR ≥ 0.52 PE-Ci	A.1 Terminate all activities in the affected enclosure or activity area. **AND** A.2 Remove excess fuel.	Immediately 24 hours

Number	Verification Requirement	Frequency
VR 4.2.10	VERIFY that vehicles and equipment within 60 ft of exposed MAR >0.52 PE-Ci contain less than 200 gal fuel each	When equipment enters MDAB

The amount of fuel involved in a pool fire is an important parameter in determining the size and intensity of the fire. A limit on pool fire size is necessary to ensure that the MAR from MDA B activities does not pose an unacceptable risk to the public, collocated workers, or workers.

4.2.11 Excavation Enclosure Requirements

OL 4.2.11.1*:* Excavating of contaminated materials will be performed within an excavation enclosure, designed to meet the extreme wind Performance Category 1 requirements.

OL 4.2.11.2: Excavating of contaminated materials will be performed within an excavation enclosure with an operational HEPA-filtered ventilation system.

OL 4.2.11.3: Excavating of contaminated materials will be performed within an excavation enclosure with an operational fire suppression system.

OL 4.2.11.4: Excavating of contaminated materials will be performed within an excavation enclosure with an operational monitoring system for airborne radioactive material.

OL 4.2.11.5: Excavating of contaminated materials will be performed within an excavation enclosure with an operational monitoring system for chemical hazards.

OL 4.2.11.6: Excavating of contaminated materials will be performed within an excavation enclosure with at least one operable infrared camera available to survey the digface.

ACTIVITY APPLICABILITY: Excavation

AREA APPLICABILITY: Excavation Areas

ACTIONS:

Condition	Action	Completion Time
A. Excavation activities occur outside of a PC-1 compliant excavation enclosure.	A.1 Terminate all excavation activities in the affected enclosure or activity area except those needed to secure the dig face. **AND** A.2 Install compliant excavation enclosure	Immediately Immediately Prior to resuming excavation activities.
B. HEPA-filtered ventilation system is not operable.	B.1 Terminate all excavation activities in the affected enclosure or activity area except those needed to secure the dig face. **AND** B.2 Secure dig face **AND** B.3 Restore HEPA-filtered ventilation system to operable.	Immediately Immediately Prior to resuming excavation activities
C. Fire suppression system is not operable.	C.1 Terminate all excavation activities in the affected enclosure or activity area except those needed to secure the dig face. **AND** C.2 Secure dig face **AND** C.3 Restore fire suppression system to operable.	Immediately Immediately Prior to resuming excavation activities
D. Monitoring system for airborne radioactive materials is not operable.	D.1 Terminate all excavation activities in the affected enclosure or activity area except those needed to secure the dig face. **AND** D.2 Secure dig face **AND**	Immediately Immediately

Condition	Action	Completion Time
	D.3 Restore monitoring system for airborne radioactive material to operable.	Prior to resuming excavation activities
E. Monitoring system for chemical hazards is not operable.	E.1 Terminate all excavation activities in the affected enclosure or activity area except those needed to secure the dig face. **AND** E.2 Secure dig face. **AND** E.3 Restore monitoring system for chemical hazards to operable.	Immediately Immediately Prior to resuming excavation activities
F. Infrared monitoring system is not operable.	F.1 Terminate all excavation activities in the affected enclosure or activity area except those needed to secure the dig face. **AND** F.2 Secure dig face **AND** F.3 Restore infrared monitoring system to operable.	Immediately Immediately Prior to resuming excavation activities

Number	Verification Requirement	Frequency
VR 4.2.11.1	VERIFY that excavation activities are occurring within an excavation enclosure designed to meet the extreme wind Performance Category 1 requirements.	Prior to initiating excavation activities in a new location.
VR 4.2.11.2	VERIFY that excavation activities are occurring within an excavation enclosure with operational HEPA-filtered ventilation system.	Daily, prior to initiating excavation activities
VR 4.2.11.3	VERIFY that excavation activities are occurring within an excavation enclosure with operational fire suppression system.	Daily, prior to initiating excavation activities

VR 4.2.11.4	VERIFY that excavation activities are occurring within an excavation enclosure with operational monitoring system for airborne radioactive material.	Daily, prior to initiating excavation activities
VR 4.2.11.5	VERIFY that excavation activities are occurring within an excavation enclosure with operational monitoring system for chemical hazards.	Daily, prior to initiating excavation activities
VR 4.2.11.6	VERIFY that excavation activities are occurring within an excavation enclosure with at least one operable infrared camera available to survey the digface.	Daily, prior to initiating excavation activities

Securing the dig face requires at least four inches of clean dirt. Note that the four inches of dirt does not allow removal of MAR from exposed inventory. The four inches of dirt does mitigate many accidents of concern, including the pool fire, assuming that fuel sources are limited to 200 gal. However, the airplane accident is an exception. The frequency associated with that accident is low (2E-4/yr for the MDA B site). The probability of an airplane crash during any given week is 4E-6. Because the exposed dig faces (given 6 active sites) are less than 25% of the site, it is acceptable risk to use four inches for securing dig faces for periods not to exceed 7 days. The enclosure of excavation activities within a PC-1 compliant structure eliminates the consequences of high winds disturbing contaminated soils. The requirement for HEPA-filtered ventilation mitigates consequences of release of airborne radioactive material. The requirement for air monitoring for radioactive material allows detection of and mitigates consequences of release of airborne radioactive material. The requirement for chemical hazards air monitoring allows detection of airborne toxic material and VOCs and reduces the risk from deflagration. Chemicals will require monitoring as described in Table 3-9. The required fire suppression system mitigates the consequences of fire. The infrared monitoring system allows early detection of incipient fires and also of exothermic chemical reactions with the potential to release hazardous chemicals.

4.2.12 MAR limits for MDA-B Facility

OL 4.2.12: The total MAR at the MDA-B facility and WCSAs within TA-21 shall be <56 PE-Ci.

ACTIVITY APPLICABILITY: All activities

AREA APPLICABILITY: MDA B site

ACTIONS:

Condition	Action	Completion Time
A. The total MAR at MDA-B site and WCSAs within TA-21 ≥56 PE Ci	A.1 Place the MAR in a safe and stable condition and stop work.	Immediately
	AND	
	A.2 Develop and implement emergency planning to address the material exceeding 56 PE-Ci as required by DOE O 151.1C .	Immediately
	AND	
	A.3 Report this event per DOE M 231.1-2 as a Group 3 (Nuclear Safety Basis), Subgroup A (TSR violations) Sequence number (2), significance Category 2	2 hours
	AND	
	A.4 Develop and submit a CAP to be approved by the LASO with concurrency by NA-10 and the NNSA Central Technical Authority.	5 days
	AND	
	A.5 Implement the approved plan	Prior to resuming work

Number	Verification Requirement	Frequency
VR 4.2.12	VERIFY that the total MAR at MDA-B and WCSAs within TA-21 is ≤ 56 curies	Weekly

4.3 Safety Management Programs

In accordance with DOE-STD-1027, MDA B is a Below Hazard Category 3, Non-Reactor Nuclear Facility (i.e., Radiological Facility). The operational controls were developed to reduce the frequency and consequence of a credible accident leading to an uncontrolled release of radioactive or hazardous materials. Because the activities that are governed by MAR administrative control (AC) requirements have potential consequences commensurate with those from radiological activities, the specific elements of the SMPs are neither safety-class nor safety-significant controls.

SBP 114-1, *Safety Basis Definitions and Acronyms*, provides the following definition for an SMP:

> *A program designed to ensure a facility is operated in a manner that adequately protects workers, the public, and the environment by covering a topic such as: quality assurance; maintenance of safety systems; personnel training; conduct of operations; inadvertent criticality protection; emergency preparedness; fire protection; waste management; or radiological protection of workers, the public, and the environment.*

SBP 113-1, *Nonnuclear Safety Basis Documentation*, provides the following guidance and instructions regarding coverage of SMPs in the FSP:

> *Guidance Note: The bulk of these programs are described in LA-UR-98-2837, Integrated Safety Management Description Document or successor, and LANL's institutional requirements as described in associated Laboratory Procedures. For applicable SMPs, reference to these documents, and a statement of commitment should be sufficient; repeating the information found in these documents should be avoided. Any approved deviations or exceptions to these requirements must be included in the description.*
>
> *In addition, the FSP must include a brief discussion, including required references, of any additional facility-specific programs that are important, but are not included in LANL's SMPs.*
>
> *Note*: LANL SD100, *Integrated Safety Management Description,* supersedes LA-UR-98-2837.

In compliance with this guidance and instructions, programs identified in this FSP are provided in the following sections. Any approved deviations or exceptions to the LANL SMPs are identified. Any additional facility-specific programs that are important, but not included in the LANL SMPs, are noted.

The SMPs listed below are those programs that were identified as controls in the Hazard Identification and Control and Hazard Analysis Results tables, or were identified as required for supporting identified hazard controls and safe operations.

4.3.1 Conduct of Operations Program (COO)

The Conduct of Operations Program implements Laboratory requirements for accepting and/or authorizing work, identifying the risks to operations, and developing and implementing the controls needed to perform the work safely and securely in order to prevent or mitigate consequences of accidents during MDA B activities. COO is conducted according to the requirements of LANL P315, *Conduct of Operations Manual* [Ref. 49], which requires planning for off-normal, abnormal and emergency conditions. The provisions for response to abnormal conditions, and discovery of an unknown item, are contained within approved operating procedures or emergency response procedures. In addition to performing work under documented procedures, under COO an excavation plan is prepared to mitigate consequences of accidental spill or energetic release from unknown items in landfill material during unknown item assessment, characterization, segregation, and disposition activities.

4.3.2 Electrical Safety Program

The Electrical Safety Program implements applicable electrical safety requirements to ensure an electrically safe workplace. Within this program, electrical systems are purchased to meet national safety standards and inspected on a regular basis.

4.3.3 Emergency Preparedness Program

The Emergency Response Program provides emergency planning and preparedness services to minimize or mitigate the consequences of an emergency incident; to protect the health and safety of workers, the public, and the environment; and ensure national security. The Emergency Preparedness Program implements Laboratory requirements on emergency preparedness planning, including activation of emergency organizations, assessment actions, notification processes, emergency facilities and equipment, protective actions, training and exercises, and recovery actions in order to mitigate the consequences of radioactive/chemical releases or explosions to the public and on worker exposure..

4.3.4 Fire Protection Program

The Fire Protection Program (FPP) minimizes the potential for the occurrence of a fire or related event, injury or loss of life from fire or related event, fires that cause an unacceptable on-site or off-site release of hazardous or radiological material that could impact the safety and health of employees, the public, or the environment, As part of this program, a *Fire Hazard Analysis* (FHA) has been prepared for MDA B and details specific measure to address the fire hazard. Important parts of the FFP at the MDAB include mitigation of the consequences of fire in the excavation area by implementation of controls for size of landfill sorting piles, distance of piles from each other, distance of piles from the excavation enclosure, and distances of dig face from the excavation enclosure, as well as minimization of transient combustibles that prevents a fire from propagating and impinging upon landfill material or the excavation enclosure. Combustible materials are further limited by the use of fire-resistant hydraulic fluid in the excavator and the use of steel decks on the flatbed transporters. The WCSAs will be routinely inspected by Fire Protection personnel. Appropriate separation distances will be established and maintained according to FPP recommendations.

The program controls ignition sources, ensures that personnel are trained to respond to fires and ensures the availability of fire detection and mitigation equipment. The mitigation equipment is inspected daily and consists of a fire suppression system that can be directed from the control room onto an incipient fire and a fire suppression system on-board the excavator. The detection system includes a camera with a heat-seeking lens that immediately would direct attention to a fire and an infrared screen in the control room that would immediately alert the operator to the presence of a fire.

4.3.5 Maintenance Program

The maintenance program ensures the performance of preventive and corrective maintenance and the assessment and inspection of the conditions of SSCs during daily work routines and at designated frequencies. This program ensures that vehicles and equipment at MDA B are maintained in a safe condition and in good working order. The Maintenance Program also ensures the effective performance and reliability of SSCs and is implemented in accordance with LANL requirements (P 950 Conduct of Maintenance, or successor document).

4.3.6 Radiological Protection Program

A Radiological Protection Program is established and maintained based on the criteria in LANL requirements P 121, Radiation Protection, or successor document). These documents comply with the requirements of 10 CFR 835, *Occupational Radiation Protection* [Ref. 50]. This program reduces the likelihood of worker exposure to radioactive material or radiation through a program that implements 10 CFR 835 and also mitigates the consequences of radiological release. An exposure monitoring and air-sampling program will be implemented and provides for the identification and quantification of airborne levels of potentially hazardous substances in order to mitigate consequences of accidental releases of radioactive or chemical materials to the public and worker exposure. The use of PPE equipment as required by the site-specific health and safety plan, radiological work permit, and integrated work documents prevents and mitigates worker exposure to radioactive and chemical hazards.

4.3.7 Training and Qualification Program:

The Training and Qualification (T&Q) Program provides workers with the knowledge and skills required to perform their assigned duties and for verifying that workers have the competence commensurate with their assigned duties and responsibilities. The T&Q program ensures that workers understand the hazards of the activity, and that the workers have adequate safety and equipment operation training. As part of the T&Q program, operators are trained on recognizing combustibles and estimating the percentage combustible content of the sort pile.

4.3.8 Configuration Management Program

A Configuration Management Program shall be implemented and maintained for MDA B in accordance with Laboratory requirements (P341, *Engineering Processes Manual,* or successor documents) [Ref. 51]. The purpose of this program is to identify and document the technical baseline of configuration controlled items and to protect equipment integrity. Laboratory requirements ensure that changes to the technical baseline are properly identified, developed, assessed (technically reviewed and validated), approved, scheduled, implemented, and documented. This program shall include maintaining operations, procedures, and any proposed test changes or experiments, within the key assumptions of the approved safety basis in order to preserve the segmentation during remediation at MDA B.

In addition, proposed changes to activities, documents, or SSCs will undergo a documented review to determine if the change could degrade required controls or invalidate safety analysis assumptions. The FOD will formally designate the individuals authorized to conduct this change review. The change review will guide a decision as to whether a proposed change requires LASO concurrence.

4.3.9 Hazardous Material and Waste Management Program

The waste management program ensures that activities related to radioactive, hazardous and mixed waste are conducted in accordance with applicable requirements and provide assurance for the safety and health of workers and the public. A Site-Specific Health and Safety Plan (SSHASP) is implemented that meets the requirements of 29 CFR 1910.120 (HAZWOPER) [Ref. 20] for radiological, chemical, biological, and physical hazards. The SSHASP provides both preventative and mitigative safety functions. For example, the SSHASP dictates the use of a blast shield during excavation activities.

The WMP dictates the use of filtered ventilation system to mitigate the consequences of accidental spill or release of particulate or organic chemical during venting, stabilization, neutralization of containerized items and chemicals.

Specific elements of this program require the implementation of operational plans which provide requirements on the prevention or mitigation of radiological and chemical hazards, as follows:

Waste Management Plan

Prior to initiating sorting of waste, a Waste Management Plan will be developed in accordance with P 409, *Waste Management* [Ref. 52], and shall be approved by the MDA B Operations Manager. The Waste Management Plan provides the methods for packaging, staging, sampling, and analyses of wastes generated during the excavation and sorting of landfill materials in accordance with applicable federal and state waste management regulations. The waste is generally assumed to be contaminated with radioactive and chemical constituents and may contain various types of industrial, hazardous, LLW, mixed LLW, TRU, and mixed TRU waste. The waste acceptance criteria of the treatment, storage, or disposal facility will generally determine packaging, characterization, and shipping requirements.

Site Traffic Control Plan

The Site Traffic Control Plan cites the requirements for transportation of waste and hazardous materials within MDA B to minimize the impacts of vehicle accidents. The plan will include requirements for securing containers during transport, approved traffic routes, and training of personnel.

Excavation Control Plan

Prior to initiating excavation activities, an Excavation Control Plan (ECP) shall be approved by the MDA B Operations Manager. The Excavation Control Plan defines the location and volumes of each batch of landfill material to be excavated, defines specific chemical hazards associated with each batch identified through sampling and analysis, and defines the process to modify the excavation areas. This prevents accidents or mitigates the consequences of hazardous material releases by limiting MAR, identifying chemical contamination in the soils, ensuring that distance requirements are met, and ensuring modification of the excavation area. The plan may include the following topics:

- Characterization data.
- Special site conditions, including special waste types (chemicals, gas cylinders, bottles, etc.).
- A diagram of excavation waste disposal unit illustrating the grid pattern.
- A calculated volume of material to be excavated, calculated by the MAR tracking data base, resulting from characterization data and acceptable knowledge.
- Projected depth of the excavation based on characterization data.

Characterization Plan

Prior to initiating sorting of landfill materials, a Characterization Plan shall be approved by the MDA B Operations Manager. The Characterization Plan provides the methodology for assessment, characterization, segregation, and the disposition of unknown items that may contain hazardous, radioactive, or toxic chemicals. It is anticipated that the excavation of landfill material will result in waste in containers, chemicals in containers, and bulk waste mixed with soil. Management and characterization of containers with unknown content shall comply with 29 CFR 1910.120 [Ref. 20]. The proper management and characterization of unknown items mitigates the potential for an uncontrolled release of these materials. This plan shall address the following elements:

- A Safe to Move assessment for containers excavated for sorting or exposed in the dig face.
- Unlabeled items, such as drums, waste, or chemical containers, are assumed to contain hazardous materials until contents are identified.
- Containers suspected of being under excess pressure, e.g., bulging or swelling drums.
- Removal of bottles and other containers found in stacks or nested groups.
- Shock-sensitive materials and compressed gas cylinders.
- Use of non-sparking tools and procedures used to ventilate drums or other waste containers.
- Special considerations for items that require stabilization or ventilation prior to movement or transfer to the DIF, including protective shielding and portable ventilation systems.
- Staging of items and use of flammable storage cabinets or other lockers prior to transfer to the DIF.
- Containerization or overpack of items for transfer out of the excavation area to the DIF or a WCSA.
- Characterization procedures for items transferred to the DIF.
- Criteria for container size, condition, or bounding conditions requiring Emergency Management and Response (EM&R) involvement.

The hazards analysis credits the Characterization Plan as an administrative control.

4.3.10 Quality Assurance Program

A Quality Assurance (QA) Program is established, implemented, and maintained at the MDABsite. The QA Program controls the integrity and reliability of SSCs and the implementation of other safety management programs. The elements of the MDA B QA Program follow LANL requirements (P 330-1, *Graded Approach for the Application of Quality Assurance Requirements*, or successor documents [Ref. 53]) including the following:

- Program Development
- Personnel Training and Qualification (including P 781-1, *Conduct of Training Manual* [Ref. 54])
- Quality Improvement
- Documents and Records (including P 1020, *Document Control and Records Management* [Ref. 55])
- Work Processes
- Design
- Procurement
- Inspection and Acceptance testing
- Management Assessment
- Independent Assessment

4.3.11 Safety and Health Program

The Safety and Health Program, as required by 10 CFR 851, *Worker Health and Safety* [Ref. 56], and 29 CFR 1910.120, *Hazardous Waste Operations and Emergency Response* [Ref. 20], shall be implemented to control worker safety and health hazards and to provide for emergency response. The controls in place to protect the workers also protect the public and the environment.

The hazards analysis credits the following elements of the Safety and Health Program:

- A Site-Specific Health and Safety Plan (SSHASP) shall be developed that meets the requirements of 29 CFR 1910.120. The SSHASP must be kept on site, shall address activity-specific health and safety hazards of each phase of site operation, and shall include the requirements and procedures for employee protection.
- An exposure monitoring and air-sampling program will be implemented and provides for the identification and quantification of airborne levels of potentially hazardous substances. Monitoring will include measurements such as organic vapors, lower explosive limits, dust concentration, radiation exposure, and infrared temperature measurements.
- The PPE requirements will be determined by the site health and safety professionals and will include assessment for self-contained breathing apparatus; supplied-air and air-purifying respirators; and chemical and flame-resistant suits, gloves, and other protective

clothing and equipment. The PPE requirements will be reflected in the SSHASP, Radiological Work Permit (RWP), and work documents (for example, IWDs).

- Filtered ventilation systems, such as portable systems and hoods, will be used to filter particulates and volatile organic compounds when venting, stabilizing, or neutralizing containerized items.
- Excavation enclosures that will be used at MDA B have the potential to release airborne radionuclides during operations that could impact Rad-NESHAPs requirements. Active high-efficiency particulate air (HEPA) filtered ventilation systems, either one-stage or single-pass (such as permanently installed systems, portable or mobile systems, and exhaust hoods) will exist at each of these facilities based on functional design requirements. The implementation and use of HEPA-filtered ventilation will be an activity-based requirement that will be controlled through standard operating procedures (SOPs) or operational checklists. To maintain the offsite external releasable radionuclide dose potential as low as reasonably achievable (ALARA) to meet the requirements of Rad-NESHAPs, the excavation enclosures will operate HEPA filtered ventilation systems during excavation operations. This approach helps minimize operations personnel exposures to nuisance and hazardous particulates.

4.3.12 Transportation Program

Transfer of radioactive waste within the MDA B facility boundary is covered under this MDA B FSP. Operations at the MDA B site do not interact with other LANL facilities, except for transfer to a waste storage, treatment, or disposal facility. The transfer of waste out of the MDA B facility boundary is subject to P151-1, *LANL Packaging and Transportation Program Procedure*..

5.0 References

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3. *Approval of Final Hazard Categorization for Material Disposal Area B, for Downgrade to Less than HC-3,* by NNSA/LASO, Los Alamos NM, March 24, 2009.

4. COR-SO-9.14.2010-282318: *Response to the Material Disposal Area B Utilization of 60-Foot Separation Distance for Excavation Areas*, K. Smith, LASO, to R. McQuinn, LANL, Los Alamos NM, September 16, 2010.

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9. *Material Disposal Area B: Process Waste Review, 1945 to 1948*, Los Alamos National Laboratory Document LA-UR-07-2379, Los Alamos National Laboratory, Los Alamos NM, August 2007.

10. SBP 111-1, *Facility Hazard Categorization and Documentation*, Los Alamos National Laboratory, Los Alamos NM, July 2009.

11. SBP 113-1, *Nonnuclear Facility Safety Documentation*, Los Alamos National Laboratory, Los Alamos NM, July 2009.

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Appendix A
Hazardous Materials Identification Worksheet (Checklist)

Table A. Radiological and Chemical Worksheet

	Hazardous Materials Identification				**Hazard Screening**	
	Hazard	**Hazard Description** Amount	Form	**Locations**	**Screen Out?**	**Yes Reasons**
I	Radiation Hazards					
1.	Radionuclides in Appendix A	Less than DOE-STD-1027 Category 3 limit	Radioactivity or soil contamination	MBA B site	No	Potential Release
2.	U-234, -235, -238 Pu-238-239, etc	Less than DOE-STD-1027 Category 3 limit	Radioactivity or soil contamination	MBA B site	No	Potential Release
II	Chemical Hazards					
II.A	Asphyxiates and Confined Spaces					
1.	Asphyxiates	N/A				
2.	Confined Space	N/A				
II.B	Irritant, Allergens, and Sensitizers					
1.		N/A				
II.C	Category 1 Chemicals					
1.	Chemicals Solid	Appendix B		MBA B site	No	Potential Release
2.	Chemical Liquid	Appendix B		MBA B site	No	Potential Release
3.	Natural gas	N/A				
II.D	Biological Agents					
		None			Yes	No material
III	Fire and Explosive Hazards					
III.A	Explosive Materials					
1.	High Explosive	None			Yes	No material
2.	Chemicals	Appendix B		MBA B site	No	Potential Release
III.B	Flammable Materials					
1.	Chemicals	Appendix B		MBA B site	No	Potential Release
III.C	Pyrophoric Materials					

Table A. Radiological and Chemical Worksheet

	Hazardous Materials Identification				Hazard Screening	
	Hazard	**Hazard Description** **Amount**	**Form**	**Locations**	**Screen Out?**	**Yes Reasons**
1.	Chemical	Appendix B		MBA B site	No	Potential Release
III. D	Oxygen & Oxidizers					
1.	Chemicals	Residual				
III.E	Product of Combustion					
1.		N/A				
III.F	Time-Sensitive Chemicals					
1.	Chemicals	Appendix B		MBA B site	No	Potential Release
IV.	Reactive Chemicals					
IV. A	Corrosive Chemicals					
1.	Chemicals	Appendix B		MBA B site	No	Potential Release
IV. B	Incompatible Chemicals					
1.	Chemicals	Appendix B		MBA B site	No	Potential Release
V.	Stored Energy					
V.A	Pressurized Gases					
1.	Chemicals	Appendix B		MBA B site	No	Potential Release
V.B	Heated Materials					
		N/A				
V.C	Cryogenic Materials					
1.	Chemicals	N/A				
V.D	Lubricants					
VI	Other Hazards			MBA B site		
1.	Fire Hazard			MBA B site	No	Potential Release of radionuclides and chemicals
2.	Electrical Hazards			MBA B site	No	Same
3	Rotational; Vibrational				No	Same
4.	Thermal Hazards			MBA B site	No	Same

Table A. Radiological and Chemical Worksheet

	Hazardous Materials Identification				Hazard Screening	
	Hazard	**Hazard Description** **Amount**	**Form**	**Locations**	**Screen Out?**	**Yes Reasons**
5.	Vehicle, Forklift, Material handling			MBA B site	No	Same
6.	Acceleration					Yes
7.	Deceleration				No	Potential Release of radionuclides and chemicals
V.D	External Events					
	Natural Phenomena	– Lightning – Seismic – Heavy snowfall – High winds – Heavy rain – Hail – Extremely high temperatures – Freezing temperatures – Wildland fire			No	Potential Release
	Other External Events	– Vehicles moving on nearby roadway – Aircraft crash			No	Potential Release

Appendix B: Chemical Inventory List in MDA B

Table B. Chemical Inventory List in MDA B

#	Chemical	CAS #	Inventory* (lb)	Type (a)	Origin (b)	Form	Revised Inventory** (lb)	TEEL-3 (mg/m^3), Rev 24	TQ at 100 m (lb)	TQ at 20 m (lb)	Exceeds TQ at 20 m
1	Nickel Carbonyl; 400 mm Hg VP	13463-39-3	1.0	PK	PK	Liq	0.050	1.12	1.90E-01	1.68E-02	**Yes**
2	Litharge, Lead oxide	1317-36-8	5.0	6MS	Inv List	Solid	0.25	108	1.67E+04	1.47E+03	
3	Beryllium metal	7440-41-7	1.0	I	Inv List	Pwdr	0.050	0.10	1.55E+00	1.40E-01	
4	Hydrochloric Acid Conc. (42%) (710 mm Hg VP)	7647-01-0	350	6MS	Inv List	Liq	17.50	149	5.49E+01	4.85E+00	**Yes**
5	Lead Oxide (yellow)	1317-36-8	20	6MS	Inv List	Pwdr	1.00	108	1.67E+03	1.47E+02	
6	Sodium dichromate	7789-12-0	5 .0	I	Inv List	Pwdr	0.25	43	6.65E+02	5.87E+01	
7	Cupric oxide	1317-38-0	5 .0	I	Inv List	Pwdr	0.250	125	1.93E+03	1.70E+02	
8	Iodic acid	7782-68-5	1.0	I	Inv List	Pwdr	0.050	2.77	4.29E+01	3.79E+00	
9	Nitric Acid conc. (90%)	7697-37-2	1,000	6MS	Inv List	Liq	50.0	237	1.95E+03	1.72E+02	
10	Calcium Chromate	13765-19-0	1.0	6MS	Inv List	Pwdr	0.050	45	6.96E+03	6.15E+02	

Table B. Chemical Inventory List in MDA B

#	Chemical	CAS #	Inventory* (lb)	Type (a)	Origin (b)	Form	Revised Inventory** (lb)	TEEL-3 (mg/m^3), Rev 24	TQ at 100 m (lb)	TQ at 20 m (lb)	Exceeds TQ at 20 m
11	Caustic Soda (sodium hydroxide)	1310-73-2	310	6MS	Inv List	Pwdr	15.5	50	7.73E+02	6.83E+01	
12	Sodium nitrite	7632-00-0	5.0	I	Inv List	Pwdr	0.25	60	9.28E+02	8.19E+01	
13	Lead Tetraoxide	1314-41-6	1.0	I	Inv List	Pwdr	0.050	108	1.67E+03	1.47E+02	
14	Lead peroxide	1309-60-0	1.0	I	Inv List	Pwdr	0.050	115	1.78E+03	1.57E+02	
15	Lead Dioxide	1309-60-0	1.0	PK	PK	Pwdr	0.050	115	1.78E+03	1.57E+02	
16	Ethyl Ether	60-29-7	14.2	PK	PK	Liq	0.71	6,000	9.29E+02	8.20E+01	
17	Lead nitrite	13826-65-8	1.0	I	Inv List	Pwdr	0.050	1.5	2.32E+01	2.05E+00	
18	Lead oxalate	814-93-7	1.0	I	Inv List	Pwdr	0.050	1.5	2.32E+01	2.05E+00	
19	Lead chromate	7758-97-6	1.0	I	Inv List	Pwdr	0.050	93.2	1.44E+03	1.27E+02	
20	Cupric acetate	142-71-2	2.0	I	Inv List	Pwdr	0.10	200	3.09E+03	2.73E+02	
21	Lead nitrate	10099-74-8	1.0	I	Inv List	Pwdr	0.050	160	2.47E+03	2.18E+02	
22	Lead Sulfate	7446-14-2	1.0	PK	PK	Pwdr	0.050	146	2.26E+03	2.00E+02	
23	Potassium hydroxide	1310-58-3	5.0	I	Inv List	Pwdr	0.250	125	1.93E+03	1.70E+02	

Table B. Chemical Inventory List in MDA B

#	Chemical	CAS #	Inventory* (lb)	Type (a)	Origin (b)	Form	Revised Inventory** (lb)	TEEL-3 (mg/m^3), Rev 24	TQ at 100 m (lb)	TQ at 20 m (lb)	Exceeds TQ at 20 m
24	Lead bromide	10031-22-8	1.0	I	Inv List	Pwdr	0.050	177	2.74E+03	2.42E+02	
25	Bromine	7726-95-6	1.0	I	Inv List	Liq	0.050	55.5	4.85E+01	4.28E+00	
26	Ammonium bisulfate	7803-63-6	1.0	I	Inv List	Pwdr	0.050	2.5	3.87E+01	3.42E+00	
27	Potassium dichromate	7778-50-9	5.0	I	Inv List	Pwdr	0.250	42.4	6.56E+02	5.79E+01	
28	Ammonium persulfate	7727-54-0	1.0	I	Inv List	Pwdr	0.050	100	1.55E+03	1.37E+02	
29	Cadmium metal	7440-43-9	1.0	I	Inv List	Pwdr	0.050	9.0	1.39E+02	1.23E+01	
30	Lead iodide	10101-63-0	1.0	I	Inv List	Pwdr	0.050	222	3.43E+03	3.03E+02	
31	Ammonium Hydroxide (28%) (560 mm Hg VP)	1336-21-6	747	6MS	Inv List	Liq	37.35	150	1.94E+02	1.71E+01	**Yes**
32	Hydrofluoric acid (40%)	7664-39-3	5.0	I	Inv List	Liq	0.25	36	1.41E+03	1.25E+02	
33	Sodium Fluoride	7681-49-4	5.0	I	Inv List	Pwdr	0.25	75	1.16E+03	1.02E+02	
34	Hydroxylamine	7803-49-8	5.0	O	Inv List	Pwdr	0.25	25	3.87E+02	3.42E+01	
35	Calcium Nitrate	10124-37-5	250	6MS	Inv List	Pwdr	12.50	125	1.93E+03	1.70E+02	

Table B. Chemical Inventory List in MDA B

#	Chemical	CAS #	Inventory* (lb)	Type (a)	Origin (b)	Form	Revised Inventory** (lb)	TEEL-3 (mg/m^3), Rev 24	TQ at 100 m (lb)	TQ at 20 m (lb)	Exceeds TQ at 20 m
36	Selenium	7782-49-2	1.0	PK	PK	Pwdr	0.050	1.0	1.55E+01	1.37E+00	
37	Cupric sulfate	7758-98-7	5.0	1.0	Inv List	Pwdr	0.25	40	6.19E+02	5.47E+01	
38	Selenium compounds	7488-56-4	1.0	I	Inv List	Pwdr	0.050	60	9.28E+02	8.19E+01	
39	Hexane	110-54-3	8.0	PK	PK	Liq	0.400	30,300	1.63E+04	1.44E+03	
40	Phosphoric anhydride	1314-56-3	5.0	I	Inv List	Pwdr	0.250	50	7.73E+02	6.83E+01	
41	Thallium oxide	1314-32-5	1.0	I	Inv List	Pwdr	0.050	20	1.24E+03	1.09E+02	
42	Benzene	71-43-2	183	6MS	Inv List	Liq	9.15	12,800	1.37E+04	1.21E+03	
43	Oxalic Acid	144-62-7	120	6MS	Inv List	Pwdr	6.00	500	7.73E+03	6.83E+02	
44	Arsenic metal and Arsenic compounds	7440-38-2	1.0	I	Inv List	Pwdr	0.050	350	5.41E+03	4.78E+02	
45	Barium Sulfate	7727-43-7	2.0	6MS	Inv List	Pwdr	0.10	500	7.74E+03	6.83E+02	
46	Phosphorus pentasulfide	1314-80-3	2.0	I	Inv List	Pwdr	0.10	250	3.87E+03	3.42E+02	
47	Phosphorus oxychloride	10025-87-3	1.0	I	Inv List	Liq	0.050	5.33	1.39E+01	1.23E+00	
48	Lead fluoride	7783-46-2	1.0	I	Inv List	Pwdr	0.050	118	1.83E+03	1.62E+02	

Table B. Chemical Inventory List in MDA B

#	Chemical	CAS #	Inventory* (lb)	Type (a)	Origin (b)	Form	Revised Inventory** (lb)	TEEL-3 (mg/m^3), Rev 24	TQ at 100 m (lb)	TQ at 20 m (lb)	Exceeds TQ at 20 m
49	Sodium cobalt nitrate	13600-98-1	1.0	I	Inv List	Pwdr	0.050	15	2.32E+02	2.05E+01	
50	Acetylene	74-86-2	8.0	6MS	Inv List	Gas	0.400	6,000	9.28E+02	8.19E+01	
51	Zinc chromate	13530-65-9	1.0	I	Inv List	Pwdr	0.050	52.9	8.18E+02	7.22E+01	
52	Zinc Sulfate	7733-02-0	1.0	PK	PK	Pwdr	0.050	500	7.73E+03	6.83E+02	
53	Lead chloride	7758-95-4	1.0	I	Inv List	Pwdr	0.050	134	2.07E+03	1.83E+02	
54	Zinc phosphate	7779-90-0	1.0	I	Inv List	Pwdr	0.050	250	3.87E+03	3.42E+02	
55	Phosphorus trichloride	7719-12-2	1.0	I	Inv List	Liq	0.050	31.4	3.04E+01	2.68E+00	
56	Phosphorus pentachloride	10026-13-8	1.0	I	Inv List	Pwdr	0.050	70	1.08E+03	9.54E+01	
57	Carbon Tetrachloride	56-23-5	13.2	6MS	Inv List	Liq	0.660	3270	3.36E+03	2.97E+02	
58	Magnesia Oxide	1309-48-4	500	6MS	Inv List	Pwdr	25.0	500	7.73E+03	6.83E+02	
59	Potassium Cyanide	151-50-8	1.0	PK	PK	Pwdr	0.050	62.6	9.28E+02	8.19E+01	
60	Sodium Cyanide	143-33-9	1.0	PK	PK	Pwdr	0.050	47.1	7.29E+02	6.44E+01	
61	Iodine (Mallinckroat)	7553-56-2	52	6MS	Inv List	Pwdr	2.60	52	8.03E+02	7.09E+01	

Table B. Chemical Inventory List in MDA B

#	Chemical	CAS #	Inventory* (lb)	Type (a)	Origin (b)	Form	Revised Inventory** (lb)	TEEL-3 (mg/m^3), Rev 24	TQ at 100 m (lb)	TQ at 20 m (lb)	Exceeds TQ at 20 m
62	Cuprous sulfide	22205-45-4	1.0	I	Inv List	Pwdr	0.050	30	4.64E+02	4.10E+01	
63	Cuprous cyanide	544-92-3	1.0	I	Inv List	Pwdr	0.050	25	3.87E+02	3.42E+01	
64	Sodium thiocyanite	540-72-7	1.0	I	Inv List	Pwdr	0.050	100	1.55E+03	1.37E+02	
65	Zinc acetate	557-34-6	1.0	I	Inv List	Pwdr	0.050	500	7.73E+03	6.83E+02	
66	Aluminum Nitrate	13473-90-0	125	6MS	Inv List	Pwdr	6.25	500	7.73E+03	6.83E+02	
67	Carbon disulfide	75-15-0	10.5	O	Inv List	Liq	0.53	1490	4.65E+02	4.11E+01	
68	Potassium chromate	7789-00-6	5.0	I	Inv List	Pwdr	0.25	56	8.66E+02	7.65E+01	
69	Chloroform	67-66-3	12.3	O	Inv List	Liq	0.615	156,000	9.13E+03	8.06E+02	
70	Potassium disulfate	7790-62-7	5.0	I	Inv List	Pwdr	0.250	250	3.87E+03	3.42E+02	
71	Cupric chloride	7447-39-4	1.0	I	Inv List	Pwdr	0.050	3	4.65E+01	4.11E+00	
72	Phosphorous Pentoxide	1314-56-3	1.0	PK	PK	Pwdr	0.050	50	7.73E+02	6.83E+01	
73	Sodium hydride	7646-69-7	1.0	I	Inv List	Pwdr	0.050	10	1.55E+02	1.37E+01	
74	Sodium peroxide	1313-60-6	1.0	I	Inv List	Pwdr	0.050	10	1.55E+02	1.37E+01	

Table B. Chemical Inventory List in MDA B

#	Chemical	CAS #	Inventory* (lb)	Type (a)	Origin (b)	Form	Revised Inventory** (lb)	TEEL-3 (mg/m^3), Rev 24	TQ at 100 m (lb)	TQ at 20 m (lb)	Exceeds TQ at 20 m
75	Zinc chloride	7646-85-7	1.0	I	Inv List	Pwdr	0.050	50	7.74E+02	6.83E+01	
76	Zinc nitrate	7779-88-6	1.0	I	Inv List	Pwdr	0.050	10	1.55E+02	1.37E+01	
77	Sodium oxalate	62-76-0	5.0	I	Inv List	Pwdr	0.250	50	7.73E+02	6.83E+01	
78	Butane, 225 ft^3	106-97-8	35.1	6MS	Inv List	Gas	1.76	126,000	1.95E+04	1.72E+03	
79	Potassium ferrocyanide	13943-58-3	5.0	I	Inv List	Pwdr	0.250	59	9.12E+02	8.05E+01	
80	Potassium thiocyanate	333-20-0	5.0	I	Inv List	Pwdr	0.250	60	9.28E+02	8.19E+01	
81	Sodium nitro ferricyanide	14402-89-2	1.0	I	Inv List	Pwdr	0.050	20	3.09E+02	2.73E+01	
82	Trichloro Acetic Acid	76-03-9	1.0	PK	PK	Pwdr	0.050	150	2.32E+03	2.05E+02	
83	Hydrooidic Acid (48%)	10034-85-2	350	6MS	Inv List	Liq	17.5	627	3.19E+07	2.82E+06	
84	Stannous chloride	7772-99-8	1.0	I	Inv List	Pwdr	0.050	160	2.47E+03	2.18E+02	
85	Trichloro-ethylene	79-01-6	12.2	PK	PK	Liq	0.610	20,400	3.39E+04	2.99E+03	
86	Acetone; 180 mm Hg VP	67-64-1	4000	6MS	Inv List	Liq	200.0	13,500	8.03E+03	7.09E+02	
87	Cupric aceto arsenite	12002-03-8	1.0	I	Inv List	Pwdr	0.050	22	3.40E+02	3.00E+01	

Table B. Chemical Inventory List in MDA B

#	Chemical	CAS #	Inventory* (lb)	Type (a)	Origin (b)	Form	Revised Inventory** (lb)	TEEL-3 (mg/m^3), Rev 24	TQ at 100 m (lb)	TQ at 20 m (lb)	Exceeds TQ at 20 m
88	All Silver units	506-64-9	1.0	I	Inv List	Pwdr	0.050	129	1.99E+03	1.76E+02	
89	Magnesium powder	7439-95-4	2.0	6MS	Inv List	Pwdr	0.100	150	2.32E+03	2.05E+02	
90	Antimony metal and all compounds	7440-36-0	1.0	I	Inv List	Pwdr	0.050	50	7.73E+02	6.83E+01	
91	Barium metal and all Barium compounds	7440-39-3	1.0	I	Inv List	Pwdr	0.050	250	3.86E+03	3.41E+02	
92	Sodium bisulfate	7631-90-5	1.0	I	Inv List	Pwdr	0.050	500	7.73E+03	6.83E+02	
93	Hydrogen Peroxide	7722-84-1	29	6MS	Inv List	Liq	1.45	142	7.27E+03	6.42E+02	
94	Toluene	108-88-3	7.23	O	Inv List	Liq	0.36	16,900	6.27E+04	5.54E+03	
95	Lead phosphate	7446-27-7	1.0	I	Inv List	Pwdr	0.050	150	2.32E+03	2.05E+02	
96	Lead sulfide	1314-87-0	1.0	I	Inv List	Pwdr	0.050	500	7.73E+03	6.83E+02	
97	Lead acetate	6080-56-4	1.0	I	Inv List	Pwdr	0.050	183	2.83E+03	2.50E+02	
98	Ammonium Tartrate	3164-29-2	8.0	6MS	Inv List	Pwdr	0.40	200	3.09E+03	2.73E+02	
99	Ammonium sulfide	12135-76-1	1.0	I	Inv List	Pwdr	0.050	40	6.19E+02	5.47E+01	

Table B. Chemical Inventory List in MDA B

#	Chemical	CAS #	Inventory* (lb)	Type (a)	Origin (b)	Form	Revised Inventory** (lb)	TEEL-3 (mg/m^3), Rev 24	TQ at 100 m (lb)	TQ at 20 m (lb)	Exceeds TQ at 20 m
100	Phosphoric salt	7723-14-0	7.0	I	Inv List	Solid	0.350	4	6.19E+02	5.47E+01	
101	Bicarbonate of Soda	144-55-8	1.0	6MS	Inv List	Pwdr	0.050	500	7.73E+03	6.83E+02	
102	O-Phenylenediamine	95-54-5	1.1	O	Inv List	Pwdr	0.055	500	7.73E+03	6.83E+02	
103	Nitrotoluenes	1321-12-6 (general nitrotoluene #) other isomers: 88-72-2 ; 99-08-1; 99-99-0	1.0	O	Inv List	Pwdr	0.050	1,000	1.54E+04	1.36E+03	
104	Pyridine	110-86-1	2.2	O	Inv List	Liq	0.11	3,000	1.43E+04	1.26E+03	
105	Cupric nitrate	3251-23-8	1.0	I	Inv List	Pwdr	0.050	295	4.56E+03	4.03E+02	
106	Potassium chlorate	3811-04-9	5.0	I	Inv List	Pwdr	0.250	350	5.41E+03	4.78E+02	
107	Strontium oxalate	814-95-9	1.0	I	Inv List	Pwdr	0.050	75	1.16E+03	1.02E+02	
108	Sodium Citrate	68-04-2	1175	6MS	Inv List	Pwdr	58.75	600	9.79E+03	8.64E+02	
109	Tartaric Acid	87-69-4	100	6MS	Inv List	Pwdr	5.000	400	6.19E+03	5.47E+02	

Table B. Chemical Inventory List in MDA B

#	Chemical	CAS #	Inventory* (lb)	Type (a)	Origin (b)	Form	Revised Inventory** (lb)	TEEL-3 (mg/m^3), Rev 24	TQ at 100 m (lb)	TQ at 20 m (lb)	Exceeds TQ at 20 m
110	Phenol	108-95-2	1.0	O	Inv List	Pwdr	0.050	769	1.19E+04	1.05E+03	
111	Zinc carbonate	3486-35-9	1.0	I	Inv List	Pwdr	0.050	500	7.73E+03	6.83E+02	
112	Hydrazine compounds	302-01-2	1.0	O	Inv List	Liq	0.050	45.9	8.88E+02	7.84E+01	
113	Hydrogen, 225 ft^3	1333-74-0	2.0	6MS	Inv List	Gas	0.100	30,000	4.64E+03	4.10E+02	
114	Tri-sodium Citrate	68-04-2	1.0	PK	PK	Pwdr	0.050	600	9.28E+03	8.19E+02	
115	Bromobenzene	108-86-1	2.2	O	Inv List	Liq	0.11	2,000	1.95E+04	1.72E+03	
116	Xylene	1330-20-7	8.0	6MS	Inv List	Liq	0.40	10,800	9.40E+04	8.30E+03	
117	Methyl alcohol	67-56-1	6.6	O	Inv List	Liq	0.330	9,430	1.26E+04	1.11E+03	
118	Potassium oxalate	583-52-8	1.0	I	Inv List	Pwdr	0.050	500	7.73E+03	6.83E+02	
119	Monobutyl Ether	111-76-2	8.0	PK	PK	Liq	0.400	3,500	2.93E+05	2.59E+04	
120	Helium, 225 ft^3	7440-59-7	2.5	6MS	Inv List	Gas	0.125	60,000	9.25E+03	8.17E+02	
121	Tributyl Phosphate	126-73-8	80	PK	PK	Liq	4.0	300	1.82E+05	1.61E+04	
122	Yellow phosphorus	7723-14-0	1.0	I	Inv List	Solid	0.050	5.0	7.73E+02	6.83E+01	

Table B. Chemical Inventory List in MDA B

#	Chemical	CAS #	Inventory* (lb)	Type (a)	Origin (b)	Form	Revised Inventory** (lb)	TEEL-3 (mg/m^3), Rev 24	TQ at 100 m (lb)	TQ at 20 m (lb)	Exceeds TQ at 20 m
123	Ammonium Sulphate (Sulfate)	7783-20-2	100	6MS	Inv List	Pwdr	5.0	500	7.73E+03	6.83E+02	
124	Sodium hypochlorite	7681-52-9	1.0	I	Inv List	Pwdr	0.050	500	7.73E+03	6.83E+02	
125	Aniline	62-53-3	2.2	O	Inv List	Liq	0.110	76.1	1.13E+04	9.98E+02	
126	Ethylene Glycol	107-21-1	7.41E+03	6MS	Inv List	Liq	370.5	152	3.86E+05	3.41E+04	
127	Igepal CA	9036-19-5	2	6MS	Inv List	Liq	0.100	500	9.81E+04	8.66E+03	
128	Nitrogen, 225 ft^3	7727-37-9	17.5	6MS	Inv List	Gas	0.875	400,000	6.19E+04	5.47E+03	
129	Oxygen, 255 ft^3	7782-44-7	20	6MS	Inv List	Gas	1.0	653942*	1.01E+05	8.92E+03	
130	Butyl Carbital (Carbitol)	112-34-5	8.34	6MS	Inv List	Liq	0.417	500	1.44E+06	1.27E+05	
131	Nitrobenzene	98-95-3	2.2	O	Inv List	Liq	0.110	1,000	1.03E+05	9.09E+03	
132	Glycerin	56-81-5	9.3	6MS	Inv List	Liq	0.465	500	2.44E+07	2.15E+06	
133	Sulfuric Acid (70%)	7664-93-9	300	6MS	Inv List	Liq	15.0	160	4.45E+12	3.93E+11	
134	Sulfite		100	6MS	Inv List	NA	5.0				

Table B. Chemical Inventory List in MDA B

#	Chemical	CAS #	Inventory* (lb)	Type (a)	Origin (b)	Form	Revised Inventory** (lb)	TEEL-3 (mg/m^3), Rev 24	TQ at 100 m (lb)	TQ at 20 m (lb)	Exceeds TQ at 20 m
135	Ambilite 1R-100	9002-23-7	100	6MS	Inv List	Pwdr	5.0	500	7.73E+03	6.83E+02	
136	Aqua Regia	8007-56-5	unspecified	PK	PK	Liq		400	NA		
137	Argon, 225 ft^3	7440-37-1	25	6MS	Inv List	Gas	1.25	600,000	9.19E+04	8.11E+03	
138	Calcium peroxide	1305-79-9	1.0	I	Inv List	Pwdr	0.050	No inf			
139	Calcium phosphides	1305-99-3	1.0	I	Inv List	Pwdr	0.050	13.4	2.07E+03	1.83E+02	
140	Carbon Dioxide, 225 ft^3	124-38-9	28	6MS	Inv List	Gas	1.40	75,000	1.16E+04	1.02E+03	
141	Chromic oxide	1333-82-0	1.0	I	Inv List	Pwdr	0.050	28.8	4.45E+03	3.93E+02	
142	Chromium acetate hydroxide	39430-51-8	1.0	I	Inv List	Pwdr	0.050	120	1.85E+03	1.63E+02	
143	Chromium Chloride	10025-73-7	1.0	I	Inv List	Pwdr	0.050	76.1	1.18E+03	1.04E+02	
144	Chromium nitrate	7789-02-8	1.0	I	Inv List	Pwdr	0.050	192	2.97E+03	2.62E+02	
145	Chromium potassium sulfate	7788-99-0	1.0	I	Inv List	Pwdr	0.050	240	3.71E+03	3.28E+02	
146	Cobalt acetate	71-48-7	1.0	I	Inv List	Liq	0.050	300			
147	Cobalt nitrate	10141-05-6	2.0	I	Inv List	Pwdr	0.10	150	2.32E+03	2.05E+02	

Table B. Chemical Inventory List in MDA B

#	Chemical	CAS #	Inventory* (lb)	Type (a)	Origin (b)	Form	Revised Inventory** (lb)	TEEL-3 (mg/m^3), Rev 24	TQ at 100 m (lb)	TQ at 20 m (lb)	Exceeds TQ at 20 m
148	Cupric arsenite	10290-12-7	1.0	I	Inv List	Pwdr	0.050	No inf			
149	Cupric borate	393290-85-2	1.0	I	Inv List	Pwdr	0.050	No inf			
150	Cupric silicate		1.0	I	Inv List	Pwdr	0.050	No inf			
151	Ferric ammonium oxalate	2944-67-4	1.0	I	Inv List	Pwdr	0.050	No inf			
152	Ferric oxalate	2944-66-3	1.0	I	Inv List	Pwdr	0.050	No inf			
153	Lead carbonate	598-63-0	1.0	I	Inv List	Pwdr	0.050	500	7.73E+03	6.83E+02	
154	Lead sulfochromate	1344-37-2	1.0	I	Inv List	Pwdr	0.050	No inf			
155	Lead thioborate		1.0	I	Inv List	Pwdr	0.050	No inf			
156	Manganese oxalate	640-67-5	1.0	I	Inv List	Pwdr	0.050	500	7.73E+03	6.83E+02	
157	Phenazine Methlsulfate	299-11-6	1.1	O	Inv List	Pwdr	0.055	No inf			
158	Okite Stripper M-3		300	6MS	Inv List	Pwdr	15.0	No inf			
159	Phosphoric acid 85%	7664-38-2	8000	6MS	Inv List	Pwdr	400.0	500	7.73E+03	6.83E+02	

Table B. Chemical Inventory List in MDA B

#	Chemical	CAS #	Inventory* (lb)	Type (a)	Origin (b)	Form	Revised Inventory** (lb)	TEEL-3 (mg/m^3), Rev 24	TQ at 100 m (lb)	TQ at 20 m (lb)	Exceeds TQ at 20 m
160	Phosphorus sesquisulfide	10026-13-8	2.0	I	Inv List	Pwdr	0.100	70	1.08E+03	9.54E+01	
161	Silicon tetrachloride	10026-04-7	1.0	I	Inv List	Liq	0.050	174	No inf		
162	Sodium chromate	113517-17-4	5.0	I	Inv List	Pwdr	0.250	98.7	1.55E+03	1.37E+02	
163	Sodium Silicate	1344-09-8	2.2	6MS	Inv List	Pwdr	0.110	500	7.73E+03	6.83E+02	
164	Sodium xxlgas		1.0	I	Inv List	Pwdr	0.050	No inf			
165	Stannous oxalate	814-94-8	1.0	I	Inv List	Pwdr	0.050	No inf			
166	Thallium iodide	7790-30-9	1.0	I	Inv List	Pwdr	0.050	No inf			
167	Thionyl chloride	7719-09-7	1.1	I	Inv List	Pwdr	0.055	68.1	7.57E+01	6.68E+00	
168	Zinc oxalate	4255-07-6	1.0	I	Inv List	Pwdr	0.050	No inf			
169	Zinc sulfide	1314-98-3	1.0	I	Inv List	Pwdr	0.050	No inf			
170	Zinc Sulfite	13597-44-9	1.0	I	Inv List	Pwdr	0.050	No inf			

Table B. Chemical Inventory List in MDA B

#	Chemical	CAS #	Inventory* (lb)	Type (a)	Origin (b)	Form	Revised Inventory** (lb)	TEEL-3 (mg/m^3), Rev 24	TQ at 100 m (lb)	TQ at 20 m (lb)	Exceeds TQ at 20 m

a): PK = Process knowledge ; 6MS = 6 months supply; I = Inorganic; O = Organic

b): PK = Process knowledge; Inv List = Inventory List; Gas cylinder are assumed to contain 225 cu ft.

* = Material Disposal Area B: Process Waste Review, 1945 to 1948 (LA-UR-07-2379, August 2007, EP2007-0236.

* = Final Hazard Categorization for Material Disposal Area B, MDAB-ABD-1004, R.0. March 2009.

* = Site Boundary is 20 m.

**= Revised inventory is assumed 5.0% (0.050) as conservative of the original inventory.

Appendix C: Beryllium Exposure to Workers and Public

Beryllium (Be) inventory is listed as 1 lb of powder in Appendix B. Based on the historical review of the chemicals and best engineering judgment, the estimated chemical inventory is assumed to be no more than 5% at the MDA B site, a conservative estimate (Section 3.3.2). The net amount, 0.05 lb, is normally screened out when compared to the threshold quantities (TQs) at 30 m and 100 m (Appendix B). However, due to the health hazard of chronic beryllium disease and the 10 CFR 850 Rule, *Chronic Beryllium Disease Prevention Program* [Ref. 14], beryllium exposure is evaluated in the unlikely event of a major fire scenario. The total 1 lb of Be is assumed to be present in a localized area and is available for release in a plume to receptors (workers and public).

C 1. PACs for Beryllium and its Compounds and Their Criteria

The PACs (AEGLs/ERPGs/TEELs) for beryllium and its compounds are defined with increasing severity as follows, with their values shown in Table C-1.

PAC-1: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing other than mild, transient adverse health effects or without perceiving a clearly defined objectionable odor.

PAC-2: The maximum airborne concentration, below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective actions.

PAC-3: The maximum airborne concentration, below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life threatening health effects.

Table C-1: PACs (AEGLs/ERPGs/TEELs) Values for Beryllium and its Compounds*

Compound	PAC-1 (mg/m^3)	PAC-2 (mg/m3)	PAC-3 (mg/m^3)
Beryllium metal, Be	0.01	0.025	0.1
Beryllium hydroxide, $Be(OH)_3$	0.024	0.24	19.1
Beryllium oxide, BeO	0.0139	1.39	11.1*
Ratio of BeO/Be	1.4	56	111

* PACs values are taken from Rev 24. 1 mg/m^3 = 2.72 ppm;
On oxidation, Be is converted to BeO, which has two orders of magnitude greater threshold value than Be metal (11.1 vs. 0.1 mg/m^3), based on the comparison of PAC-3 values. Thus, in a major fire scenario, if Be is oxidized to BeO, then it is a much lesser hazard to a receptor on a short exposure.

C2. Beryllium: Airborne Release Fractions/Respirable Fractions

Mishima et al [2006, 2008] wrote comprehensive reports on the airborne release fractions and respirable fractions (ARFs/RFs) based on the literature review on the physical and chemical properties of beryllium metal and its oxide, oxidation and ignition of beryllium metal, and accidents involving beryllium releases. The reports include the experimental findings and discussion of the Jordan report [2001]. Most importantly, the reports provide the size fraction information (<8.0 µm to <100 µm in 12 increments) that was used to calculate the ARF/RF values for different forms of beryllium (large coherent metal, powder/chips, turnings/swarfs, and dust layer) under various accident conditions. The values are supported by experimental data and summarized in Table C-2.

Table C-2. Summary of ARF/RF Values for Encased Be Metal*

Condition	Airborne Release Fraction (ARF)/Respirable Fraction (RF) Values			
	Large, Coherent Items	**Powder/ Chips**	**Turnings/ Swarfs**	**Dust Layer**
Explosion, detonation	1E-1/0.3	1E-2	1E-2	4E-1
Explosion, deflagration	<1E-6	1E-2	1E-2	4E-1
Explosive Release [e]	<1E-6	1E-3	1E-2	1E-1/0.7
Fire, Be heated	3E-6	1.5E-5	2E-4	3E-4
Fire, Be ignited		4E-1	4E-1	4E-1
Fire, packaged combustible waste, waste ignited, Be heated	-	1.5E-5	-	3E-4
Fire, packaged combustible waste, waste and Be ignited	-	-	-	4E-1
Free-fall Spill	<1E-6	<1E-6	<1E-6	2E-3/0.3
Crush-Impact	<1E-6	<1E-6	<1E-6	1E-3/0.3
Shock-Vibration	<1E-6	<1E-6	<1E-6	1E-3/0.3
Resuspension	<1E-6	<1E-6	<1E-6	4E-5/hr (ARR)

*Taken from Jofu Mishima et al [2006, 2008] and see the footnote for explanations. Oxidation largely depends on the fire temperature, duration of the fire, and the amount of material involved and its form.

Beryllium powder size fraction with a diameter of <10 µm is about 3% [2006, 2008]. For a fire, with the Be heated, Be powder has an ARF x RF of 3E-4 (Table C-2). The ARF/RF for powder/chips is 1.5E-5. The combined ARF x RF is 0.030 (3E-4) + 0.97 (1.5E-5) = 2.35 E-5, which is used for the chemical dispersion model.

C3. Beryllium Concentration Calculations

Quantitative estimation of the concentration is evaluated for a major fire scenario and an earthquake (seismic) or lightning, as bounding, where the total quantity of 1.0 lb beryllium is at risk. The calculations are performed using the EPIcode chemical dispersion model, which is an approved Toolbox code by DOE [2004]. EPIcode's Windows® version (7.0) is used as a term release for this bounding scenario.

The recommended parameters from DOE-EH-4.2.1.3-EPIcode guidance for documented safety analysis [2004] used for consequence calculations are as follows.

- Release type: Term release is highly conservative relative to a fire that involves lofting.
- Stability Class: F, which is stable and most conservative class among A to F classes.
- Wind speed: 1-2 m/sec is assigned for F stability. 1.5 m/sec at 10 m height is recommended.
- Deposition velocity of zero and 0.3 cm/sec is used.
- Release effective height: 0 meter, which is a ground-level release.
- Receptor height 1.5 m. This is normally chest height.
- Release time (RT) and sampling time (ST) of 15 min each is recommended as the time-weighted average (TWA) to compare with the ERPG/TEEL values, although they are defined as exposure up to one hour [Craig et al, 2000].
- RF =1.0, because ERPG/TEEL-3 assumes total concentration exposure to a receptor.
- Terrain Standard: Open country which is a conservative; City terrain is urban or metropolitan
- Downwind X-meter: Plume centerline, Y-meter 0.

The results, using a MAR of 1.0 lb beryllium, with the following two fire scenarios considered, are summarized in Table C-3. Distances used are 30 m, 100 m, 300 m, 500 m, and 1,000 m. X/Q values (s/m^3) are listed for both scenarios. EPIcode calculations are shown in Attachment-C-1.

a: ARF = 2.35E-5; Deposition Velocity = 0 cm/sec, no oxidation

b: ARF = 2.35E-5; Deposition Velocity = 0.3 cm/sec, no oxidation

Table C-3. Summary of Beryllium Concentrations in MDA B at Different Distances

	a: Be-Powder/Chips R.T =15 min S.T = 15 min	**b: Be-Powder/Chips R.T =15 min S.T = 15 min**
MAR	**1.0 lb**	**1.0 lb**
ARF	2.35 E-5	2.35 E-5
Source Term	2.35 E-5 lb	2.35 E-5 lb
Deposition Vel.	0 cm/sec	0.3 cm/sec
Parameters Used	Surface wind speed 1.5 meter/sec (h=10m) ; Stability class F, Effective release ht 0 meter; Receptor ht 1.5 m (Ground level); RF = 1.0; Gaussian distribution; Terrain Standard; Downwind X-meter, Y-meter 0, (Plume centerline)	
Concentration	mg/m^3	mg/m^3
30 X-meter	**6.8E-5**	**5.2E-5**
100	**5.7E-4**	**3.2E-4**
300	1.0E-4	4.4E-5
500	4.0E-5	1.5E-5
1,000	1.2E-5	3.7E-6
χ/Q s/m^3, (30 m)	5.8E-3	4.4E-3
χ/Q s/m^3, (100 m)	4.81E-2	2.7E-2
ERPG-3 (mg/m^3)	1.0E-1	1.0E-1
ERPG-2 (mg/m^3)	2.5E-2	2.5E-2
ERPG-1 (mg/m^3)	**1.0E-2**	**1.0E-2**
Oxidation	No	No

In both cases, the concentrations (mg/m^3) are 2 to 3 orders of magnitude lower than the ERPG-1 value, indicating no concern for the workers at 100 m and the public at 30 m. Concentration at 30 m is lower than at 100 m, due to the lofting effect. The site boundary for public is at 20 m; however, EPIcode calculates the concentration at 30 m (minimum distance), and the conclusion at 20 m is the same.

C4. Regulations: Protection of Public and Workers

The Environmental Protection Agency (EPA) has imposed a National Emission Standard for Hazardous Air Pollutants (NESHAPs), per 40 CFR 61 and its subpart C, which relates to the Beryllium (Be) emission standard [2004]. The Be air quality limit is 0.01 $\mu g/m^3$ averaged over a 30-day TWA, to protect the public (no expected chronic beryllium disease). The accident evaluated at 15 min can be evaluated as a 30-day TWA (30 days = 2,880 segments of 15 min each). This is based on a 10-g release of Be over a 24-hour period. Based on the results in Table C-3, pertinent points are as follows.

- The Be concentration for 1-lb powder release for 15 min TWA is 0.052 µ/m^3 at 30 m (site boundary) public, with deposition velocity of 0.3 cm/sec. Without deposition, the Be concentration is 0.068 µg/m^3 at 30 m (SB, public). Both values are 2 to 3 orders of magnitude lower than the EPA limit of 28.8 µg/m^3, which implies that the public is well protected. Non-involved workers at 100 m are also well protected.

- If a fire scenario with lofting (5MW or 10 MW) is considered, then Be concentrations at 30 m are 1 to 2 orders of magnitude lower as compared to the values listed in Table C-3 for the term release. As stated above, the term release concentrations are already lower than the EPA emission standard limit.

- The occupational exposure threshold limiting value (TLV) on 8-hr TWA is 2.0 µg/m^3. However, 10 CFR 850, *Chronic Beryllium Disease Prevention Program, Final* Rule [1999], Section 850.23, requires a protection level at an exposure of 0.2 µg/m^3 for the workers in the worker's breathing zone by personal monitoring.

- This action level is intended to further reduce or prevent the occurrence of chronic beryllium disease. This new guideline, coupled with best practices and procedures such as P 101-21, Chronic Beryllium Disease Prevention Program [2008], a beryllium monitoring program, and controls, provide additional safety margin to protect involved workers.

- The administrative controls (ACs) can be worker training, work process control, emergency preparedness (e.g., rapid evacuation of the facility when an accidental release occurs), and participation in the Chronic Beryllium Disease Prevention Program.

References

10 CFR Part 850 — *Chronic Beryllium Disease Prevention Program,* Final Rule, Vol. 64, No. 235, 68854-68914, U.S. Code of Federal Regulations, Washington DC, December 8, 1999.

P 101-21 — *Chronic Beryllium Disease Prevention Program,* Los Alamos National Laboratory, Los Alamos NM, April 2008.

40 CFR 61 — *EPA National Emission for Hazardous Air Pollutants (NESHAPs), Subpart C for Beryllium Emission,* Subpart 61.32 *Emission Standard for Beryllium,* U.S. Code of Federal Regulations, Washington DC, 7-1-2004.

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Jordan 2001	Hans Jordan, *Airborne Release Fractions of Beryllium Metal in a Fire – Literature Review and Recommendations*, LA-13843-MS, Los Alamos National Laboratory, Los Alamos NM, September 2001.
Tool Box 2004	DOE Safety Analysis Toolbox Central Registry – http://www.hss.energy.gov/csa/csp/sqa/centralregistry.htm
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Craig 2000	Craig, D. K., J. S. Davis, L G. Lee, J. Prowse, and P W. Hoffman, *Toxic Chemical Hazard Classification and Safety Evaluation Guidelines for Use in DOE Facilities*, WSRC-MS-92-206, Rev. 3, December 2000.

Attachment C-1: Beryllium Dispersion Calculations by EPIcode

Case 1

EPIcode Version 7.0 Library 2007 Term Release

Jun 30, 2009 05:50 PM

Source Material:	BERYLLIUM
CAS Number:	7440-41-7
Source Term:	1.000 lb
Release Duration:	15 min
Airborne Fraction:	2.35E-05
Effective Release Height:	0.00 m
Wind Speed (h=10 m:	1.5 m/s
Distance Coordinates:	All distances are on the Plume Centerline
Stability Class (Standard):	F
Deposition Velocity:	0.00E+00 cm/s
Receptor Height:	1.5 m
Inversion Layer Height:	None
Sample Time:	15.0 min
Maximum Concentration:	7.2E-04 mg/m^3
Max Concentration Distance:	0.067 km
ERPG-1:	N/A
ERPG-2:	0.0250 mg/m^3
ERPG-3:	0.1000 mg/m^3

DISTANCE km	MAXIMUM CONCENTRATION (mg/m^3)	ARRIVAL TIME (hour:min)	X/Q (s/m^3)
0.030	6.8E-05	<00:01	5.77E-03
0.100	5.7E-04	00:02	4.81E-02
0.300	1.0E-04	00:08	8.59E-03
0.500	4.0E-05	00:13	3.41E-03
1.000	1.2E-05	00:26	1.00E-03
1.500	6.0E-06	00:40	5.10E-04

Case 2

EPIcode Version 7.0 Library 2007 Term Release

Jun 30, 2009 05:48 PM	
Source Material:	BERYLLIUM
CAS Number:	7440-41-7
Source Term:	1.000 lb
Release Duration:	15 min
Airborne Fraction:	2.35E-05
Effective Release Height:	0.00 m
Wind Speed (h=10 m):	1.5 m/s
Distance Coordinates:	All distances are on the Plume Centerline
Stability Class (Standard):	F
Deposition Velocity:	0.30 cm/s
Receptor Height:	1.5 m
Inversion Layer Height:	None
Sample Time:	15.0 min
Maximum Concentration:	4.5E-04 mg/m^3
Max Concentration Distance:	0.063 km
ERPG-1:	N/A
ERPG-2:	0.0250 mg/m^3
ERPG-3:	0.1000 mg/m^3

DISTANCE km	MAXIMUM CONCENTRATION (mg/m^3)	ARRIVAL TIME (hour:min)	X/Q (s/m^3)
0.030	5.2E-05	<00:01	4.37E-03
0.100	3.2E-04	00:02	2.73E-02
0.300	4.4E-05	00:08	3.74E-03
0.500	1.5E-05	00:13	1.29E-03
1.000	3.7E-06	00:26	3.10E-04
1.500	1.6E-06	00:40	1.36E-04

Appendix D: Results of What-If/Hazards Analysis

Risk mitigation at MDA B is through Safety Management Programs (SMPs) that are integrated into operations in compliance with the requirements of Integrated Safety Management.

Table D. Hazard Analysis – Hazard Scenarios

Haz ID #	Hazard Scenario	Controls	Unmitigated							Mitigated						
			Freq	Conseq			Risk			Freq	Conseq			Risk		
				P	CW	W	P	CW	W		P	CW	W	P	CW	W
Fire																
F1	Fire ignites as a result of vehicle/equipment collision within excavation area and engulfs exposed MAR	FPP WMP T&QP ERP	U	L	M	M	IV	II	II	EU	L	L	L	IV	IV	IV
F2	Component of equipment/vehicle overheats/sparks and initiates vegetation/other combustible fire and engulfs exposed MAR.	MP FPP ERP	U	L	M	M	IV	II	II	EU	L	L	L	IV	IV	IV
F3	Electrical fire in excavation area.	FPP MP ERP ESP	U	L	M	M	IV	II	II	EU	L	L	L	IV	IV	IV
F4	During refueling of equipment/vehicle ignites. Fire engulfs exposed MAR	T&Q FPP ERP MP	U	L	M	M	IV	II	II	EU	L	L	L	IV	IV	IV

Table D. Hazard Analysis – Hazard Scenarios

Haz ID #	Hazard Scenario	Controls	Unmitigated							Mitigated						
			Freq	Conseq			Risk			Freq	Conseq			Risk		
				P	CW	W	P	CW	W		P	CW	W	P	CW	W
F5	Excavation and sorting of landfill material causes reaction of incompatible chemicals and a fire within the enclosure.	T&Q FPP ERP COO WMP HSP	**U**	L	M	M	IV	II	II	**U**	L	L	L	IV	IV	IV
Loss of Confinement																
C1	Equipment/vehicle falls into sinkhole/other void space in landfill. Resulting in Equipment/vehicle contamination.	WMP COO ERP RPP	**A**	L	L	M	III	II	II	**U**	L	L	L	III	III	III
C2	Excavator drops bucket load of landfill material.	COO ERP RPP T&Q	**U**	L	M	M	IV	II	II	**EU**	L	L	L	IV	IV	IV
C3	Radioactive material is released during direct push sampling.	RPP COO ERP	**A**	L	M	M	III	II	II	**A**	L	L	L	III	III	III

Table D. Hazard Analysis – Hazard Scenarios

Haz ID #	Hazard Scenario	Controls	Unmitigated							Mitigated						
			Freq	Conseq			Risk			Freq	Conseq			Risk		
				P	CW	W	P	CW	W		P	CW	W	P	CW	W
C4	Chemical release during direct push sampling.	WMP ERP COO HSP	A	L	M	M	III	II	II	A	L	L	L	III	III	III
C5	During equipment decontamination, contamination becomes airborne.	RPP COO ERP	U	L	L	M	IV	IV	II	U	L	L	L	IV	IV	IV
C6	During site preparation, construction activities impact buried waste.	T&QP COO ERP	EU	L	M	M	IV	III	III	EU	L	L	L	IV	IV	IV
C7	Collision between vehicle/equipment carrying waste container(s) and other vehicle/equipment. Container(s) spill contaminated material.	WMP RPP T&QP ERP	U	L	M	M	IV	II	II	U	L	L	L	IV	IV	IV
C8	A worker drops a container resulting in release of radioactivity and/or chemical material.	WMP T&QP ERP	A	L	M	M	III	II	II	U	L	L	L	IV	IV	IV

Table D. Hazard Analysis – Hazard Scenarios

Haz ID #	Hazard Scenario	Controls	Unmitigated							Mitigated						
			Freq	Conseq			Risk			Freq	Conseq			Risk		
				P	CW	W	P	CW	W		P	CW	W	P	CW	W
C9	Excavation and sorting of landfill material causes breach of gas cylinder and release of hazardous/toxic gas (e.g., nickel carbonyl) resulting in worker exposure.	WMP T&QP ERP HSP	U	L	L	M	IV	IV	II	EU	L	L	L	IV	IV	IV
Explosion/Deflagration																
E1	A detonation occurs below grade during direct push sampling.	ERP RPP WMP Blast Distance	EU	L	M	H	IV	III	II	EU	L	L	M	IV	IV	
E2	A detonation occurs at the digface during excavation.	ERP FPP WMP Blast distance	EU	L	M	H	IV	III	II	EU	L	L	L	IV	IV	IV
E3	A mechanical failure of equipment results in a gas cylinder leak and subsequent explosion and fire.	MP FPP ERP Blast distance	U	L	M	H	IV	II	I	EU	L	L	M	IV	IV	III
Natural Phenomenon Hazards																

Table D. Hazard Analysis – Hazard Scenarios

Haz ID #	Hazard Scenario	Controls	Unmitigated							Mitigated						
			Freq	Conseq			Risk			Freq	Conseq			Risk		
				P	CW	W	P	CW	W		P	CW	W	P	CW	W
N1	Lightning strikes enclosure that ignites fire threatening landfill material or waste containers	FPP ERP	U	L	M	M	IV	II	II	EU	L	L	L	IV	IV	IV
N2	Wildland fire spreads to MDA B and threatens the excavation waste areas.	ERP FPP	EU	L	M	M	IV	II	II	EU	L	L	L	IV	IV	IV
N3	Seismic event causes deflagration, in an intact waste container; fire ensues.	ERP FPP	U	L	M	M	IV	II	II	EU	L	L	L	IV	IV	IV
N4	High wind renders radioactive material airborne. (Assume PC 1 excavation enclosure.)	COO WMP	A	L	L	L	III	III	III	A	L	L	L	III	III	III
External Events																
Ex1	An off-site vehicle accident occurs on a nearby roadway and fire spreads to MDA B and engulfs exposed MAR	ERP FPP	U	L	M	M	IV	II	II	EU	L	L	L	IV	IV	IV

Table D. Hazard Analysis – Hazard Scenarios

Haz ID #	Hazard Scenario	Controls	Unmitigated							Mitigated						
			Freq	Conseq			Risk			Freq	Conseq			Risk		
				P	CW	W	P	CW	W		P	CW	W	P	CW	W
Ex2	Aircraft crashes into enclosure and excavation area causing a fuel fire.	ERP FPP	EU	L	M	M	IV	III	III	EU	L	L	L	IV	IV	IV
Radiation Exposure																
R1	Worker falls into sinkhole/other void space in landfill resulting in exposing worker to radioactivity and chemical material.	RPP COO T&QP HSP	A	L	L	M	III	III	II	U	L	L	L	IV	IV	IV

Appendix E – Comparison of MDA B Chemical Inventories to PAC-2 TQs at 30 m

Methodology

This evaluation is based on the chemical threshold quantities documented in SB-DO: CALC 07-024, *Chemical Threshold Quantities for Safety Basis Categorization*. That calculation package derived threshold quantities based on TEEL-3 limits for safety basis purposes, and also for TEEL-2 limits for emergency planning purposes. The TEEL limits were taken from the SCAPA-produced list that was current at that time, Revision 21. It is the conservative TQ data from SB-DO: CALC 07-024, Appendix 2, *Dispersion Limited Material-At-Risk for Emergency Planning Guidance (worst case meteorological data)* that is used in this chemical evaluation. Although the familiar historical "TEEL" term is used throughout this document, it is recognized that the current title of the list reflects Protective Action Criteria (PAC) which include:

- Acute Exposure Guideline Level (AEGL) values published by the U.S. Environmental Protection Agency (EPA)
- Emergency Response Planning Guideline (ERPG) values produced by the American Industrial Hygiene Association (AIHA)
- Temporary Emergency Exposure Limit (TEEL) values developed by SCAPA.

Revision 24 of the TEEL list was used as the basis for comparison to MDAB inventories to remain consistent with the evaluation done for the purpose of chemical hazard categorization. To update the TQs determined in SB-DO: CALC 07-024 for those chemicals whose TEEL-2 concentrations increased or decreased between TEEL List Revision 21 and Revision 24, the TQ was adjusted by the Rev21:Rev24 TEEL concentration ratio. The available inventory was compared to the updated TEEL-2 TQ to determine which chemicals were potentially available in sufficient quantity to exceed TEEL-2 threshold concentrations to the public receptor, if released from MDA-B. These conversions are documented in SB-DO-CALC-10-XX MDA-B Chemical Comparison to TEEL-2 Threshold Quantities

The chemicals potentially available for release from MDA-B excavation areas are assumed to be limited to those previously postulated in the Facility Hazard Category document (MDAB-ABD-1004), plus the additional chemicals encountered while digging in enclosure 12 on October 12, 2010. These 179 chemicals are assumed to constitute the chemical "inventory" that was buried in the MDA-B trenches in the 1940's.

Except where smaller or larger quantities were specifically justified in the notes in Table B-1 of the FHC, this analysis assumes one typical container full of any listed chemical might be encountered in a single backhoe (or similar excavation machinery) bucket scoop, and that the intact container might be breached and the chemical contents spilled into the dig face.

The identification of chemicals potentially buried in the trenches within MDA-B was derived from the best available historical information, including a warehouse inventory list from the 1940's and recollections of persons who worked in the laboratories that used the chemicals, and those who collected waste material and delivered it to the trenches for burial. There were no manifests that documented specific materials or quantities that were discarded and buried. Therefore, the available chemical inventory assumed to be available in MDA-B is based largely on judgment.

Reactions or interactions of chemical mixtures are evaluated by general class (instead of an exhaustive permutation of chemical interactions) to identify reaction products that might require controls. These evolved reaction products are not quantified and compared to TEEL-2 limits, but are qualitatively considered for adequacy of controls.

The examination of public exposure to chemical releases is carried out at a distance of 30 meters instead of the closest access at 20 meters. This is because the Gaussian atmospheric dispersion calculation method is not valid at 20 meters. Though results would be questionable at any distance closer than 100 meters, there is a precedent for uses down to 30 meters (DOE-STD-1027 basis for HC-3 thresholds based on EPA methodology, and DOE O 151.1C for Emergency Planning). The use of 30 meters is adequate for prioritization of chemicals and identification of necessary controls due to conservatism in the unmitigated emergency planning TQ calculations in SB-DO CALC: 07-024, including:

All solid materials that were not specifically identified as lumps, chunks, crystals, or pieces were analyzed as powders with an airborne release fraction of 0.1 (compared to 0.01 or 0.001 if crystalline or solid form was assumed).

In determining the worst case TQ values, very stable atmospheric conditions (Stability category F and 1 meter/sec wind speed) were assumed in calculation of the atmospheric dispersion factor, X/Q. This resulted in TQ values about 9 times more limiting that if average conditions of D stability and 4.5 meter/sec wind speed were used.

Calculation Inputs

The following documents provided input to this calculation

MDA-B Chemical Inventory was based on Table B-1 Chemical Inventory List, from Final Hazard Categorization document MDAB-ABD-1004, Rev 1.1.

Three previously unlisted chemicals that were detected in enclosure 12 on 10-27-10 were added to the above inventory list.

30 meter TQs for the MDA-B inventory chemicals were taken from Emergency Planning Worst Case data in Appendix 2 of SB-DO Calc: 07-024, which was based on the TEEL-2 limits specified in Rev 21 of the TEEL list (Protective Action Criteria for Chemicals - Including AEGLs, ERPGs, & TEELs).

Revised TEEL-2 values from Rev 24 of the TEEL list (Protective Action Criteria for Chemicals - Including AEGLs, ERPGs, & TEELs).

Summary and Conclusion

Table E-1 presents the results from this analysis. Chemicals Using conservative analysis assumptions, 49 of 179 inventory chemicals (if sodium hydroxide is evaluated as both sodium hydroxide and caustic soda) were identified that could potentially expose public receptors to airborne concentrations that exceed the TEEL-2 limits published in Rev 24 of the TEEL list.

Further, a qualitative evaluation of chemical mixtures, reaction products, and decomposition products identified seven resulting gases that could harm the public receptor.

Table E-1 Comparison of MDA B Chemical Inventories to PAC-2 TQs at 30m

The chemicals of concern (potential to exceed TEEL 2 levels) have an estimated inventory greater than the TEEL-2 TQ's reflected by a ratio of greater than one in the last column of the table.

CHEMICAL	CAS	Material Form	Previous Max credible quantity, MCQ (lb) (from FHC)	New Inventory[1] (~ 1 full container) (lbs)	TEEL-2 concentration mg/m3 from Rev24	TEEL-2 TQ (lbs) @ 30 m [Worst Case Met Conditions, SBDO Calc 07-024]	TQ RATIO= New Inventory / TEEL-2 TQ @ 30 m Rev 24
Acetone	67-64-1	L	8.00	8.00	7600	3.68E+02	0.02
Acetylene	74-86-2	G	8.00	80.00	2500	6.72E+01	1.3
All Silver units (CAS # and PAC are for silver cyanide)	506-64-9	Pwdr	0.10	1.00	25.70	6.32E+00	0.2
Aluminium Nitrate	13473-90-0	Pwdr	1.25	12.50	350	1.89E+01	0.1
Ambilite 1R-100[2]	NA						---
Ammonium bisulfate	7803-63-6	Pwdr	0.10	1.00	0.50	1.26E-01	7.9
Ammonium Hydroxide	1336-21-6	Soltn	4.00	17.80	60	6.04E+00	2.8
Ammonium Nitrate[3]	6484-52-2	Pwdr	out	out	out	2.53E+00	---
Ammonium persulfate	7727-54-0	Pwdr	0.10	1.00	20	1.26E-01	0.2
Ammonium sulfide	12135-76-1	Pwdr	0.10	1.00	40	1.06E+01	0.1
Ammonium Sulphate (Sulfate)	7783-20-2	Pwdr	0.10	1.00	500	1.26E+02	0.01
Ammonium Tartrate	3164-29-2	Pwdr	0.10	1.00	40	1.01E+01	0.1

CHEMICAL	CAS	Material Form	Previous Max credible quantity , MCQ (lb) (from FHC)	New Inventory[1] (~ 1 full container) (lbs)	TEEL-2 concentration mg/m3 from Rev24	TEEL-2 TQ (lbs) @ 30 m [Worst Case Met Conditions, SBDO Calc 07-024]	TQ RATIO= New Inventory / TEEL-2 TQ @ 30 m Rev 24
Aniline	62-53-3	L	0.22	2.20	45.70	5.75E+02	0.004
Antimony metal and all compounds	7440-36-0	Pwdr	0.10	1.00	20	6.32E+02	0.002
Aqua Regia (see Hydrochloric & nitric acids)	8007-56-5	L	Bounded by hydrochloric and nitric acid ---				
Argon	7440-37-1	G	2.00	2.00	350000	1.15E+04	0.0002
Arsenic metal and Arsenic compounds	7440-38-2	Pwdr	0.10	1.00	2	6.32E-01	2.0
Barium metal and all Barium compounds	7440-39-3	Pwdr	0.10	1.00	50	6.32E+00	0.1
Barium Sulfate	7727-43-7	Pwdr	2.00	20.00	350	1.26E+01	0.2
Benzene	71-43-2	L	8.00	8.00	**2550**	4.19E+01	0.04
Beryllium metal[3]	7440-41-7	Pwdr	out	out		6.32E-03	---
Bicarbonate of Soda (sodium bicarbonate)	144-55-8	Pwdr	0.10	1.00	50	1.26E+01	0.1
Bromine	7726-95-6	L	0.10	1.00	1.57	1.16E-01	9.0
Bromo-benzene	108-86-1	L	0.22	2.20	125	7.67E+01	0.02
Butane	106-97-8	G	8.00	80.00	40400	2.42E+02	0.1
Butyl Carbital (Carbitol) CAS & PAC are for Butoxyethoxy) ethanol, 2-(2-; (Diethylene glycol	112-34-5	G	8.00	8.00	500	1.17E+05	0.0001

CHEMICAL	CAS	Material Form	Previous Max credible quantity , MCQ (lb) (from FHC)	New Inventory[1] (~ 1 full container) (lbs)	TEEL-2 concentration mg/m3 from Rev24	TEEL-2 TQ (lbs) @ 30 m [Worst Case Met Conditions, SBDO Calc 07-024]	TQ RATIO= New Inventory / TEEL-2 TQ @ 30 m Rev 24
monobutyl ether)							
Cadmium metal	7440-43-9	Pwdr	0.10	1.00	1.25	1.26E-01	3.2
Calcium	13765-19-0	Pwdr	0.10	1.00	50	1.26E+01	0.1
Calcium Nitrate	10124-37-5	Pwdr	2.50	25.00	25	6.32E+00	4.0
Calcium peroxide (No PAC data, used calcium oxide 1305-78-8	1305-79-9	Pwdr	0.10	1.00	5	1.26E+00	0.8
Calcium phosphides	1305-99-3	Pwdr	0.10	1.00	NOT LISTED		---
Carbon Dioxide	124-38-9	G	2.00	2.00	50000	1.36E+03	0.002
Carbon disulfide	75-15-0	L	0.80	8.00	498.00	1.26E+01	0.6
Carbon Tetra-chloride	56-23-5	L	8.00	14.36	1190	1.00E+02	0.1
Caustic Soda (sodium hydroxide)	1310-73-2	Pwdr	2.50	25.00	5	1.26E+00	19.8
Chloroform	67-66-3	L	0.80	12.30	312	1.49E+01	0.8
Chromic acid CAS and PAC are for Chromic trioxide; (Chromium(VI) oxide (1:3))	1333-82-0	Pwdr	0.10	1.00	0.06	5.05E-02	66.0
Chromium acetate	39430-51-8	Pwdr	0.10	1.00	11	3.16	0.4
Chromium Chloride	10025-73-7	Pwdr	0.10	1.00	7.61	1.89	0.5

CHEMICAL	CAS	Material Form	Previous Max credible quantity , MCQ (lb) (from FHC)	New Inventory[1] (~ 1 full container) (lbs)	TEEL-2 concentration mg/m3 from Rev24	TEEL-2 TQ (lbs) @ 30 m [Worst Case Met Conditions, SBDO Calc 07-024]	TQ RATIO= New Inventory / TEEL-2 TQ @ 30 m Rev 24
Chromic chloride							
Chromium nitrate	7789-02-8		0.10	1.00	20	5.05	0.2
Chromium potassium sulfate	7788-99-0	Pwdr	0.10	1.00	40	6.32	0.1
Cobalt acetate	71-48-7	L	0.10	1.00	NOT LISTED		---
Cobalt nitrate	10141-05-6	Pwdr	0.20	2.00	12.50	7.58E-01	0.6
Cupric acetate	142-71-2	Pwdr	0.20	2.00	3.50	1.89E-01	2.3
Cupric aceto arsenite Paris Green	12002-03-8	Pwdr	0.10	1.00	22	5.56E+00	0.2
Cupric arsenite	10290-12-7	Pwdr	0.10	1.00	NOT LISTED		---
Cupric borate NO PAC data, used Boric Acid, CAS 10043-35-3	393290-85-2	Pwdr	0.10	1.00	100	2.53	0.04
Cupric chloride	7447-39-4	Pwdr	0.10	1.00	0.53	2.53	7.5
Cupric nitrate	3251-23-8	Pwdr	0.10	1.00	60	1.52E+01	0.1
Cupric oxide	1317-38-0	Pwdr	0.50	5.00	15	1.26	1.3
Cupric silicate	16509-17-4		0.10	1.00	NOT LISTED		---
Cupric sulfate	7758-98-7	Pwdr	0.50	5.00	6	1.52E+00	3.3
Cuprous cyanide	544-92-3	Pwdr	0.10	1.00	7.05	1.52E+00	0.6

CHEMICAL	CAS	Material Form	Previous Max credible quantity , MCQ (lb) (from FHC)	New Inventory[1] (~ 1 full container) (lbs)	TEEL-2 concentration mg/m3 from Rev24	TEEL-2 TQ (lbs) @ 30 m [Worst Case Met Conditions, SBDO Calc 07-024]	TQ RATIO= New Inventory / TEEL-2 TQ @ 30 m Rev 24
Cuprous sulfide	22205-45-4	Pwdr	0.10	1.00	6.26	1.52E+00	0.6
Ethyl Chloride	75-00-3	G	1.00	10.00	10000	6.66E+01	0.04
Ethyl Ether	60-29-7	L	50.00	50.00	1500	3.83E+01	1.3
Ethylene Glycol	107-21-1	L	8.00	9.94	100	2.09E+04	0.0005
Ferric ammonium oxalate No PAC data, used Ammonium oxalate; (Ethanedioic acid, diammonium salt) CAS 1113-38-8	2944-67-4	Pwdr	0.10	1.00	4	1.01	1.0
Ferric oxalate No PAC data, used Ammonium oxalate; (Ethanedioic acid, diammonium salt) CAS 1113-38-8	NA	Pwdr	0.10	1.00	4	1.01	1.0
Glycerin	56-81-5	L	0.80	8.00	500	1.99E+05	0.0000
Helium	7440-59-7	G	2.00	2.00	35000	1.16E+03	0.002
Hexane	110-54-3	L	8.00	8.00	11600	3.88E+01	0.02
Hydrazine compounds	302-01-2	L	0.10	1.00	17	2.68E+01	0.04
Hydriodic Acid (assume 56%)	10034-85-2	Soltn	7.00	7.00	115	2.38E+02	0.001
Hydrochloric Acid Conc. (assume 42%)	7647-01-0	Soltn	18.00	23.64	32.80	1.97	12.0
Hydrofluoric acid (assume 60%)	7664-39-3	Soltn	2.20	2.20	19.60	5.46E+00	0.4

CHEMICAL	CAS	Material Form	Previous Max credible quantity , MCQ (lb) (from FHC)	New Inventory[1] (~ 1 full container) (lbs)	TEEL-2 concentration mg/m3 from Rev24	TEEL-2 TQ (lbs) @ 30 m [Worst Case Met Conditions, SBDO Calc 07-024]	TQ RATIO= New Inventory / TEEL-2 TQ @ 30 m Rev 24
Hydrogen	133-74-0	G	2.00	2.00	15000	5.84E+02	0.01
Hydrogen Cyanide[3]	74-90-8	G	out	out	7.84	1.98E-01	---
Hydrogen Fluoride (anhydrous)[3]	7664-39-3	G	out	out	19.60	4.95E-01	---
Hydrogen Peroxide	7722-84-1	L	4.00	28.90	71	2.91E+02	0.1
Hydroxyl-amine	7803-49-8	Pwdr	0.50	5.00	5	1.26E+00	4.0
Igepal CA CAS # is for Polyoxyethylene monooctylphenyl ether	9036-19-5	Soltn	2.00	2.00	350	5.61E+03	0.0004
Iodic acid	7782-68-5	Pwdr	0.10	1.00	0.14	3.16E-02	28.5
Iodine (Mal-linckroat)	7553-56-2	Pwdr	0.10	1.00	5.20	1.31E+02	0.01
Isopropyl Alcohol	67-63-0	L	1.00	10.00	1000	1.08E+03	0.05
Lead acetate	6080-56-4	Pwdr	0.10	1.00	75	1.01E+01	0.1
Lead bromide	10031-22-8	Pwdr	0.10	1.00	0.44	1.01E-01	8.9
Lead carbonate	1319-46-6	Pwdr	0.10	1.00	4	7.58E-01	1.0
Lead chloride	7758-95-4	Pwdr	0.10	1.00	7.50	8.84E-02	5.3
Lead chromate	7758-97-6	Pwdr	0.10	1.00	1	8.84E-02	4.0
Lead Dioxide	1309-60-0	Pwdr	0.10	1.00	20	7.58E-02	0.2

CHEMICAL	CAS	Material Form	Previous Max credible quantity , MCQ (lb) (from FHC)	New Inventory[1] (~ 1 full container) (lbs)	TEEL-2 concentration mg/m3 from Rev24	TEEL-2 TQ (lbs) @ 30 m [Worst Case Met Conditions, SBDO Calc 07-024]	TQ RATIO= New Inventory / TEEL-2 TQ @ 30 m Rev 24
Lead fluoride	7783-46-2	Pwdr	0.10	1.00	15	7.58E-01	0.3
Lead iodide	10101-63-0	Pwdr	0.10	1.00	0.56	1.26E-01	7.1
Lead nitrate	10099-74-8	Pwdr	0.10	1.00	4	9.47E-02	1.0
Lead nitrite	13826-65-8	Pwdr	0.10	1.00	0.36	8.84E-02	11.0
Lead oxalate	814-93-7	Pwdr	0.10	1.00	0.36	8.84E-02	11.1
Lead Oxide (yellow)	1317-36-8	Pwdr	0.10	1.00	0.05	1.26E-02	73.6
Lead oxide CAS # is Lead tetroxide	1314-41-6	Pwdr	0.10	1.00	0.28	6.32E-02	14.3
Lead peroxide (lead dioxide CAS#)	1309-60-0	Pwdr	0.10	1.00	20	7.58E-02	0.2
Lead phosphate	7446-27-7	Pwdr	0.10	1.00	30	7.58E+00	0.1
Lead Sulfate	7446-14-2	Pwdr	0.10	1.00	30	8.84E-02	0.1
Lead sulfide	1314-87-0	Pwdr	0.10	1.00	350	7.58E+00	0.01
Lead sulfo-chromate	1344-37-2		0.10	1.00	NOT LISTED		---
Lead thioborate	NA		0.10	1.00	NOT LISTED		---
Litharge CAS # is lead tetraoxide	1314-41-6	Pwdr	0.50	5.00	0.28	6.32E-02	71.7

CHEMICAL	CAS	Material Form	Previous Max credible quantity , MCQ (lb) (from FHC)	New Inventory[1] (~ 1 full container) (lbs)	TEEL-2 concentration mg/m3 from Rev24	TEEL-2 TQ (lbs) @ 30 m [Worst Case Met Conditions, SBDO Calc 07-024]	TQ RATIO= New Inventory / TEEL-2 TQ @ 30 m Rev 24
Magnesia Oxide	1309-48-4	Pwdr	1.00	10.00	150	1.26E+01	0.3
Magnesium powder	7439-95-4	Pwdr	0.20	2.00	30	1.26E+01	0.3
Manganese oxalate No PAC data	6556-16-7		0.10	1.00	NOT LISTED		---
Mercury (elemental)[3]	7439-97-6	G	out	out	2.05	5.18E-02	---
Methl-sulfate No PAC data	299-11-6		0.20	2.00	NOT LISTED		---
Methyl alcohol	67-56-1	L	0.80	8.00	2750	3.01E+02	0.03
Monobutyl Ether	111-76-2	L	8.00	8.00	500	3.30E+03	0.002
Napthalene	91-20-3	Pwdr	1.00	10.00	75	4.62E+01	0.5
Nickel Carbonyl	13463-39-3	L	0.50	1.45	0.25	6.34E-03	228.7
Nitric Acid conc.	7697-37-2	L	50.00	66.12	61.80	1.71E+01	3.9
Nitro-benzene	98-95-3	L	0.22	2.20	100	5.16E+03	0.0004
Nitrogen	7727-37-9	G	2.00	2.00	250000	8.10E+03	0.0003
Nitro-toluenes (general Nitro-toluene #) other isomers: 88-72-2 ; 99-08-1 ; used powder **99-99-0**	1321-12-6	Pwdr	0.10	1.00	50	1.42E+01	0.1
Okite Stripper M 3 used Oakite Stripper cas # 75-09-2, methylene chloride		L	30.00	30.00	1940	6.58E+01	0.6
O-Phenylene-diamine	95-54-5	Pwdr	0.10	1.00	200	1.26E+01	0.02

CHEMICAL	CAS	Material Form	Previous Max credible quantity , MCQ (lb) (from FHC)	New Inventory[1] (~ 1 full container) (lbs)	TEEL-2 concentration mg/m3 from Rev24	TEEL-2 TQ (lbs) @ 30 m [Worst Case Met Conditions, SBDO Calc 07-024]	TQ RATIO= New Inventory / TEEL-2 TQ @ 30 m Rev 24
Oxalic Acid	144-62-7	Pwdr	0.22	2.20	40	1.26E+00	0.2
Oxygen	7782-44-7	G	2.00	2.00	TEEL withdrawn in R24	9.25E+03	
Phenol	108-95-2	Pwdr	0.10	1.00	88.50	2.24E+01	0.04
Phosphoric acid 85%	7664-38-2	Pwdr	18.00	33.50	500	1.26	0.3
Phosphoric anhydride	1314-56-3	Pwdr	0.50	5.00	10	2.53E+00	2.0
Phosphoric salt (red)	7723-14-0	S	0.70	7.00	0.75	1.26E+01	0.4
Phosphor-ous Pentoxide	1314-56-3	Pwdr	0.10	1.00	10	2.53E+00	0.4
Phosphorus oxychloride	10025-87-3	L	0.10	1.00	3	6.66E-01	1.6
Phosphorus pentachloride	10026-13-8	Pwdr	0.10	1.00	12.40	1.07E+00	0.3
Phos-phorus penta-sulfide	1314-80-3	Pwdr	0.20	2.00	50	1.26E+00	0.2
Phosphorus sesqui-sulfide same CAS as pentachloride	10026-13-8	Pwdr	0.20	2.00	12.40	1.07E+00	0.6
Phosphorus trichloride	7719-12-2	L	0.10	1.00	11.20	8.85E-01	1.1
Potassium ferro-cyanide	13943-58-3	Pwdr	0.50	5.00	59	1.52E+01	0.3
Potassium chlorate	4/9/3811	Pwdr	0.50	5.00	300	7.58E+01	0.1
Potassium chromate	7789-00-6	Pwdr	0.05	0.50	6	8.84E-01	0.3

CHEMICAL	CAS	Material Form	Previous Max credible quantity , MCQ (lb) (from FHC)	New Inventory[1] (~ 1 full container) (lbs)	TEEL-2 concentration mg/m3 from Rev24	TEEL-2 TQ (lbs) @ 30 m [Worst Case Met Conditions, SBDO Calc 07-024]	TQ RATIO= New Inventory / TEEL-2 TQ @ 30 m Rev 24
Potassium Cyanide	151-50-8	Pwdr	0.10	1.00	5	1.26E+00	0.8
Potassium dichromate	7778-50-9	Pwdr	0.50	5.00	10	6.32E-01	2.0
Potassium disulfate	7790-62-7	Pwdr	0.50	5.00	50	1.26E+01	0.4
Potassium hydroxide	1310-58-3	Pwdr	0.50	5.00	2	5.05E-01	9.9
Potassium oxalate	583-52-8	Pwdr	0.10	1.00	150	3.79E+01	0.03
Potassium thiocyanate	333-20-0	Pwdr	0.50	5.00	60	15.20	0.3
Pyridine	110-86-1	L	0.22	2.20	600	3.14E+01	0.01
Selenium	7782-49-2	Pwdr	0.10	1.00	1	2.53E-01	4.0
Selenium compounds	7488-56-4	Pwdr	0.10	1.00	1.81	3.79E-01	2.2
Silicon tetra-chloride	10026-04-7	L	0.10	1.00	NOT LISTED		
Sodium bisulfite	7631-90-5	Pwdr	0.10	1.00	25	6.32E+00	0.2
Sodium chromate this CAS # not listed, used 7775-11-3	1137-77-5	Pwdr	0.50	5.00	0.75	7.58E-02	26.4
Sodium Citrate	68-02-2	Pwdr	0.20	2.00	50	1.26E+01	0.2
Sodium cobalt nitrite	13600-98-1	Pwdr	0.10	1.00	3	7.58E-01	1.3
Sodium cyanide	143-33-9	Pwdr	0.10	1.00	5	1.26E+00	0.8
Sodium dichromate	7789-	Pwdr	0.50	5.00	0.72	7.58E-02	27.6

CHEMICAL	CAS	Material Form	Previous Max credible quantity, MCQ (lb) (from FHC)	New Inventory[1] (~ 1 full container) (lbs)	TEEL-2 concentration mg/m3 from Rev24	TEEL-2 TQ (lbs) @ 30 m [Worst Case Met Conditions, SBDO Calc 07-024]	TQ RATIO= New Inventory / TEEL-2 TQ @ 30 m Rev 24
	12-0						
Sodium fluoride	7681-49-4	Pwdr	0.50	5.00	5.53	1.26E+00	3.6
Sodium hydride	7646-69-7	Pwdr	0.10	1.00	10	2.53E+00	0.4
Sodium hydroxide	1310-73-2	Pwdr	1.00	10.00	5	1.26E+00	7.9
Sodium Hydroxide Ar packets	1310-73-2	Pwdr	50	50	5	1.26E+00	40-
Sodium hypo-chlorite	7681-52-9	Pwdr	0.10	1.00	50	1.26E+02	0.1
Sodium nitrite	7632-00-0	Pwdr	0.50	5.00	1	2.53E-01	19.8
Sodium nitro ferricyanide	14402-89-2	Pwdr	0.10	1.00	12.50	3.16E+00	0.3
Sodium oxalate	62-76-0	Pwdr	0.50	5.00	50	1.26E+01	0.4
Sodium peroxide	1313-60-6	Pwdr	0.10	1.00	10	2.53E+00	0.4
Sodium Silicate	1344-09-8	Pwdr	2.00	2.00	150	3.79E+01	0.1
Sodium thiocyanite	540-72-7	Pwdr	0.10	1.00	6	1.52E+00	0.7
Sodium xxlgas	In warehouse inventory, but insufficient information to identify chemical -						
Stannous chloride	7772-99-8	Pwdr	0.10	1.00	50	3.79E+00	0.1
Stannous oxalate	814-94-8		0.10	1.00	NOT LISTED		---
Strontium oxalate	814-95-9	Pwdr	0.10	1.00	60	1.52E+01	0.1

CHEMICAL	CAS	Material Form	Previous Max credible quantity , MCQ (lb) (from FHC)	New Inventory[1] (~ 1 full container) (lbs)	TEEL-2 concentration mg/m3 from Rev24	TEEL-2 TQ (lbs) @ 30 m [Worst Case Met Conditions, SBDO Calc 07-024]	TQ RATIO= New Inventory / TEEL-2 TQ @ 30 m Rev 24
Sulfite	In warehouse inventory, but insufficient information to identify chemical. ---						
Sulfuric Acid	7664-93-9	L	18.00	36.30	8.70	**9.09E+07**	0.0000005
Tartaric Acid	87-69-4	Pwdr	0.10	1.00	75	1.89E+01	0.1
Thallium iodide	7790-30-9		0.10	1.00	NOT listed		---
Thallium oxide	1314-32-5	Pwdr	0.10	1.00	2	5.05E-01	2.0
Thionyl chloride	7719-09-7	L	0.80	8.00	11.70	8.82E-01	7.5
Toluene	108-88-3	L	8.00	8.00	4520	5.82E+02	0.01
Tributyl Phosphate	126-73-8	L	0.80	8.00	150	5.39E+02	0.001
Trichloro Acetic Acid	76-03-9	Pwdr	0.10	1.00	15	3.39E+00	0.3
Trichloro-ethylene	79-01-6	L	8.00	12.90	2420	3.27E+02	0.04
Tri-sodium Citrate	68-04-2	Pwdr	0.10	1.00	125	3.33E+01	0.03
Xylene	1330-20-7	L	8.00	8.00	3990	2.82E+03	0.003
Yellow phosphorus	7723-14-0	Pwdr	0.10	1.00	3	7.58E-01	1.3
Zinc acetate	557-34-6	Pwdr	0.10	1.00	6	1.52E+00	0.7
Zinc carbonate	3486-35-9	Pwdr	0.10	1.00	100	2.53E+01	0.04
Zinc chloride	7646-85-7	Pwdr	0.10	1.00	50	2.53E+00	0.1
Zinc chromate	13530-65-9	Pwdr	0.10	1.00	15	8.84E-01	0.3

CHEMICAL	CAS	Material Form	Previous Max credible quantity , MCQ (lb) (from FHC)	New Inventory[1] (~ 1 full container) (lbs)	TEEL-2 concentration mg/m3 from Rev24	TEEL-2 TQ (lbs) @ 30 m [Worst Case Met Conditions, SBDO Calc 07-024]	TQ RATIO= New Inventory / TEEL-2 TQ @ 30 m Rev 24
Zinc nitrate	7779-88-6	Pwdr	0.10	1.00	10	2.53E+00	0.4
Zinc oxalate	4255-07-6		0.10	1.00	NOT LISTED		---
Zinc phosphate	7779-90-9	Pwdr	0.10	1.00	NOT LISTED		---
Zinc Sulfate	7733-02-0	Pwdr	0.10	1.00	3.50	8.84E-01	1.1
Zinc sulfide	1314-98-3		0.10	1.00	NOT LISTED		---
Zinc Sulfite	NA		0.10	1.00	NOT LISTED		---

[1] Usually the FHC took 10% of the maximum container size as the site inventory unless noted in the comment section of Appendix B of that document. Typically the new inventory is 10 times that assumed in the FHC. However, the ratio may vary depending on the assumptions for specific chemicals in the FHC.
[2]This chemical was in the original warehouse inventory, but no information is available.
[3]This chemical was in the original warehouse inventory, but deposition in MDA-B was unlikely.

References:

LANL 2010 MDAB-ABD-1004, R.1.1, Final Hazard Categorization for Material Disposal Area B, Los Alamos National Laboratory, Los Alamos NM, September 2010

LANL 2007 SB-DO: CAL 07-024, *Chemical Threshold Quantities for Safety Basis Categorization*, Los Alamos National Laboratory, Los Alamos NM, September 2010

TEEL list Rev21 AEGLs, ERPGs and TEELs for Chemicals of Concern , Revision 21, U.S. Department of Energy; Environment, Safety & Health; http://www.atlintl.com/DOE/teels/teel/Revision_21.xls

TEEL list Rev24 Protective Action Criteria (PAC) Rev 24 based on 60-minute AEGLs, ERPGs, or TEELs for Chemicals of Concern 2008, http://www.atlintl.com/DOE/teels/teel/Revision_24.xls

Document Action Request

Section 1 – Originator Request

Document No.: MDAB-ABD-1005	Revision No.: 5.1
Title: Facility Safety Plan for Material Disposal Area B	Page 1 of 1

Description of requested action (Attach numbered additional sheets if needed.):
Safety Basis- Authorization Basis Document. This FSP uses a What-if checklist as a rigorous, qualitative method for evaluating potential hazards and impacts to identify appropriate type, level, and number of physical and administrative barriers to prevent or mitigate potential accident consequences to the workers, thepublic, and the environment.

Originator Name (print):	Z#:	Organization:	Date:
Jose Romero	234904	IRM-DCS	12/20/2010

Section 2 – Responsible Manager Approval for Processing

☐ New Procedure ☐ Minor Revision ☒ Major Revision ☐ Deactivation ☐ Cancellation ☐ Perform Concurrent Periodic Review?

Superseded Document(s) and Revision Number:

☒ Approved ☐ Disapproved (return to originator) Comments:

Signature:	Print Name, Title:	Z#:	Date:
[signature]	Peter Rice	0214458	2/9/2011

Section 3 – Hazard Grading

Hazard Determination: ☒ Low ☐ Moderate ☐ High/Complex

Document is authorized to serve as IWD? ☐ Part I only ☐ Full IWD ☒ N/A

Section 4 – Required Reviews (see P315, Ch 16, Section 16.5.3)

Discipline:	Name:	Signature:	Date:

Validation Required: ☐ Yes ☒ No ☐ Waive Comment:

Scope of Validation: ☐ Entire Procedure ☐ Change Only

Validation Method: ☐ Walkdown ☐ Simulation ☐ Tabletop ☐ First Time Use

Training Determination completed?: ☐ Yes ☒ N/A Completed by: [signature] for Pam Flores

USQ/USI Number (if needed):	Signature:	Z#:	Date:
N/A PR 2-10-11			

Derivative Classifier: ☐ Unclassified ☐ OUO ☐ UCNI ☐ Classified	Signature: N/A	Z#:	Date:

Section 5– Final Approvals

☒ Release ☐ Hold Details:

Responsible Manager Signature:	Print Name, Title:	Z#:	Date:
[signature]	Peter Rice	214458	2-10-11